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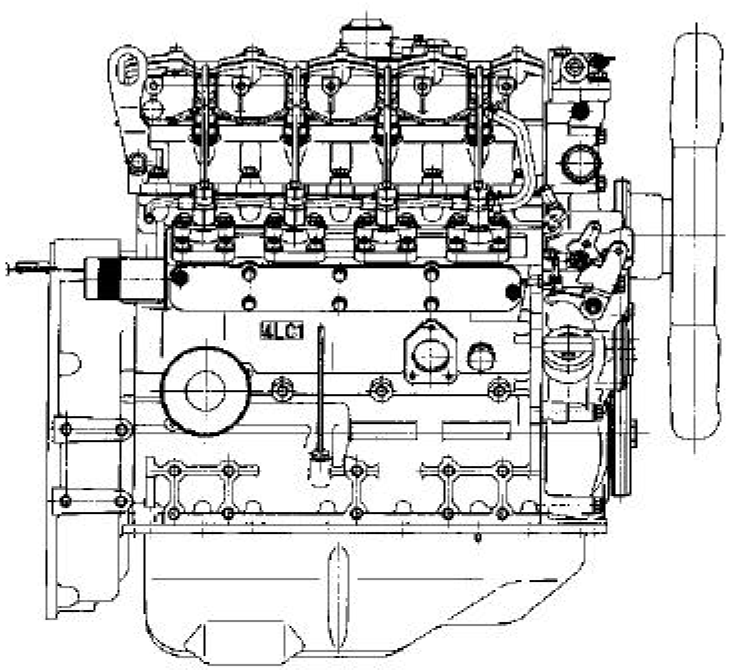
Foreword

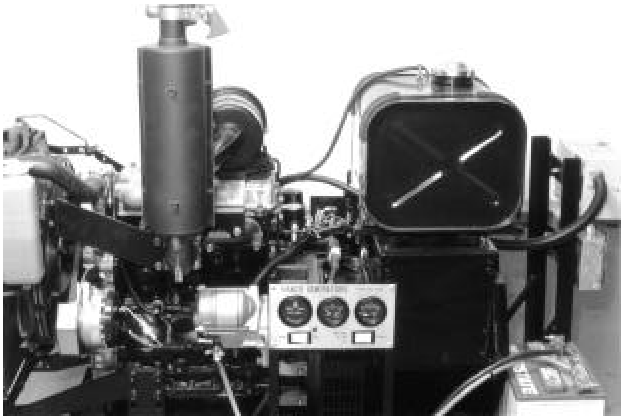
This book is designed to cover several aspects of the L-series engines. L-series engines currently in production are the 3LA, 3LB, 3LD, 4LB, 4LC, and the 4LE. This training manual is divided into six sections to make referencing information easier.

The introduction covers engine application notes and maintenance schedule. Section two is the engine component section that provides in-depth descriptions of each component. This will include component operation and important points that are critical to the disassembly, inspection and reassembly of the engine. Section three is the engine service section, which illustrates important information regarding fuel injection operation and routine fuel injection service items. Section four provides a comprehensive listing of all the critical engine specifications for the 3L engines. Section five contains the same specifications as they relate to the 4L engines. A broad range of component failures are illustrated in section six. Non-L-Series specific service information on various topics is placed in the appendix.

Due to the similarities between the 3L & 4L engines, we have created a single technician guide to cover both engines. This training manual outlines the important aspects of the repair manual; *however, it is not a stand-alone manual*. It must be used in conjunction with the appropriate Workshop Manuals.



I. Introduction – Application Notes



The L series engines are used in a variety of industrial applications ranging from small generators (pictured here) and light duty farm machinery to construction equipment. Their compact design makes them an ideal power system when conservation of space is of the utmost consideration. Internally, both the 3L and 4L engines share many similar parts. The main difference between these engines is their displacement and horsepower output. Additionally, the 4L series has the option of being turbocharged.

There are several L-series engines that are CARB (California Air Resource Board) certified. CARB emissions standards for the L series apply to engine models in the 11-25 hp range and 25-50 hp range. To meet the new CARB standards, the pump's injection timing has been changed. This eliminates the cost of expensive emission control scrubbing devices. The leaner fuel mixture (shorter injection duration) helps increase the exhaust temperatures while lowering emissions at a fraction of the cost of scrubbing devices. Another feature unique to Isuzu engines, is the conical shaped heat shield. This gives the incoming fuel injections a "swirl affect" that increases atomizing for maximum combustion efficiency; this too helps reduce exhaust emissions.

These are just some of the engineering refinements that Isuzu has implemented to stay abreast with the latest in diesel and diesel emission technologies. In the ensuing pages, a more thorough look at the internal components as well as fuel system will be covered.

I. Introduction – Maintenance Schedule

The following maintenance schedule is a comprehensive service program that takes a preventative approach to engine repair. Isuzu has established these standards with maintenance as the basis for prolonged product life. Isuzu highly recommends that if a routine maintenance schedule is not part of your customer support service, one should be implemented to better serve the needs of your customers.

Maintenance Item	Daily	250 hrs	500 hrs	750 hrs	1000 hrs
Oil level	✓				
Oil leaks	✓				
Proper oil pressure	✓				
Low oil warning lamp	✓				
Oil filter replacement ①		✓	✓	✓	✓
Engine oil ①		✓	✓	✓	✓
Fuel leaks	✓				
Contaminated fuel	✓				
Fuel filter replacement			✓		✓
Injector nozzle check			✓		✓
Coolant level	✓				
Coolant leaks	✓				
Fan belt tension	✓				
Coolant temperature	✓				
Coolant replace	Replace every 6 months				
Electrolyte levels	✓				
Radiator fin cleaning					✓
Radiator cap fitting check	✓				
Radiator cleaning					✓
Radiator cap function test	There is no service interval specification provided by Isuzu				
Air cleaner check/replace	Refer to element manufacturer for interval				
Wire/Connector integrity	There is no service interval specification provided by Isuzu				
Battery charge %	Refer to battery manufacturer or battery test tool for interval				
Electrolyte gravity %	Refer to battery manufacturer for interval				
Starter cleaning					✓
Generator cleaning					✓
Battery cleaning	✓				
Pre-heat condition	✓				
Abnormal engine noises	✓				
Exhaust color	✓				
Cylinder compression					✓
Valve lash check & set					✓

① Remove and replace after initial 50 hrs of engine operation. Then follow the regular maintenance schedule thereafter.

L-Series Engines

Below is a brief description of the application/development criteria and design characteristics of the L engine family:

Clean
- Individual Zexel® injection pumps w/short high pressure fuel injection pipes to reduce volumetric loss and minimize injection delay common at high speeds.
- Ricardo Commet-V type combustion chamber
- Steel laminated head gasket and liquid gasket for other sealing surfaces means no more asbestos
- Blow-by gases recirculated into intake with use of PCV valve

Quiet
- Single OHV cam that drives injectors, intake and exhaust valves (less gear driven components)
- Large mesh area on gear driven components
- Auto-thermatic pistons that reduce engine noise at start up and after warm up.

Small size
- Overhead valve to reduce engine height
- Full siamese engine block design reduces length

Ease of Maintenance
- All service points of engine are placed on the same side (oil fill, dipstick, filter, injection pumps, nozzles and glow plugs).
- Electric fuel pump purges air automatically

Identification

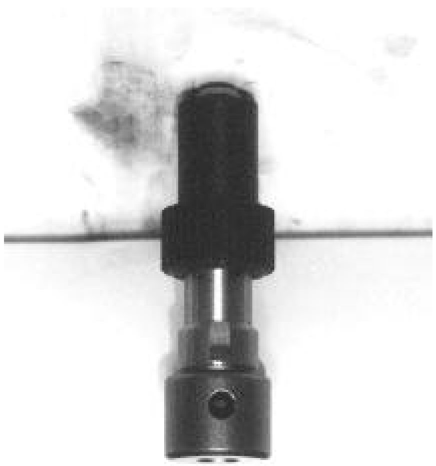
The production date for any Isuzu engine can be obtained be reading the letter codes on the ID tag (usually located on the head cover) and using the table below.

A	B	C	D	E	F	G	H	I	J
0	1	2	3	4	5	6	7	8	9

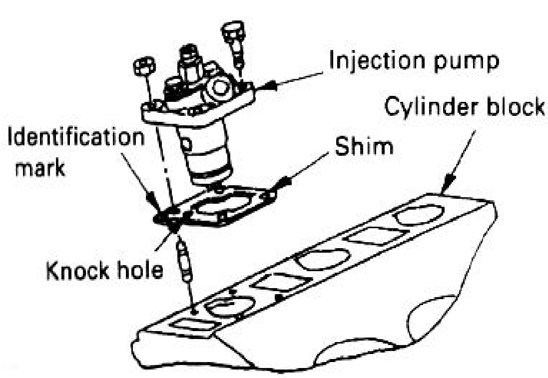
Example: BA/JB=10/91 (Engine produced October, 1991).

Pump Description

All L-series engines use individual injection pumps to supply fuel to the injection nozzles. The fuel pumps are mounted to the engine block, and are operated by the camshaft. Inside of the pump, there is a plunger barrel, timing sleeve, and plunger assembly. The plunger barrel contains the pump's timing sleeve. The barrel uses a guide pin to locate the timing sleeve in the correct position. The internal area of the plunger barrel also serves as the fuel reservoir. The timing sleeve fits over the plunger and both components fit inside of the plunger barrel



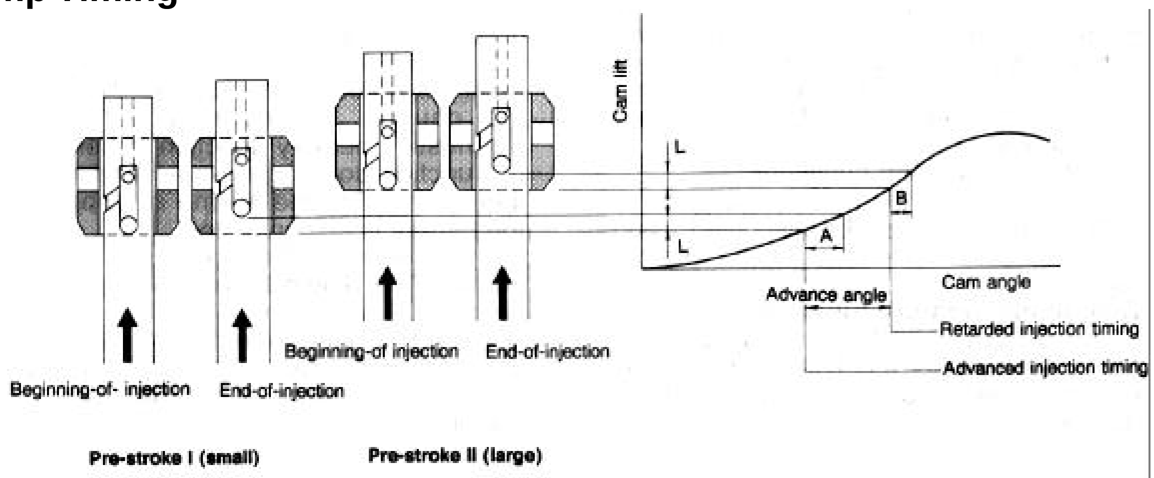
The timing sleeve component contains both the fill port and the spill port. Fuel enters the pressure chamber through the fill port. As the plunger rises, it closes the fill and spill ports, forcing pressurized fuel out the delivery valve to the injector nozzle. Any residual fuel is bled off through the spill port on the plunger return stroke.



Pump timing is determined by the thickness of shims placed between the pump housing and the cylinder block. Each shim varies in thickness by .1mm (.004"), creating a 1° change in timing (thicker=retard, thinner=advance). The shims are a "crush" design and must not be reused.

IMPORTANT: All pump shims must be of the same thickness when replaced. No single pump can have a different thickness shim installed. If this cannot be achieved, there could be a problem with the injection pump. During the warranty period, a pump requiring service must be returned to an authorized Zexel distributor.

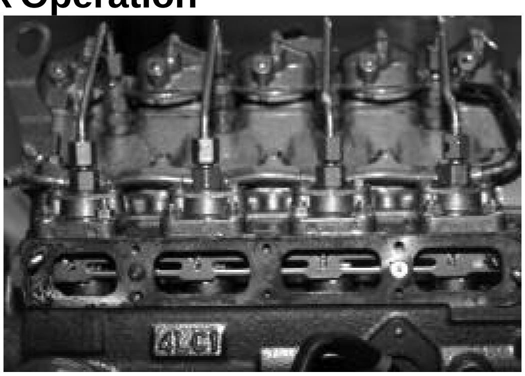
Pump Timing



This drawing shows the relationship between cam lift and cam angle when pre-stroke length is changed. The stroke length represented as "L" is always constant. When the pumps are advanced by using a thinner shim, the timing sleeve is lowered and the start of injection occurs at the beginning of the cam lift. (Note: the sleeve is fixed to the pump housing.)

Conversely, when the pump is retarded by using a thicker shim, the pre-stroke is lengthened because the timing sleeve is raised. Raising the pump housing changes the start of injection to the last half of the cam lift. It also reduces the total number of cam degrees to complete one injection.

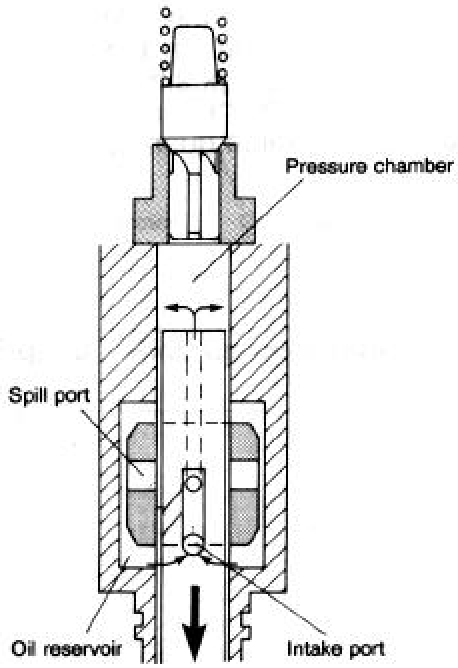
Rack Operation



The plunger's roller follower rides directly on the cam lobe. Plunger position is controlled by cam lobe lift. Rack movement rotates the sleeve, changing the spill port position relative to the plunger's helix. This, in turn, varies the amount of fuel injected.

NOTE: In order to remove the pumps from the block, the rack slide must be centered otherwise the pumps will hang-up on the cylinder block casting.

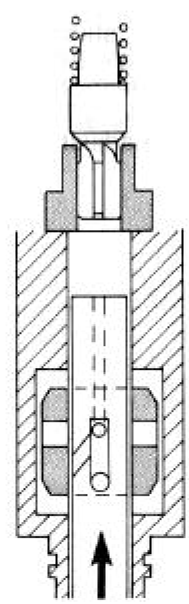
Pump Injection Sequence



Intake

Intake

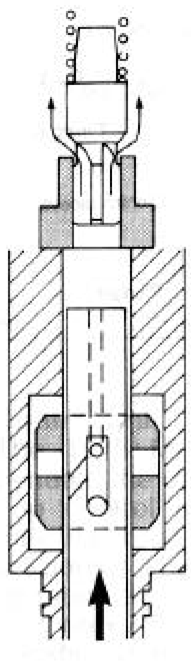
Fuel enters the high-pressure chamber from the intake port. However, even though the plunger begins to rise, pressure inside the chamber does not increase because the fuel from the inlet port flows back into the fuel reservoir via the spill-port hole


Beginning-of-injection

Beginning of Injection

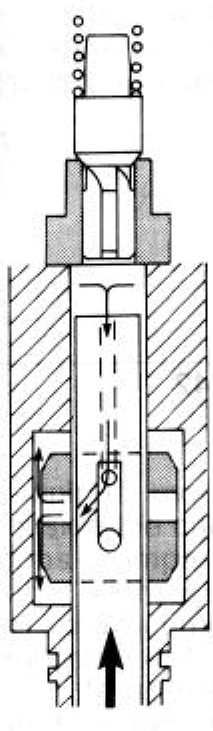
As the plunger rises, it blocks the spill port hole in the timing sleeve. The plunger blocks the inlet port preventing additional fuel from entering the high-pressure chamber. It is during this transition that pressure inside the chamber begins to develop.

Pump Injection Sequence (continued)



Pressure feed

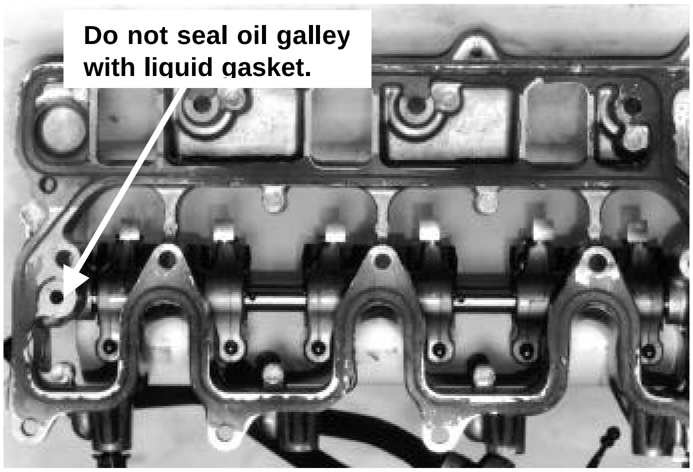
Pressure Feeding
Since the intake port and helix are kept closed by the timing sleeve, fuel pressure continues to rise, the delivery valve opens, and fuel flows to the injector.



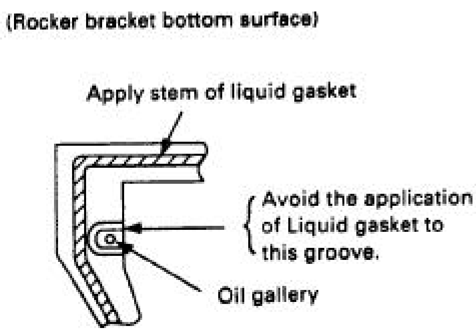
End-of-Injection

End of Injection
On the return stroke, when the plunger helix reaches the timing sleeve's spill port, the pressurized fuel flows through the spill port and into the oil reservoir. At this moment pressure in the chamber drops which ends the injection cycle.

Valve Train



<u>IMPORTANT! Upon reassembly, make certain that all rocker springs are installed in their correct location. Also ensure that the oil galley is not blocked when applying liquid gasket.</u>

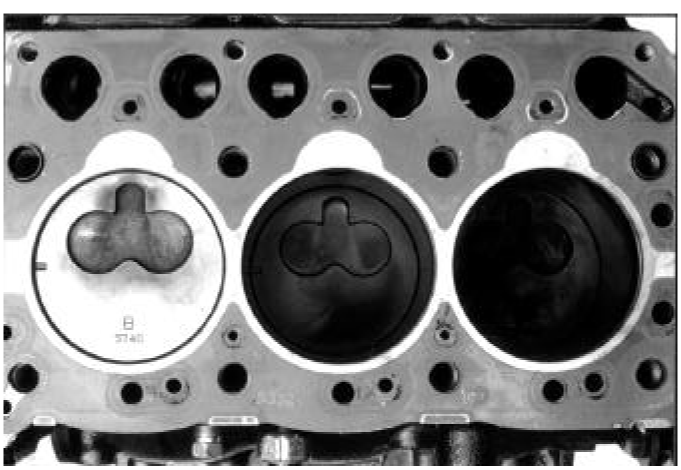


L-series engines use individual rocker arms mounted on a common shaft. The rockers and shaft are mounted inside the rocker bracket assembly. Both components can be removed for servicing by simply removing the balance shaft's retaining plug at the rear of the bracket.

Before disassembly, note the positioning of the left and right offset rocker arms. Off-setting the rocker arms straightens out the push rod angle. It also helps move the push rod end of the rocker arm away from the bracket area to eliminate rocker to bracket contact.

During disassembly, difficulties removing the shafts may be experienced. This is due to the slight interference fit in the bracket holes, which may be compounded with varnish or sludge build-up on the shaft.

NOTE: During reassembly, special care must be taken to properly seal the rocker bracket assembly. Since this is the intake manifold, improper sealing will result in excessive oil consumption.

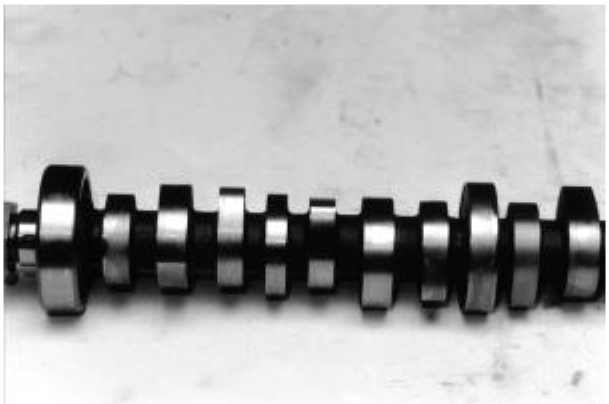


The rocker shaft is oil pressure fed through a galley machined in the cylinder head. This galley intersects with the main oil galley in the block to provide full pressure oiling to the rocker arms.

<u>Important: When replacing the head gasket, be sure that the oil hole in the gasket is aligned correctly with the oil galley in the block. Failure to do so will prevent oil from reaching the rocker shafts</u>.

The head gasket is available in one thickness only.

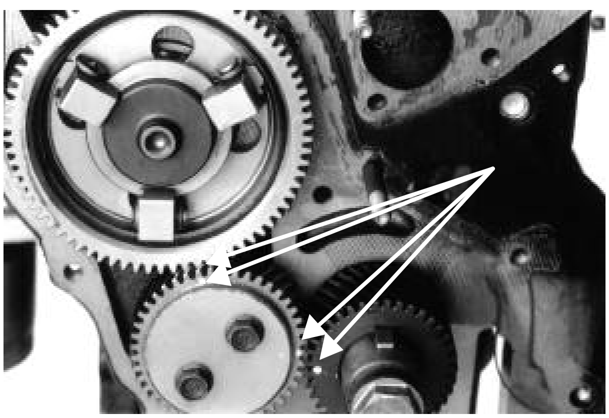
Camshaft Design



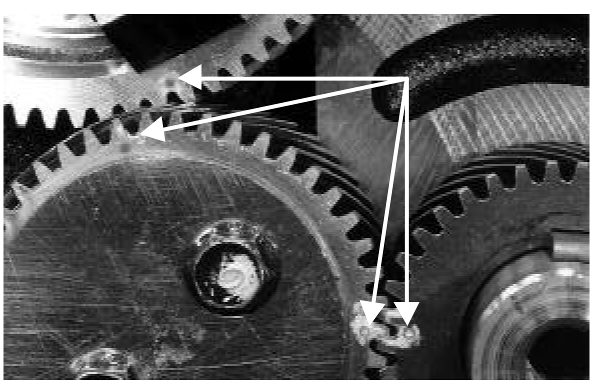
The camshaft is a cast iron billet and has lobes for *both* the valves *and* fuel pumps. The cam is supported by two ball bearings and a needle bearing (located in the center of the block) to reduce friction and improve shaft durability. The lifters are conventional flat tappet design, requiring periodic valve adjustment. The camshaft also has an oil galley drilled into the front of the shaft that provides lubrication for the flywheel sleeve assembly.

NOTE: It is not uncommon to see marks that resemble tracks on the fuel pump lobe. These are track marks from the fuel pump's roller lifter. This is a normal characteristic of this design.

Camshaft Gear Timing



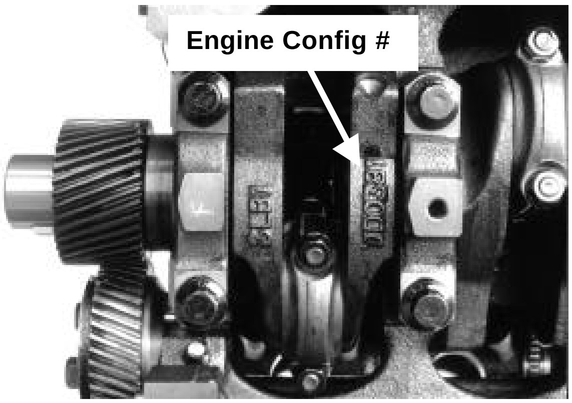
Correct camshaft timing is shown at the left. The crankshaft is positioned with the key way at the top. The crankshaft gear timing mark will be at approximately 9 o'clock. The idler gear is positioned with one mark at 3 o'clock (lined up with the crankshaft's mark), and with a second mark at 12 o'clock. The camshaft gear timing mark aligns with that second mark on the idler gear.



IMPORTANT: The initial timing of these gears is absolutely essential. Due to the combination of different gear ratios, the timing marks will not line-up with their respective gears after the engine has been rotated a few times.

II. Engine Component Description

Crankshaft



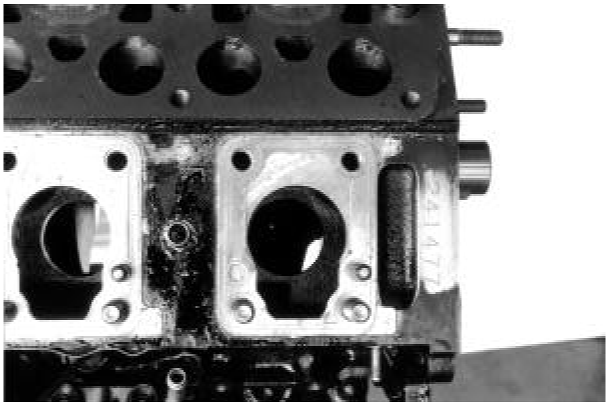
The crankshaft is forged steel with induction hardened main and connecting rod journal surfaces. Induction hardening is applied to the friction surfaces of the journals, crank pins and oil seal surfaces to improve wear resistance.

The crankshaft has the engine configuration number cast on the crankshaft for identification.

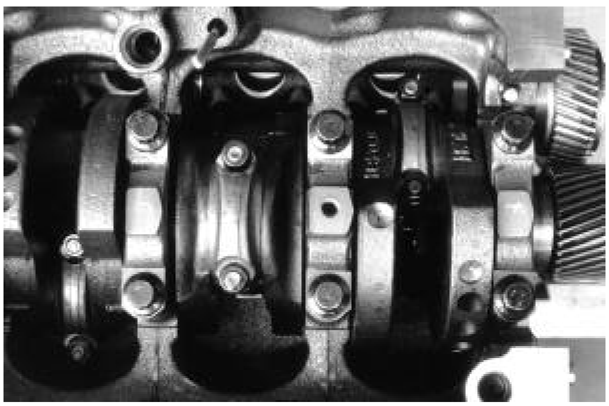
Each rod journal has its own set of counter weights to simplify balancing and help reduce crankshaft vibrations. Certain L-Series engines are externally balanced with the use of weights on the crankshaft damper. **NOTE: The dampers should NEVER be interchanged. Excessive engine vibration and damage will occur.**

IMPORTANT: The crank is hardened using Tufftriding. Isuzu does not recommend grinding the crankshaft undersize.

Cylinder Block



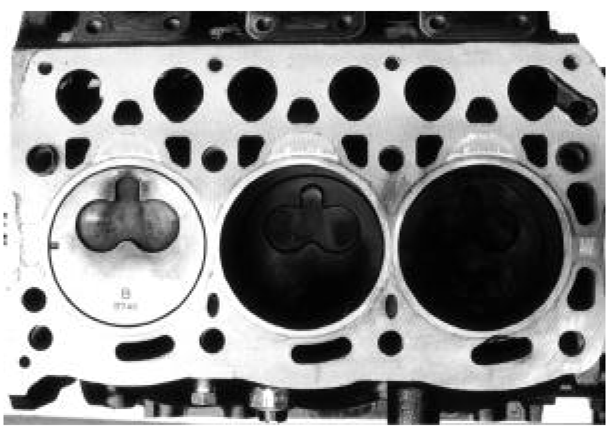
The engine’s serial number is stamped on the front of the engine block. This number is used by parts technical personnel to track an engine's application or verify a specification. Also shown are the castings in the block for the individual injection pumps.



The 3L cylinder block features four main bearing supports. The 4L block contains 5 main bearings. The caps are identified as detailed below:

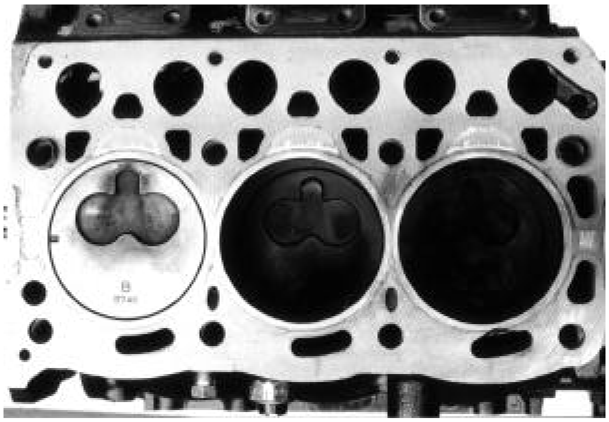
4L	3L
#1 “F”	#1 “F”
#2 *	#2 *
#3 “C”	#3 “C”
#4 “R”	**#4 “C” and a “▲”**
#5 “R”	

* has oil pump pick-up tube hole



The engine block uses cast-in-place rather than removable liners. The block is a semi-dry deck configuration incorporating overhead oiling for the rockers. The cylinders and the deck surface are cast together giving the block extra support around the tops of the cylinders. Coolant circulates around the periphery of the cylinder bore area. This helps reduce piston ring temperatures by eliminating cylinder hot spots that are inherent with siamese cylinder bores.

Piston Sizing



Pistons are matched during assembly to the final bore diameter and deck height dimensions. Piston clearances are set-up at the factory within a window to keep noise to a minimum level; but these clearances are tight enough to prevent piston skirt galling.

L-Series engines do not use replaceable cylinder liners. Service grade pistons are available for warranty repairs, in standard size only.

If the engine is out of warranty, pistons are available for cylinders bored .010 over. Boring the cylinders and use of oversize pistons is not approved for Isuzu warranty repairs.

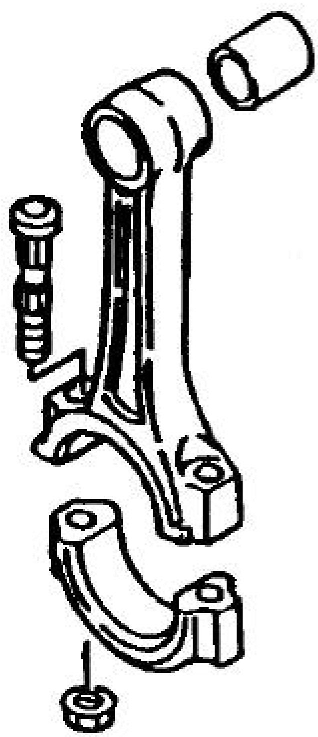
TIP: Previously, pistons were bore sized and identified with grade lettering for service replacement. This system has been terminated for the L-series engine and your parts book should reflect the change. Please refer to bulletin #AIPDN-PTS-ED02-98 for ordering replacement pistons.

Note: The bore size identification stamp is located on the block just above the fuel pump hole.

Connecting Rod

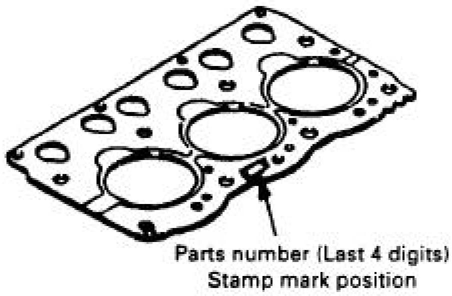
A forged steel I-beam connecting rod is used for all L-series engines. They are full floating design with bushed wrist pin ends.

NOTE: When removing and replacing the connecting rod assemblies, be sure to install the connecting rod with the Isuzu Logo facing the same direction as the piston's forward notch.



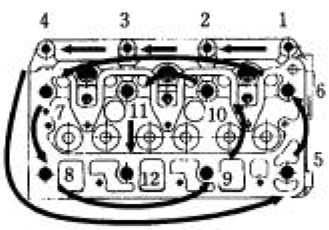
IMPORTANT: The rod cap bolts are not to be removed. It is shown only for clarity, but is not a standard rod cap bolt. These bolts have serrations (to prevent the bolts from turning) and are pressed onto the rod. When servicing, the entire rod must be replaced.

Cylinder Head Gasket



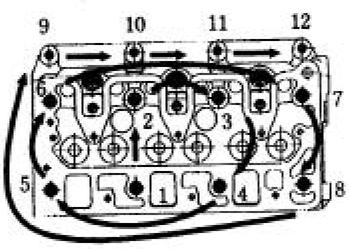
IMPORTANT: The head gasket must be installed with the flat side of the sealing bead facing up. Also the large flat end of the gasket must face forward.

Head bolt loosening sequence.



Head bolt torque sequence.

(See engine repair specifications section.)

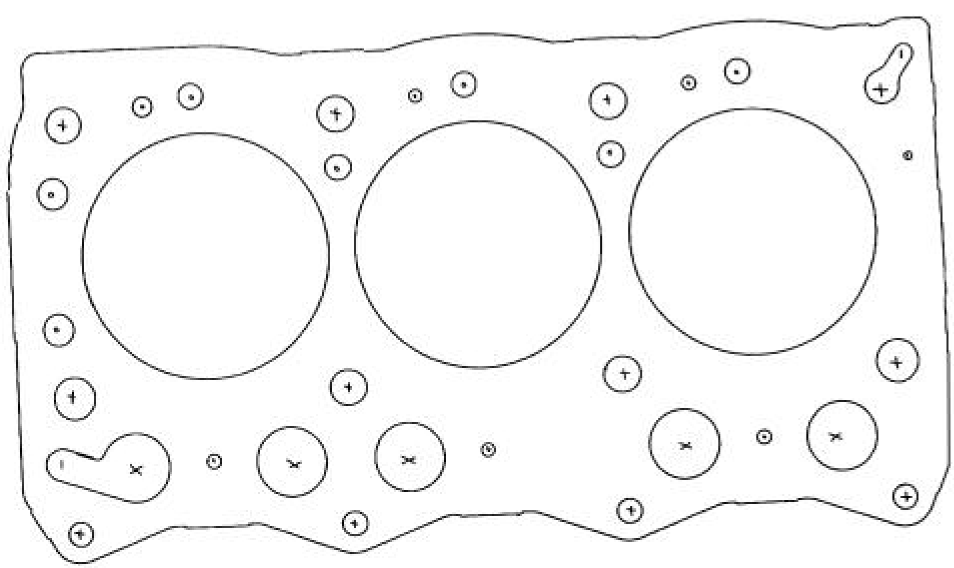


The L-series engines use a three layer ultra thin laminated steel head gasket that requires no retorqueing after the engine break-in period. Holes for coolant are drilled between the valve seats for effective cooling of the combustion area.

The sealing bead surrounding the cylinders of the gasket is stainless steel. It protects the head gasket from the high cylinder pressures. The sealing bead also protects the gasket from the high temperatures released by the hot plugs.

The gasket comes pre-coated with a silicon material. Therefore, no additional application of sealers or gasket adhesives is necessary, and no re-torqueing of the head bolts is required if the prescribed angular tightening method is used.

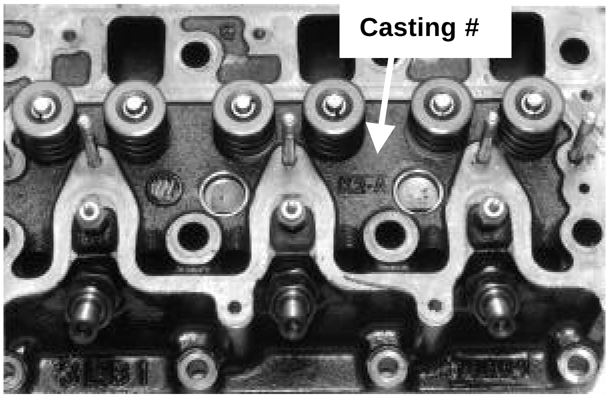
To identify the gallies, use the drawing and legend below.



Legend

o Coolant
- Oil
+ Bolt
x Push Rod

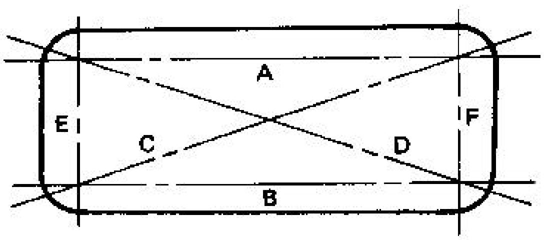
Cylinder Head



The L-series cylinder heads are cast iron with replaceable valve guides and valve seats. The head casting number is embossed at the front of the head's casting just below the injector nozzle bore.

Compression tests are conducted using a compression gauge adapter used as a glow plug insert, special tool number 5-88402-656-0. Refer to workshop manual for procedure.

The service limit for this engine is 370 psi (26.0 kg/cm^2). Standard pressure is 441 psi (31.0 kg/cm^2). Isuzu allows an 8% variance between cylinders on compression tests, but there can be no more than a 15% difference between any two cylinders.



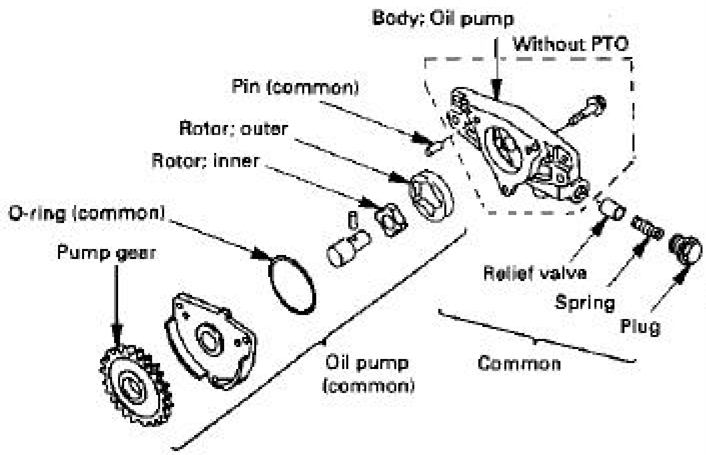
Letters A-F represent the different measurements that need to be taken to determine head warpage.

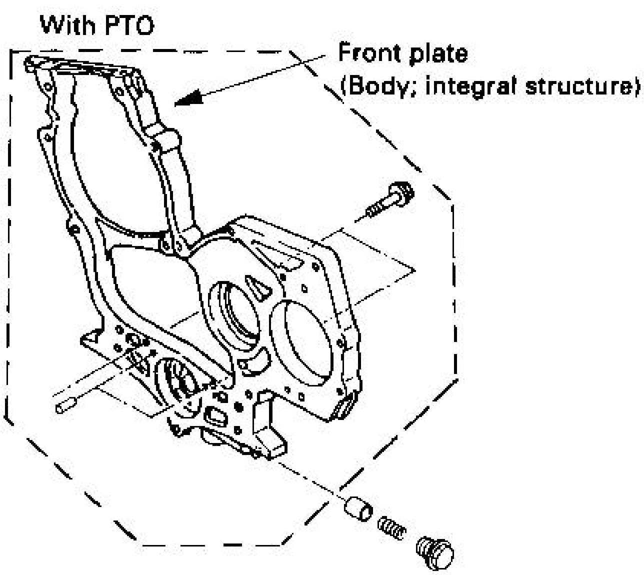
Upper & Lower face warpage specifications:
Standard: 0.075 mm. (0.0029 in.)
Limit: 0.15 mm. (0.0059 in.)
Max Grinding Allowance: 0.3 mm. (0.0118 in.)

Head Height:
Standard: 64 mm. (2.5197 in.)
Limit: 63.7 mm. (2.5079 in.)

IMPORTANT: Valve depression must be checked to ensure that it is still within specification.

Lubrication





Lubrication is achieved with a conventional wet sump oiling system. Internally, the trochoid oil pump uses a set of rotors instead of spur gears.

It is a very efficient and smooth operating pump. Compared with the spur gear type pump, the trochoid pump gives practically continuous flow, due to less leakage on the discharge side of the pump.

The pump is mounted to the front of the engine block and driven by the crankshaft.

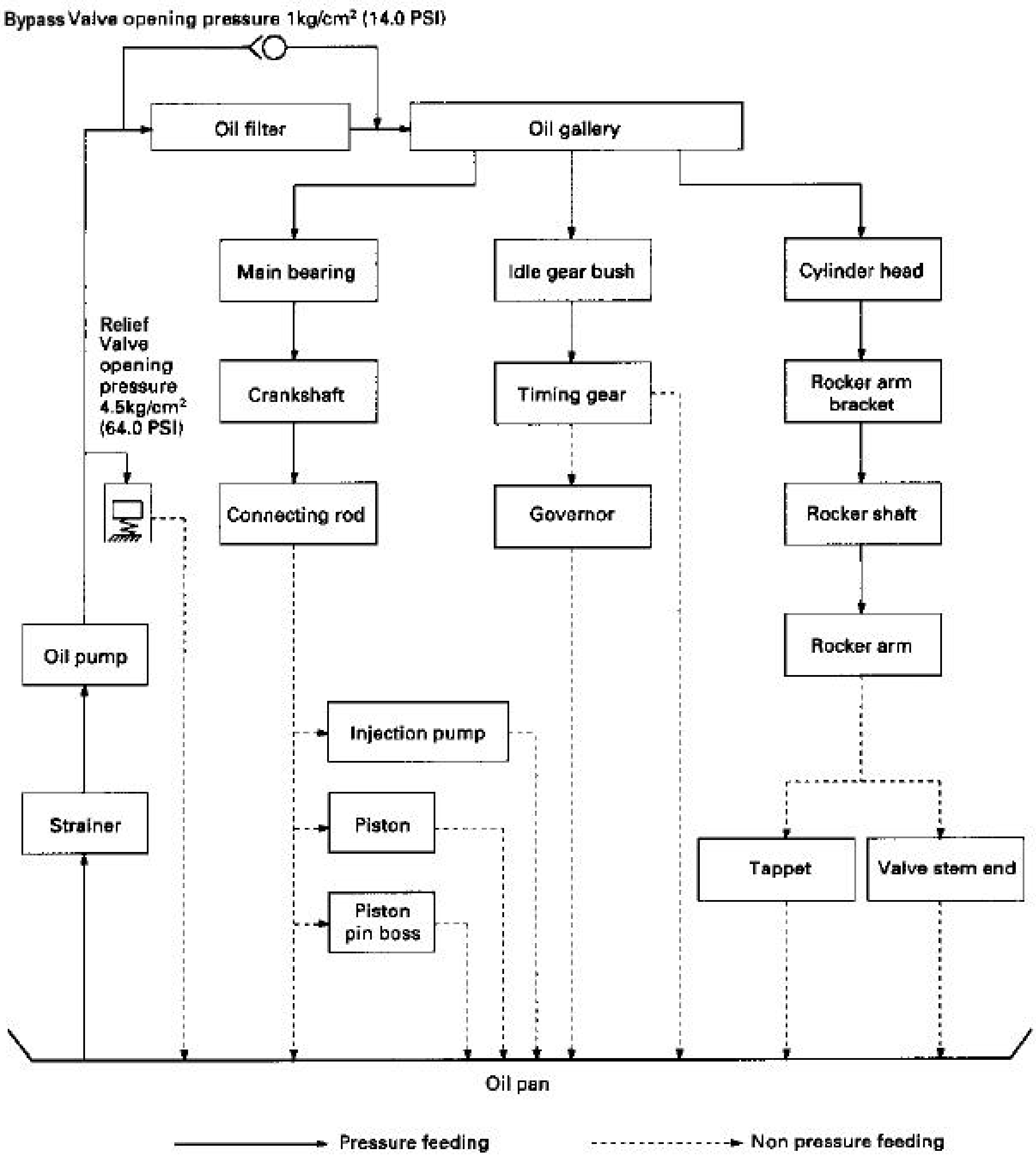
On the pump's exterior housing, there are two lugs machined for dowel pins. This enables the pump to be repositioned in exactly the same location without having to set pump gear backlash.

The pump is a serviceable unit. Internal components are interchangeable between PTO and non-PTO versions.

TIP: Always remove the pump's pressure relief valve during a rebuild. Look for a cocked pressure spring, burred relief valve or burred pump housing that would cause the pressure valve to fail. (If housing is burred, it must be replaced.)

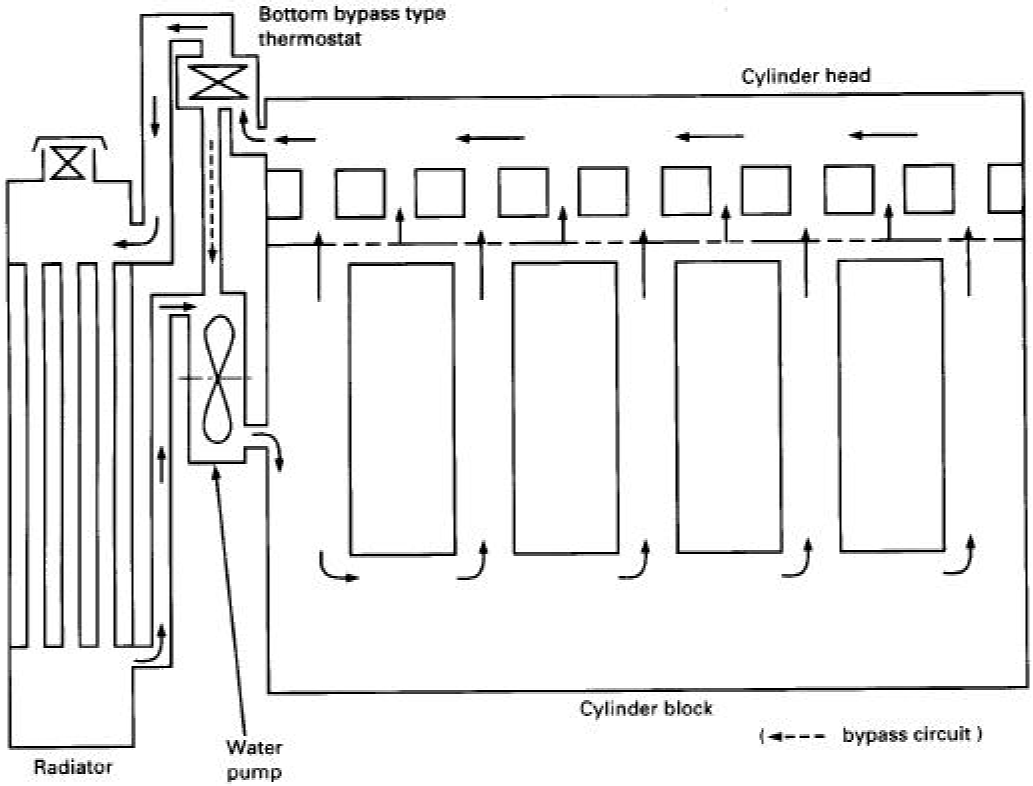
Lubrication (continued)

Below is the oil full flow diagram. Note the valve opening pressure for the oil filter bypass valve (14 PSI is where the valve *begins* to open. The same is true for the oil pump relief valve, which *begins* to open at 64 PSI.).



Cooling System

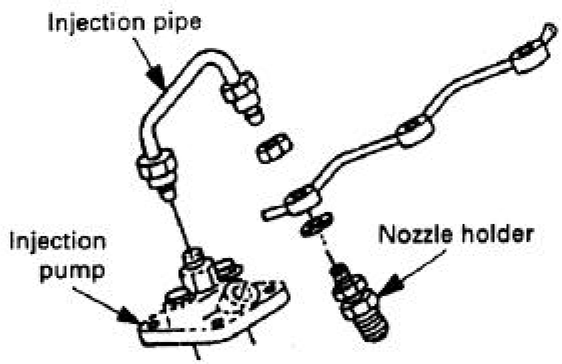
Below is the coolant flow diagram. Good coolant circulation is ensured by utilizing water jackets formed with a one-piece casting core, which eliminates burrs in the water passage.



Maintain a coolant/water solution concentration ratio of $^{50}/_{50}$. Use only de-mineralized (soft) water, since hard water tends to neutralize the corrosion inhibitors in the antifreeze and add scale (particularly in hot spots) to the cooling system. It is absolutely ***required*** that you use a ***low-silicate*** formula anti-freeze. Do not add any additional water pump lubricants to the cooling system. Refer to the Workshop Manual for radiator cap and cooling system testing and specifications.

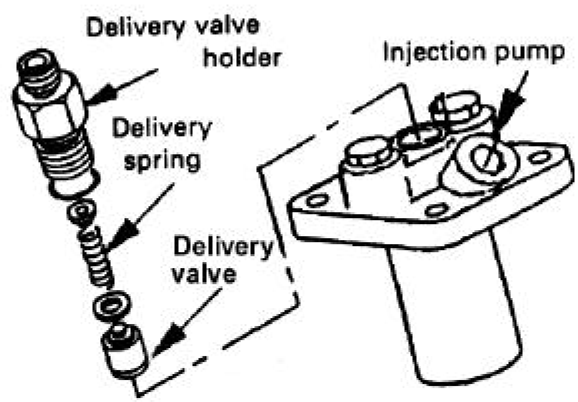
Use a commercially available antifreeze tester when testing for coolant/water mixture. Testing for pH is essential, as too high an acidity or alkalinity can cause severe damage to the engine and cooling systems. The pH readings should be 7.5-8.5 (SAE J1034 allows for 7.5-11.0). Litmus test paper is available from most commercial tool suppliers and product distributors.

Spill Port Timing



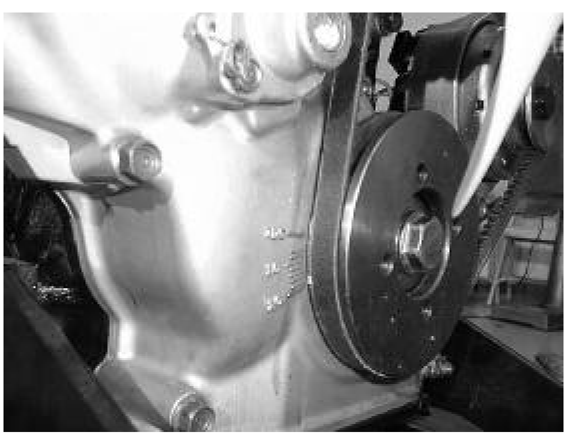
Spill-port timing is a precise method of measuring the initial injection of fuel by the pump and the duration of injection. It is a standard procedure used by Isuzu when timing Zexel pumps. This procedure is a very precise method of timing fuel because it shuts off fuel to the high-pressure chambers relative to the position of the piston.

Disconnect the injection pipe from the nozzle holder.



Remove the nozzle delivery valve holder from the pump. Reinstall the holder without the delivery spring and delivery valve. Pressurize the pump. Then rotate the engine clockwise until fuel quits flowing out of the holder. (This is the beginning of the injection).

NOTE: Remember that the injection pump uses shims to advance or retard injection. Thicker retards the timing, thinner advances it).



Observe the reading on the crank pulley in relation to the timing marks on the gear case cover. If this value is out of range, change the thickness of the shims from underneath the pump. Each shim varies in thickness by .1mm (.004”), creating a 1° change in timing (thicker=retard, thinner=advance). The shims are a “crush” design and must not be reused.

NOTE: Refer to the proper specification sheet for timing adjustment information.

After spill port is performed, be sure to reassemble all components and install correctly for proper operation.

Valve Adjustment

Bring the engine up on number one compression stroke. Verify the position by checking for clearance in-between the valve stem tip and the rocker arm. **NOTE: Valves can be adjusted beginning with #1 or #3 (3L) or #4 (4L). This adjustment can only be made with a cold engine.**

3L Engines

Cylinder Number	1		2		3	
Valve Arrangement	I	E	I	E	I	E
Valve Numbers	✓	✓	✓	------------	------------	✓

4L Engines

Cylinder Number	1		2		3		4	
Valve Arrangement	I	E	I	E	I	E	I	E
Valve Numbers	✓	✓	✓	---------	---------	✓	---------	---------

Loosen the adjuster jam nut; insert a 0.40 mm (0.016”) feeler gauge in-between the rocker tips and the valve stems to adjust the valves. **NOTE: Proper adjustment is obtained when there is a slight drag against the feeler gauge. Jam nut torque is 5.8-8.7 lbs. ft (0.8-1.2 kg m)**

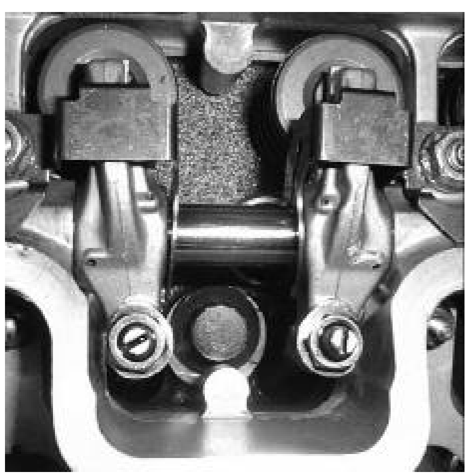
Rotate the crankshaft 360° (so that the opposing piston is now on its exhaust stroke) and adjust the remaining valves.

3L Engines

Cylinder Number	1		2		3	
Valve Arrangement	I	E	I	E	I	E
Valve Numbers	------------	------------	------------	✓	✓	------------

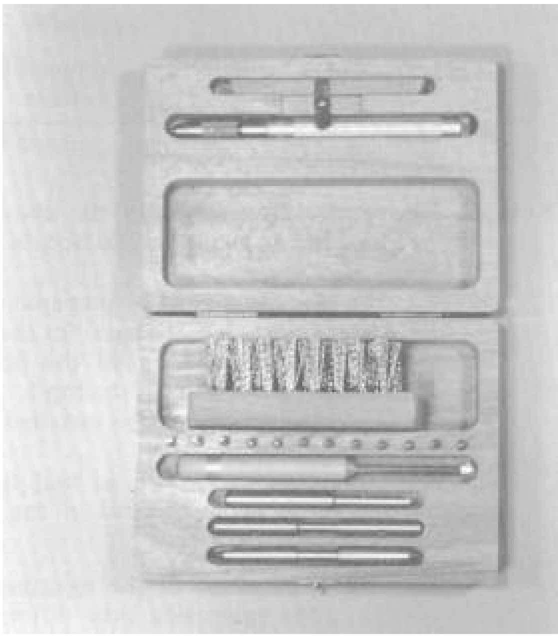
4L Engines

Cylinder Number	1		2		3		4	
Valve Arrangement	I	E	I	E	I	E	I	E
Valve Numbers	---------	---------	---------	✓	✓	---------	✓	✓



Injector Service

The following procedures are service recommendations from Zexel:



Thoroughly clean all carbon residue and carbon build–up on the surface of the nozzle using Zexel cleaning kit #1057790010.

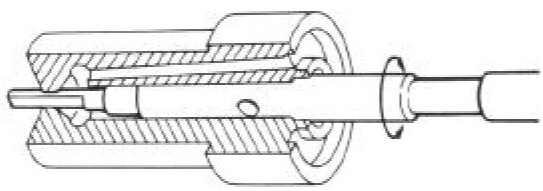
Soak all parts other than the nozzle in cleaning oil.

Use a soft wire brush to clean excessively dirty parts.

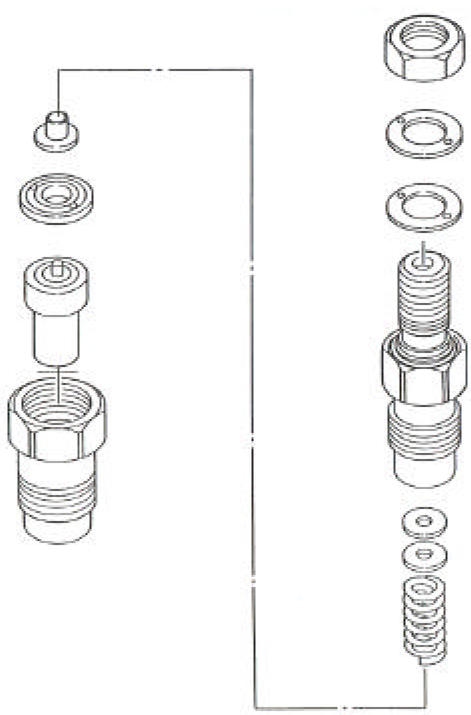
IMPORTANT! Do not use metal or abrasive cleaning media to clean the nozzle holder. Their abrasive nature will leave scars on the ground surface and may cause fuel leaks.

Injector Service (continued)

Remove the needle valve from the nozzle. Clean the seat's surface and shaft section using the piece of hardwood from the cleaning kit or a clean soft cloth dipped in oil.



Likewise, clean the spray hole with the special needle also supplied with the cleaning kit.

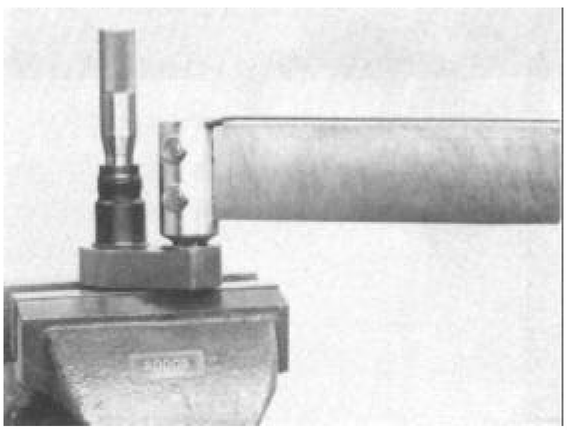


Re-wash the injector components to remove any final debris.

Reassemble the injector.

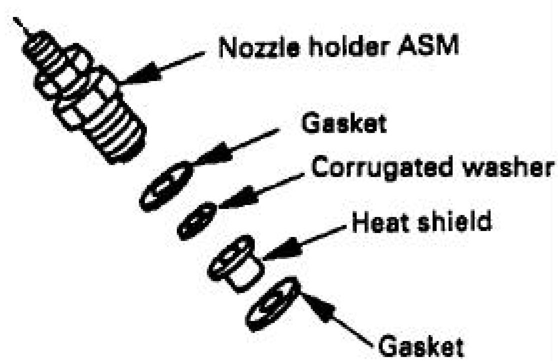
Injector Service (continued)

Note: Before assembling the injector, perform a needle slide test to ensure that there is no obstruction that could cause a fuel leak.



Insert the body nozzle holder to center the nozzle in the retaining nut. For reassembly torque specifications, see Appendix “Nozzle Holder Tightening Standards.”

NOTE: Use a flare nut/crowfoot socket on the torque wrench.

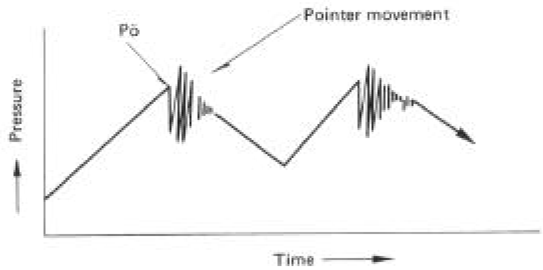


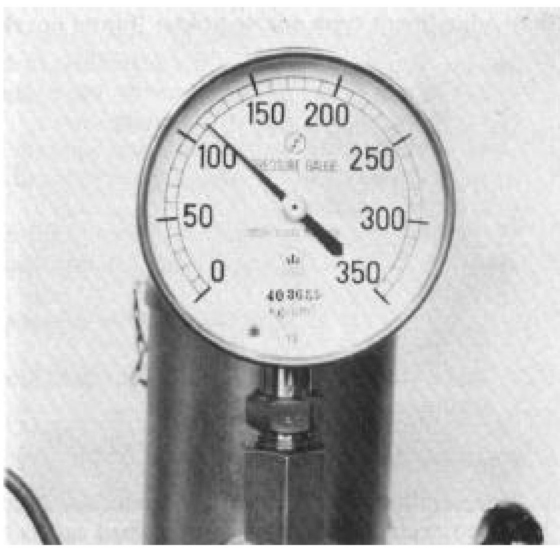
When installing nozzle assembly into the cylinder head, be sure to replace the gaskets and washers, as they can only be used once. **NOTE: The blue side on the corrugated washer faces the nozzle.**

Tighten the retaining nut with a torque wrench to 29-36 lb. ft. (39-49 Nm).

Injector Pop-off Test

WARNING: FLUID FROM THE NOZZLE TESTER WILL SPRAY OUT UNDER GREAT PRESSURE. IT CAN EASILY PUNCTURE A PERSON'S SKIN. KEEP YOUR HANDS AWAY FROM THE NOZZLE TESTER AT ALL TIMES.





Use the following procedure to check nozzle opening pressure, spray pattern, chatter and leakage:

Mount the nozzle and holder assembly to the gauge (J28829) and bleed the system of air.

Open the pressure gauge valve and pump the lever at a rate of one stroke per second.

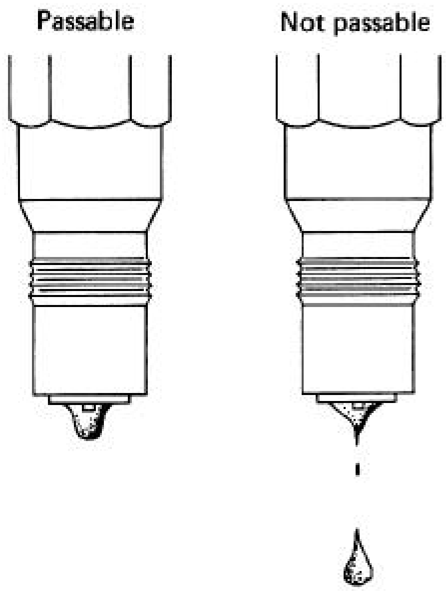
Then check the opening pressure. When the pressure gauge pointer decreases rapidly, read pop-off value. (Refer to engine's specification sheet for values. An Indirect Injection will have lower readings than a Direct Injection engine.)

IMPORTANT! If the nozzle opening pressure is not steady or cannot be checked the trouble is with the nozzle assembling procedure.

If the nozzle "pop-off" pressure does not meet factory pressures, disassemble the nozzle and make a shim adjustment. The following size shims are available through AIPDN.

Shim Part Number	Shim Size ^{mm}
894176-9620	0.10
894176-9630	0.20
894176-9640	0.30
894176-9650	0.40
894176-9660	0.50
894176-9670	0.52
894176-9680	0.54
894176-9690	0.56
894176-9700	0.58
894176-9710	0.80

Injector Leak Test



The leak test should be conducted immediately following the nozzle opening pressure adjustment check.

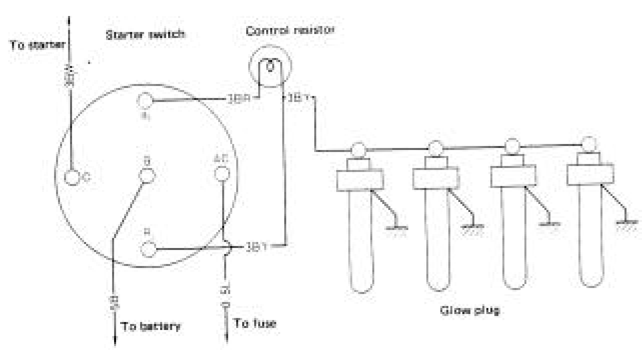
⇒ Wipe the nozzle with a clean shop towel.

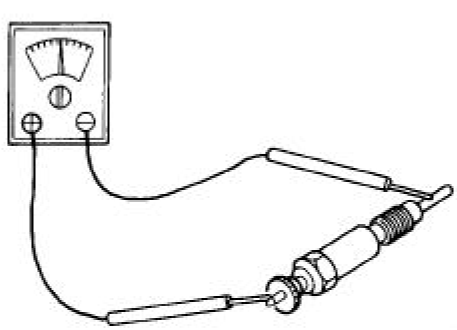
⇒ Decrease the tester pressure about 20 kg/cm^2 less than the pop-off pressure and maintain the position.

⇒ There should be no fuel discharge from the nozzle for at least 10 seconds.

⇒ Re-clean or replace any nozzle that doesn’t meet the criteria.

Glow Plug Inspection





The following procedure tests the resistance value of the glow plug. **NOTE: The test can be performed on or off the engine.**

Total glow plug resistance value should be £ 0.9 ohms.

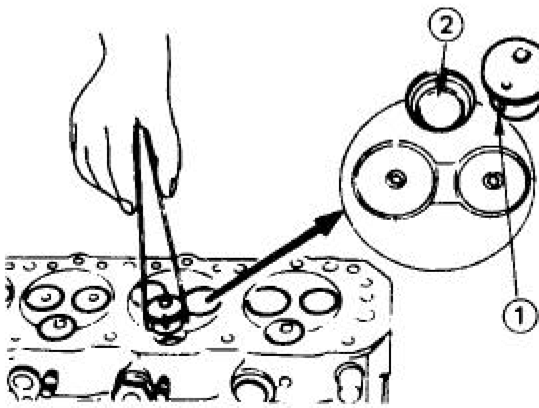
On engine service:

- Remove the buss bar from the glow plug.
- Attach the DVOM red lead to the to the tip of the glow plug.
- Attach the DVOM black lead to a good ground source. Verify the ground integrity by testing it with the DVOM.

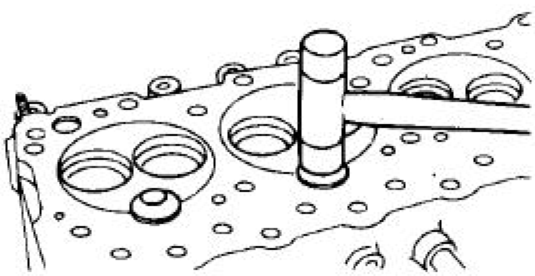
Off engine service:

- Disconnect and remove glow plug.
- Place DVOM leads across glow plug (one lead at each end) to obtain resistance reading.

Hot Plug Replacement



Note: Illustration is generic and does not precisely represent the L-Series hot plugs.



Hot plugs for the L-series are similar to other Isuzu diesel engines.

If the plug needs to be replaced, knock out the old plug from behind, though the injector nozzle hole.

Always remember that the plug groove in the cylinder head needs to be clean and free of any burrs that would prevent proper seating. Align the hot plug knock ball (1) with the cylinder head groove (2) and tap it temporarily into position with a plastic hammer.

NEW PLUG:
Place a 1” thick metal plate over the top of the hot plug and press fit the plug using 4 to 5 tons of force on the metal plate.

OLD PLUG:
When re-using plugs, be sure to place the plug in the same hole that it came out of originally. Tap the plug head into place and ensure that the plug is firmly seated. Grind off any surface protrusions so that it is completely flush with the surface of the head.

NOTE: Most current/newer model surfacing machines do not require hot plug removal before head refinishing. Consult your particular equipment manual.

Maintenance Specifications

Item	Metric Measure	US Measure
Engine Oil Capacity ① *3LA/B1* *3LD1*	5.1 Liters 6.8 Liters	5.4 quarts 7.2 quarts
Engine Oil Pressure ⑤	4-5 Kg/cm^2	43-51 lbs
Compression Pressure ②	31 Kg/cm^2	441 psi ②
Valve Adjustment	.40 ± 0.05 mm	0.015 ± .002 in
Engine Coolant Capacity ③	2.2 Liters	2.3 quarts
Injection Starting Pressure	12.7-13.7 Mpa	1850-1990 psi
Injection Timing ④	19° BTDC	
Fan Belt Deflection Tension	8.0 mm-12 mm	0.3-0.5 in
Glow Plug Resistance	0.7-0.9 Ω	

① These specifications vary depending upon the type of equipment in which the engine is being installed. Only use API class CD or better.

② First warm up engine until coolant temperature reaches 167° F (75° C)
Measured at 250 rpm
Service Limit is 26 Kg/cm^2 (370 psi)

③ Use only an Ethylene glycol based anti-freeze/ water mixture. A $^{50}/_{50}$ concentration ratio provides maximum protection to –37°C or –34°F. Never exceed a $^{60}/_{40}$ concentration ratio, which provides protection to ≈ -50°C or –58°F.

④ Timing may vary depending on engine specification.

⑤ Pressure may be lower at engine idle.

Mechanical Specifications

Cylinder Head/ Valve Train	Standard	Service Limit
Valve Clearance①	0.40 mm/ 0.01575 in	0.025 mm/ 0.010 in
Cylinder head Warpage②	0.075 mm/ 0.0029 in	0.15 mm/ 0.0059 in
Cylinder Head Height ③	64.0 mm/ 2.5197 in	63.7 mm/ 2.5079 in
Valve Depression ④	0.7 mm/ 0.0276 in	1.2 mm/ 0.0427 in
Hot Plug Depression	0.05 mm/ 0.002 in	0.05 mm/ 0.002 in
Valve Margin Thickness ⑤	1.0 mm/03937 in	.7 mm/.0276 in
Valve Stem Diameter	7.0 mm/ .2756 in (Int.) 7.0 mm/ .2756 in (Exh.)	6.85 mm/ .2697 (Int.) 6.80 mm/ .2677 (Int.)
Valve Spring Installed Height	29.9 mm	-------------------------------------
Valve Seat Angle	45°	

① Valve adjustment clearances are established cold.
② Maximum grinding allowance is 0.3 mm/ 0.0118 in
③ Measurement is established by measuring from the head's sealing surface to the rocker bracket surface area.
④ Dimension taken from the cylinder head surface to the top of the valves
⑤ Specification is for both intake and exhaust valves.

Short Block Specifications	Standard	Service Limit
Main Bearing Bore Diameter	55.98 mm/ 2.2039 in	56.0 mm/ 2.2047in
Cylinder Block Height *3LA1/LB1* *3LD1*	 281 mm/ 11.0630 in 308 mm/ 12.1260 in	 280.7 mm/ 11.0512 in 307.7 mm/ 12.1142 in
Main Bearing Journal Diameter *3LA1/LB1* *3LD1*	 52.0 mm/ 2.0472 in 60.0 mm/ 2.3622 in	 51.86 mm/ 2.0417 in 59.86 mm/ 2.3567 in
Crank Pin Diameter *3LA1/LB1* *3LD1*	 43.0 mm/ 1.6929 in 49.0 mm/ 1.9291 in	 42.87 mm/ 1.6878 in 48.87 mm/ 1.9240 in
Connecting Rod Big End Diameter *3LA1/LB1* *3LD1*	 46 mm/ 1.8110 in 52 mm/ 2.0472 in	---------------------------------
Piston Protrusion	.400 mm/ .0158 in	--------------------------------
Piston to Cylinder Clearance	0.015-.035 mm/ 0.0006-.0014 in	
Main Bearing Clearance	0.029-0.072 mm/ 0.0011-0.0028 in	.0127 mm/ 0.005in
Connecting Rod Bearing Clearance	0.035 mm-0.073 mm/ 0.0014-0.0029 in	0.12 mm/ 0.0047 in
Crank Gear/ Idler Gear Backlash	0.07 mm/ 0.0028 in	0.2 mm/ 0.0079 in
Cam Gear/ Idler Backlash	0.06 mm/ 0.0024 in	0.2 mm/ 0.0079 in
Crankshaft End Play	0.06-.26 mm (0.0024-0.0102 in)	0.30 mm/ 0.0118 in

IV. Engine Repair Specifications – 3L

Torque Specifications

Cylinder Head/ Valve Train	Kg m	lb/ft
Cylinder Head Torque①② *M12 x 1.5* *M8 x 1.25*	 8.5-9.5 + 60° $^{+30°}/_{-0°}$ 2.5-3.5	 61-69 + 60° $^{+30°}/_{-0°}$③ 18-25
Valve lash adjusting jamb nut	0.8-1.2	5.8-8.7
Valve cover bolts	0.2-0.5	1.4-3.6
Exhaust Manifold	1.9-2.9	13.7-21.0
Rocker Arm Bracket Assembly	0.8-1.2	5.8-8.7
Exhaust Manifold	1.9-2.9	13.7-21.0
Nozzle Holder Assembly	4.0-5.0	29.0-36.2
Glow Plug	1.5-2.0	10.8-14.5

① Torque using the specified sequence
② Bolts must ***not*** be reused. New bolts only.
③ Clarification: On the second step, turn 60° (and no less, but up to an additional 30°)

Short Block Specifications	Kg m	lb/ ft
Crankshaft Bearing Cap	8.5-9.5	61.5-68.7
Rod Bearing Cap *3LA/LB1* *3LD1*	 3.8-4.2 7.5-8.5	 27-30 54-61
Camshaft Gear Nut	7.0-9.0	50.6-65.0
Idler Gear	2.7-3.5	19.5-25.3
Oil Pump w/o PTO w/PTO	1.9-2.9 0.8-1.2①	13.7-21.0 5.8-8.7①
Front Plate	1.9-2.9	13.7-21.0
Timing Gear Case	1.9-2.9	13.7-21.0
Starter	8.7-10.5	63.0-76.0
Flywheel Housing	4.2-5.6	30.4-40.5
Flywheel Bolts②	9.0-11.0	65.0-79.5
Crank Pulley	17.0-19.0	123.0-137.4
Oil Strainer Bolt	1.9-2.9	13.7-21.0

① When PTO is provided, install the oil pump to the front plate.
② Bolts must ***not*** be reused. New bolts only.

Lubrication and Sealant Specifications

Application	Thread Lockers	Lubricants	Sealant
Flywheel Bolts	---------------------------	Engine Oil	------------------------
Oil Pan	---------------------------	---------------------------	TB1207C
Rocker Bracket①	---------------------------	---------------------------	TB1207C
Air Inlet Pipe	---------------------------	---------------------------	TB1207C
Front Plate (PTO only)	---------------------------	---------------------------	TB1207C
Timing Case $^{w}/_{wo}$ PTO	---------------------------	---------------------------	TB1207C
Water Pump	---------------------------	---------------------------	TB1207B
Core Plugs	---------------------------	---------------------------	TB1207B
Injection Pump Housing Cover	---------------------------	---------------------------	TB1207C
Fuel Cut Solenoid	---------------------------	---------------------------	TB1207C
Oil Seal Retainer	---------------------------	---------------------------	TB1207C
Connecting Rod Bolts	---------------------------	Engine Oil	------------------------
Cylinder Head Bolts	---------------------------	Engine Oil	------------------------
Main Cap Bolts	---------------------------	Engine Oil	------------------------
Head Gasket	---------------------------	---------------------------	------------------------
Exhaust Gasket	---------------------------	---------------------------	------------------------
Oil Pump O-ring	---------------------------	Engine Oil	------------------------
Oil Strainer O-ring	---------------------------	Engine Oil	------------------------
Drain Plug O-ring	---------------------------	Engine Oil	------------------------
Head Cover Gasket	---------------------------	---------------------------	------------------------
Oil Pump Back Cover	---------------------------	---------------------------	------------------------
Camshaft	---------------------------	Extreme Pressure Lubricant	------------------------
Lifters	---------------------------	Extreme Pressure Lubricant	------------------------
Engine Bearings	---------------------------	Engine Oil	------------------------
Piston Pin	---------------------------	Engine Oil	------------------------
Pistons	---------------------------	Engine Oil	------------------------
Piston Rings	---------------------------	Engine Oil	------------------------
Valve Guides	---------------------------	Engine Oil	------------------------
Valves	---------------------------	Engine Oil	------------------------

① During Installation of the rocker arm bracket, be sure not to cover the rocker shaft oil passage.

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Maintenance Specifications

Item	Metric Measure	US Measure
Engine Oil Capacity ①		
4LB1/LC1	7.3 Liters	7.7 quarts
4LE1	8.7 Liters	9.2 quarts
Engine Oil Pressure ⑤	4-5 Kg/cm^2	43-51 lbs
Compression Pressure ②	31 Kg/cm^2	441 psi
Valve Adjustment	.40 ± 0.05 mm	0.015 ± .002 in
Coolant Capacity ③		
4LB1	2.5 Liters	2.6 quarts
4LC1	2.7 Liters	2.8 quarts
4LD1	2.8 Liters	3.0 quarts
Injection Starting Pressure	12.7-13.7 Mpa	1850-1990 psi
Injection Timing ④	16° BTDC	
Fan Belt Deflection Tension	8.0 mm-12 mm	0.3-0.5 in
Glow Plug Resistance	0.7-0.9 Ω	

① These specifications vary depending upon the type of equipment in which the engine is being installed. Only use API class CC or CD. On 4LB1 with turbocharger, use only API grade CD.

② First warm up engine until coolant temperature reaches 167° F (75° C)
Measured at 250 rpm
Service Limit is 26 Kg/cm^2 (370 psi)

③ Use only an Ethylene glycol based anti-freeze/ water mixture. A $^{50}/_{50}$ concentration ratio provides maximum protection to –37°C or –34°F. Never exceed a $^{60}/_{40}$ concentration ratio, which provides protection to ≈ -50°C or –58°F.

④ Timing may vary depending on engine specification.

⑤ Pressure may be lower at engine idle.

Mechanical Specifications

Cylinder Head/ Valve Train	Standard	Service Limit
Valve Clearance①	0.40 mm/ 0.01575 in	------------------------------------
Cylinder Head Warpage②	0.075 mm/ 0.0029 in	0.15 mm/ 0.0059 in
Cylinder Head Height ③	63.9 mm/ 2.515 in	64.1 mm/ 2.523 in
Valve Depression ④	0.7 mm/ 0.0276 in	1.2 mm/ 0.0427 in
Hot Plug Depression	0.05 mm/ 0.002 in	0.05 mm/ 0.002 in
Valve Margin Thickness ⑤	1.0 mm/03937 in	.7 mm/.0276 in
Valve Stem Diameter	7.0 mm/ .2756 in (Int.) 7.0 mm/ .2756 in (Exh.)	6.85 mm/ .2697 (Int.) 6.80 mm/ .2677 (Int.)
Valve Spring Installed Height	29.9 mm	-------------------------------------
Valve Seat Angle	45°	

① Valve adjustment clearances are established cold.
② Maximum grinding allowance is 0.3 mm/ 0.0118 in
③ Measurement is established by measuring from the head's sealing surface to the rocker bracket surface area.
④ Dimension taken from the cylinder head surface to the top of the valves
⑤ Specification is for both intake and exhaust valves.

Short Block Specifications	Standard	Service Limit
Main Bearing Bore Diameter	55.98 mm/ 2.2039 in	56.0 mm/ 2.2047in
Cylinder Block Height *4LB1* *4LC1/4LD1*	 280.94 mm/ 11.060 in 307.94 mm/ 12.123 in	 281.06 mm/ 11.065 in 308.06 mm/ 12.128 in
Main Bearing Journal Diameter *4LB1/4LC1* *4LD1*	 56.0 mm/ 2.2047 in 60.0 mm/ 2.3622 in	 55.86 mm/ 2.1992 in 59.86 mm/ 2.3567 in
Crank Pin Diameter *4LB1* *4LC1* *4LE1*	 43.0 mm/ 1.6929 in 46.0 mm/ 1.8110 in 49.0 mm/ 1.9291 in	 42.87 mm/ 1.6878 in 45.87 mm/ 1.8059 in 48.87 mm/ 1.9240 in
Piston Protrusion	.400 mm/ .0158 in	--------------------------------
Piston to Cylinder Clearance	0.015-.035 mm/ 0.0006-.0014 in	
Main Bearing Clearance	0.029-0.072 mm/ 0.0011-0.0028 in	.0127 mm/ 0.005in
Connecting Rod Bearing Clearance	0.035 mm-0.073 mm/ 0.0014-0.0029 in	0.10 mm/ 0.0039 in
Crank Gear/ Idler Gear Backlash	0.04 mm/ 0.0017 in	0.2 mm/ 0.0079 in
Cam Gear/ Idler Backlash	0.03 mm/ 0.0012 in	0.2 mm/ 0.0079 in
Crankshaft End Play	0.058-.208 mm (0.0023-0.0082 in)	0.30 mm/ 0.0118 in

Torque Specifications

Cylinder Head/ Valve Train	Kg m	lb/ft
Cylinder Head Torque①② *M12 x 1.5* *M8 x 1.25*	 8.5-9.5 + 60°~90° 2.5-3.5	 61-69 + 60°~90° 18-25
Valve lash adjusting jamb nut	0.8-1.2	5.8-8.7
Valve cover bolts	0.2-0.4	1.4-2.9
Exhaust Manifold	1.9-2.9	13.7-21.0
Rocker Arm Bracket Assembly	0.8-1.2	5.8-8.7
Exhaust Manifold	1.9-2.9	13.7-21.0
Nozzle Holder Assembly	4.0-5.0	29.0-36.2
Glow Plug	1.5-2.0	10.8-14.5

① Torque using the following sequence
② Bolts must ***not*** be reused. New bolts only.
③ Clarification: On the second step, turn 60° to 90°

Short Block Specifications	Kg m	lb/ ft
Crankshaft Bearing Cap	8.5-9.5	61.0-69.0
Rod Bearing Cap *4LB1* *4LC1* *4LE1*	 3.8-4.2 2.3-2.7 + 100-115° 7.5-8.5	 27-30 17-20 + 100-115° 54-61
Camshaft Gear Nut	7.0-9.0	50.6-65.0
Idler Gear	2.7-3.5	19.5-25.3
Oil Pump w/o PTO w/PTO	1.9-2.9 0.8-1.2①	13.7-21.0 5.8-8.7①
Front Plate	1.9-2.9	13.7-21.0
Timing Gear Case	2.1-3.1	15.2-22.4
Starter	9.5-11.5	68.7-83.2
Flywheel Housing	4.2-5.6	30.4-40.5
Flywheel	9.0-11.0	65.0-79.5
Crank Pulley	17.0-19.0	123.0-137.4
Oil Strainer Bolt	1.9-2.9	13.7-21.0

① When PTO is provided, install the oil pump to the front plate.

Lubrication and Sealant Specifications

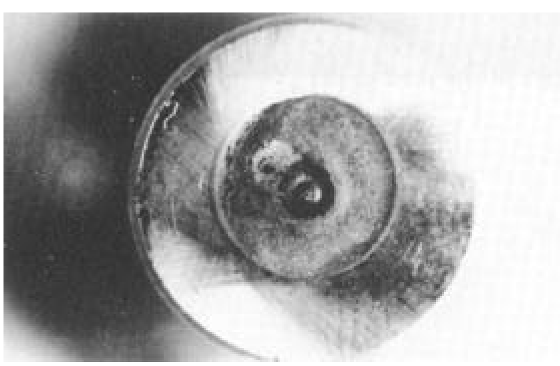
Application	Thread Lockers	Lubricants	Sealant
Flywheel Bolts	---------------------------	Engine Oil	------------------------
Oil Pan	---------------------------	---------------------------	TB1207C
Rocker Bracket①	---------------------------	---------------------------	TB1207C
Air Inlet Pipe	---------------------------	---------------------------	TB1207C
Front Plate (PTO only)	---------------------------	---------------------------	TB1207C
Timing Case w/wo PTO	---------------------------	---------------------------	TB1207C
Water Pump	---------------------------	---------------------------	TB1207B
Core Plugs	---------------------------	---------------------------	TB1207B
Injection Pump Housing Cover	---------------------------	---------------------------	TB1207C
Fuel Cut Solenoid	---------------------------	---------------------------	TB1207C
Oil Seal Retainer	---------------------------	---------------------------	TB1207C
Connecting Rod Bolts	---------------------------	Engine Oil	------------------------
Cylinder Head Bolts	---------------------------	Engine Oil	------------------------
Main Cap Bolts	---------------------------	Engine Oil	------------------------
Head Gasket	---------------------------	---------------------------	------------------------
Exhaust Gasket	---------------------------	---------------------------	------------------------
Oil Pump O-ring	---------------------------	Engine Oil	------------------------
Oil Strainer O-ring	---------------------------	Engine Oil	------------------------
Drain Plug O-ring	---------------------------	Engine Oil	------------------------
Head Cover Gasket	---------------------------	---------------------------	------------------------
Oil Pump Back Cover	---------------------------	---------------------------	------------------------
Camshaft	---------------------------	Extreme Pressure Lubricant	------------------------
Lifters	---------------------------	Extreme Pressure Lubricant	------------------------
Engine Bearings	---------------------------	Engine Oil	------------------------
Piston Pin	---------------------------	Engine Oil	------------------------
Pistons	---------------------------	Engine Oil	------------------------
Piston Rings	---------------------------	Engine Oil	------------------------
Valve Guides	---------------------------	Engine Oil	------------------------
Valves	---------------------------	Engine Oil	------------------------

① During Installation of the rocker arm bracket, be sure not to cover the rocker shaft oil galley .

Fuel System
Nozzle Holder component failure

Description:
Broken coil on the holder spring directly related to large amounts of carbon build – up on the nozzle spring. Carbon build-up can also be seen on the push rod. This condition is directly related to combustion gases passing through the nozzle holder spring chamber. Problem can be avoided be routine inspection of the nozzles.

Description:
Broken coil due to oxidation caused by moisture or high sulfur content in the fuel. Condition can be prevented through routine inspection of the fuel and filter.

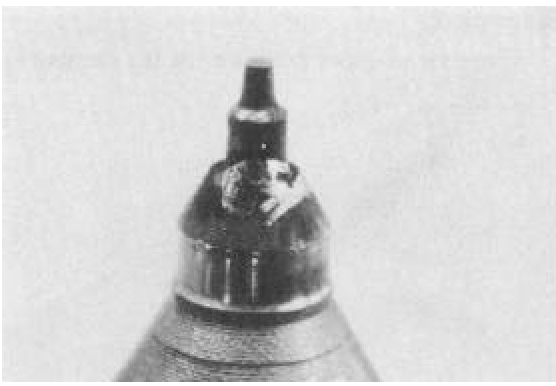


Description:
Sulfuric acid corrosion at the pintal caused by high sulfur content in the fuel. This is a result of water reacting with the sulfur to form sulfuric acid.

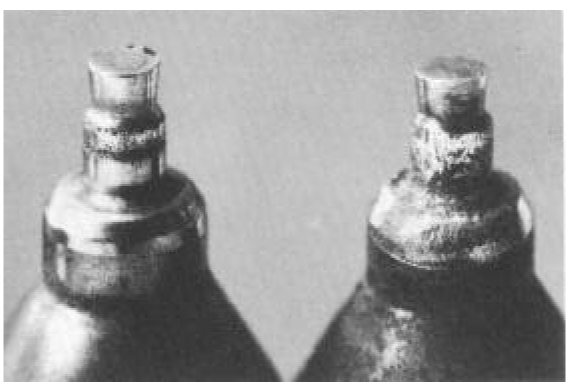
Fuel System

Nozzle component failure (continued)

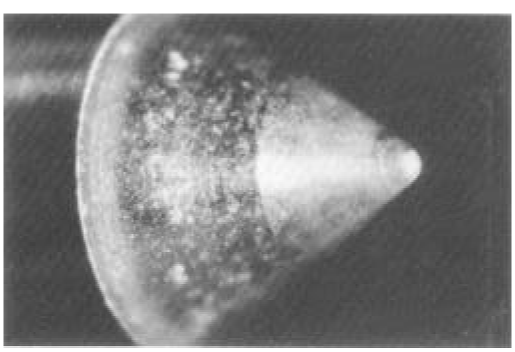
Description:
Corrosive abrasion of the pintal nozzle edge caused by direct contact with blow-by of the combustion gases in the combustion chamber.



Description:
Nozzle seat damage caused by metal contaminants in the fuel that pressed onto the seat area. The condition can cause leaks or distorted spray patterns from improper nozzle seating.



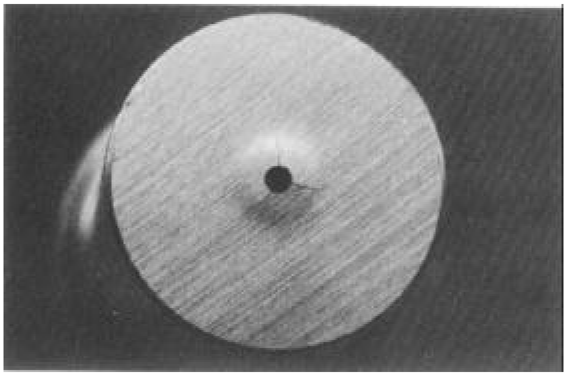
Description:
Pintal valve abrasion caused by sulfuric acid. This condition will cause the nozzle to stop functioning.



Description:
Foreign material build-up on the nozzle seat surface. This condition will cause an injector leak.

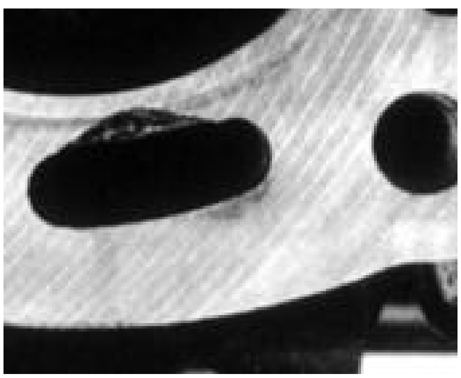
Fuel System

Nozzle component failure (continued)

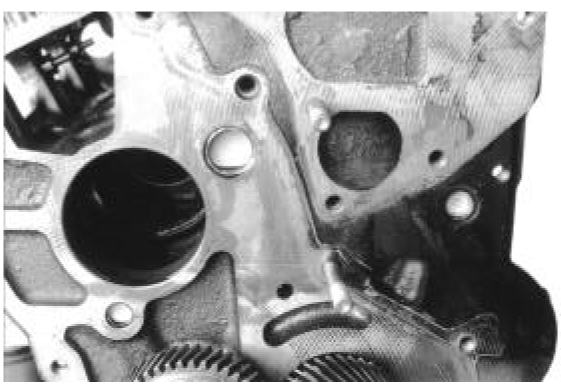


Description:
Damage to the nozzle seat and spray hole sections when the nozzle holder is over tightened.

Cylinder Block



Description:
Damaged head gasket, cylinder head, pistons, connecting rods and crankshaft caused by poor cylinder block casting, cooling system cavitation, or cooling system electrolysis.



Description:
Low oil pressure readings or premature engine bearing wear due to missing internal oil galley plugs.

Piston

Description:
Piston Failure due to reusing a previously cracked piston skirt.

Description:
Broken piston skirt tang due to excessive piston to wall clearance. (Creates piston slap sound).

Description:
Seized piston skirt due to insufficient piston to wall clearance. (a.k.a. piston galling).

Description:
Failed piston due to lack of oil in the engine at the time of failure.

(Heat failure can be identified by "4 point" scoring resulting in vertical scoring on the sides of the pin boss on both sides of the piston.)

Piston Failure

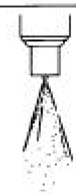
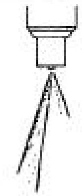
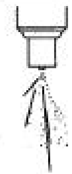
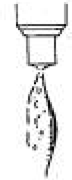
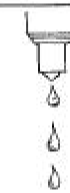
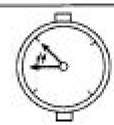
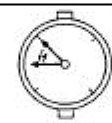
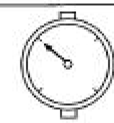
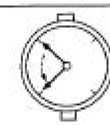
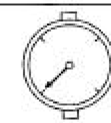
Description:
A wrist pin seized in this bore due to a previously used bent wrist pin or damaged piston pin bore.

Description:
(Normal piston skirt wear)

NOZZLE TROUBLESHOOTING GUIDE

Nozzle opening pressure too low	Nozzle opening pressure too high	Unsatisfactory chatter	Oil leak from nozzle seat	Improper spray pattern	Excessive pressure drop	External oil leak	Cause
●	●						Improper adjustment of nozzle opening pressure
	●	●		●			Clogged pintle nozzle hole and spray hole (carbon residue, foreign matter)
	●	●	●	●	●		Needle valve sticking
●		●	●	●	●		Abrasion, damage or accumulation of foreign matter at seat section
		●		●			Damage to pintle section of needle valve (pintle type nozzle)
●		●		●			Broken needle valve holding shaft
		●			●		Corrosion of sliding section
●		●					Damage to nozzle spring
●		●					Damage to push rod
					●	●	Scars or wear to nozzle's high pressure surface
					●	●	Scars or wear to spacer's high pressure surface
					●	●	Scars or wear to holder's high pressure surface
					●	●	Foreign matter accumulation in each mating surface of nozzle, spacer and holder
					●	●	Insufficient tightening of inlet connector
					●	●	Defective gasket of each seal section
				●			Damage or excessive wear to nozzle hole area
		●		●		●	Defective retaining nut (deformation caused by corrosion or insufficient cleaning)

PERFORMANCE EXAMPLES OF USED NOZZLES

Judgement Rank	A	B	C	D	E
Spray pattern example					
Pressure gauge pointer movement	 Continuously moves in the neighborhood of nozzle opening pressure.	 The sames as "A"	 Stabilizes and does not move in the neighborhood of nozzle opening pressure.	 Rises to nozzle opening pressure, but the pressure markedly drops.	 Pressure does not rise even when the tester handle is operated.
Spray pattern	Almost uniform	Extremely non-uniform	Atomizes, but no pulsation of needle.	Incorrect atomization with extreme after-drip.	Dripping
Possible cause of malfunction	(Normal)	1) Common cause is carbon residue sticking to the nozzle edge. 2) Occasionally the needle edge is damaged or broken.	1) A large quantity of carbon residue is sticking to the nozzle edge. 2) Occasionally caused by foreign materials caught in the spray hole.	1) Damage to the seat section. 2) Fine foreign matter caught in the seat section. 3) The seat section has worn excessively.	1) Needle stick 2) The seat section has been damaged or worn excessively. 3) Foreign matter caught in the seat section. 4) Damage to nozzle holder internal parts.
Judgement after nozzle cleaning (removal of carbon residue and foreign matter, etc.)	Usable as is.	Replace with a new nozzle if the "A" performance is not restored after cleaning.	The same as "B" ←	The same as "B" ←	The same as "B" Note: Replace with a new nozzle holder or parts (in the case of Item 4 above).

NOZZLE HOLDER TIGHTENING STANDARDS

Unit: kg-m

Parts / Type	Retaining nut	Nozzle holder plug	Adjusting screw lock nut	Cap nut	Leak off pipe joint bolt	Eye lock nut	Inlet connector
KB-S	M20x1.5 ZMC2 6–8 " Br 8–10 3/4-16UNF ZMC2 6–8 " ZMC2 8–10 M22x15 ZMC2 6–8 " Br 8–10 M24x1.5 Br 9–11	M22x1.5 Br 5–6	M8x0.75 Br 2.5	M22x1.5 ZMC2 4–5 " Br 5–6	M8x1 ZMC2 1–1.5 " Br 1–1.5 M8x1.25 ZMC2 1–1.5 " Br 1–1.5 M10x1 ZMC2 1.5–2 " Br 1.5–2		M12x1.5 ZMC2 5–6 " Br 6–7 M14x1.5 ZMC2 6–7 " Br 7–8 M16x1.5 Br 8–10 M18x1.5 Br 10–12
KBA . . S	M22x1.5 Br 10–12				M8x1 Br 1–1.5		M14x1.5 Br 7–8
KBL . . S	M20x1.5 ZMC2 6–8 " Br 8–10 3/4-16UNF ZMC2 6–8 " Br 8–10 M22x1.5 ZMC2 6–8 " Br 8–10 M24x1.5 Br 9–11			M14x1 ZMC2 3–4 " Br 4–5 M20x1 ZMC2 4–5 " Br 5–6 M22x1 ZMC2 4–5 M22x1.5 ZMC2 4–5 " Br 5–6	M8x1 Br 1–1.5 M8x1.25 ZMC2 1–1.5 " Br 1–1.5 M10x1 ZMC2 1.5–2 " Br 1.5–2		M12x1.5 ZMC2 5–6 " Br 6–7 M14x1.5 ZMC2 6–7 " Br 7–8 M16x1.5 Br 8–10 M18x1.5 Br 10–12
KB . . . T	M24x1.5 Br 18–20	M22x1.5 Br 5–6	M8x0.75 Br 2.5–3.5	M22x1.5 Br 4–5	M10x1 Br 1.5–2.0		029301-0090 M18x1.5 Br 10–12 029300-4030 M18x1.5 Br 1.5–17 150604-1420 M18x1.5 Br 150604-3820 M20x1.5 1.5–17
KB . . . U	M36x3 Br 24–27	M36x3 Br 12–14	M12x1.5 Br 2.5–3.5	M36x3 Br 10–12	M14x15 Br 5–6		M22x1.5 B4 20–23

Note: ZMC2 . . . . . Galvanizing and chrome treatment
Br . . . . Black oxide coating

Type \ Parts	Retaining nut	Nozzle holder plug	Adjusting screw lock nut	Cap nut	Leak off pipe joint bolt	Eye lock nut	Inlet connector
KBF . . .T	M24x1.5 Br 18–20	M22x1.5 Br 5–6	M8x0.75 Br 2.5–3.5	M22x1.5 Br 4–5	M10x1 Br 1.5–2.0		029301-0090 M18x1.5 Br 10–12 029300-4030 M18x1.5 Br 15–17 150604-1420 M18x1.5 Br 150604-3820 M20x1.5 15–17
KBF . . .U	M36x3 Br 24–27	M36x3 Br 12–14	M12x1.5 Br 2.5–3.5	M36x3 Br 10–12	M14x1.5 Br 5–6		M22x15 Br 20–23
KCA . . .S	M22x1.5 ZMC2 8–10 " Br 10–12					M12x1.5 ZMC2 4–5 " Br 4–5 M14x1.5 ZMC2 5–6 " Br 5–6	
KCA . . SD	M22x1.5 ZMC2 8–10 " Br 10–12					M12x1.5 ZMC2 4–5 " Br 4–5 M14x1.5 ZMC2 5–6 " Br 5–6	
KD . . . .S	M20x1.5 ZMC2 6–8 " Br 8–10 3/4-16UNF ZMC2 6–8 " Br 8–10 M22x1.5 ZMC2 6–8 " Br 8–10 M24x1.5 Br 9–11		M22x1 ZMC2 5–6 M22x1 Br 6–7	M22x1 ZMC2 5–6 " Br 5–6	M8x1 M8x1.25 ZMC2 1–1.5 " Br 1–1.5 M10x1 ZMC2 1.5–2 " Br 1.5–2		M12x1.5 ZMC2 5–6 " Br 6–7 M14x1.5 ZMC2 6–7 " Br 7–8 M16x1.5 Br 8–10 M18x1.5 Br 10–12
KDL . . .S	M20x1.5 ZMC2 6–8 " Br 8–10 3/4-16UNF ZMC2 6–8 " Br 8–10 M22x1.5 ZMC2 6–8 " Br 8–10 M24x1.5 Br 9–11		M22x1 ZMC2 5–6 M22x1 Br 6–7	M22x1 ZMC2 5–6 " Br 5–6	M8x1 M8x1.25 ZMC2 1–1.5 " Br 1–1.5 M10x1 ZMC2 1.5–2 " Br , 1.5–2		M12x1.5 ZMC2 5–6 " Br 6–7 M14x1.5 ZMC2 6–7 " Br 7–8 M16x1.5 Br 8–10 M18x1.5 Br 10–12

Note: ZMC2 . . . . . Galvanizing and chrome treatment.
Br . . . . Black oxide coating

Turbocharger Boost Pressure Diagnosis

Listen below are suggested checks for determining the cause of lowered turbo boost pressure (in the sequence they should be performed). To obtain maximum boost pressure, the engine must be operated at rated RPM under a full load condition. Boost pressure is measured with a mercury manometer. A pressure gauge may be substituted.

One of the following checks will uncover the reason for low boost pressure.
(Normal pressure is 11-16 psi.)

1. Check the throttle linkage for travel to full fuel position.

2. Measure the maximum no load engine RPM. Adjust if necessary.

3. Inspect the manifolds and turbo for cracks, loosened mounting bolts or leaking gaskets.

4. Check the intake and exhaust systems for restriction, i.e., dirty air cleaner, collapsed hose or crushed exhaust pipe.

5. Check the fuel system, i.e., air in the fuel, dirty fuel inlet screen (rock stopper), dirty fuel filter, contaminated fuel or reduce fuel delivery to the injection pump.

6. Check the valve clearance adjustment.

7. Check the injection nozzles, i.e., popping pressure, spray pattern or leakage.

8. While the injection nozzles are removed, check the compression pressure.

9. With the turbo mounted to the manifold inspect the following:
   It is necessary to remove the intake and exhaust piping from the turbo.
   a) The wastegate (if used) does not close completely.
   b) Check the compressor wheel for damage.
   c) Check the turbine side for heavy carbon deposits or damage.
   d) Measure the wheel shaft end play and bearing clearance.

10. Have the injection pump tested by an authorized Zexel dealer for proper calibration.

Exhaust Temperature Test

Exhaust temperature is measured with a pyrometer, thermo coupler, or infrared meter.

The temperature probe is installed in a straight section of the exhaust pipe approximately 6 inches from the turbo flange or manifold flange for naturally aspirated engines.

The reading is taken with the engine operating at rated output.

When the exhaust temperature is high, check the following: 1. Retarded timing. 2. Air intake system restriction. 3. Excessive exhaust system back pressure.

When exhaust temperature is low, check the following: 1. Low compression. 2. Inadequate fuel delivery from injection pump.

Crankcase Pressure Test

Crankcase pressure is measured with a water manometer.
NOTE: 2 in. of water (or less) is normal. Pressure should never measure more than 2 in.

The manometer pickup tube is inserted into the oil level gauge tube, from which the level gauge has been removed. **Do not insert the tube into the oil.** Do not attempt to seal engine openings.

The reading is taken with the engine operating at rated output.

Inlet Manifold Pressure (Boost Pressure) Test

Boost pressure is to be measured with a mercury manometer. A pressure gauge may be used when a manometer is not available. 1 inch of mercury =.49 PSI

The measuring device is to be installed in or straight run of the inlet air pipe. The most desirable location is 6 inches from the inlet manifold flange.

The reading is taken with the engine operating at its peak rated output.

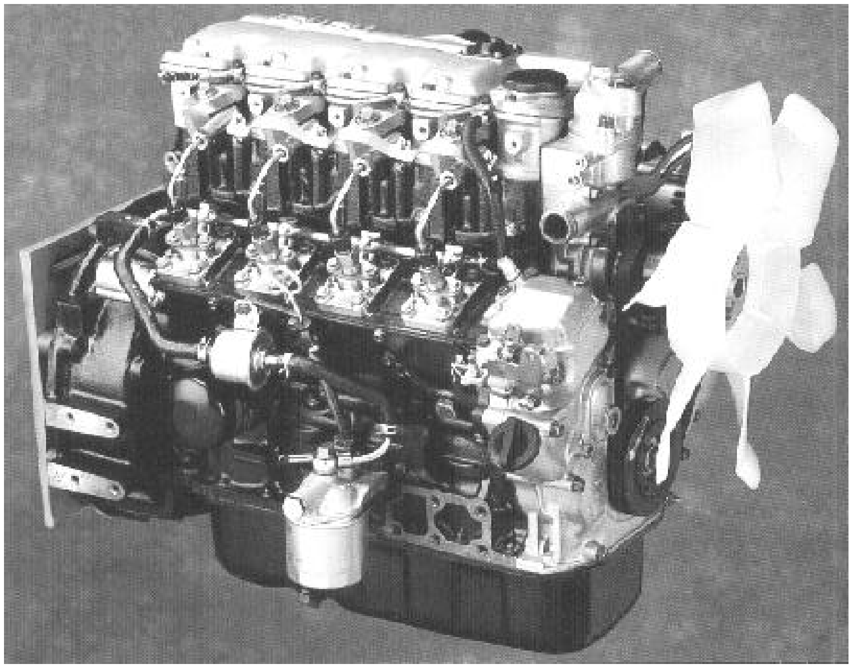
Specifications for these tests:

The results of all three of these tests will vary between engine models and between specifications of the same model. To find the specifications applicable to your particular engine, reference American Isuzu Motors Inc. Engine & Components Operations Publication #SV-5013-00 (“Engine Service Specifications Manual”).

Used Oil Sample Data (Limits)

Item	Unit of Measurement	Limit
Kinematic Viscosity	(@ 98.9°C (CST)/210° F	-20 to 50% of new oil
Total Base No.	KOH mG/G	1 (min.)
Total Acid No.	KOH mG/G	3 (max.)
B-Heptane Insoluble	Wt %	3 (max.)
Resin Insoluble	Wt %	Reference [1 (max.)]
Ash Sulfate	Wt %	Reference [0.5 (max.)]
Diesel Fuel Content	Wt %	5 (max.)
Water Content	Wt %	.5 (max.)
Worn Metal particle: Fe	PPM	150
Worn Metal particle: Cu	PPM	50
Worn Metal particle: PB	PPM	50
Worn Metal particle: Cr	PPM	20 (or 80..Cr-plated liner)
Worn Metal particle: Al	PPM	20-40
Worn Metal particle: Si	PPM	20

Based on testing a new oil sample of exact same kind as used oil.



Re-engineering equipment for a new engine model is typically an expensive proposition and stepping up to EPA's Tier 2 regulations in 2004 for off-highway engines in the 25 to 100 hp range will mean just that, but not if the envelope of the replacement engine is identical with the present engine. Current and prospective users of Isuzu's L-Series engines will be pleased to learn that the new direct-injection (DI) versions have the same physical footprint as the current IDI models.

The industrial engines are developed from the technology of well-proven automotive engines. It is certainly the automotive sector that represents the leading edge in gaseous emissions, but that is also true of customer expectations with respect to noise, vibration and ease of use. Isuzu produces more than 800,000 diesel engines per year and plans to produce 1.8 million by 2005.

The L-Series diesels will still be in the picture at that time and that was always the plan from the time they were introduced by American Isuzu to the U.S. market back in 1993, replacing the well-known K-Series. The three cylinder L-Series engines were joined by four cylinder versions in 1995. These engines were conceived to be among the quietest, most compact, lightweight, water-cooled engines in their class and the plan was that this basic platform would meet CARB, EPA and other applicable emission standards well into the future.

If one looks at the global automotive picture, it is estimated that fully 90 percent of the vehicular diesel engines will be direct injected after 2000 and the percentage would be even higher were it not for Third World production. The main motivations are the reduction of CO, and particulate matter emissions and the improvement of fuel economy.

So this is the battleground and direct injection appears to be the weapon of choice. And from this massive automotive capital base flows the technology base that will then be applied to other engine applications. Virtually all automotive diesel engines above 3.5 L displacement already use DI technology and many smaller automotive engines are also DI.

Many of Isuzu's engines were developed for automotive as well as industrial use. Included would be the J-Series and the B-Series in the under 100 hp range. The L-Series, however, was developed strictly for industrial use, yet it too makes use of the tools of automotive engine design.

With the new DI three cylinder model 3LD2 displacing 1499 cc and the four cylinder 4LE2 displacing 2179 cc, the L-Series is the smallest series that Isuzu manufactures today. The 3LD2 has a bore and stroke of 83.1 x 92 mm and a maximum output of 34.8 hp at 3000 rpm, with peak torque of 73.5 lb.ft. at 1800 rpm. The 4LE2 has a bore and stroke of 85 x 96 mm and a maximum output of 54.4 hp at 3000 rpm, with peak torque of 113.4 lb.ft. at 1800 rpm. All ratings are SAE J1995 gross hp. Dry weight of the 3LD2 and 4LE2 is given at 290 and 396 lb. respectively.

Despite the very small differences in bore and stroke, the engines are virtually identical in other respects. Isuzu insists new DI L-Series still offers OEMs a single engine family with high component commonality in both three and four cylinder configurations.

The compact and lightweight L-Series feature one-piece, cast iron blocks and heads, and overhead valve design with two valves per cylinder. The block is deep skirted for strength, rigidity and durability. Unit injection pump housings are cast into the blocks. The engine water jacket is formed with a one-piece casting core to eliminate irregular cooling passages.

The ductile iron crankshaft is underslung to the block with five main bearings for the 4LE2 and four main bearings for the 3LD2. The flame-hardened, chilled casting camshaft is mid-mounted in the block and it is gear driven. The camshaft is a one-piece design.

Low noise and vibration were very active design themes for the L-Series. A single camshaft actuates unit pump injectors as well as intake and exhaust valves. Valves are actuated through forged steel push rods and aluminum die cast rocker arms. Gears are helical and the number of gears in the gear train is only three and this permits a smaller gear cover with a lower profile and reduced forward noise emissions.

Finite element analysis (FEA), modal analysis and acoustic intensity techniques were used to evaluate every engine component and determine the contribution to the overall noise level. FEM was used to develop spherical cylinder block sidewalls and to optimize bulkhead ribs. Integral camshaft journal bearings featured on the L-Series had a tendency to lower rigidity of the engine block but this was overcome by numerous FEMJ iterations.

Other L-Series noise reduction features include the use of auto thermatic type pistons, an oil pan constructed of vibration damped steel sheet on the 3LD2, crankshaft balancers and an optimized fuel injection system. There is no difference in noise level comparing the DI and IDI at no load and only a 2 dB(A) difference at full load. Fuel injection lines from the unit pumps to the injectors are short and all the same length. Additionally, the fan or blower speed can also be lowered for an extra measure of noise reduction. Isuzu feels it has accomplished something with respect to sound quality as well as sound level.

Both the 3LD2 and the 4LE2 direct injected diesels are naturally aspirated and feature Isuzu's new "Cobra" combustion chamber, which uses an interesting high swirl conservation strategy. The aim is twofold. First, reduce the peak temperature in the premixed combustion stage to lower combustion noise and NOx emissions. A two-spring injector is vital to achieving this part of the rate shaping. Second, promote vigorous, fast mixing in the diffusion combustion stage - after top dead center - to lower smoke and particulate matter emission and to improve fuel consumption.

The unit injection pump is driven by the camshaft lobes that have a concave-shaped cam profile and this determines rate shaping throughout the combustion cycle. A lower initial injection rate in the premix stage and a higher rate in the diffusion stage provides a more complete and efficient burn.

So most of the fuel is actually injected during the combustion diffusion stage via a high-pressure nozzle with small holes to minimize fuel particle size and new combustion chamber design optimized through the use of computational fluid dynamics (CFD) analysis. The entire combustion cycle is reduced in length, but it is characterized by relatively higher swirl in the later stages.

Tier 2 compliance is the real driving force here, but fuel consumption should be lower 10 to 15 percent. The overall efficiency of the DI L-Series engines is demonstrated by a heat rejection rate that is 20 to 25 percent lower than the comparable IDI engines. Users may be less interested in fuel consumption lately, but the overall improvement in efficiency cannot be overlooked.

The engine lube oil filler and level gauge, oil filter cartridge, unit injection pumps, and injection nozzles are all located on the right side of the engines. The L-Series reputation for leak-free operation should be continued, always a strong point for Isuzu. The fuel system is also self-bleeding and self-priming, meaning that should the operator run out of fuel, he can just add fuel and restart the engine.

Summing up features of the new DI L-Series, high engine performance and efficiency, compliant with Tier 2 regulations; low noise and pleasant sound quality, low fuel consumption, low heat rejection, compact envelope size, one side service access, high reliability. And don't forget, the same footprint as the IDI versions.

Notes: