Automotive Sector

MAN-00025

SCORPIO – *Getaway* CRDe

REPAIR MANUAL

923XXXR010607EN-RM

CONFIDENTIAL

- ***ONLY FOR INTERNAL CIRCULATION WITHIN M&M AUTHORISED DEALERS & SERVICE CENTRES***
- ***PASSING ON TO THRID PARTY IS NOT PERMITTED***
- ***ALWAYS CHECK FOR THE LATEST VERSION***

RELEASED BY :

TECHNICAL PUBLICATION CELL
MAHINDRA & MAHINDRA LTD – NASHIK
VERSION 1 – JUN 2007

Automotive Sector

Preface

We are pleased to introduce the Service Manual for Scorpio ***getaway*** Version 1.

The layout of the manual is in such a manner that it facilitates trouble shooting and attending the aggregate on the vehicle. And if necessary attending the aggregate after removing it from the vehicle. The information contained in the manual has been prepared for experienced mechanics that are involved in the daily repair. This manual does not cover the theoretical details on the operation of the system.

The work procedures have been explained in details with emphasis on the care to be taken at various stages. Tightening torques have been explained in most of the sections as a specific value. This value is the midpoint for the acceptable engineering torque values. These values are intended for use in service assembly and installation using OEM fasteners. While replacing fasteners always use the same type of fastener as removed.

We hope that this Manual will be used extensively. It has been our attempt that this manual will help in providing a higher customer satisfaction level.

We have taken all care to ensure that the data and procedures are correct till the time of going to publication. However as a part of our continuous endeavor to improve our product, it is possible that the data will get changed. We would request you to keep updating the manual with the information we will communicate periodically. We would request you to let us have your opinion and feedback.

Publication Cell,
Customer Care,
Mahindra & Mahindra Ltd.
Automotive Sector

Automotive Sector

CRUZ 2600 DI Engine

Contents

Description

The 2.6-liter Turbocharged and intercooled common rail direct injected diesel engine with a bore and stroke of 94 mm develop 115 BHP at 3800 RPM and a torque of 283 Nm (28.3 Kg m) at 1800 RPM.

A waste gated turbocharger controls the boost to 2.2 bar. The compressed air is cooled by the charge intercooler which is mounted upstream of the turbocharger. The cooled air enters the inlet manifold's plenum and it enters the Cast iron cylinder head through the inlet valves having a 45-degree angle.

The piston features re-entrant type combustion chamber and having ferrous ring insert in the Top ring groove. A 3-ring pack is used. The top ring is asymmetrical barrel face and with CKS coating and keystone shape. The 2nd ring is taper faced. The 3rd is Conformable Oil Ring. The piston is having an offset of 0.5 mm.

The forged connecting rod is connected to induction-hardened crankshaft. The small end of the connecting rod is trapezoidal shaped to reduce the mass as well as to ensure higher loading. The crankshaft is induction hardened with the filets hardened & ground. The flywheel has a shrunk fit ring gear and also a ball bearing to act as pilot for the gearbox input shaft. The front end is having a rubber moulded dampener pulley

The high pressure pump & camshaft are chain driven.

Trouble Shooting

Refer to the Service diagnosis chart. Additional tests & diagnostic procedures may be necessary for specific engine complaints that can not be isolated using only the diagnostic chart.

Information concerning the additional checks is provided within the following diagnostic.

Cylinder compression pressure Test

The results of the cylinder compression test can be utilized to diagnose several engine malfunctions.

Before carrying out the compression test ensure that the battery is in good working condition. Otherwise the indicated pressures may not be valid for diagnostic purpose.

- Remove all the injectors.
- Fit the dummy injector (MST Tool) and connect it with the compression gauge.
- Disconnect the engine RPM sensor or phase sensor connector so that the engine does not start.
- Crank the engine.
- Note the compression value should be 30 bars.
- Repeat the procedure for the other cylinder.
- Refer to the Specification for the value.

Engine cylinder Head Gasket Failure Diagnosis

A leaking engine cylinder head gasket usually results in loss of power, loss of coolant and engine misfiring, overheating and poor fuel economy.

An engine cylinder head gasket leak can be:
A. Between adjacent cylinders
Or
B. *Between a cylinder and adjacent water jacket*.

Cylinder head gasket failure between cylinders is indicated by

Loss of power and /or engine misfiring.

Cylinder head gasket leaking between a cylinder and coolant passage results in coolant foaming or overheating and loss of coolant indicate an engine water jackets.

Cylinder to Cylinder Leakage Test

Check the cylinder compression pressure as already explained. Leakage between cylinders will be result in drop of compression pressure by nearly 50 to 70% in the affected cylinders.

Cylinder to Water jacket Leakage Test

- Remove the radiator cap.
- Warm up the engine and allow it to warm up until the engine thermostat opens.
- If large combustion /combustion pressure leak exist, bubbles will be visible in coolant.
- If bubbles are not visible, install a radiator pressure tester and pressurize the cooling circuit. If a cylinder is leaking combustion pressure into the water jackets then the tester's needle will pulsate with every combustion stroke of the cylinder.

Symptom	Causes	Remedial action
Engine will not start & emit black smoke	1. Air intake obstructed	✓ Replace the element. ✓ Check for free operation of Turbocharger.
	2. Defective injectors	✓ Replace
	3. Lack of compression.	✓ Check compression pressure.- if low check for valve seat ,rings & liner wear
	4. Cylinder head gasket failure	✓ Replace the cyl. head gasket.
	5. Engine timing-	✓ Check timing chain.

	Valve 6. CR system	✓ Refer diagnostic manual.
Noisy engine & black smoke.	1. Faulty injectors. 2. Loose main bearings 3. Broken parts 4. Rockers loose or out of adjustment.	✓ Replace injectors ✓ Tighten the main bearings. ✓ Inspect and replace the broken parts. ✓ Adjust tappet.
Engine does not give full power.	1. Air intake restricted. 2. Clogged fuel filter. 3. Incorrect tappet clearance 4. Defective injectors. 5. Air leaks in pressure line after turbocharger(Turbo to intercooler, intercooler & intercooler to intake manifold) 6. Air leak in pipe – manifold to FIP 7. Fuel return pipe to tank blocked. 8. Boost pressure pipe/hose	✓ Replace air cleaner element if required. ✓ Replace filter. ✓ Adjust tappets in cold condition. ✓ Replace ✓ Plug the leaks, replace hose or clip if required. ✓ Replace the hose or tighten ✓ Locate the kink/block in return pipe and rectify. ✓ Check the pipe, washer

	assembly damaged.	& rectify.
	9. Valve leak	✓ Check the compression, relap if required.
	10. Turbocharger damaged.	✓ Get the Turbocharger repaired at authorized TEL dealer.
	11. Gas leaks between exhaust manifold & cylinder head.	✓ Replace gaskets.
	12. Restricted exhaust system.	✓ Replace Turbocharger
	13. Exhaust gas leak between turbo & manifold.	✓ Tighten the TC mounting bolts. Replace gasket if required.
	14. Gas leak between EGR pipe joints	✓ Remove the restriction in exhaust system.
	15. EGR pipe leak.	✓ Change the gasket or the hose.
	16. Fuels supply line kink creating restriction.	✓ Replace the pipe. ✓ Remove the restriction.
	17. EGR valve improper functioning.	✓ Check the EGR using the blink codes. Proceed appropriately.
	18. Compression leak.	✓ Check compression.
	19. Jammed piston rings	✓ Replace piston rings.
	20. Viscous fan	✓ Check the VFD as

	continuously engaged. Check CR system	outlined in cooling. Replace if required. Refer the diagnostic manual
Noisy engine & high smoke (White/ Grey)	1. Cylinder head gasket defective. 2. Worn out or damaged valve seats. 3. Leaking injector holder	✓ Replace the cylinder head gasket. ✓ Lap the valve seats or regrind. ✓ Tighten the injector holder.
Black smoke.	1. Air intake restricted. 2. Incorrect tappet setting. 3. Defective injectors 4. Air leaks. 5. EGR valve stuck open 6. Restricted exhaust system. 7. Gas leak between exhaust manifold & cylinder head. 8. Worn out rings, liners & valves.	✓ Check for hoses, replace air cleaner element. ✓ Adjust tappets. ✓ Check injectors. ✓ Check for leaks between Turbocharger to intercooler, intercooler & intercooler to inlet manifold. ✓ Check the EGR valve ✓ Remove restriction or replace parts. ✓ Replace manifold gasket or parts. ✓ Overhaul engine.
Excessive oil consumption	1. Cracked vacuum line hoses.	✓ Check the vacuum line from the alternator to the EGR valve - check for

		leaks, crack. Replace cracked hoses.
	2. Clogged air filter element.	✓ Replace element.
	3. Restriction in air intake to compressor duct.	✓ Locate & remove restriction.
	4. Restrictions in turbocharger oil drain line.	✓ Remove the restriction in the drainpipe.
	5. Restriction in crankcase breather.	✓ Check the crankcase ventilation & rectify.
	6. Damaged oil separator	✓ Replace the oil separator
	7. Turbocharger damaged.	✓ Change oil, filter, service the Turbocharger & use recommended oils & drain intervals. Follow the recommended procedure while shutting down. ✓ Repair Turbocharger.
	8. Worn out rings, liners, and valves.	✓ Overhaul engine.
	9. External oil leaks	✓ Stop the external oil leakages.
	10. Leakages through inlet manifold mounting face	✓ Change the vacuum hoses. ✓ Change the manifold gasket or replace the

	allowing dust entry. 11. Bend/kink in any of the oil return pipe's/vacuum hoses. 12. Defective vacuum pump.	manifold. ✓ Remove the bend or kinks. ✓ Replace the vacuum pump.
Blue smoke.	1. Clogged air filter element. 2. Restriction in air intake to compressor duct. 3. Air leak between the Turbocharger to intake manifold. 4. Excess oil. 5. Wear in valve seal. 6. Wear in piston rings & liner. 7. TC oil seal leaks	✓ Replace element. ✓ Locate & remove restriction. ✓ Locate the leaks, change hose or clamp if required. ✓ Correct the oil level. ✓ Check the valve stem seals, replace if required. ✓ Check the compression pressure, replace rings & liners. ✓ Check the Turbocharger if defective get it attended.
White smoke.	1. Improper timing 2. Defective cylinder head gasket.	✓ Check sprockets & chain for wear. Rectify ✓ Replace the cylinder head gasket.

	3. Restriction in fuel supply	✓ Remove the restrictions.
Starter will not work or only cranks slightly	1. Electrical complaints. 2. Check water level. 3. Hydrostatic lock	✓ Refer the electrical section. ✓ If water level reduced drastically then check for hydrostatic lock. ✓ Remove the water in the cylinder and find the cause for water entry.
Starter will not crank the engine.	1. Weak battery. 2. Corroded or loose battery connection 3. Faulty starter. 4. Improper earthing.	✓ Check the battery specific gravity. ✓ Clean & tighten battery connections. ✓ Repair starter. ✓ Rectify earthing.
Noisy valves	1. Tappets loose. 2. Rocker arms touching the rocker cover. 3. Thin or diluted oil. 4. Low oil pressure. 5. Bent push rods. 6. Worn rocker arms. 7. Worn valve guides. 8. Excessive runout of valves seats	1. Set the tappet clearances. 2. Install the correct rocker cover gasket. If after that also the problem persist change the rocker cover. 3. Change oil. 4. Check the oil level. 5. Install new push rods. 6. Replace the rocker arms. 7. Replace the valve guides. 8. Grind valve seats and valves.

	9. Oil thickening	9. Replace oil & find the reasons of thickening, rectify.
Oil pressure drop	1. Low oil level. 2. Defective oil pressure sensor. 3. Clogged oil filter. 4. Clogged oil cooler 5. Clogged oil strainer. 6. Pressure relief valve in oil filter bracket stuck. 7. Oil leaks- internal 8. Worn parts in oil pump. 9. Excessive oil clearances 10. Thin or diluted oil. 11. Excessive bearing clearance. 12. Oil pump relief valve stuck. 13. Oil pump	✓ Check engine oil level. ✓ Install new sensor. ✓ Replace filter. ✓ Clean the oil cooler. ✓ Clean the strainer. ✓ Clean the valve & bore and assemble. ✓ Check the gasket between the block & front cover or any of the MOG plugs ✓ Replace the worn parts or pump. ✓ Check oil clearances. ✓ Change oil to correct viscosity. ✓ Remove the valve, inspect, clean & refit. ✓ Remove sump, inspect the parts & replace.

	suction tube loose, bent or cracked. 14. Oil pump cover warped or cracked	 ✓ Install new pump.
Oil leaks	1. Worn oil seals 2. Misaligned or deteriorated gaskets. 3. Loose fastener, broken or porous metal parts	✓ Replace seals. ✓ Replace gasket. ✓ Tighten fastener ✓ Repair or replace.

Care of the System --

The performance of the engine is dependent on ensuring that the following maintenance is carried out as per the schedule without fail.

Accessory Belt : To be checked and adjusted if required at every 10,000 Kms. To be replaced at every 80,000 Kms.

Air cleaner: The element should be replaced at every 40,000 Kms or when red indicator band shows. For the detailed procedure, **refer to the Air Intake System.**

Oil:. The oil should conform to **CH4** grade and with a viscosity Index of 15W40. It should be kept in mind that in the turbocharger engine the oil has to have do an additional load of lubricating and cooling the Turbocharger shaft If any oil of lower specification is used it can break down under the high thermal load at the turbine end of the shaft especially during the hot shutdown.
This oil grade also ensures that the oil consumption is within the desire limits. **Use Maximile Supreme** Grade of oils. The Oil change intervals are first at 5000 Kms. & then subsequently every 15000 Kms.

Cooling system: Ensure that no leakages are present. For details of the coolant and ratio refer the *Cooling System*.

Turbocharger: The engine is having an exhaust gas driven turbocharger. The turbocharger shaft speed varies from about 40, 000 when engine is idling to about 1,70,000 when the engine is having the full rated RPM.

EGR: On vehicles fitted with EGR system the following additional points check have to done during scheduled maintenance.

- Check for any exhaust gas leakage through sealing faces, EGR pipe. Formation of any black soot indicates leakage.
- Check the vacuum hoses for any leaks, cracks.
- Retighten all nuts and bolts as per the recommend torque.

Tappet setting has to be carried out every 20000 Kms.

While doing the tappet clearance, in case of vehicle fitted with EGR system ensure that the EGR pipe is not bent or overstress the pipes, elbow.

If the pipes are removed then it is essential that while fitting back; new gaskets be used. Do not open the pipe from one end only; it will cause the pipe to twist. If the EGR pipe has to be removed, then open from both the ends.

In Car Repairs -

The in car repairs which can be carried out are:

Tappet setting

Accessory Belt tension adjustment.

Accessory belt removal & Refitment.

VFD Assembly with Fan Blade removal

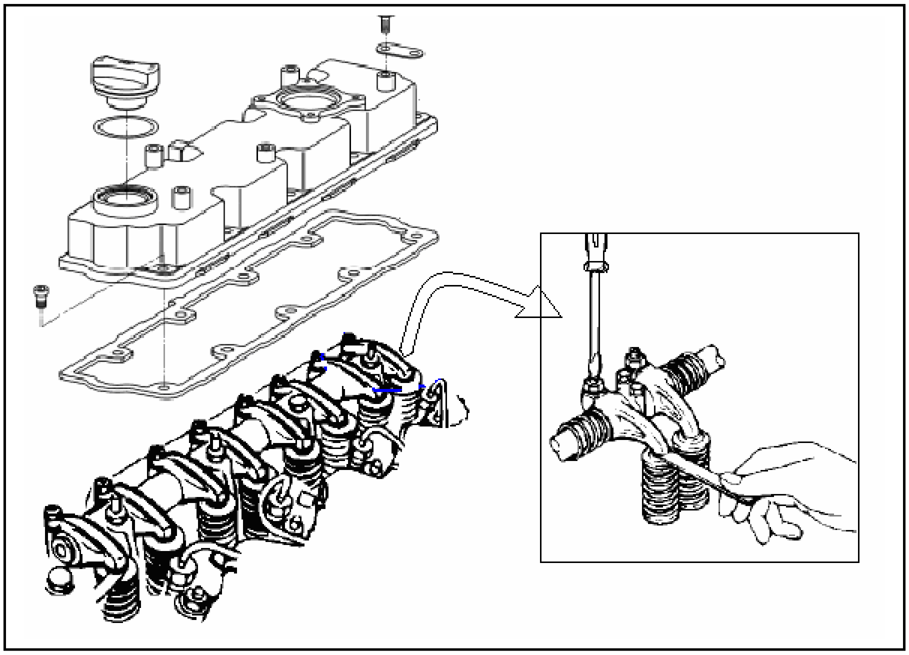
High Pressure pump Removal

Oil filter changing.

Turbocharger removal & Refitment.

Cylinder head gasket Replacement.

Tappet setting -



1. Remove the oil filler cap.

2. Remove the oil separator & pipe from the ladder frame /sump to the rocker cover.

3. Remove the tappet cover mounting Allen screws along with the rubber washer.

4. Remove the tappet cover.

5. Remove NVH Cover & then Rocker Arm Cover with Gasket

6. Adjust the tappet clearance as per the following procedure …

- Bring no.1 piston at TDC. Ensure no 4 cylinder valve at dancing / rocking position.

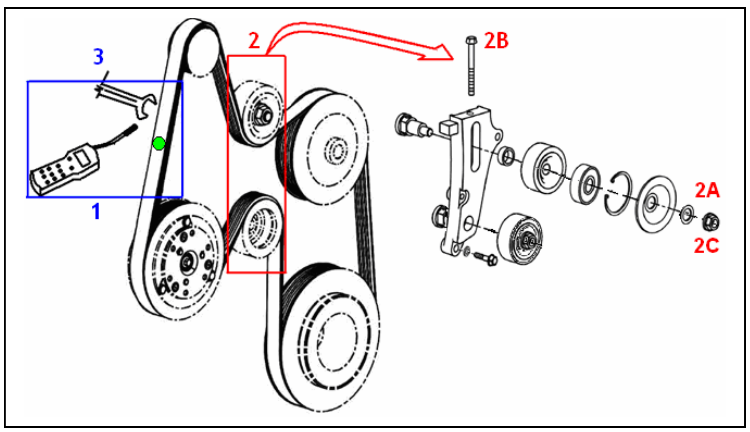
- Adjust the tappet clearance of 1st cylinder both Inlet & Exhaust valves as per specifications.

- Turn the engine 180^0 further in the direction of engine rotation. Adjust tappet of 3rd cylinder valves as per specifications.

- Turn the engine 180^0 further in the direction of engine rotation. Adjust tappet of 4th cylinder valves as per specifications.

- Turn the engine 180^0 further in the direction of engine rotation. Adjust tappet of 2nd cylinder valves as per specifications.

Accessory Belt tension Adjustment –



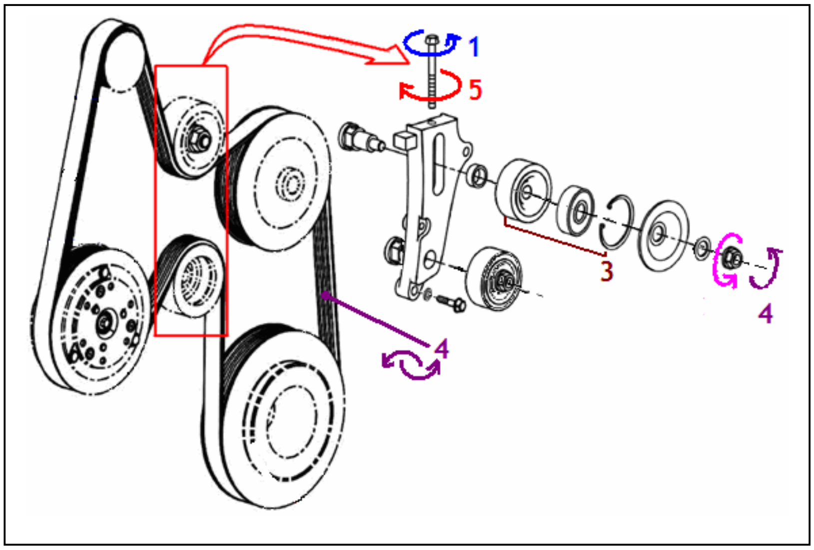
1. Check the Belt Tension…
   - Turn on the Belt Tension Gauge, select reading mode in Hertz (Hz) & hold the probe approximately 5mm distance in Front of the belt (CAUTION: Do not touch the probe to the belt, this can damage the probe!) as shown in the illustration above by X.
   - Tap on the belt near the probe.
   - Note the reading. If the reading is within 125 TO 145, this should be OK.
   - If the reading is less than 125 Hz then it needs adjustment.

2. Adjust the belt tension ….
   2.A - Loosen the Tensioner Pulley Shaft Nut.
   2.B – Tighten the Belt Tensioning Bolt.
   2.C - Tighten the Tensioner Pulley Shaft Nut

3. Repeat the procedure as per the Step-1
   - If the belt tension value should be 140+5 Hz.

If the value is less than 140+5 Hz, Repeat the Steps 2 & 3.

Accessory belt Remove & Refit –



1. Loosen the Tensioner bolt to relieve the tension.

2. Loosen the Tensioner Pulley Nut. Take out the pulley assembly with Dust Shield, washer & take the belt out.

3. Take the belt out.

4. Put the new belt in place & fit the Tensioner Pulley Assembly along with dust shield & washer on the bracket, hand tighten the nut. Tighten the Tensioner Pulley Nut with torque of 32.5 ± 2.5 Nm.

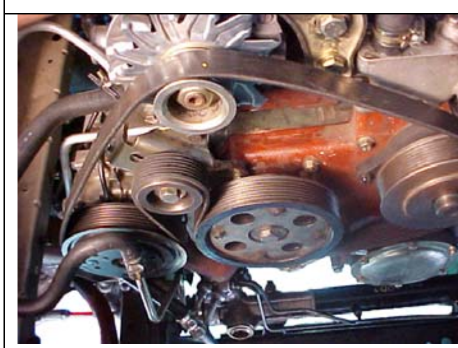
5. Tighten the Tensioner Bolt so as to get the specified belt tension; follow the accessory belt tension check procedure for checking / adjusting the belt tension to the installation tension --**170 ± 2 Hz**.

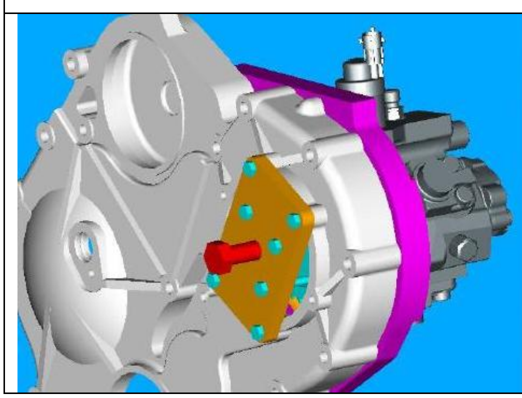
6. Run the engine for 5 minutes & confirm the stabilized tension is at 140 to 145 Hz.

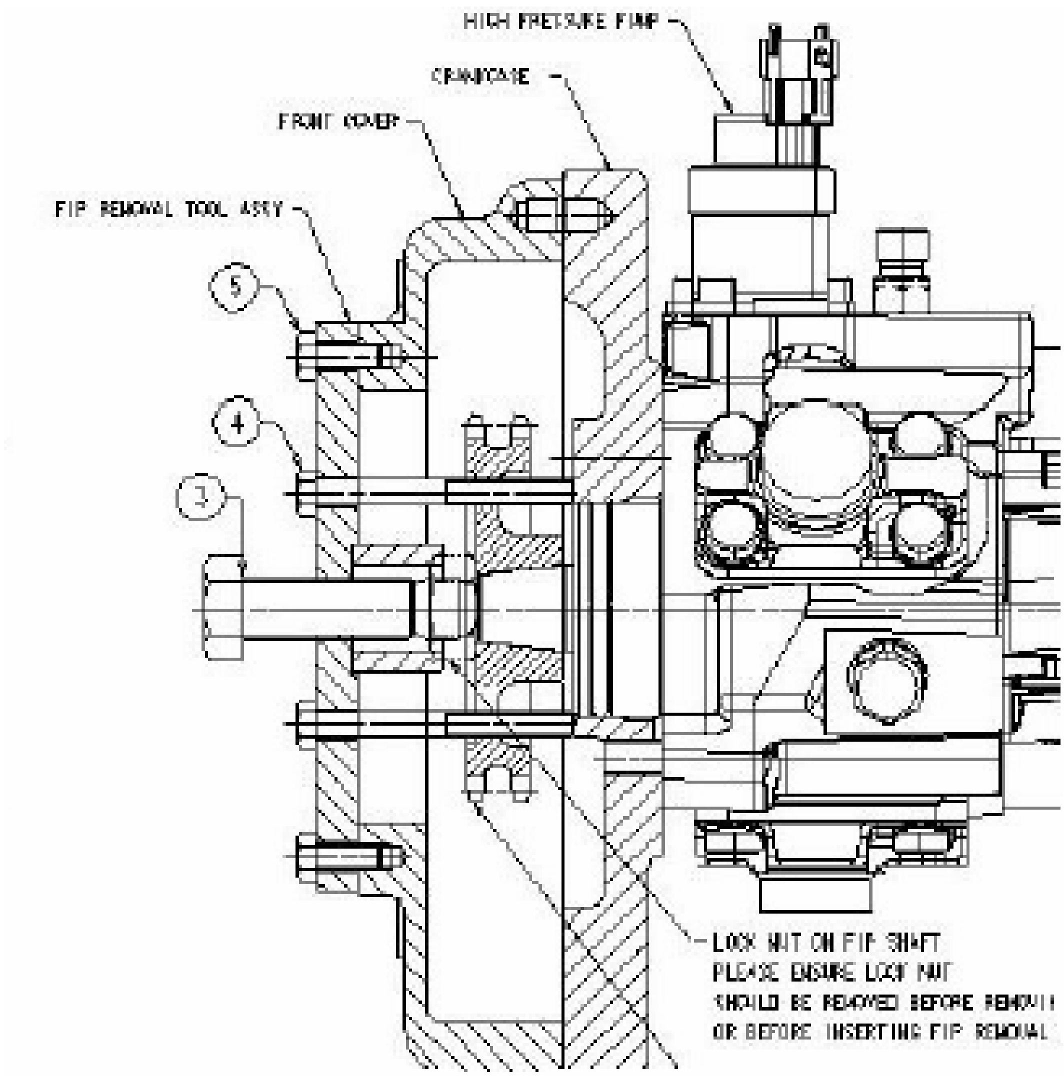
Fan Blade & Viscous Fan Drive Removal & Assembly –

	Caution: Do not remove the accessory belt before removing the nut.
	Loosen the water pump nut. **Note that the threads are anticlockwise threads. Hence to loosen then the direction of rotation has to be clockwise when viewed from front.** **Do not tamper or service the center portion of the fan.** **The nut should rest on pulley after tightening.**
	The fan blade assembly and the VFD assembly can be removed together.

High Pressure Pump Removal & Refitment -

	Remove tappet cover.
	Bring the 1st cylinder in compression **Note -** To confirm the first cylinder TDC position remove the 1st cylinder injector, insert the MST and the dial gauge. Check by the dial if the piston is in TDC)
	Remove the VFD assembly along with the fan blade assembly.
	Remove the fan belt.
	Remove the High Pressure Pump connections and fuel supply.

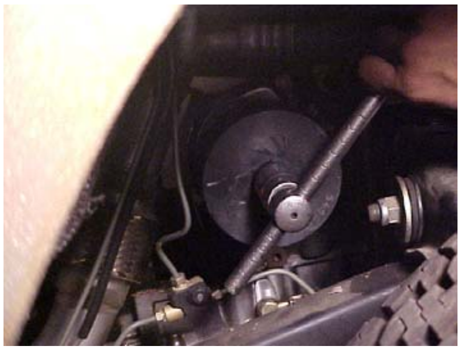
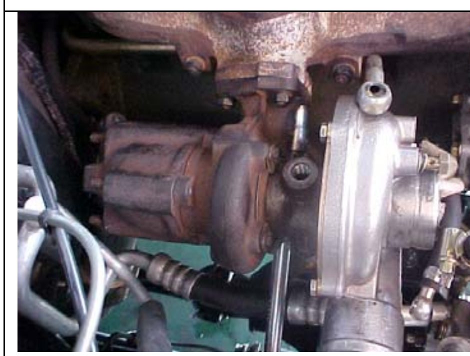
	Remove the injector pipes.
	**CAUTION** If the piston is not at TDC then the holes will not align with the block. As a consequence when the MST is used subsequently the MST can break.
	Rotate the engine to align three holes of High Pressure Pump sprocket with three tapped hole provided on crank case for mounting threaded pins of removal tool.
	FIT the three nos.-threaded pins on crankcase through FIP sprocket holes and tighten with 17-mm spanner.

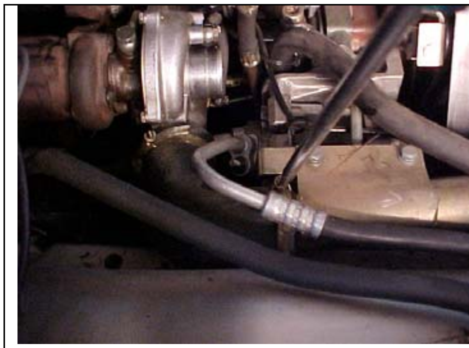
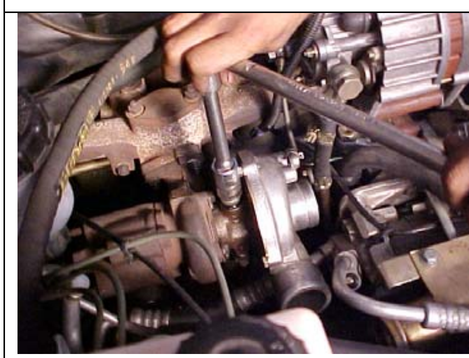

HIGH PRESSURE PUMP
CRANKCASE
FRONT COVER
FIP REMOVAL TOOL ASSY
5
4
3
LOCK NUT ON FIP SHAFT
PLEASE ENSURE LOCK NUT
SHOULD BE REMOVED BEFORE REMOVI
OR BEFORE INSERTING FIP REMOVAL

Oil filter removal & refitting --

	Remove the right side wheel apron.
	Remove the oil filter using the MST 545
	After removal, ensure that the central stud is fully tight. *It can work out loose while removal of the filter.* If it has worked loose then tighten it to torque of 25-30 Nm (18-22 Lbft)
While fitting the new oil filter. Apply oil on the "O" rings. Tighten by hand only.	

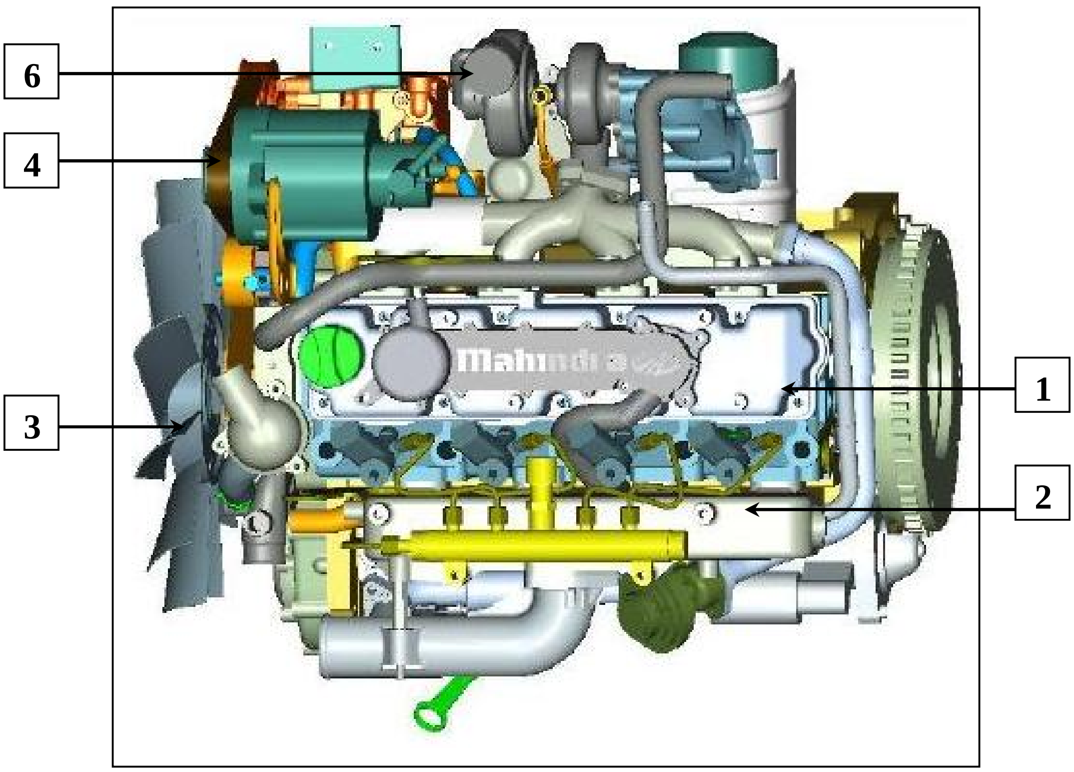
Turbocharger removal & Refitment -

	Remove the right side wheel apron. Remove the oil filter using the MST 545 Remove the oil cooler assembly
	The above 3 steps are suggested for ease of operations & access.
	Remove the air intake hose to turbocharger.

	**CAUTION** Please cover the opening to the turbocharger with cover to avoid accidentally dropping any foreign object e.g. spanner
	Remove the exhaust pipe from after the elbow. (Access is only after lifting it on a two post or in a pit and using a extension with UJ.)
	Remove the oil feed pipe and the oil return pipe.
CAUTION	**(It is recommended to apply rust cleaning spray (WD 40) in the nuts before attempting to remove otherwise, the stud will come off.)**

	Remove the turbocharger mounting 3 nuts.

Cylinder Head Gasket Removal & Refitment -



1. Remove the rocker cover
2. Remove the Injector's high-pressure pipes.
3. Remove the **Fan blade** assembly along with VFD

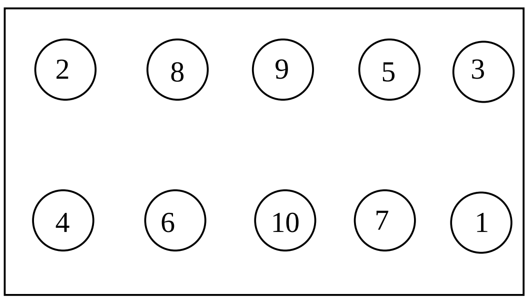
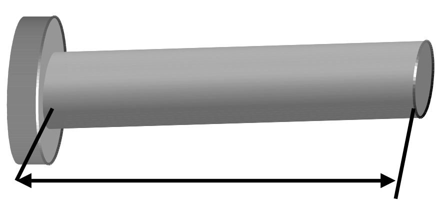
4. Remove the **Accessory Belt**.

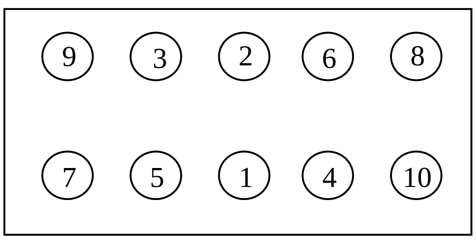
5. Remove the Water pump.

6. Remove the **Turbocharger**.

7. Remove the rocker shaft assembly.

8. Remove the cylinder head bolts.

	**Note** - While removing ensure that the bolts loosening is the reverse of the tightening sequence
	Remove the Cylinder head assembly.
	Measure the length of the cylinder head bolt. If it is up to 135 mm then the bolt can be reused. If the length is more than 135 mm, use new bolt.
	The cylinder head gasket is of the **Multi Layer Steel (MLRS) Type** gasket. Though it can be assembled either way it is recommended that for optimum performance the Top, which is identified by the lettering, is facing upward. (The cylinder Head gasket cannot be reused – even if it appears to be good.)

CAUTION	**Do not use any sealant/lubricant like shellac or oil on either block or head or gasket face.**
CAUTION	The cylinder head bolts are to be tightened with slight trace of clean engine oil. (2-3 drops only). Do not put excess quantity of oil.
	The tightening sequence is as shown. The tightening torque's is 90 Nm then followed by 60-degree angular torque. Again torque by 60 degree. The angular torque in 2 stages ensure that the tightening/clamping loads of all the bolts are very close to each other.

<u>Working principle, of the various subsystems of the Engine</u> –

The various subsystems are:

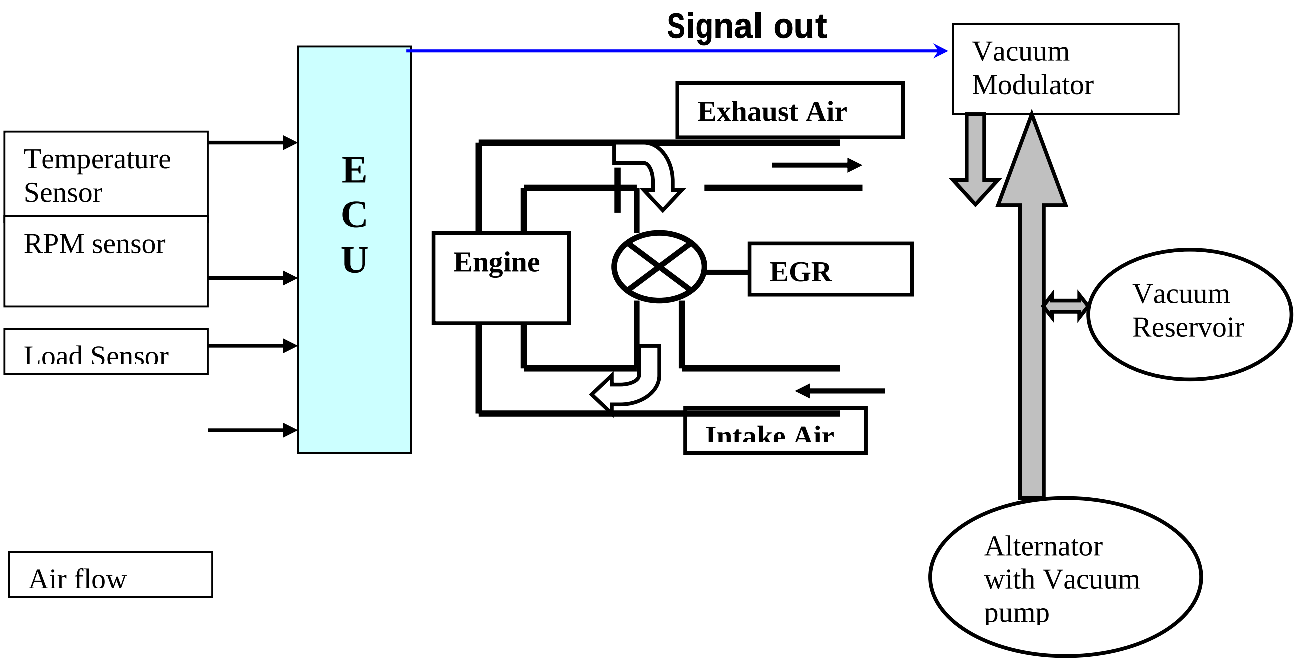
Turbocharger: Please refer to the Air Intake System section.

[Exhaust Gas Recirulation](#).

[Crankcase ventilation](#)

[Oil circulation.](#)

Working Principle of Exhaust Gas Recirculation



During acceleration and in higher loads the combustion chamber temperatures increase. The high combustion temperatures increase the NOx generation. The higher percentage of NOx generated in the combustion chamber come out through the tail pipe in the atmosphere.

To reduce the amount of NOx coming through the tail pipe the EGR system adds exhaust gases into the fresh air that is going into the combustion chamber. Since the exhaust gas is already burnt hence when mixed with fresh air acts an inert gas. Thus when the exhaust gas mixed with fresh air enters the combustion chamber, it performs a dual role. The first role it does is that it reduces the amount of oxygen available for combustion. The second role that it acts is as a heat absorbent/heat sink.
The net effect is that it reduces the combustion temperatures. This results in lower amount of NOx being generated.

To control the amount/percentage of exhaust gases to be circulated back to the combustion chamber an ECU is used. The ECU monitors the coolant temperature, attitude, engine speed, and accelerator pedal position and the air flow. Based on the above parameters the ECU operates a switch that in turn controls the amount of vacuum going to the EGR valve. The amount of vacuum applied controls the lift of the EGR valve.

EGR Valve

Remove the EGR valve and check it valve-sticking, deposition of carbon etc. If excess carbon deposits and sticky valve noticed then it should be cleaned with a suitable solvent, so that the correct valve seat is ensured.

After cleaning the valve blow air from the bottom side of the valve and check for any leakages.

EGR Pipe

Remove the EGR pipe and check for gas leakage, damages etc. Clean the gasket seating area from any carbon deposits, burrs etc. Spray WD 40 rust cleaning spray on the nut.

To check the pipe for any leakages, close one end of flange and from other end blow air at 2 bars. Dip the pipe in water and observe if any leakage is observed. If any leaks are observed then the pipe has to be replaced. Do not attempt to weld/ seal the leakage joint

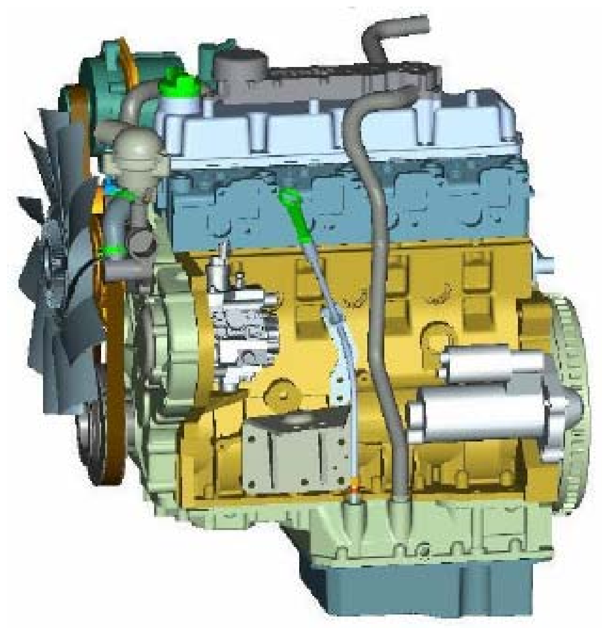
EGR Solenoid switch

The solenoid switch does not require any maintenance. For any damage replace the component.

Vacuum Modulator Valve

Does not require any maintenance. However please check and confirm that that the line from the modulator to air cleaner is clean and the hole at the air cleaner hose end is not choked.

Working principle of Crankcase Ventilation System –



The ventilation system is closed ventilation type. A hose connects the ladder frame / sump assembly to the oil separator. Te oil separator is a labriyanth type. The oil goes through the labriyanth, the oil collected drops down. The excess pressure acts below the diaphragm. The diaphragm is acted from below by the crankcase pressure and from top the suction by air cleaner. A spring also acts on top of the diaphragm. Once the pressure exceeds the diaphragm lifts and the excess crankcase pressure goes to the air intake system.

Certain amount of oil will be carried from the oil separator to the Air inlet hose, which is normal. However if it is excessive please look for all the causes mentioned in the high blow bye.

Oil circulation system –

An external gear type pump sucks the oil through the strainer. The oil pump is driven by the gear, which is mounted, on the crankshaft.

The oil pump delivers pressurized oil to the supply bore in the block. This oil is delivered to the oil cooler and after getting cooled comes on the outer side of the element. The filtered oil goes through the centre of the oil filter and is connected to the main oil gallery.

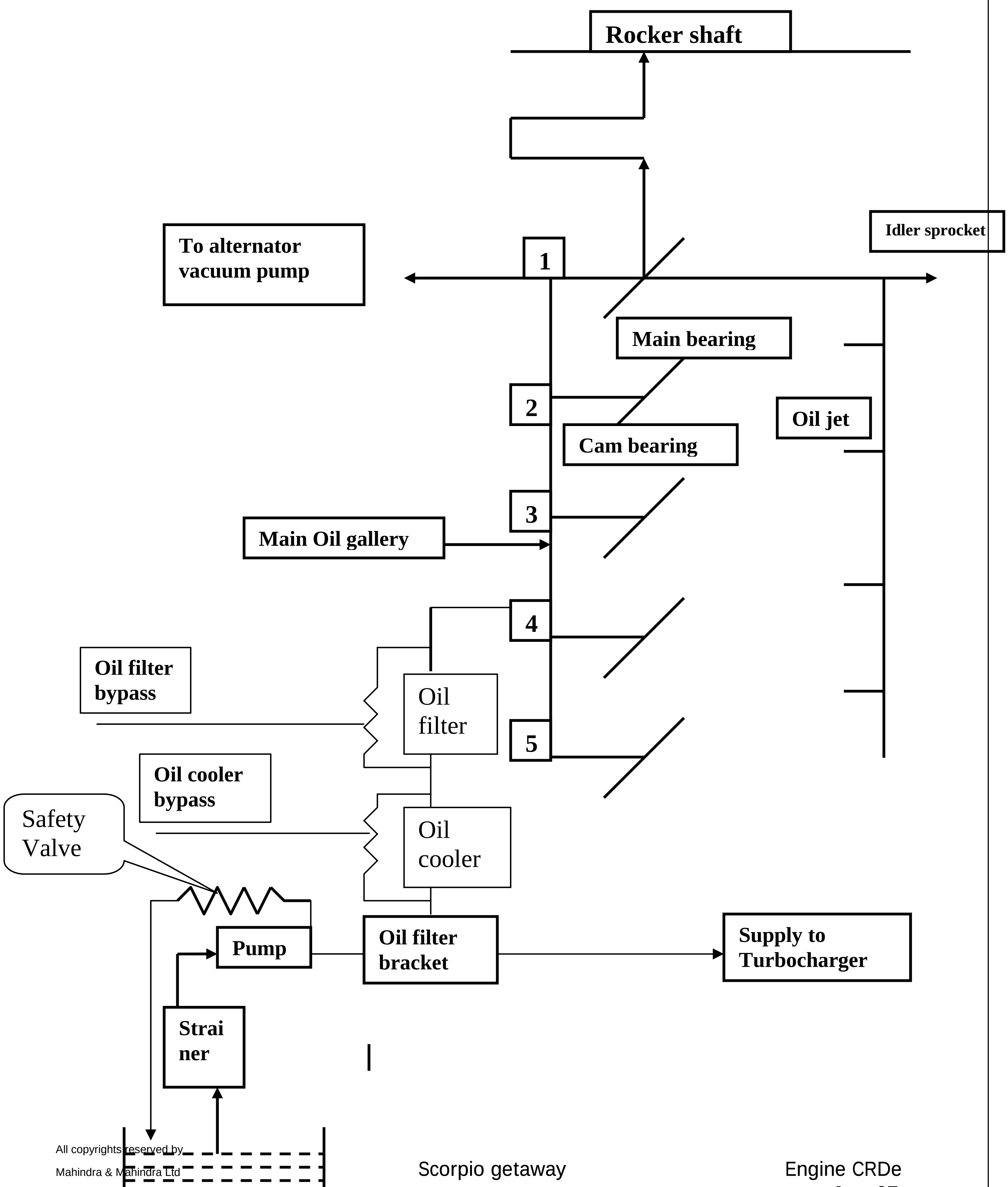
The main oil gallery runs to the front of the block where it is delivered to the timing cover. From therein it takes a small loop in the timing cover and again comes to the front of the block. Goes to another oil gallery. Oil from this gallery supplies oil to the piston cooling jets

Oil from the main oil gallery goes to the crankshaft main journal and camshaft, while from the rear end it is supplied to the alternator's vacuum pump. The oil supply for the turbocharger is from the oil filter bracket.

The oil routed from the main oil gallery lubricates the timing gears and the idler gear bush. Part of this oil gets sprayed from idler shaft hole. The camshaft gear and the thrust plate are lubricated by engine oil routed from the first camshaft bushing through the camshaft hole.

The oil from the First camshaft bush goes to the top of the cylinder and enters an oil gallery, which extend up to 110 m from the front. Oil from this gallery comes to the base of the first rocker shaft-mounting bracket. The oil then enters the rocker shaft. Oil enters the rocker bushing at through two holes facing the bottom half. At the same time it sprays from the oil hole at the side of the rocker to lubricate the valve stem and the surfaces over which the valve cap slides. The oil then returns to the sump through the push rod holes in the cylinder head.

In both the oil cooler and oil filter, bypass valves are provided which operate if the differential pressure exceeds 0.8 bar.


Rocker shaft
Idler sprocket
To alternator vacuum pump
1
Main bearing
2
Oil jet
Cam bearing
3
Main Oil gallery
4
Oil filter bypass
Oil filter
5
Oil cooler bypass
Safety Valve
Oil cooler
Pump
Oil filter bracket
Supply to Turbocharger
Strai ner

Oil filter bracket & pressure relief valve in oil filter bracket is deleted. Crack opening pressure of relief valve in oil pump has been reduced from 6 bar to 4.5 bar. Oil pressure sensor, is mounted on main oil galleries (which is on exhaust side.)

Oil gallery is drilled from front bottom side for oil supply to hydraulic tensioner. This oil gallery is plugged by M9 tapered plug from bottom side.

Oil supply to turbo charger is from opening in exhaust side main oil gallery.

Dismantling & overhauling of the Engine.

Comprise of 5 steps:

Removal of the engine

Dismantling.

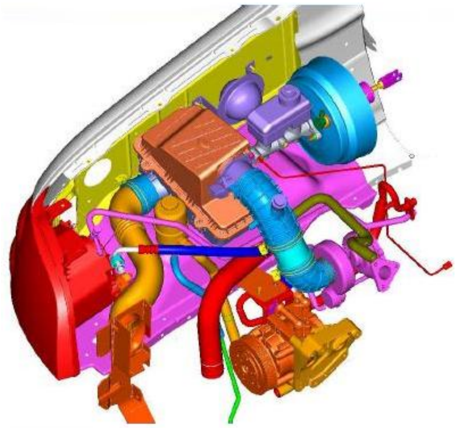
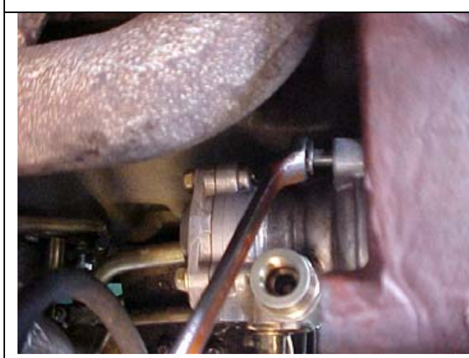
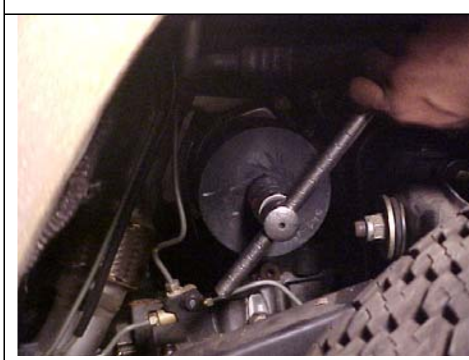
Inspection

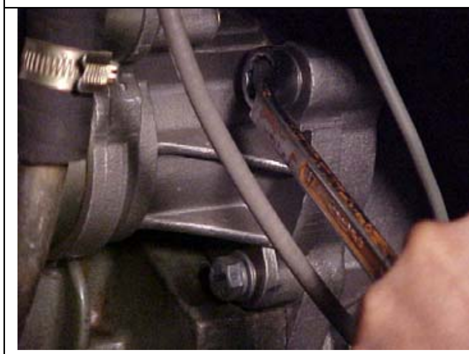
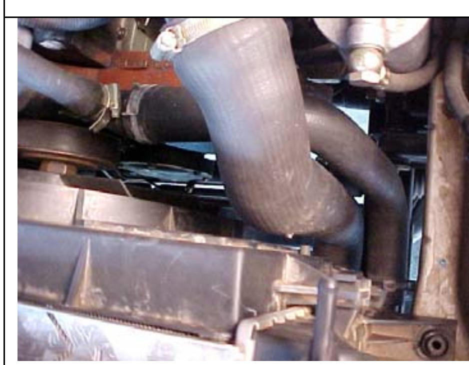
Assembly

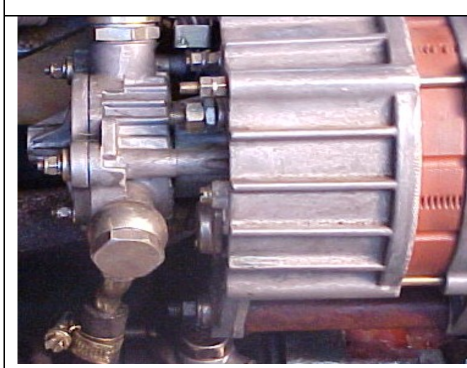
Testing

Removal of the engine from the vehicle -

	Disconnect the battery cables & remove the battery.
	Remove the bonnet.
	Remove the radiator drain cock. Collect the coolant -if the coolant is clean it so that it can be reused.
	Remove the electrical connections of: ▪ Oil pressure sensor ▪ Water temperature sensor. ▪ Starter motor ▪ All sensors (HFM,ISS,Phase) ▪ Connection to Injectors, Modulator.

	Remove the air cleaner assembly. Remove the hose connection from the Turbocharger end TC to intercooler.
	Remove the exhaust pipe at the Turbocharger outlet elbow.
	Remove the oil filter using the MST 545
!	Remove the Turbocharger mounting bolts and remove the Turbocharger. **It is recommended to remove the Turbocharger before the removal in order to avoid any accidental damage**

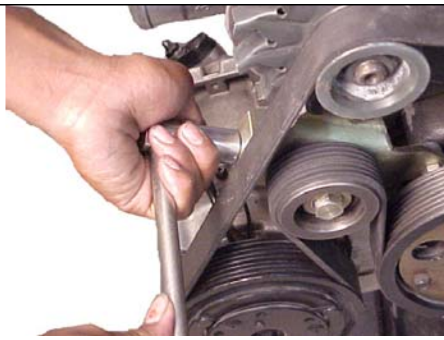
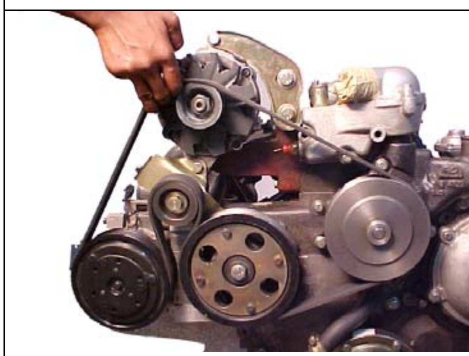
	to it while removing.
	Remove the oil evaporator system.
 	Remove the starter motor.
	Remove the fuel lines from filter to High Pressure Pump & return to fuel tank.
	Remove hoses connecting the water pump to radiator.
	Remove the hose connected from the water pump to heater and also the heater return line.

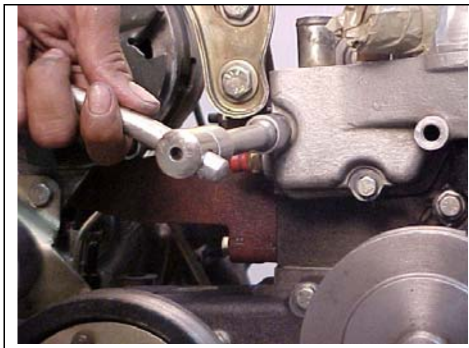
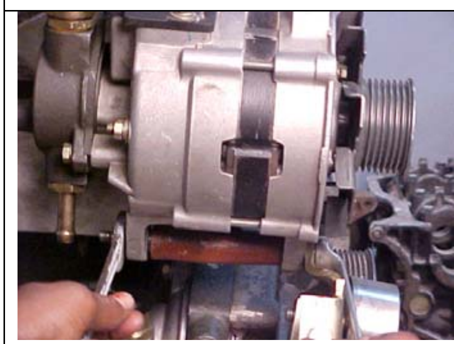
	Remove the fan shroud.
	Remove the radiator.
	Remove the power steering connection hoses from the power steering pump.
	Remove the pipes connecting from AC compressor suction and discharge lines.
	Remove the vacuum hose from the vacuum pump in alternator to booster.

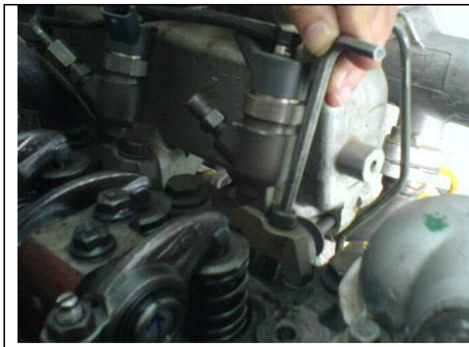
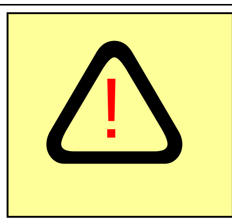
	Drain the oil from the sump.
	Attach lifting device.
	Remove the front insulators mounting bolts,
	Remove the gearbox mounting Allen screws.
	Pull out and lift the engine from the engine compartment.

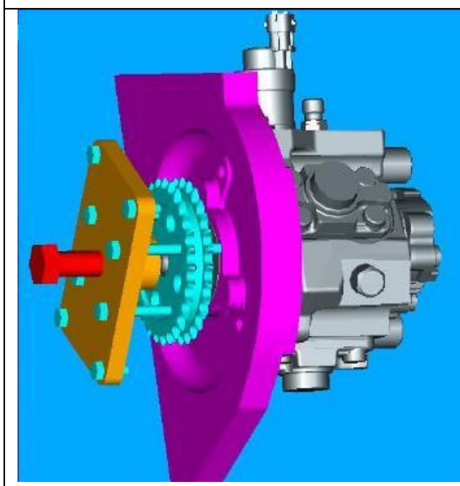
Dismantling --

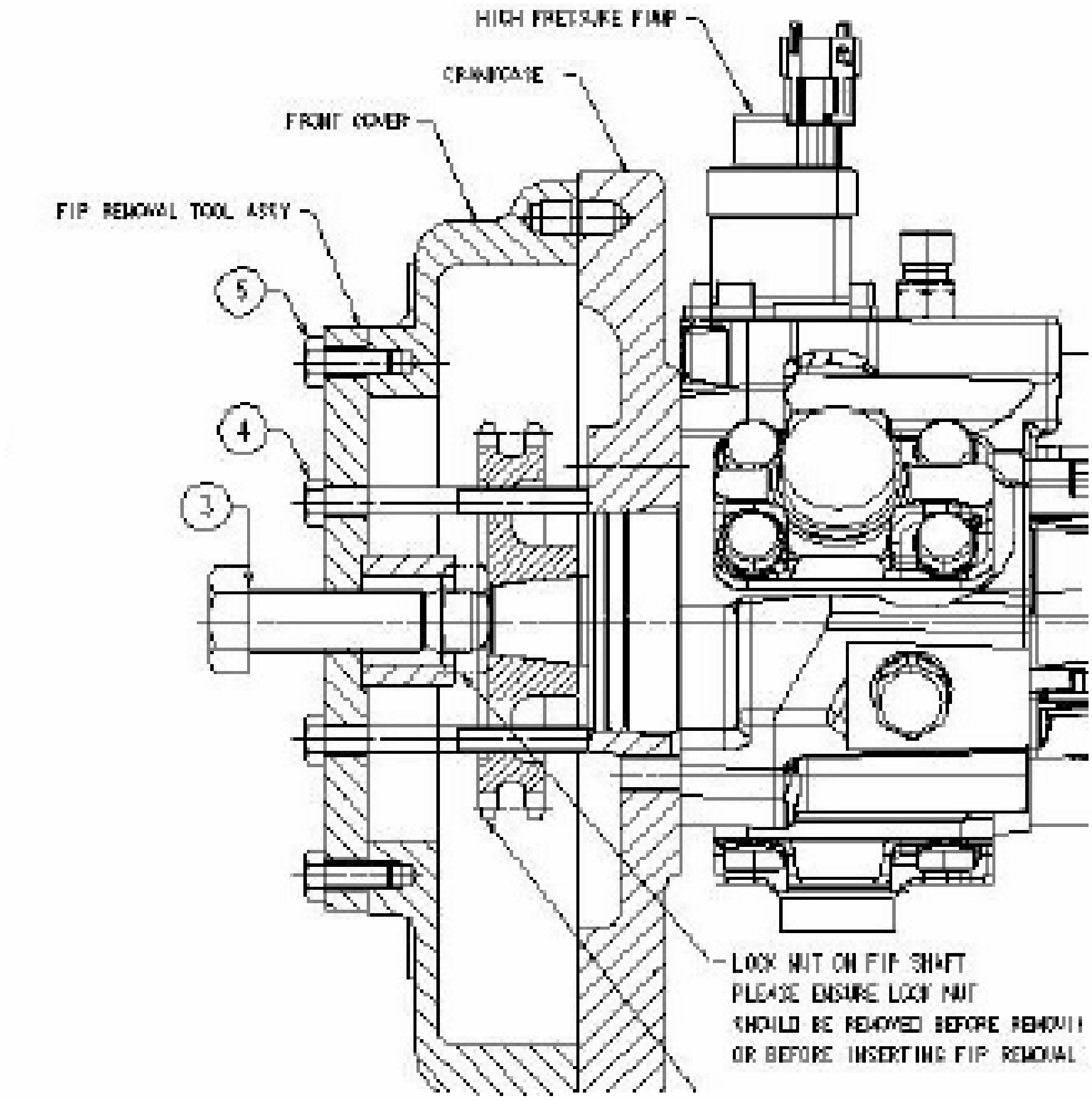
	After removing the engine from the vehicle mount it on the engine stand.
	Remove the rocker cover
	Remove the High-pressure pipes.
	Remove the leak off pipe.
	Loosen the Viscous Fan Drives nut. Loosen the water pump nut. **Note that the threads are anticlockwise threads. Hence to loosen then the direction of rotation has to be clockwise when viewed from**

	front
	Loosen the tensioner bolt first. Loosen the belt tension with the bolt on bracket.
	Remove the accessory belt.
 	While assembly take care that main drive pulley is assembled correctly. It should be noticed that the main drive pulley can be assembled in either direction, however the front end is identified by holes drilled for balancing (this are not thorough holes). If assembled wrongly it will cause misalignment by 5to 6 mm
	Remove the pipe from the oil cooler to the water pump.

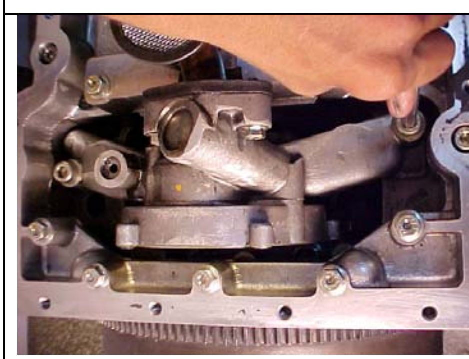
	Remove the water pump.
	Remove the pipe oil cooler to the block.
	Remove the oil cooler.
	Remove the accessory like power steering pump. AC pump and the alternator.

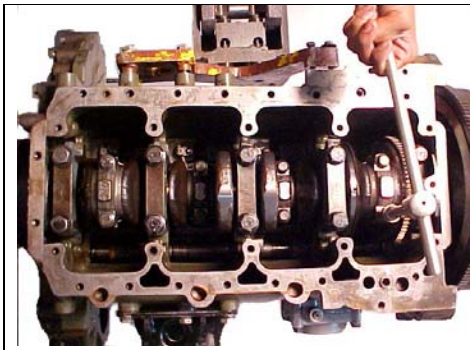
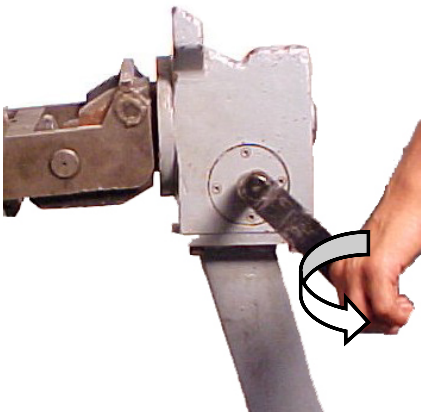
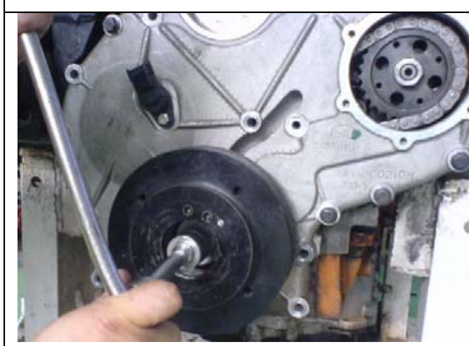
	Remove the injectors.
	Bring the first cylinder into compression. Confirm using the MST
	Remove the front cover on the timing cover.
	Ensure that the “O” rings on the front cover is kept securely so that it can be reused if not damaged while reassembly.

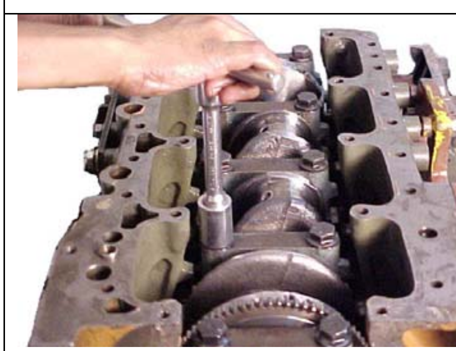
	Remove the HPP mounting nut
	Using the pusher remove the High Pressure Pump.
	Rotate the engine to align three holes of FIP sprocket with three tapped hole provided on crank case for mounting threaded pins of FIP removal tool.
	FIT the three nos.-threaded pins (on crankcase through HPP sprocket holes and tightened with 17-mm spanner.

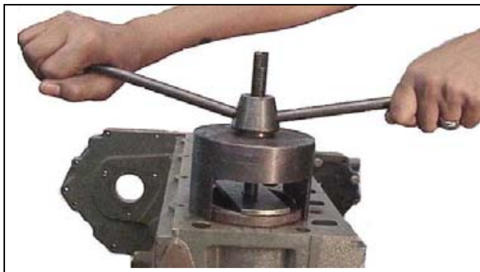

HIGH PRESSURE PUMP
CRANKCASE
FRONT COVER
FIP REMOVAL TOOL ASSY
5
4
3
LOCK NUT ON FIP SHAFT
PLEASE ENSURE LOCK NUT
SHOULD BE REMOVED BEFORE
OR BEFORE INSERTING FIP REMOVAL

	Insert three slotted pins in the other three holes of HPP sprocket and rest against crankcase face
	Now slide pins in the slot so that bottom portion of slot will butt against the back face of sprocket when HPP shaft is pushed away from sprocket.
	Remove the three nuts used for mounting the HPP flange on the crankcase
	Remove the HPP sprocket-mounting Nut
	Assemble the Flange of MST with help three M8 bolts on the face of three threaded pins.
	Now assemble the M 16 threaded on the flange. Rotate the threaded bolt with 24mm spanner so that FIP is pushed out from the sprocket.
	Please hold the HPP with hand while pushing out from sprocket.
	Do not remove all the pins i.e. detail no. 2 & 5 till HPP is reassembled on the sprocket. **(If the MST is removed while the FIP is not in place then chance of sprocket getting bent and later the chain failure is high.)**
	Remove rocker cover

	Remove the rocker shaft assembly
	Remove the cylinder head mounting bolts.
	Remove the cylinder head along with the inlet and exhaust manifold.
	Rotate the engine.
	Remove the oil sump.
	Remove the oil pump along with the suction.
Ensure that the oil sump gasket is removed. It will help in locating all ladder frame mounting bolts	
	Rotate the engine by 90 degree.
	Remove the oil jets along with the gasket.

	Remove the connecting rod caps and take out the pistons.
	Rotate the engine by 90 degree.
	Remove the dampener pulley
	Remove the tensioner pulley
	Remove the timing cover.

	Remove the idler gear after removing the 3 bolts.
	Remove the camshaft's main bolt and the 2-thrust plate locking bolts.
	Remove the camshaft.
	Lock the flywheel using the MST 252 and loosen the flywheel mounting bolts
	Remove the flywheel.
	Remove the rear end oil seal with the retainer.
	Remove the main bearing bolts.
	Remove the bearing caps along with bearing shell halves.
	Remove the crankshaft.
	Remove the bearing shells & thrust washers.
	Rotate the engine.

	Remove the cylinder liners using the MST.
	Remove the tappets by reversing the engine.

Inspection:

All the components should be inspected for wear. Any components, which are beyond the wear limits, have to be replaced.

Over & above the wear limits: The following points also need to be ensured.

Piston: Check for scuffing/scoring on the skirt. A hard thick layer of carbon lacquer on top land is acceptable. (If the thick layer is present on the piston check that the liner does not have scuffing)

However scuffing of the top land and skirt giving indication of overheating which is not acceptable.

Liner: Any scoring on the liner is not acceptable.

Crankshaft: Check for scoring on the main as well as connecting rod journal. If scoring is nominal and will not the increase the oil clearance then the crankshaft can be used in, as it is condition.

However if it is unacceptable then the journal has to be ground up to service limits only.

Any deep groove in the rear end oil seal seating area is unacceptable. It will result in oil leaks.

Valve: If valve tip is worn out/ ridged then not acceptable

Main bearing and connecting rod bearing — If the scoring is nominal and oil clearance is not affected, then it can be reused. However if flaking /peeling of the bimetal in any particular zone only is present then use new shell. Look for foreign particle embedded, deep scratches.

Dampener pulley rubber bonding – inspect for any gap between the rubber ring and the outer/inner ring, Cracks on ring. Any deep groove in the front oil seal seating area is unacceptable. It will lead to leakages.

If any deterioration of rubber or gap noticed between the ring and the rubber replace the dampener pulley.

It is suggested that the dampener pulley be replaced at every 3,00,000 Kms.

Caution:

While measuring the inner diameter of the connecting rod big end and main journal please take the measurements after torque tightening only. For measurement purpose the torque should be 85±8 Nm. Do not reuse this bolt

If line boring of the crankshaft's journal in the block is done to rectify any ovality. Then please ensure that the material from block half is not removed. In absence of taking this precaution the piston will move up. It will change the compression, influencing the performance. In the worst case the valves can hit the piston.

Assembly –

The assembly sequence is the reverse of the dismantling procedure.
To obtain a good life of the rebuilt unit absolute cleanliness of the parts is taken as a prerequisite and also the fact that all the parts have been inspected.

The additional points which are mentioned are necessary to give you the engine life same as the original engine.

Bolts: The following bolts are recommend to be replace every time they are opened-if the Maximum length exceeds the specification. However the connecting rod bolt has to be changed every time without exception.

The bolts have to be tightened by base torque then 2 stage angular torque. The angular torque's ensures that the bolts are torque tightened up to yield point. And the 2 stage ensures that the clamping load for each bolt is within a very close tolerance.

Cylinder head bolts - 10 no --Maximum length 136.6/135.4 mm
Main Bearing Bolts - 10 no Maximum length 90.6/89.4mm
Connecting rod bolt s- 8 noReplace every time
Flywheel bolts - 6no Maximum length 29.58/30.42 mm

Cylinder block – *Top face --* Ensure that the tapping for the cylinder head bolt as well as the crankshaft's main journal is fine. Ensure that no water or oil after cleaning is in the bolt holes (esp. the cylinder heads.). If found please remove them, if necessary using cotton cloth (not cotton waste).

If the oil /water is not removed then it is possible that while tightening the bolt. It may not allow complete tightening of the bolts and one will get a false reading.

Cylinder head gasket –

It is a multi layer steel gasket type. Do not use any oil or shellac on the cylinder head gasket or on the block face or the cylinder head face. The gasket has to be fitted dry.

The gasket can be assembled any face up or down. However it is suggested that the face with the numbers should be facing up.

Piston & Rings –

While fitting the piston rings ensure that the rings end gap are staggered in 120°.
The first ring end gap should not be on the thrust axis but the minor axis i.e. on the gudgeon pin axis. Please note that the first ring is keystone shaped hence the top mark has to face up. The 2nd ring is taper faced.

The face, which should be on the top, has to be facing up. The 3rd ring is the conformable type oil ring. It can be assembled either way.

While assembling the piston on to the liner- apply clean oil liberally on the liner surface.

Bearing shells -

Before fitting the bearing shell ensure that the parent bore of the block/connecting rod are clean.

Wipe with a clean cloth the back end of shells before assembling on to the block or connecting rod.
Ensure that the bearing shells are located properly in the notches.

Oil seals -

Ensure that
- ✓ All the oil seals are fitted using the dolly MST.
- ✓ Always ensure that the lip is coated with grease before fitment.
- ✓ Apply engine oil on the outside diameter of seal. The receiving bore should be free of burrs, dent.

Testing -

After the engine is reassembled in the engine stand; it is recommended that:

The engine is assembled back to the vehicle. All the connections are made.

- ✓ Start the engine
- ✓ Run at idle for 5 minute. Observe for leaks.
- ✓ Drive the vehicle at 50% of the maximum speed in each gear for about 10 to 30 Km each (Aprox.)
- ✓ Hand over the vehicle to customer to drive with speed limitation for 2000 Kms.
- ✓ After 5000 Kms. Readjust the fan belt and tappet clearance. Change the engine oil.

DO NOT RUN THE ENGINE WITHOUT LOAD FOR HOURS FOR BEDDING IN. THIS PROCESS ONLY HARMS THE ENGINE.

RUNNING THE ENGINE WITHOUT LOAD CAUSE RING FLUTTERING AND DAMAGE TO RINGS AS WELL AS LINERS.

RUNNING THE ENGINE AT IDLE FOR PROLONGED TIME HAS SERIOUS CONSEQUENCES ON MAJOR ENGINE COMPONENTS

Specifications & Wear Data -

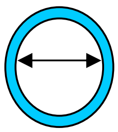
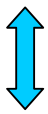
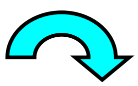
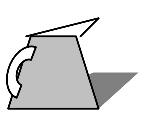
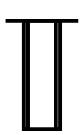
Figure	Description	Value
	**Bore**	94 mm
	**Stroke**	94 mm
	Power- Max	115 BHP @ 3800
	Torque-Max	283 Nm@1800
	Firing Order	1-3-4-2
	**Direction of rotation**	Clockwise from fan side
	Compression Pressure	Standard Service Limit 30 bar
	Piston	Re-entrant Bowl
	Piston Pin	Full floating. Surface hardened & ground.
	**Oil grade & Quantity**	API grade CH4 Viscosity Index 15W40 6 litres Maximile Supreme
	**Cylinder liner**	Replaceable wet type Cast Iron

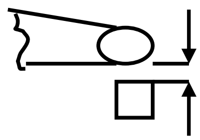
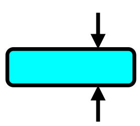
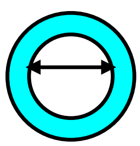
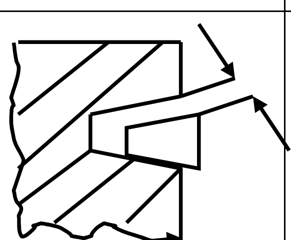
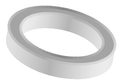
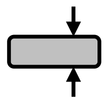
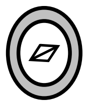
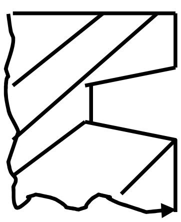
Figure	Description	Value
	**Tappet clearance (Cold)** **Inlet** **Exhaust**	0.45 mm 0.45 mm
	Inlet valve **OPENS** **CLOSES**	4°BTDC 12°ABDC
	Exhaust Valve **OPENS** **CLOSES**	31°BBDC 2°ATDC
	**Oil pump shaft**	Standard Service Limit 13.984/13.966 13.956
	**Oil pump shaft Bush**	Standard Service Limit 14.000/14.018 14.038
	Oil filter bypass opening pressure	0.8 bar
	Relief valve opening pressure (for gear drive engines only)	2.5/3.5 bar
	Oil pressure at **Idle (60~80°C)** **Max speed(60~80°C)**	2.5 bar
	**Piston ring to groove clearance** **1st ring** **2nd ring** **3rd ring**	Standard Service Limit 0.11/0.15 0.25 0.05/0.09 0.15 0.04/0.072 0.15

Figure	Description	Value
	**Piston ring end gaps** **1st ring** **2nd ring** **3rd ring**	Standard — Service Limit 0.33/0.55 — 0.9 0.8/1.05 — 1.5 0.25/0.55 — 0.9
	**Gudgeon pin O.D ϕ**	32/31.994
	**Connecting rod - Small end bush I.D ϕ in assembled condition**	Standard 32.041/32.025
	Gudgeon pin to connecting rod small end bush clearance.	Standard — Service Limit 0.047/0.025 — 0.05
	Gudgeon pin to piston pin hole clearance	Standard — Service Limit 0.017/0.004 — 0.03
	**Piston weights grading** **A** **B** **C** **D** **E**	 836-840 gm 841-845 gm 846-850 gm 851-855 gm 856-860 gm
	Connecting rod grading as per weights **F** **G** **H** **I** **J** **K** **L** **M** **N** **O** **P**	$\geq$ 1260 $\geq$1265 $\geq$1270 $\geq$1275 $\geq$1280 $\geq$1285 $\geq$1290 $\geq$1295 $\geq$1300 $\geq$1305 $\geq$1310 $\geq$1315

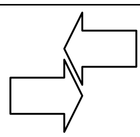
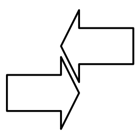
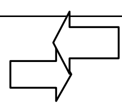
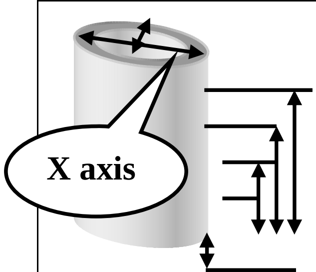
	R **S** **T** **U** **Recommended for service replacement**	≥1320 ≥1325 to 1330 M i.e. 1295 to 1300 gms
	Connecting rod bend or twist	0.05 in 50mm length.
	**Connecting rod end play**	Standard Service Limit 0.1/0.3 0.5
	**Crankshaft end play**	Standard Service Limit 0.10/0.37 0.5
	**Camshaft end play**	Standard Service Limit 01/0.3 0.4
	Liner projection from crankcase top surface	0.02/0.09
	**X Axis- Along C/s** **Y Axis- Perpendicular to cranks shaft** **A- 25 mm** **B- -86.6 mm** **C- 113 mm** **D- 163 mm** **Roundness/Ovality- Difference in X & Y plane at any pt.** **Cylindricity/Taper - Difference in same plane x/y at any point**	Standard Limit ϕ ID 94.022/94.04 Roundness ≤ 0.05 Cylindricty ≤ 0.05

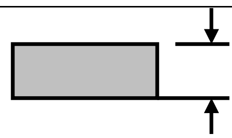
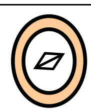
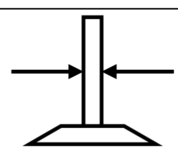
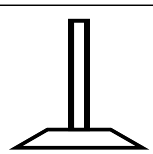
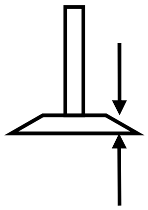
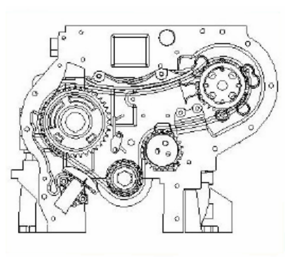
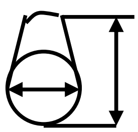
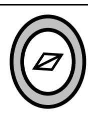
Figure	Description	Value	
	Crankcase top surface distortion	Standard 0.07	Service Limit 0.1
	Cylinder head bottom face distortion	Standard 0.05	Service Limit 0.1
	**Height of cylinder head from top to bottom face**	Standard 97.7/98.3	Service Limit 97.4
	**Rocker lever bush I.D (in pressed condition)**	22.0	
∅	**Rocker shaft O.D**	21.98/21.980	
	Rocker to shaft clearance	Standard 0.02/0.06	Service Limit 0.2
	Push rod bent	Standard ≤ 0.25	Service Limit 0.4
	Valve spring **Free Length** **Squareness** **Installed Load/Installed length**	Standard 53.6 0.15 381.5N/43 mm	Service Limit 50.6 0.2 347 N
	Valve seat angle	44°45′ to 45°	
	**Valve stem O.D** **Inlet** **Exhaust**	 6.95/7.10 6.95/7.10	
	**Valve to Valve guide clearance** **Inlet** **Exhaust**	 0.03/0.07 0.05/0.09	

Figure	Description	Value	
	**Thickness of the valve head**	Standard 2.0	Service Limit 1.5
	**Chain** **Crank Sprocket** **Idler Sprocket** **HPP Sprocket**	Duplex bush type 98 Links, Endless & Riveted. 38 Teeth 22 Teeth 28 Teeth	
	**Difference between Cam height & base circle diameter** **Inlet** **Exhaust**	Standard 6.0796 6.9076	Service Limit 5.5796 6.4076
	**Camshaft Bush I.Dϕ**	49.025/49.0	
	Camshaft Journal O.D	48.98/48.95	
	Camshaft bush to cam journal clearance	Standard 0.02/0.075	Service Limit 0.1
	Camshaft bend	$\leq$ 0.01	
	I.D of tappet hole in crankcase	24.48	
	Tappet to tappet hole clearance	Standard 0.02/0.075	Service Limit 0.15
Figure	**Description**	Value	

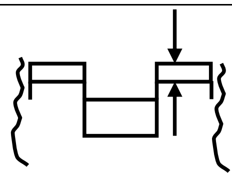
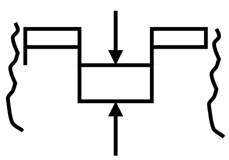
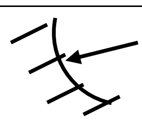
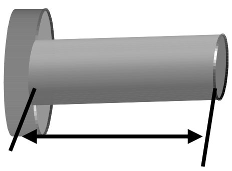
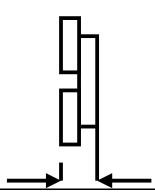
	**Crankshaft pin** **∅ OD** **Roundness/Ovality** **Cylindricity/Taper**	Standard Service Limit 53.0/52.981 ≤ 0.01 0.03 ≤ 0.012 0.03
	Main Bearing oil clearance	Standard Service Limit 0.016/0.074 0.1
	Undersize of the c/s crank pin ∅ OD **0.25mm US** **0.50 mm US** **0.75 mm US**	Dimensions of the crankpin. 52.75/52.731 52.50/52.481 52.25/52.231
	**Crankshaft journal** **∅ OD** **Roundness/ Ovality** **Cylindricity/ Taper**	Standard Service Limit 59.0/58.981 ≤ 0.005 0.03 ≤ 0.008 0.02
	Undersize of the c/s journal pin ∅ OD **0.25mm US** **0.50 mm US** **0.75 mm US**	Dimensions of the journal 58.75/58.371 58.50/58.481 58.25/58.231
	**Crankshaft bend** **CAUTION**	Standard Service Limit ≤ 0.025 0.06 FILLETS ARE HARDENED. DO NOT ATTEMPT TO STRAIGTEN
	**Crankshaft fillet radius**	Standard Service Limits 3.0/3.5

Figure	Description	Value
	Crankshaft Hardness Minimum	50 HRC
	Connecting rod Bearing oil clearance	Standard 0.016/0.040 Service Limit 0.070
	**The Maximum length of bolts after which they can not be used** Cylinder head bolts Main Bearing Bolts Connecting rod Flywheel bolts length	 136.6/135.4 mm 90.6/89.4mm Replace everytime 29.58/30.42 mm
	Thermostat **Starts opening at** **Fully opens at** **Lift**	 80~84°C 96°C mm
	Water pump pulley ratio	1.25
	**Flywheel** **Width from Mounting face to clutch face**	35±0.13
	Flywheel **Flatness** **Runout**	Standard / Service Limit ≤ 0.05 / 0.1 ≤ 0.05 / 0.1

Automotive Sector

Lubricants & Sealants -

Mahindra Maximile Supreme Or any other engine oil conforming to API grade CH4 or above and a viscosity Index of 15W 40.

If any oil conforming to CG4 grade is used then the oil change interval is 7000 Kms. Oils of MIL 2104 C or below are not acceptable

RTV silicone sealant - RHODOSEAL. Part number 0024532 to be used:

- **Between Rear oil seal retainer & Block**
- **Between ladder frame & block**

All other places Loctite 547. Part number 0084337 are used.

Hard gaskets are used only at: -

- ✓ **Cylinder head Gasket.**
- ✓ **Turbocharger to Exhaust manifold mounting.**
- ✓ **Exhaust manifold to cylinder head.**
- ✓ **Exhaust manifold to EGR pipe**
- ✓ **EGR pipe to elbow.**

Rust cleaning solution (For the Turbocharger mounting nuts):

Brand Name: WD-40---
Manufacturer- WD-40 COMPANY
MARKETEDBY—Hardcastle & Waud Manufacturing Co. Ltd.
Brabourne Stadium,
87, Veer Nariman Road
MUMBAI-20.

Tightening Torque's --

Description	Torque Value
Bolt - Cylinder head	90Nm+ 60°+ 60° (66.4 Lbft+60°+ 60°)
Connecting rod cap Mounting bolts	45 Nm+ 90° (33 Lbft +90°)
Main Bearing cap	168±17 Nm (123 ±12.5 Lbft)
Flywheel	90 Nm + 60° (66 Lbft+ 60°)
Cranks shaft pulley (apply oil on bolt before tightening)	90 Nm + 90°+ 90°
Cam sprocket mounting bolts	135 ± 10 Nm
HPP Mounting Nut	30 ± 3 Nm
Idler Shaft Mounting Bolts **M8 X 1.25** **M7 X 1.00**	 25 ± 3 Nm 15 ± 3 Nm
HPP sprocket lock nut	70 ± 5 Nm
Camshaft thrust Plate mounting Bolts	25 ± 3 Nm (18.4 ± 2.2 Lbft)
Viscous Fan clutch nut	45 ± 5 Nm
Injector holding clamping bolts	25 ± 3 Nm (18.4 ± 2.2 Lbft)
Front cover on crankcase	25 ± 3 Nm (18.4 ± 2.2 Lbft)
Oil jet Assembly bolt M6	10 ± 1 Nm
Alternator Bracket bolts on Cylinder head	40 ± 5 Nm
Alternator brace bolt on alternator bracket	32.5 ± 2.5 Nm
High Pressure Pipe – HPP to Rail	20±2 Nm
High Pressure Pipe to Injector	27 ± 2 Nm
High Pressure Pipe to rail	35 Nm
Rail mounting on intake manifold	22.5 ± 2.5 Nm
Phase Sensor Mounting on Ft. cover	8 ± 0.5 Nm
Damper Pulley Mounting Bolt	90 Nm +90°+ 90°
Chain Guide (Cam shaft to HPP) Mounting Bolts	14 ± 1 Nm
Chain Guide (HPP to Idler Sprocket) Mounting Bolts	

Special Tools --

Description / Part No. / Sketch	Usage View
Piston Ring Compressor **MST 262** 	
Holder Assembly for rear oil seal installer **MST 264** 	
Rear Oil Seal Installer **MST 265** 	
Flywheel Lock **MST 271** 	

Description / Part No. / Sketch	Usage View
Lock Pin for Chain Tensioner **MST 273** 	
Special Spanner for Nut - Engine Mounting -- MST - 542 	
Extractor Flywheel Bearing **MST - 543** 	
Drift Flywheel Bearing **MST - 544** 	

Description / Part No. / Sketch	Usage View
Wrench Oil Filter Remover **MST - 545** 	
Cylinder Head Bolt Deep Socket **MST 588** 	

Mahindra
Automotive Sector

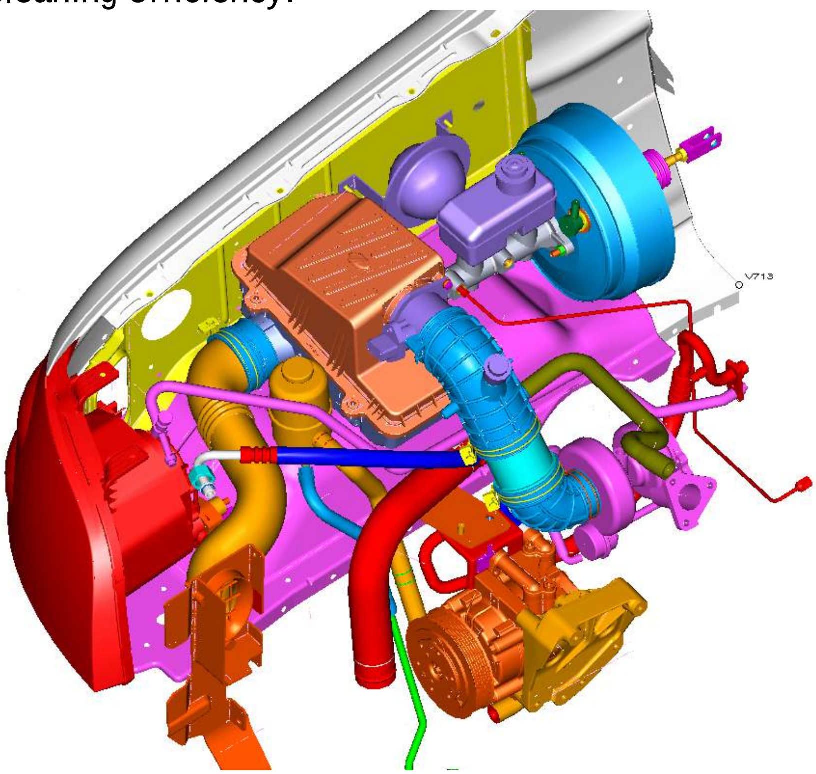
Air Intake System-CRDe

Contents

Description

The air is sucked through a foam air cleaner. The air enters the air cleaner housing at the bottom and leaves at the top.

The air cleaner is made up of 5 different layers of foam. Each layer is having different cleaning efficiency.



After filtration the air goes to the turbocharger.

A HFM sensor is attached to the outlet of the air cleaner. The air to the turbocharger has to go through the HFM. The HFM measures the air mass going to the engine. The quantity of the air going is used to compute the fuelling.

After the HFM and before turbocharger there is mechanical or electrical service indicator. In case of electrical service indicator, signal of choked air cleaner goes to the instrument cluster. In case of mechanical one, red band appears in choked condition.

The waste gated turbocharger controls the boost to 1.6. The compressed air is cooled by the charge intercooler, which is mounted just below the radiator. The cooled air enters the inlet manifolds. It enters the Cast iron cylinder head through the inlet valves having a 45-degree angle.

Trouble Shooting –

Symptom	Causes	Remedial action
Engine does not start & emits black smoke	Air intake obstructed	✓ Check whether service indicator light glows or red band appears and replace element if light is on /red band appears. ✓ . Refer to the **care of the system** also ✓ Check for free operation of Turbocharger
Engine does not give full power.	1. Air intake restricted. 2. Air leaks in system after turbocharger 3. Air leak in pipe – manifold to FIP 4. Boost pressure control valve stuck in open condition. 5. Boost pressure pipe/hose assembly damaged 6. Turbocharger damaged.	✓ Replace element ✓ Plug the leaks, replace hose or clip if required. ✓ Replace the hose or tighten ✓ Correct the control valve & find the cause ✓ Check the pipe, washer & rectify. ✓ Get the Turbocharger repaired at authorized TEL dealer.
Black smoke.	1. Air intake restricted.	✓ Check for hoses, replace element.

	2. Air leaks.	✓ Check for leaks between Turbocharger & inlet manifold Remove restriction or replace parts.
Excessive oil consumption	1. Clogged air filter element. 2. Restriction in air intake to compressor duct. 3. Air leak between the Turbocharger to intake manifold. 4. Restrictions in turbocharger drain line. 5. Restriction in crankcase breather. 6. Thick oil/sludge or coke in the turbocharger's central housing 7. Turbocharger damaged.	✓ Replace element. ✓ Locate & remove restriction. ✓ Locate the leaks, change hose or clamp if required. ✓ Remove the restriction in the drainpipe. ✓ Check the crankcase ventilation & rectify. ✓ Change oil, filter, service the Turbocharger & use recommended oils & drain intervals. Follow the recommended procedure while shutting down. ✓ Repair Turbocharger.
Whining noise clearly audible after 2000 RPM	1. Indication of air leak esp. in between: Turbocharger to inlet manifold.	✓ Tighten the clamps at the intercooler inlet and outlet. ✓ Tighten the clamps at the Turbocharger inlet & outlet. ✓ Check the hoses for leak ✓ Check & replace the pipe to and from intercooler.

Care of the System -

The air cleaner element should be replaced every 40,000 km or If service indicator light glows under normal driving conditions.

Under extremely dusty conditions replace earlier than above.

It should be noted that if the engine is run with clogged air cleaner, then it will lead to seepage of oil from turbocharger into the air intake system.

Ensure that the recommended engine oil only is used and the specified drain intervals are maintained.

To achieve an optimum cooling of the compressed air it is vital that the vehicle's number plate position is not changed and/ or an oversize number plate does not block the aperture for the air draft for the intercooler.

The Turbocharger & boost control valve does not require any special maintenance. However check the boost pressure pipe for proper fitment (connection from compressor to boost valve). Damage, cracks, chips at ends, etc.

Check the operation of the waste gate valve by blowing compressed air with 2.0 bar in the valve hose. The valve should open, pressing the turbocharger stem and opening the exhaust valve (flap valve)

Check the oil separator system, in particular for any leak in vacuum leak. As any vacuum leak will lead to a high-pressure build up and then it will go through the intake system and give a signal of high blow by or be confused with compressor oil leak.

Do not attempt to disturb length of the waste gate controlling actuator rod.

If the Turbocharger is removed, please do not lift the turbocharger using the actuator rod as a lifting handle.

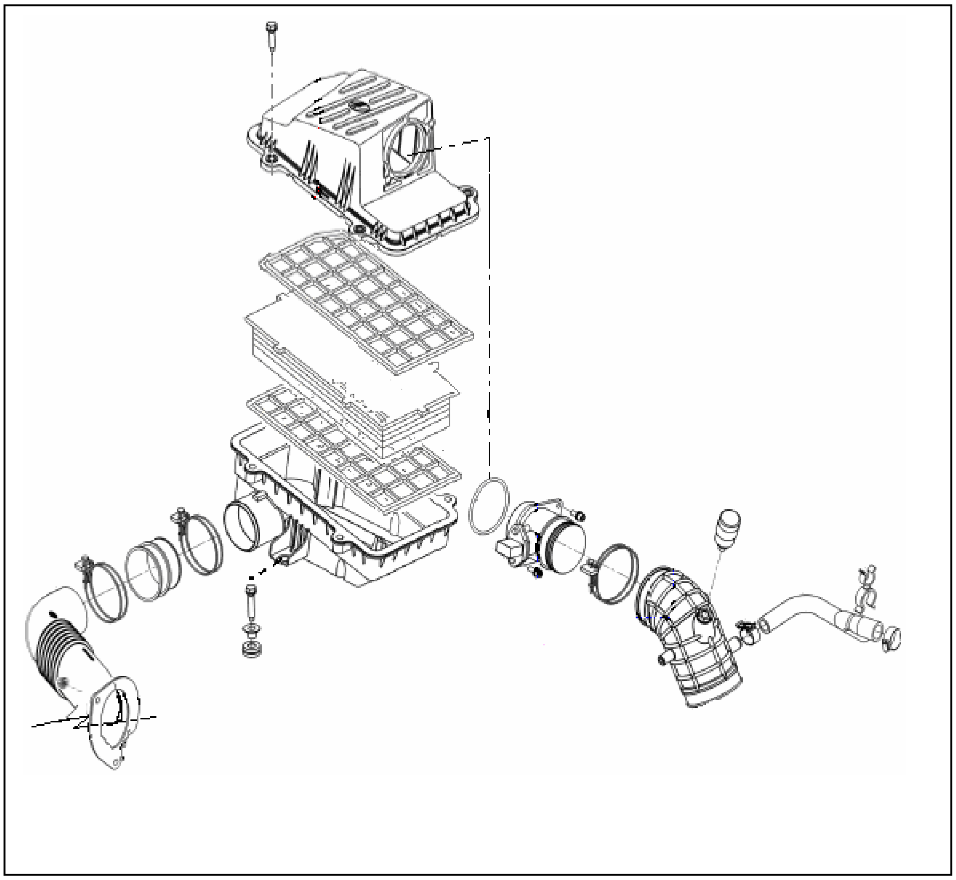
In Car Repairs -

Air cleaner Removal

Turbocharger removal & Refitment

Air cleaner Servicing --

Replacing the filter element -



1. Open the clean Hose clip & separate the hose.

2. Open the Air Cleaner Top Cover Bolts.

3. Remove the Air Filter Element along with grates & clean the bottom bowl.

4. Separate the Top as well as bottom Grates & replace the Air Filter Element; assemble the grates & put the assembly back in place. Position the new element properly, taking care of lug projections.

5. Assemble the top cover & tighten the top cover bolts in diagonally opposite order.

6. Assemble the Clean Hose on the Air Cleaner Outlet-Air Mass Sensor Neck & tighten the Hose Clip.

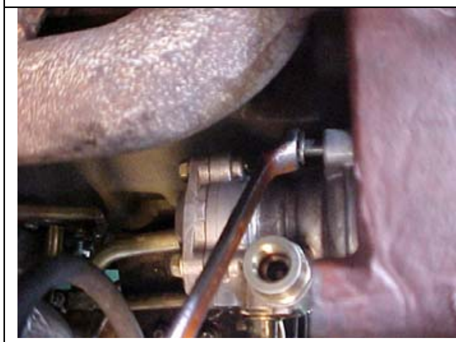
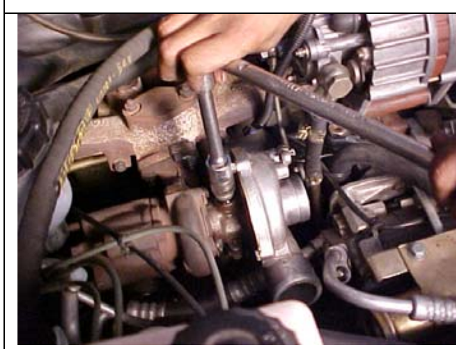
CAUTION

The cleaning of the element is not recommended under any circumstances.

Do not wring the foam.

Do not use if foam is cut, torn or foam layers are separated.

Turbocharger removal & Re-fitment -

	Remove the air cleaner assembly
	Remove the exhaust pipe from after the elbow. (Access is only after lifting it on a two post or in a pit.)
	Remove the air intake hose to turbocharger.
	Remove the oil feed pipe and the oil return pipe.
	**It is suggested that all the opening in the Turbine housing, compressor housing and the center housing be covered with plugs or masking tape.** **This is recommended as even a small particle/ washer if trapped between the blades & housing can destroy the turbocharger.**
	(It is recommended to apply rust

	cleaning spray in the nuts before attempting to remove otherwise the stud will come off.)
	Remove the turbocharger mounting 3 nuts.
	**Please do not lift the turbocharger using the actuator rod as a lifting handle.**
	While fitting back the Turbocharger, it is essential to **purge the oil supply line of any air.**

Working Principle, Inspection & Fitment procedures of the Turbocharger -

The Turbocharger is basically an axial inflow air compressor, which is driven by an exhaust gas driven turbine.

The exhausts gases coming out of exhaust manifold impinge on the turbine blade give the drive to turbine shaft. At the other end of the turbine shaft the compressor is assembled. The whole assembly is supported on a floating bush. The bush gets an oil supply directly from the engine and has oil film between the shaft and bearing as well as the bush and the central housing.

The exhaust gases from the Turbine impinge on the turbine blade & rotate the shaft. The compressor blades at the other end suck the air from the air filter. After compression the temperature of the compressed air increases thus reducing the air density. Hence if the air is cooled and then the air density increases thus helping in getting more power as well as improve emissions. The compressed air is sent to the intercooler, which is mounted just below the radiator. Hence the incoming ram air also cools the compressed air and gives it to the intake manifold.

The turbocharger is matched to give an optimum boost for the desired engine speed band. A waste gate controls the boost. The waste gate is used to bypass the excess exhaust gas away from the turbine and thus maintain the boost as well as control the backpressure. A spring-loaded diaphragm controls the waste gate.

A flap valve is installed in the turbine housing just before the turbine blade. Opening the valve allows the excess gases to bypass the turbine. The flap movement is controlled by a push rod, which is controlled by a spring-loaded diaphragm. At the other end of the diaphragm the compressed air is sensed through a hose which is connected at a tapping in the compressor housing.

The length of the pushrod, functioning of the diaphragm and the hose connection are essential for the precise operation of the push rod. Any air leak from the hose connecting the compressor housing to the waste gate-controlling diaphragm will also affect the performance of the turbocharger/ engine.

Inspection

- ✓ Inspect the suction side (i.e. up to the air cleaner) for oil traces.
  In a close crank case ventilation system it is normal to have oil in this area. These oil particles are carried from blow bye of the engine, which gets condensed from gas to oil. Look for any undue gumming of oil, hard carbon particles in this area. If such an observation is present then all the causes for excess blow symptoms have to be checked and eliminated.

- ✓ Inspect the compressor and turbine blades for any damage caused by foreign object. The inspection can be done through the compressor housing inlet and turbine housings outlet.

- ✓ Inspect the blades outer edge and observe if any rubbing marks are noticed on the housing.

- ✓ Rotate the shaft wheel assembly by hand and check for freeness, and any binding.
- ✓ Push the shaft to side and rotate to check for wheel rub. It should turn smoothly.

- ✓ Lift both end of shaft up and down at the same time and feel for excessive journal bearing clearance. If clearance is normal then very little shaft movement will be detected.

- **If all the above checks are satisfactory then the turbocharger can be reused.**

- ♦ *If the turbocharger parts are damaged, wheel rubbing marks present, shaft not rotating freely or binding or excessive journal clearance then the Turbocharger should be serviced*.

- ✓ Do not attempt to service or overhaul the Turbocharger. It should be done only at the authorized Turbo Energy Ltd service center. Any attempts to attend without the use of special tools or procedure can damage to turbocharger or personnel!

<u>Turbocharger Installation</u> -

Do not mishandle, tumbled, dropped or keep any ports open.
Do not use the actuator control rod for lifting or carrying.
Do not disturb the setting of the actuator.

Check

The inlet connection & outlet exhaust connection to turbocharger for foreign material, cracks, blockages, sand particles, loose nuts etc. This check should be done more thoroughly if any damage has been noticed in compressor or turbine blades as under normal operating conditions the blades can damaged only if a foreign object hits them.

Check all the hoses and pipes from turbocharger outlet to intercooler and intercooler to inlet manifold for crack, aging, leaks. Check the hose clips for proper functioning. If in doubt – replace.

The oil supply pipe should be checked carbon deposits, crack, distortions etc. Clean the supply pipe before fitting.

Do not attempt to change the orientation of turbocharger and ensure the correct gaskets are used.

Do not reuse any of metallic gaskets even if they appear to be good. It will lead to leakage & drop in the performance of the engine.

Installation –

Once a new turbocharger is being installed.

i. Fill fresh clean oil from the oil supplies port and after that give the shaft few rotations.

ii. Fit the supply pipe.

iii. Crank the engine till a steady stream of oil comes out through the drainpipe. (**CAUTION**: Do not crank the engine for too long. Excessive cranking will result in emptying of the pump cavity causing the plunger to run dry.)

This will ensure that the oil supply line to Turbocharger is purged of any air pocket.

After this fit the return line from turbocharger to sump, taking care to avoid any kinks.

With engine running condition, check the air, exhaust and oil connections for leaks.

Specifications -

Description	Value
Turbocharger Model	K 04
Turbocharger specifications	K0 4-2075 ECD5.82
Turbocharger supplier	Turbo Energy Ltd.
Air velocity between the Air filter compressor inlet	35 M/sec
Air velocity between the compressor outlet and the inlet manifold	50 M/Sec (Max)
Maximum static back pressure at downstream of turbine	60mbar
Oil pressure at upstream of turbocharger	2.5 bar

Tightening Torque's -

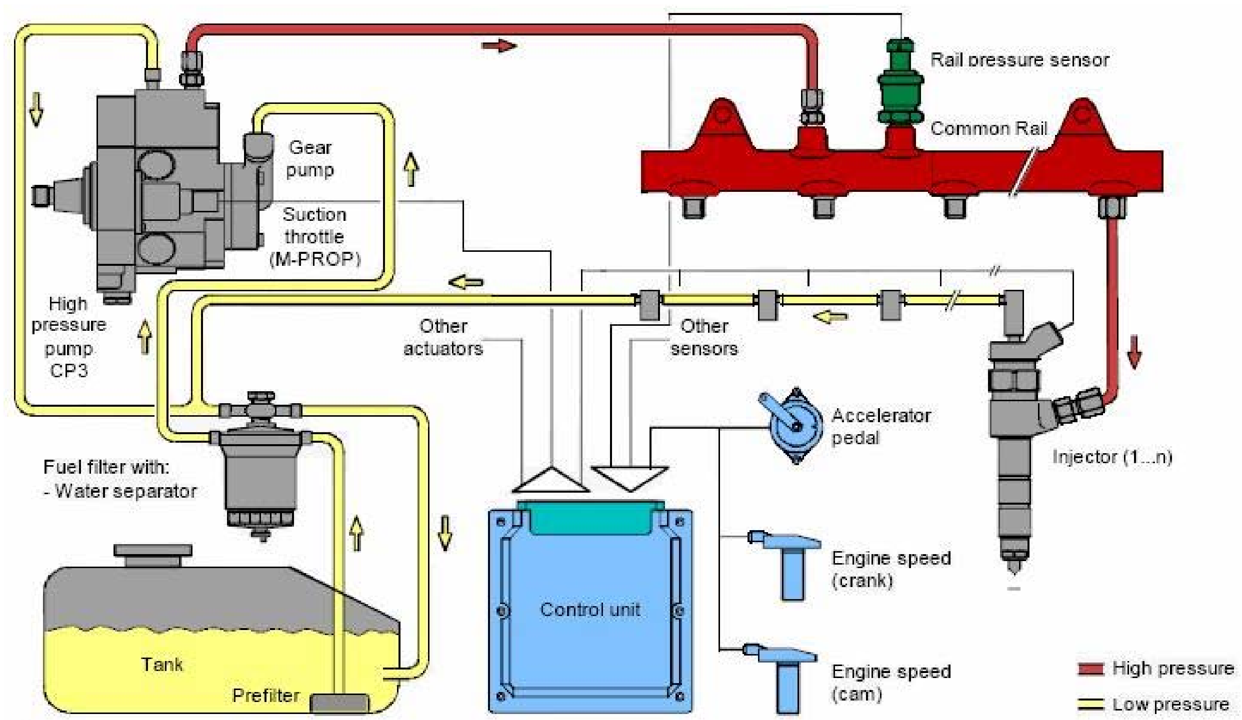
Bolt location	Torque in Nm (Lbft)
Turbocharger Mounting stud/ nut	25 ± 3 Nm(18.4 ± 2 lbf-ft)
Inlet manifold	25 ± 3 (18.4 ± 2 lbf-ft)
Air cleaner top cover bolts	4.5 Nm (3 lbf-ft)

Automotive Sector

Fuel System- CRDe

Contents

Description



The fuel system can be divided into following subgroups.

- Fuel filling.
- Fuel supply from tank to High Pressure pump .
- High Pressure Pump & injectors including the High pressure pipes.
- Return line from High Pressure Pump to tank

The fuel is filled from the opening provided at rear left. The fuel cap is ventilated and threaded type. The cap is locked in place when further turning action result in clicking of the ratchet. the fuel tank lid is electrically operated . The switch is fitted on the centre bezel .

While filling the tank, the air entrapped inside is vented by the vent tube, which is connected at the mouth of the inlet pipe. The venting is done from the highest point in the fuel tank. The fuel tank has a capacity of 58 liters.

During operation the fuel pump due to the vacuum created by the internal feed pump the fuel is sucked through the filter, to the high pressure pump.

The high pressure pump, pressurizes, & supplies the fuel to the common rail . The fuel then comes to the injectors.

The fuel back leak from injectors and return from HPP comes through return line.

The entire length of the fuel tank is protected at the bottom by a stone guard.

For the detailed understanding of the Common rail system, please refer the Common Rail System (CR System) explained separately.

Trouble Shooting –

Symptom	**Causes**	Remedial action
Engine will not start & emit black smoke	1. Clogged fuel filter/ fuel lines 2. Defective injectors	✓ Change fuel filter ✓ Check fuel supply line. ✓ Refer diagnostic manual
Noisy engine & black smoke.	1. Injector coking. 2. CR System	✓ Clean external coking ✓ Refer the diagnostic manual
Engine speed falls off.	1. Clogged fuel filter/ fuel lines 2.	✓ Change fuel filter ✓ Check fuel supply line. ✓ Refer diagnostic manual.
Engine does not give full power.	1. Clogged fuel filter/ fuel lines	✓ Change fuel filter ✓ Check fuel supply line.

	2. Defective injectors.	✓ Replace filters. ✓ Locate the kink/block in return pipe and rectify. ✓ Refer diagnostic manual
Black smoke.	1. Defective injectors 2. CR system	✓ Check injectors. ✓ Refer diagnostic.
Engine will not start	1. Weak battery 2. Corroded or loose battery connection 3. Faulty starter. 4. CR system	✓ Check the battery specific gravity. ✓ Clean & tighten battery connections. ✓ Repair starter. ✓ Refer diagnostic manual.

Care of the System –

The fuel injection system depends on supply of clean diesel fuel for the proper functioning of the fuel system.

To ensure that High Pressure Pump receives clean fuel all the times it is advisable that the fuel filter is replaced at the specified intervals.

The fuel filter should be changed at every 20,000 Kms. If the operating conditions are poor then reduce the change interval. The fuel filter is equipped with water separator. If the water level indication comes on in the instrument panel, then the water should be immediately drained.

The internal components of the High Pressure Pump depend on the lubricating properties of diesel for lubricating them. Hence, if water is present in the fuel then lubrication between the component break down and there is seizure.

Automotive Sector

In Car Repairs -

The In Car repairs which can be carried out are:

Removal & Replacement of the fuel filer

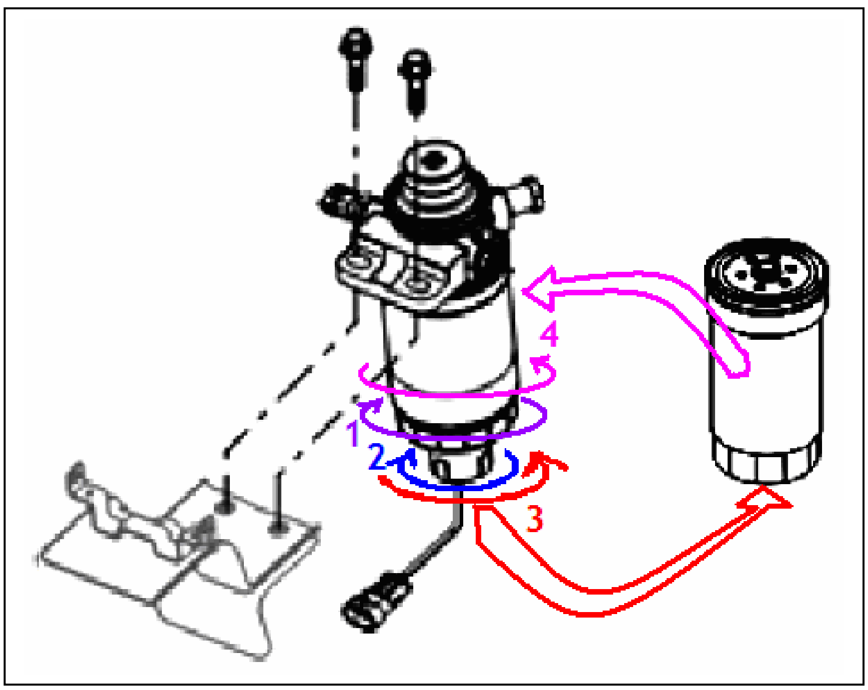
Draining the water from the fuel filters

Removal & refitting injectors

Removal & refitting the HPP

Removal of the fuel tank

Removal & Replacement of the fuel filer –



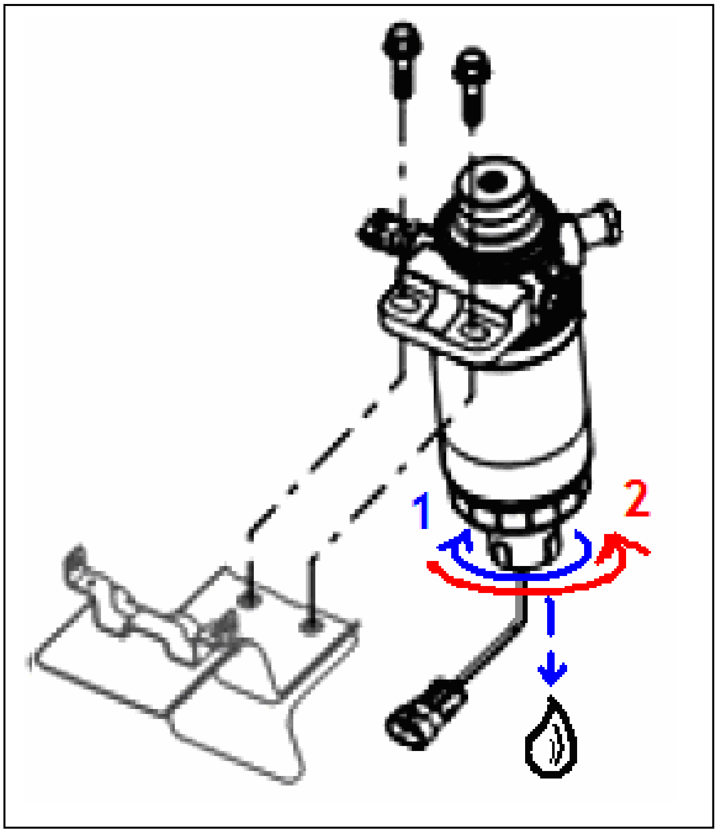
1. Loosen the Fuel Filter Element.

2. Loosen 'Water in Fuel Sensor' at the bottom of the Fuel Filter element.

3. Fit the 'Water in Fuel Sensor' taken out from old Fuel Filter Element on the New Fuel Filter Element.

4. Fit the New Element fitted with sensor on the filter body, tighten properly.

Draining the water from the fuel filter –



1. Loosen Water in Fuel Sensor at the bottom of the Fuel Filter.

2. Allow the Water accumulated in the filter to drain out.

3. Tighten the Water in Fuel Sensor properly.

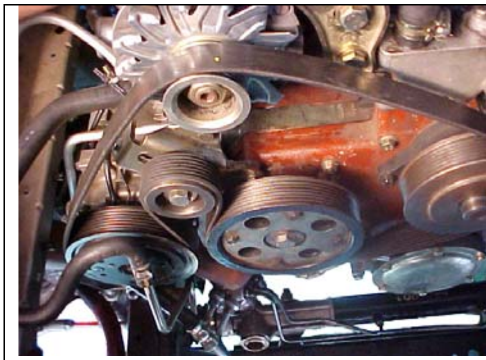
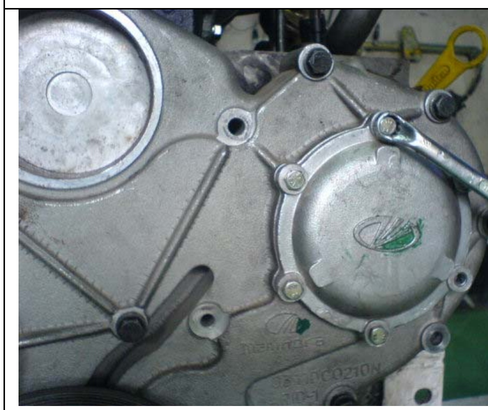
Removal & refitting injector –

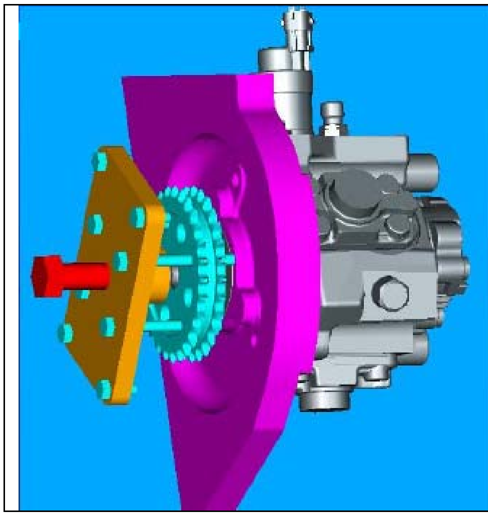
	Loosen the high-pressure pipes from both the common rail end & injectors.
	Avoid loosening only at one end as it can cause strain in the pipes, while removing the injectors
	Remove the leak off pipe.
	Remove the injector clamps.
	Remove the injector.
	While refitting, the injector use a new washer between the injector & cylinder head.(Thickness of washer should be 3mm)
	Avoid using two-injector washer. Normally it tends to happen if the

	older washer is not removed and has got stuck to cylinder head. It will change the injector tip height to change and affect combustion.

Removal & refitting the HPP -

	Remove tappet cover.
	Bring the 1st cylinder in compression. (To confirm the first cylinder TDC position remove the 1st cylinder injector, insert the MST and the dial gauge. Check by the dial if the piston is in TDC)
	Remove the VFD assembly along with the fan blade assembly.

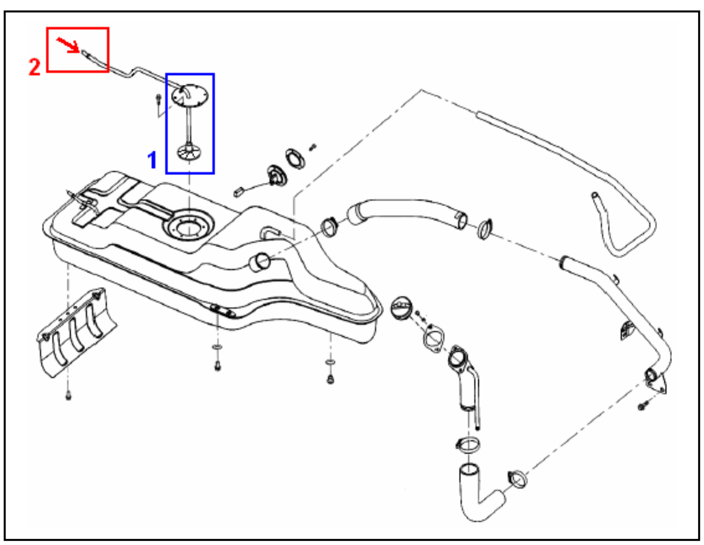
	Remove the fan belt.
	Remove the injector pipes.
	Remove the front cover in the timing cover.
	Loosen & remove the High Pressure Pump locking nut.

	Remove the High Pressure Pump using the pusher.

Removal of the fuel tank -

- Disconnect the fuel tank supply hose and the vent hose.
- Disconnect the fuel supply and return hoses
- Disconnect the fuel gauges, tank unit electrical connection.
- Remove the skid plate.
- Remove the mounting 5 no bolts.
- Lower the fuel tank on to the transmission jack
- The assembly procedure is the reverse of the disassembly.

Fuel Tank Strainer Cleaning –



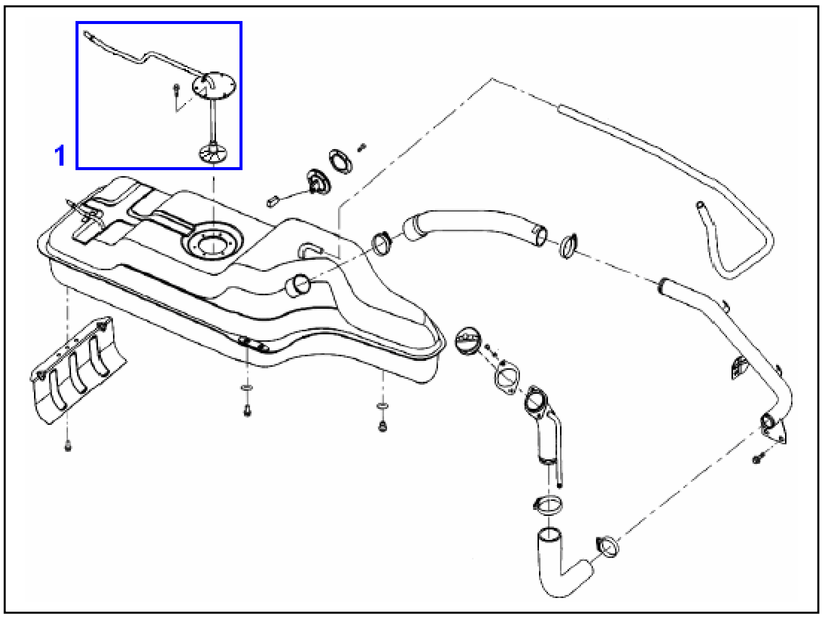
Remove the Fuel Tank from the vehicle.

1. Take out the 'Fuel Strainer with main line assembly' by removing the fastening bolts.

2. Blow the compressed air gradually with low pressure as per the direction indicated by the arrow in the illustration above.

Clean the fuel tank. Complete the Fuel Tank Assembly & refit it on the vehicle.

Fuel Tank Strainer Replacement -



- Remove the Fuel Tank from the vehicle.

1. Take out the 'Fuel Strainer with main line assembly' by removing the fastening bolts. Replace the 'Fuel Strainer with main line assembly'.

    - Clean the fuel tank. Complete the Fuel Tank Assembly & refit it on the vehicle.

Dismantling, Inspection & overhaul of the High Pressure Pump –

The HPP is non - serviceable.

Specifications –

Bosch CRS 2.2

HPP Type: CP1H

ECU: EDC 16C

Tightening Torque's –

Location	Torque in Nm (lbf-ft)
High pressure pipe pump to Rail	20 ± 2 Nm (15±1 lbf-ft)
High pressure pipe to Rail	35 Nm (26 lbf-ft)
High Pressure Pipe to injector	27±2 Nm (20± 1 lbf-ft)
Injector holder clamping	25±3 Nm (18 ± 2 lbf-ft)
Rail mounting on intake manifold	22.5±2.5 Nm (16.5 ± 2 lbf-ft)

Mahindra
Automotive Sector

Emission Control system

Contents

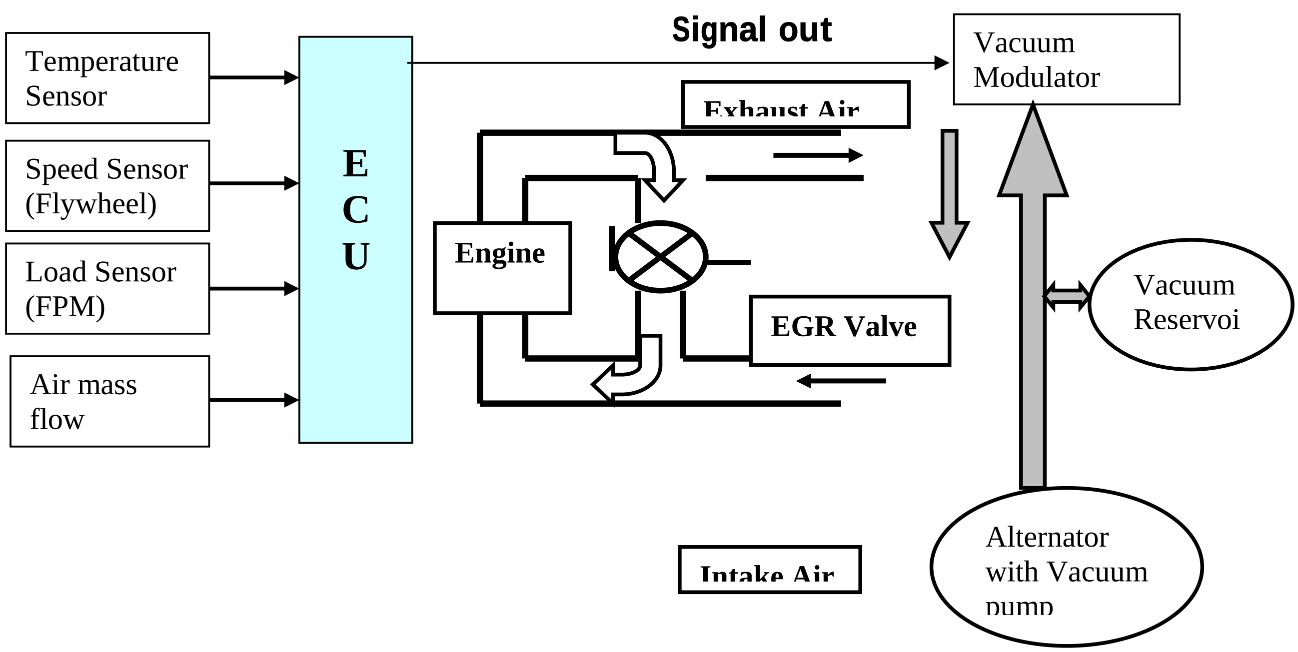
Description

The CRDe engines meet the BS II and BS III emission norms.

Overall, two systems are used.

[Exhaust Gas re-circulation](#)
[Closed crankcase ventilation](#)

Working Principle of the Exhaust Gas Recirculation –



During acceleration and in higher loads the engine generates high combustion temperatures. The high combustion temperatures increase the NOx generation. The higher percentage of NOx generated in the combustion chamber come out through the tail pipe in the atmosphere.

To reduce the amount of NOx coming through the tail pipe the EGR system adds exhaust gases into the fresh air that is going into the combustion chamber. Since the exhaust, gas is already burnt hence when mixed with fresh air acts an inert gas. The role it does is that it reduces the amount of oxygen available for combustion. The net effect is that it reduces the peak combustion temperatures. This results in lower amount of NOx being generated.

To control the amount/percentage of exhaust gases to be circulated back to the combustion chamber the ECU, which is already controlling the common rail functions, is used.

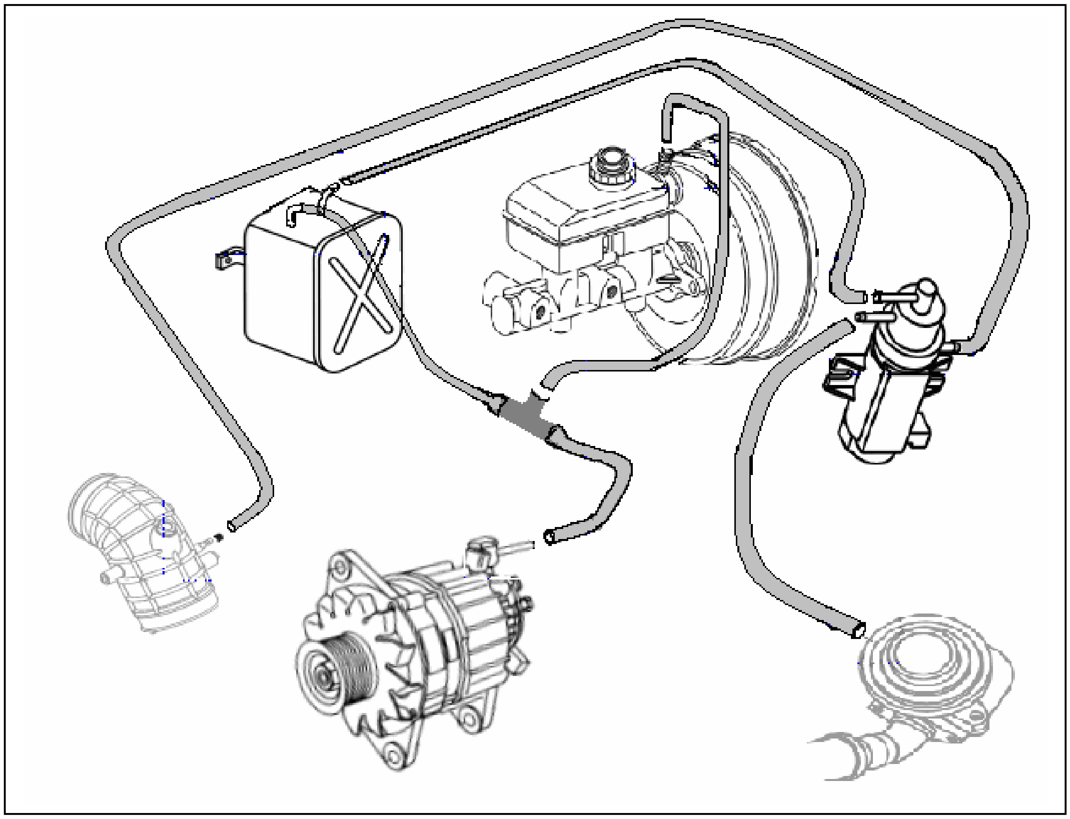
The ECU monitors the air flow, coolant temperature, attitude, engine speed, and accelerator pedal position. Based on the above parameters the ECU operates a switch that in turn controls the amount of vacuum going to the EGR valve. The amount of vacuum applied controls the lift of the EGR valve. The lift of the EGR valve is sensed. This lift is used as feedback signal to the ECU

The inputs of the engine speed (from the flywheel sensor); Throttle position (from the potentiometer.) is fed in one map. Another map uses the throttle position and correlate in terms of the acceleration. The third map uses the water temperature. Another map uses the input from airflow sensor (HFM), correlates with the load and decides the amount of EGR opening. The inputs from tall these maps are added together to give an input to the EGR pressure modulator.

At the same time it has a set point that if the water temperature is less than 25 ° C or more than 95°C. Then the EGR will not be operated.

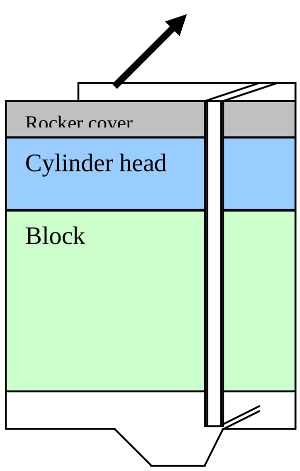
The acceleration map ensures that if the rate of acceleration is above a certain level then the EGR will not operate. This feature allows full engine power to be available during acceleration (say during overtaking).

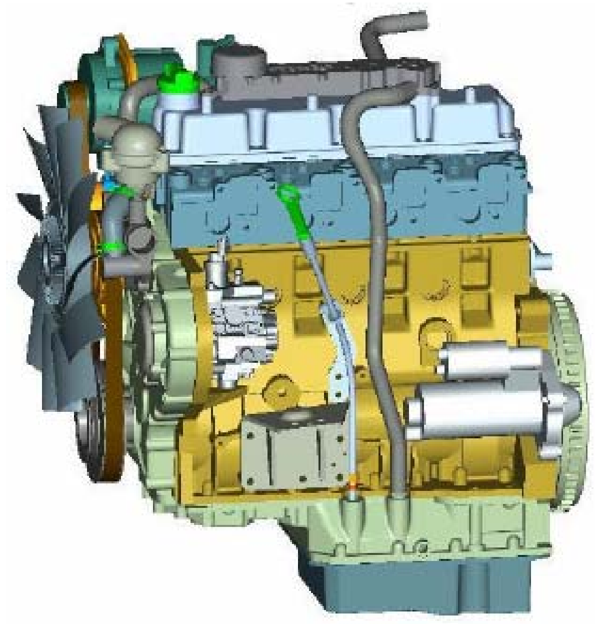
The vacuum connections are shown below.



Working principle of Crankcase Ventilation System –

Functional blcok diagram of the Crankcase ventialtion is given below –





The ventilation system is closed ventilation type. A hose connects the oil sump to the rocker cover. This hose balances the gas pressure in the rocker cover and sump.

The oil vapours from the rocker cover go to the oil separator, which is mounted directly on top of the rocker cover.

Before entering the separator the vapour & oil mixture has to pass through the wire mesh.

After entering the separator the oil + vapours go through the baffle type labyrinth separator. The oil, which gets condensed go back to the rocker cover through the valves provided on the bottom face of the separator.

A spring-loaded diaphragm controls the outlet from the oil separator to the inlet manifold. The vacuum of the inlet is applied on a spring-loaded diaphragm. (Note to avoid pressure build up in low speed driving there is a minimum clearance of 0.5 mm)

Certain amount of oil will be carried from the oil separator to the Air inlet hose, which is normal. However if it is excessive please look for all the causes mentioned in the high blow bye.

Trouble Shooting -

Symptom	Causes	Remedial action
Engine does not give full power.	1. Gas leak between EGR pipe joints. 2. EGR pipe leak. 3. EGR valve improper functioning. 4. Vacuum hose crack, loose, fallen off	✓ Change the gasket or the hose. ✓ Change the pipe. ✓ Check the EGR using the blink codes. Proceed appropriately. ✓ Ensure vacuum connections at vacuum modulator, reservoir, and alternator.
Noisy engine & high smoke	1. Cylinder head gasket defective. 2. Worn out or damaged valve seats. 3. Leaking injector holder. 4. Leakage at EGR Valve flange face, exhaust manifold and EGR pipe end.	✓ Replace the cylinder head gasket. ✓ Lap the valve seats or regrind. ✓ Tighten the injector holder. ✓ Confirm & check -Gasket condition - Bolt torque.
Black smoke.	1. EGR valve stuck open	Check the EGR valve.
Excessive oil consumption	1. Cracked vacuum line hoses 2. Restriction in crankcase breather. 3. Damaged oil	✓ Check the vacuum line from the alternator to the EGR valve (for BSII)- check for leaks, crack. Replace cracked hoses. ✓ Locate & remove restriction. ✓ Check the crankcase

	separator 4. Bend/kink in any of the oil return pipe's/vacuum hoses.	ventilation & rectify. ✓ Replace the oil separator ✓ Change the vacuum hoses. ✓ Remove the bend or kinks.

Care of the System

To meet the emission norms it is essential that the Fuel system, Air intake system & cooling system be maintained as per the schedule .For details refer to the particular section

Generally it is not appreciated that if the engine is running below the optimum temperature (happens when thermostat is removed then tailpipe emissions in particular the particulate increases (up to 30%). Similarly a wrong grade or poor quality of fuel increases the emissions. A blocked air cleaner or restriction in intake system increases the emissions

Oil separator system -

Check the hose connection at every 10,000 Kms for cracks, aging and leaks.

EGR -

On vehicles fitted with EGR system the following additional points check have to done during scheduled maintenance.

- Check for any exhaust gas leakage through sealing faces, EGR pipe. Formation of any black soot indicates leakage.
- Check the vacuum hoses for any leaks, cracks.
- Retighten all nuts and bolts as per the recommend torque.

If the pipes are removed then it is essential that while fitting back new gaskets is used. Do not open the pipe from one end only; it will cause the pipe to twist. If the EGR pipe has to be removed, then open from both the ends.

The EGR is controlled by the Engine ECU. The ECU is an electronic device. Hence it is prone to get damaged if spikes are generated in the system.

It is advised that the following precautions be taken.

- If any welding work is being carried out on the vehicle then the battery terminals are removed.
- Similarly, the practices of shorting the battery to check the battery have to be avoided. (It can cause a spike.).
- The practice of changing battery with a running engine is also not acceptable. Again, the resultant spike can damage the controller beyond repairs.

EGR Valve -

Remove the EGR valve and check it valve-sticking, deposition of carbon etc. If excess carbon deposits and sticky valve noticed then it should be cleaned with a suitable solvent, so that the correct valve seat is ensured. After cleaning the valve blow air from the bottom side of the valve and check for any leakages.

To check for the functioning of the EGR valve apply vacuum on the vacuum connection of the EGR valve. The lift of the valve at the required vacuum should be achieved.

EGR Pipe -

Remove the EGR pipe and check for gas leakage, damages etc. Clean the gasket seating area from any carbon deposits, burrs etc. Spray WD 40 rust cleaning spray on the nut.

To check the pipe for any leakages, close one end of flange and from other end blow air at two bars. Dip the pipe in water and observe if any leakage is observed. If any leaks are observed then the pipe has to be replaced. Do not attempt to weld/ seal the leakage joint

EGR Solenoid switch –

The solenoid switch does not require any maintenance. For any damage replace the component.

EGR ECU –

The EGR is controlled by the ECU controlling the Common rail.

However, like any ECU care has to be taken that if any welding work is being carried out on the vehicle then the battery terminals are removed.

Similarly, the practices of shorting the battery to check the battery have to be avoided. (It can cause a spike.). The practice of changing battery with a running engine is also not acceptable. Again, the resultant spike can damage the controller beyond repairs

Checking the System

EGR System –

The EGR system functioning can be checked only when we use the diagnostic equipment- 'Insight'.

Automotive Sector

Cooling System

Contents

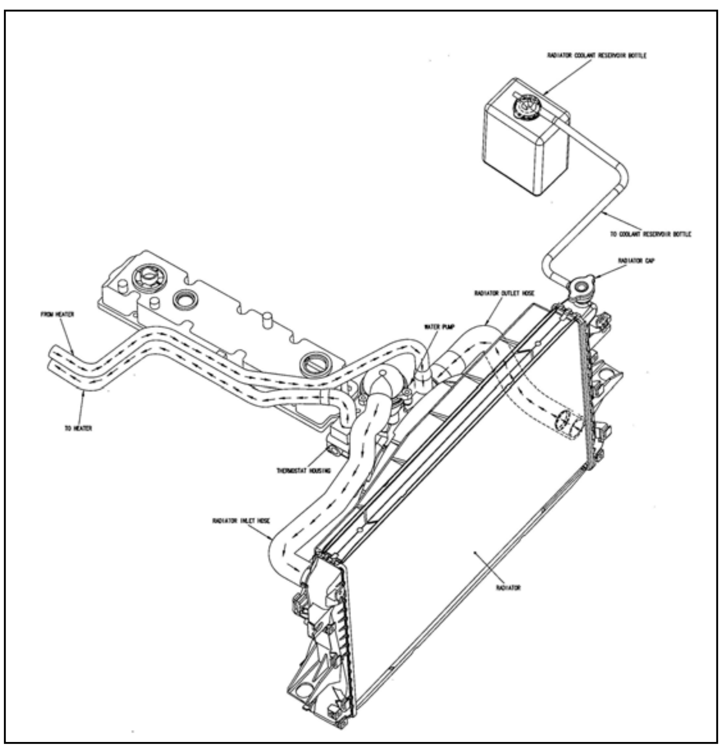
Description

The cooling system is designed to cater to the following functions:

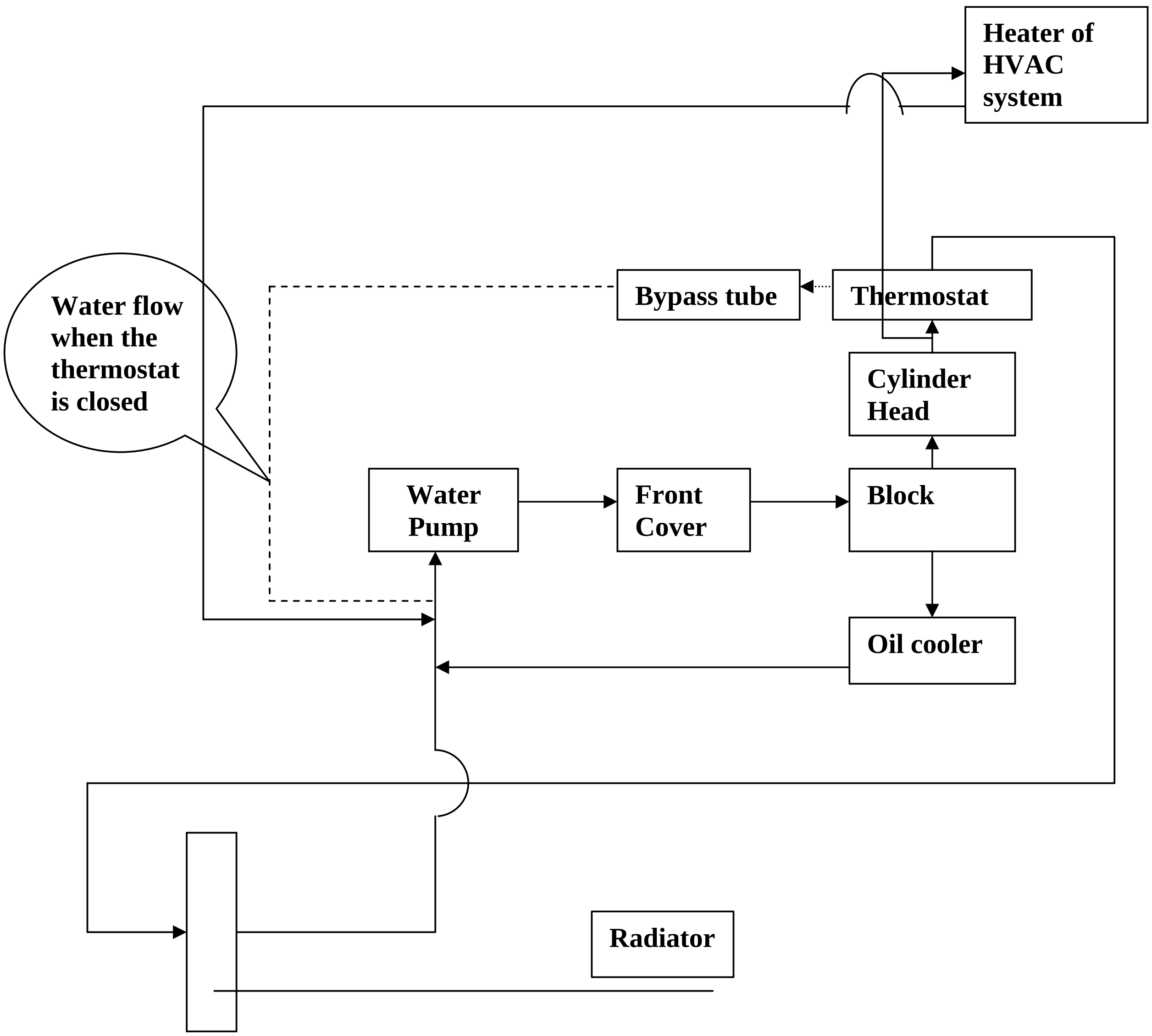
- Remove & dissipate excess heat from the combustion process.
- To maintain the optimum temperature for complete and uniform combustion.
- To provide heating for the heater system.(In the models where the Heater is provided)

The cooling system includes the following components/ sub system:

- ✓ Radiator
- ✓ Radiator Pressure cap
- ✓ Coolant
- ✓ Cooling fan (Mechanical or Electrical)
- ✓ Fan drive
- ✓ Fan shroud, Thermostat
- ✓ Water pump
- ✓ Thermostat housing, cover thermostat, Recovery tank
- ✓ Hoses & their clamps.



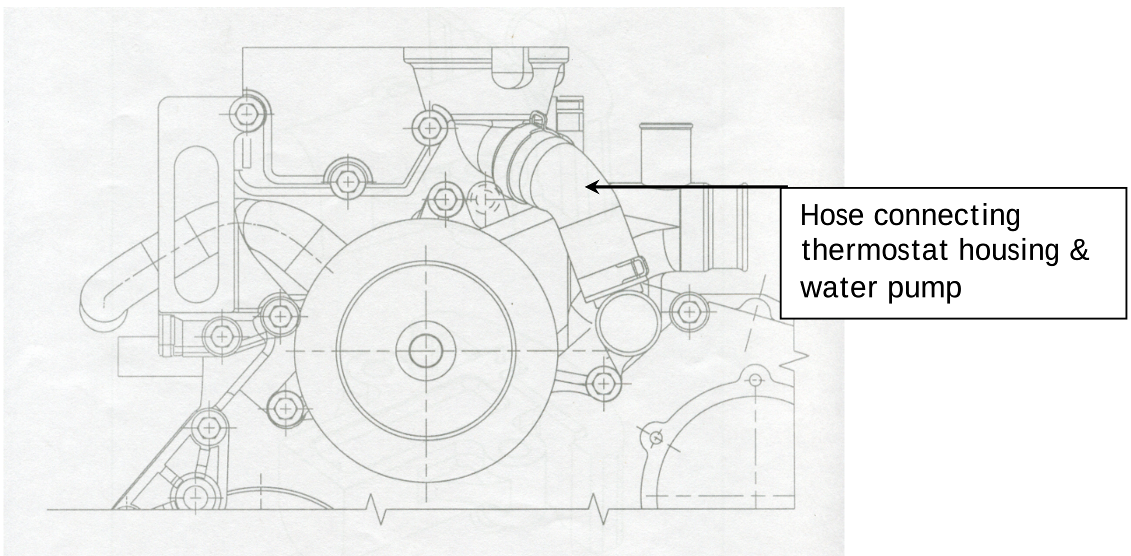
The layout of the cooling system is shown in the sketch, above.
The functional system is shown in the block diagram.



Broadly speaking the water flows from the water pump to the Front cover from the cover it goes to cylinder block and from the block to the cylinder head and then to the bottom of thermostat. In case the thermostat is closed, water goes through the bypass tube to water pump. Once the thermostat opens the water goes to the radiator and after getting cooled the water is again fed to the water pump. One pipe goes from the thermostat housing to the heater core of HVAC unit and then returns back.

Water pump & cover -

The coolant from the outlet elbow of the cross flow type radiator enters the inlet of the water pump. The centrifugal water pump delivers the water to the front cover from there to the cylinder block.



Cylinder block & cylinder head -

In the block the water enters a main cooling passage which runs along the length of the block in one side (inlet manifold side). The top passage ensures that the maximum cooling is provided to the hottest zone of the cylinder liners i.e. the top portion.

At the same time a passage at the front end connect the inlet to another gallery at the bottom of the liner. In between the top and lower passage in the block the coolant flows between the block & liners due to the thermos siphon effect. The water then goes to the cylinder head and from there to bottom of the thermostat. One external pipe from the back end of the block goes to the oil cooler. The return pipe form the oil cooler is connected to the inlet of the water pump.

Radiator & No loss tank –

The radiator cap controls the system pressure to 0.9 bar. Once the pressure exceeds 0.9 bar the cap lifts off the seat and the coolant is allowed to escape into a no loss tank.

As the engine cools down the system pressure falls and vacuum is formed .The vacuum valve in the radiator cap opens and allows the water from the no loss tank to go back into the radiator. Thus the system does not have any coolant loss during normal operation.

Water for HVAC –

The hot water at the thermostat housing is diverted to the heater unit, which is located in the passenger compartment for the HVAC function.
The return from the heater is connected to the inlet of the water pump. It should be noted that a water valve near the heater/climate box controls the amount of the water, which enters the heater unit. The occupants determine the amount of the opening of the water valve. It will be full quantity when it is set is maximum heater mode and vary till the coldest mode where it will become nil as the valve will be fully closed

Trouble Shooting –

Before going into the specifics of the cooling system it is worthwhile to find out under which driving conditions the complaints is present.

Some of the causes are:

Prolonged /excess idling
Very high ambient temperature
Slow traffic
Traffic jams
High speed
Steep Gradients

To avoid overheating under such conditions it will be worthwhile to:
Idle with the AC off. In case the temperature indicator needle is close to the red band.

Increase the engine idling speed.

Symptom	Causes	Remedial action
Noise	**Fan shroud** 1. Fan contacting the shroud **Water pump** 1. Loose water pump impeller. 2. Water pump bearing worn/ failure. 3. Loose mounting of pump **Belts** 1. Belt loose 2. Glazed/stretched fan belt. 3. Rough surface on drive pulley. 4. Belt alignment **Alternator/Water pump** 1. Alternator bearing failure **Belt tension mechanism** 1. Idler pulley bearing failure 2. Idler mounting bracket failure. 3. Tension bolt failure.	✓ Reposition the shroud and inspect the engine insulators. ✓ Replace the water pump. ✓ Replace water pump. ✓ Tighten mounting bolt ✓ Tighten belt ✓ Replace serpentine belt, ✓ Replace pulley. ✓ Check the belt alignment & rectify. ✓ Replace alternator bearing ✓ Replace idler bearing. ✓ Replace the idler bracket. ✓ Replace the tension bolt.

Coolant loss- boil over	**Coolant** 1. Overfilled recovery tank. 2. Insufficient coolant additive causing lower boiling points. 3. Additive deteriorated due to aging/ contamination. 4. Low coolant level. **Hot shut down** 1. Quick shut downs after a long and hot run. **Leakage's** 1. Leaks due to loose hose clamps. Loose nuts, bolts drain plugs, faulty hose or leaking radiators. **Blockages** 1. Casting flash in the block. 2. Casting flash in the cylinder head. 3. Blocked radiator causing under filling of the cooling system. 4. Air trapped in system. 5. Air in the system causing occasional	✓ Reduce the coolant level. ✓ Add the additive. ✓ Replace the coolant ✓ Add coolant ✓ Allow the engine to run at idle for some time before stopping. ✓ Find the area of leaks , replace hose or if necessary the clamp also ✓ Pressure test the system to check for leaks and then repair as necessary. ✓ The flash may be visible by removing the cooling system components or the core plugs. Repair or replace. ✓ Flush radiator. ✓ Purge the system. ✓ Purge the system. ✓ Replace the cap/ pipe.

	burping. 6. Faulty expansion bottle cap or pipe.	
Coolant loss- boil over	**Gas mixing** 1. Cylinder head gasket failure. **Pressurization** 1. Defective radiator cap. **Timing** 1. Improper engine timing **Belt** 1. Slipping belts 2. Belt failure **Water pump** 1. Water pump shaft broken or damaged impeller. **Thermostat** 1. Faulty Thermostat. **Hoses.** 1. Radiator hoses collapsed **Fan** 1. Cooling fan not engaging. **Air flow** 1. Air flow reduced	✓ Replace the cylinder head gasket ✓ Replace the cap. ✓ Check the engine timing, FIP timing, injector pressure and also the tappet clearance. ✓ Adjust belt tension. ✓ Replace belt ✓ Replace water pump ✓ Replace Thermostat. ✓ Replace hoses. ✓ Check the functioning of the VFD replace if required. ✓ Clean the radiator fins. ✓ Remove the obstruction. ✓ Check the brake system.

	to choked fins 2. Airflow reduced due to obstruction. **Vehicle** Brakes dragging.	
High Temperature Indication	**Improper indication** 1. Faulty sensor 2. Faulty gauge	✓ Replace the sensor. ✓ Replace the gauge
Coolant entry into Crankcase or cylinder	1. Low cylinder head torque. 2. Faulty head gasket. 3. Blow hole in crankcase, head , liner	✓ Replace the cylinder head gasket, torque as per procedure. ✓ Replace the cylinder head gasket ✓ Replace the affected part.
Low Temperature Gauge Indication-Under cooling	1. Thermostat stuck open 2. Faulty sensor. 3. Faulty gauge.	✓ Replace thermostat. ✓ Replace sensor. ✓ Replace gauge.
Coolant reserve system inoperative	1. Coolant level low 2. Leak in system 3. Overflow tube clogged or leaking. 4. Recovery bottle vent blocked. 5. Radiator cap defective.	✓ Replenish coolant to FULL level. ✓ Pressure test to isolate & repair. ✓ Remove clogging ✓ Clean vent. ✓ Change the cap.
No coolant flow trough Heater Core	1. Restricted return inlet in water pump. 2. Heater hoses	✓ Remove restriction. ✓ Remove restriction or replace hose.

	collapsed or restricted. 3. Restricted heater core. 4. Restricted outlet in the thermostat housing. 5. Heater valve controls not functioning. 6. Heater valve stuck.	✓ Remove flash or restriction. ✓ Remove restriction. ✓ Repair controls. ✓ Repair or replace

Care of the System -

Unless there is loss of coolant the coolant additive added is adequate for 80,000 of the vehicle.

The recommended coolant additive is given in the Recommended Coolant section.

In Car repairs -

Fan belt tension adjustment

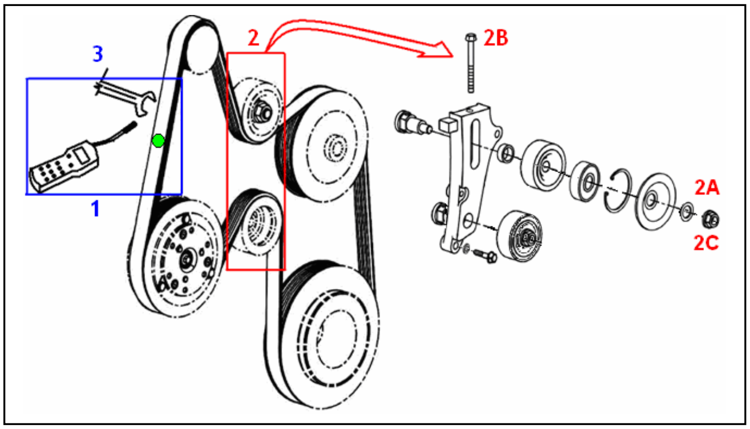
Fan belt replacement

Fan Blade & the viscous fan drive removal & fitment

Water pump removal

Radiator removal

Accessory Belt tension Adjustment -



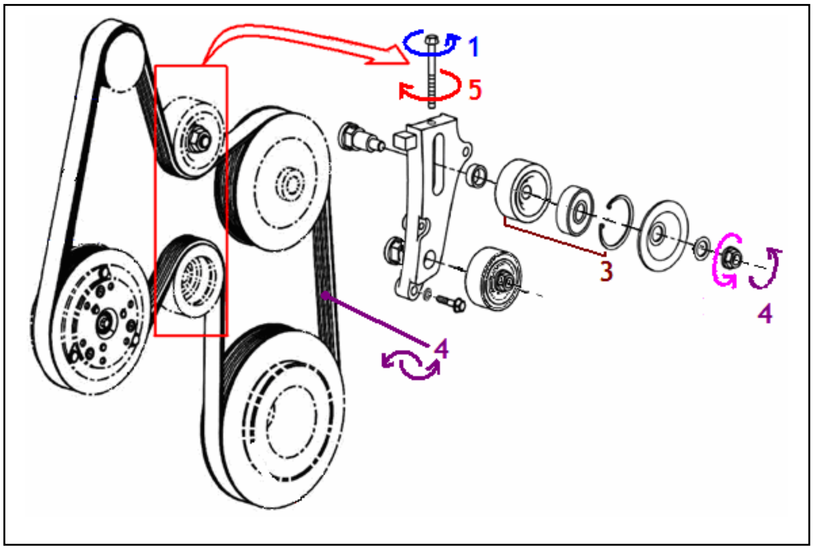
1. Check the Belt Tension…
   - Turn on the Belt Tension Gauge, select reading mode in Hertz (Hz) & hold the probe approximately 5mm distance in Front of the belt (CAUTION: Do not touch the probe to the belt, this can damage the probe!) as shown in the illustration above by X.
   - Tap on the belt near the probe.
   - Note the reading. If the reading is within 125 TO 145, this should be OK.
   - If the reading is less than 125 Hz then it needs adjustment.

2. Adjust the belt tension ….
   2.A - Loosen the Tensioner Pulley Shaft Nut.
   2.B – Tighten the Belt Tensioning Bolt.
   2.C - Tighten the Tensioner Pulley Shaft Nut

3. Repeat the procedure as per the Step-1
   - If the belt tension value should be 140+5 Hz.

If the value is less than 140+5 Hz, Repeat the Steps 2 & 3.

Accessory belt Remove & Refit -



1. Loosen the Tensioner bolt to relieve the tension.

2. Loosen the Tensioner Pulley Nut. Take out the pulley assembly with Dust Shield, washer & take the belt out.

3. Take the belt out.

4. Put the new belt in place & fit the Tensioner Pulley Assembly along with dust shield & washer on the bracket, hand tighten the nut.
   Tighten the Tensioner Pulley Nut with torque of 32.5 ± 2.5 Nm.

5. Tighten the Tensioner Bolt so as to get the specified belt tension; follow the accessory belt tension check procedure for checking / adjusting the belt tension to the installation tension --**170 ± 2 Hz**.

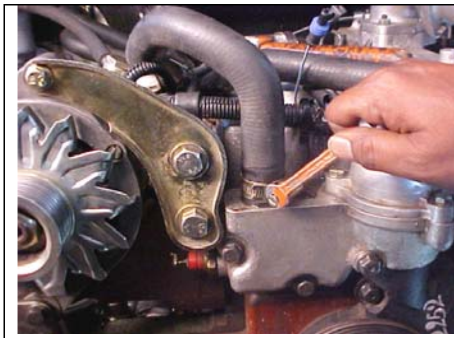
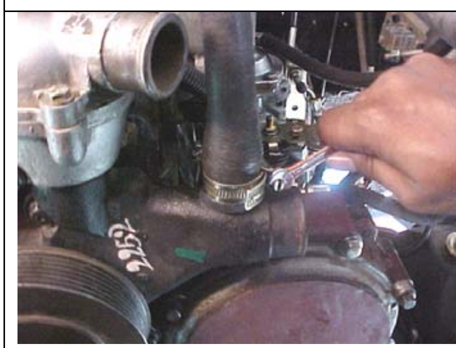
6. Run the engine for 5 minutes & confirm the stabilized tension is at 140 to 145 Hz.

Fan Blade & viscous fan drive assembly removal -

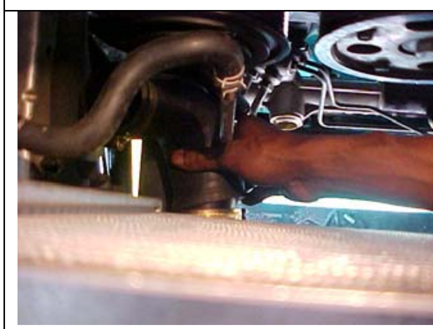
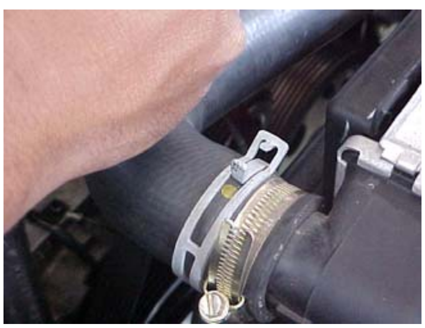
	Caution: Do not remove the fan belt before removing the nut.
	Loosen the water pump nut. **Note that the threads are anticlockwise threads. Hence to loosen then the direction of rotation has to be clockwise when viewed from front**
	The fan blade assembly and the VFD assembly can be removed together.

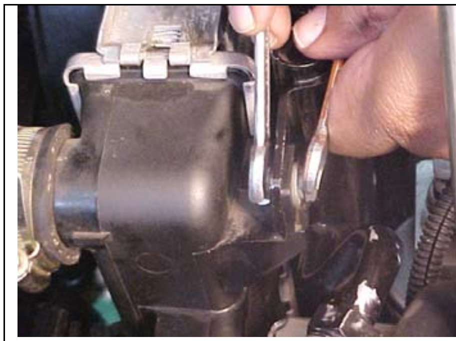
Water Pump removal -

	Do not remove the cylinder block drain plate or the radiator drain cock with the system hot and pressurized. Serious burns from the splashing of hot coolant can occur. Before draining the system. The system pressure has to be relieved. Holding the radiator cap with a rag slowly open the radiator cap. The water may splash upward causing injury
	Remove the fan blade
	Remove the fan belt

	Remove the thermostat housing along with the thermostat after removing the mounting bolts.
	Remove the inlet and outlet hoses.
	Remove the HVAC return line from the water pump inlet.
	Remove the hose connecting the oil cooler to the water pump.
	Remove the water pump assembly after removing the mounting bolts.
	While assembly, ensure that the “O” ring is seated securely and does not fall down.

Radiator Removal & Re-fitment -

	Do not remove the cylinder block drain plate or the radiator drain cock with the system hot and pressurized. Serious burns from the splashing coolant can occur. Before draining the system. The system pressure has to be relieved. Holding the radiator cap with a rag slowly open the radiator cap. The water may splash upward causing injury
 	Remove the radiator inlet and outlet hose
	Remove the inlet and outlet hose for the intercooler.
	Remove the fan shroud.

	Remove the condenser mounting bolts.
	Remove the radiator mounting bolts and remove the radiator along with the pipe connecting it to the no loss tank.

Dismantling & Assembly of the Cooling System

[Water Pump]

[Viscous Fan Drive]

CAUTION

Do not remove the radiator drain cock or the Engine coolant plate drain with the engine in hot condition.

Always remove the pressure on the system by removing the radiator cap before undertaking any work on the cooling system.

If the coolant is not contaminated then collect the coolant in a clean container so that it can be reused. Replace coolant as per recommendation

Water pump -

A centrifugal water pump is used to circulate the coolant through the water jackets, cylinder head, hoses and radiator. The water pump is belt driven by the engine main drive pulley. It ratio of pulley diameter ensures that the water pump rotates 1.30 times the engine speed.

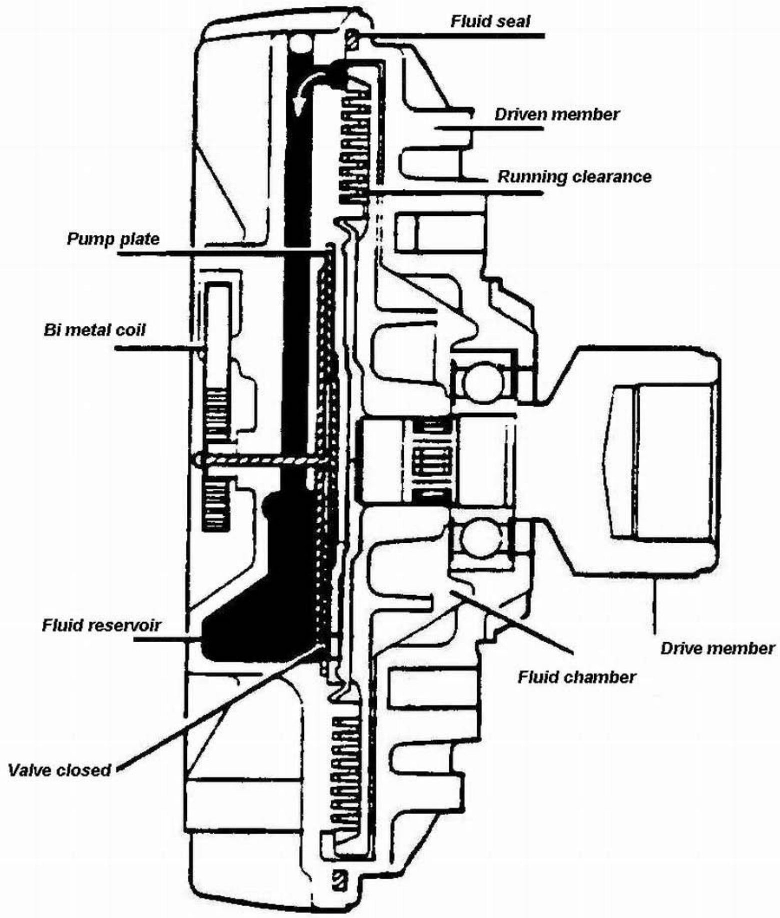
The water pump impeller is pressed onto the shaft. The shaft is supported on two bearings that are integral to the shaft.

The water pump seal is located between the impeller and the housing. The housing has a small hole to allow the seepage to escape. That also acts as an indication point if the water pump seal fails.

Water pump removal & Refitment.
The water pump is not serviceable and has to be changed as an assembly.

Viscous Fan Drive Operation -

The viscous drive unit for the engine-cooling fan provides a means for controlling the speed of the fan relative to the temperature of the engine. The viscous fan unit is a type of fluid coupling, which drives the fan blade by means of silicone fluid

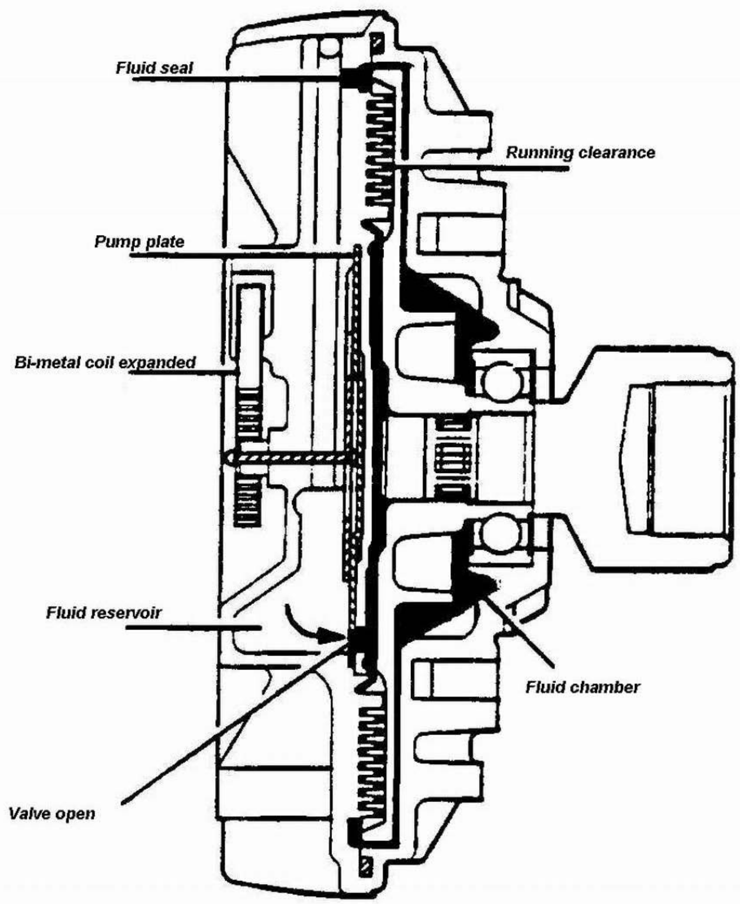


Viscous unit disenggaged

There are two main components of the viscous fan drive: input (drive member), which consist of a threaded shaft passing through a bearing into the clutch plate and secured to the water pump. The output (driven) member comprises of the main body to which the fan is attached, with the temperature sensing mechanism (bi- metal coil) and pump plates.

The fan drive has to be engaged only periodically, between 5 to 10% of the normal operating conditions because the rest of the time the vehicle cools itself by ram air-cooling.

To engage and disengage the fan drive the bi metal coil senses the air temperature behind the radiator. When a pre determined temperature is reached, the coil opens a valve, which allows the fluid to enter the drive area and due to centrifugal forces circulate to the annular drive area



Viscous unit enggaged

There are two sets of annular grooves. , One in the drive clutch and the other in the drive body, a specific clearance being provided between two sets of grooves. When this clearance is filled with viscous fluid a shearing action caused by the speed differential between the two drive components, transmit the torque to the fan. The fluid is thrown to the outside of the unit by the centrifugal force from where it is recirculated to the reservoir via the pump plate adjacent to the drive member.

If the engine sped is increased the amount of slip will also increase to limit the maximum fan speed.

When the air temperature from the radiator drops sufficiently, the bi metal coil closes the valve and prevents fluid entering the drive area. The fluid that is in the drive area will gradually pump out into the reservoir and the fan will return to an idle condition

Checking the VFD –

This procedure will only give an indication that the fan is cutting in and out, but will not be able to check the accuracy of the cut in temperature.

Depending on the level of the test equipment there are several ways to check the if the fan is working correctly.

Using a non-contact tachometer –

1. Run the engine at idle without any load for approximately 3 minutes, for example at 2000 rpm, observer the fan drive speed. In the disengaged mode the fan speed will be approximately 800 rpm. By running for 3 minutes it will ensure that the fan drive has pumped out the silicone fluid into the reservoir and that the fan drive will be in the cut out (idle)
2. Either

   (a) Blank the radiator by using a sheet of cardboard, which has a 15-cm hole, cut out of in line with the center of the fan drive. This will allow a flow of air on the bimetal coil and the cardboard will allow the radiator to heat up quickly.

   Keep a check on the vehicle temperature gauge and let the water temperature rise to about 105°C. this will ensure that the fan drive will engage

   (b) Using a commercial hot air blower, which will provide a hot air flow of at least 75°C, direct the air on to the centers of the fan drive through the radiator. Keep the hot air on for several minutes. This will cut the fan drive in, and the fan speed will increase. It is important that only a powerful blower is used so that the hot air should reach the fan drive after going the radiator at the correct temperature.

3. Once the fan drive has become engaged by either method (a) or (b). Check the fan speed with the non-contact tachometer. At 2000 rpm input speed the fan speed should be 1800 rpm.

Testing without a non-contact tachometer –

4. Use the same method explained in step 2, but this time listen to the noise level generated by the fan. With the fan in the idle condition the noise level should be very low, however when the fan speed increases in the engaged mode there will be a significant roar from the fan. This will clearly indicate if the fan drive is working.

If the fan drive fails to engage during these tests, there is something wrong with the VFD (Viscous Fan Drive). The unit should be replaced.

While returning the failed unit (to Plant for vehicles under warranty) take care to see that the unit is packed with the sensing coil facing down and sent in the same way. If this is not observed then the silicone fluid will flow down to bearing, damaging the bearing and also making it impossible to do any investigation.

Viscous Fan Drive removal –

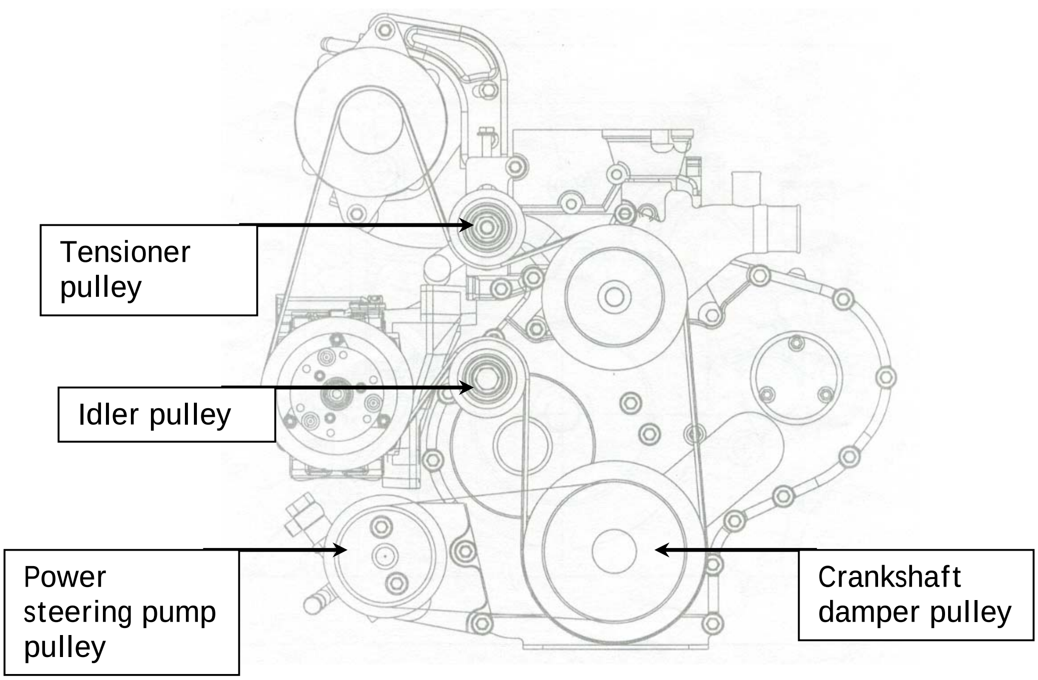
	Caution: Do not remove the fan belt before the removing the nut.
	Remove the shroud.

	Loosen the clutch fan nut. **Note that the threads are anticlockwise threads. Hence to loosen then the direction of rotation has to be clockwise when viewed from front**
	The fan blade assembly and the VFD assembly can be removed together.
	Note: The VFD assembly should be kept in 2 positions only. As far as possible – in vertical plane. If in horizontal then the bimetallic strip should be facing down. **If stored in horizontal position resting on the nut face then the silicone fluid will flow down to the bearing assembly and result in contamination of the bearing's lubricant.**

Serpentine Poly V Belt -

This engine is having Poly V belt drive.

The fan belt tension has to be measured approximately at the centre between the A/C Compressor pulley and the alternator pulley.



The belt must be routed correctly.

The main drive pulley can be assembled in either direction; however the front end is identified by holes drilled for balancing (these are not thorough holes). If assembled wrongly it will cause misalignment by 5to 6 mm

Belt Diagnosis -

When diagnosing serpentine accessory drive belt,
Small crack that run across the ribbed surface of the belt from rib to rib are considered normal.

Cracks running along a rib are not normal

The correct belt tension is required to ensure optimum performance of the belt.

Do not apply any external means to reduce noise. Application of oil will reduce the belt life.

A detailed drive belt analysis is given below –

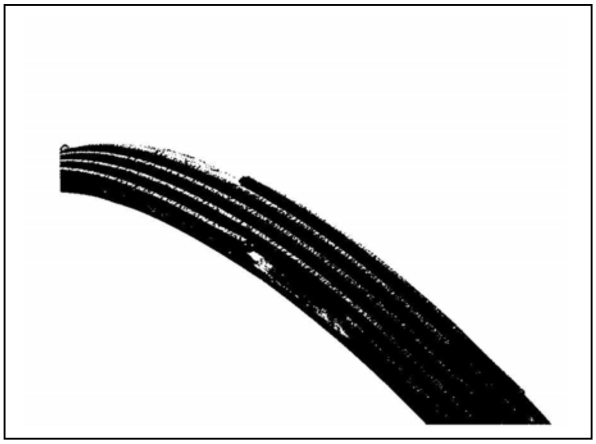
Symptom	Possible reasons	Correction
Rib chunking (One or more ribs has separated from belt body)- Chunking happens when several cracks in one area of rib move parallel to the cord line.	1. Foreign objects embedded in pulley groove 2. Installation damage. 3. Poor surface of grooves in pulley.	✓ Remove foreign objects from pulley grooves. Replace belt ✓ Replace belt. ✓ Clean pulley, replace if required.
Piling- happens when the material is sheared off the undercord and builds up in the groove.	1. Lack of tension 2. Misalignment of pulleys 3. Worn out pulleys 4. Excessive tension.	✓ Adjust tension ✓ Correct the alignment.
Rib or belt wear.	1. Pulley or pulley's mis aligned. 2. Abrasive environment 3. Rusted pulley's 4. Sharp or jagged pulley groove tips. 5. Poor surface finish.	✓ Correct the alignment. ✓ Clean pulleys- replace if required. ✓ Change pulley. ✓ Replace belt.
Tooth shear	1. Low belt tension 2. Seizure of driven part. 3. Misalignment.	✓ Correct the tension. ✓ Replace belt. ✓ Align pulleys

Tooth Wear	1. Incorrect tension 2. Worn out pulleys	✓ Adjust tension. ✓ Change pulleys
Longitudinal Belt cracking (Cracks between two ribs.)	1. Belt has mis-tracked from pulley groove. 2. Pulley groove tip has worn out the rubber to tensile member.	✓ Replace belt. ✓ Change pulley.
Belt slips	1. Belts slipping because of insufficient tension 2. Belt or pulley subjected to substances that reduce the belt life (oil, grease, ethylene alcohol) 3. Driven component's bearing failure. 4. Belt hardened and glazed from heat and excessive slippage.	✓ Adjust belt tension. ✓ Clean pulleys. ✓ Replace the failed components. ✓ Replace belt
Groove jumping (belt does not maintain correct position on pulley)	1. Belt tensions either too high or too low. 2. Pulleys not within design tolerances. 3. Foreign objects in groove. 4. Pulley misalignment, 5. Belt cord line is broken.	✓ Adjust belt tension. ✓ Replace pulleys. ✓ Clean pulleys. ✓ Correct the alignment ✓ Replace belt.
Belt broken	1. Excessive tension. 2. Tensile members damaged during	✓ Adjust belt tension ✓ Correct the alignment

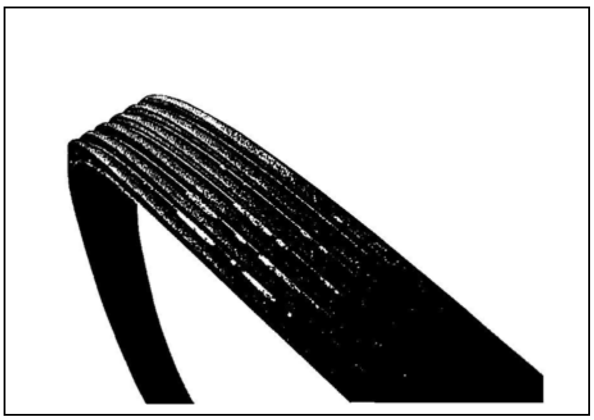
	installation. 3. Severe misalignment. 4. Bracket pulley or bearing failure.	✓ Replace the failed component.
Noise Objectionable squeak, squeal rumble heard or felt while drive belt is in operation	1. Belt slippage 2. Bearing noise 3. 4. Belt misalignment 5. Belt to pulley mismatch. 6. Driven component induced vibration 7. System resonant frequency induced vibration.	✓ Adjust belt. ✓ Replace the defective bearing. ✓ Adjust alignment. ✓ Use the correct belt. ✓ Vary belt tension within specifications. ✓ Replace belt.
Tensile failure	1. Tension sheeting contacting stationary object. 2. Excessive heat causing woven fabric to age. 3. Excessive installation tension. 4. Foreign body in drive. 5. Belt crimped due to improper handling. 6. Tension sheathing splice has fractured.	✓ Correct rubbing condition. ✓ Replace belt. ✓ Correct the tension. ✓ Replace pulley.
Oil contamination	1. Oil leaks.	✓ Correct the oil leak condition.
Cord edge failure (Tensile member exposed at edges of belt or separated	2. Excessive tension 3. Belt contacting stationary object. 4. Pulleys out of	✓ Adjust tension. ✓ Remove the stationary objects fouling. ✓ Replace pulleys.

from Belt body)	tolerance. 5. Insufficient adhesion between tensile member & rubber matrix.	✓ Replace pulley.

Rib chunking –

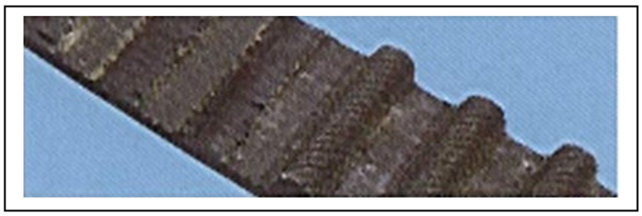


<u>Piling</u> –

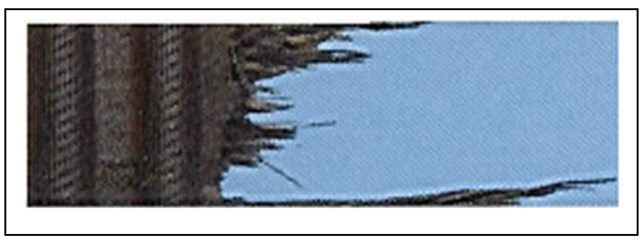


Tooth Shear –

Tooth wear –



Tensile failure –



Oil contamination –

Cord Edge failure –

Specifications –

Description	Value
Radiator capacity	2.15 liters
Cooling system capacity	9.3 liters
Coolant	GLYSANTIN G45-23
Ratio	30%
Coolant to be added after draining/flushing	2.79 liters
Radiator pressure	0.9 bar
Viscous Fan Drive - fan starts at (For reference only)	75°C of air temperature at Sensor Input speed – 3600 rpm
Viscous Fan Drive - fan stops at (For reference Only)	35°C of air temperature at Sensor Input speed – 1300 rpm
Input speed of Fan pulley	1.30 x Engine speed.
No of fan blades	11
Fan blade size	400 mm
Fan Belt tension	New installation –165 ± 2 Hz Stabilized –134 Hz Min
Fan Belt tension - Gates make	New installation –170 ± 5 Hz Stabilized –140 Hz Min

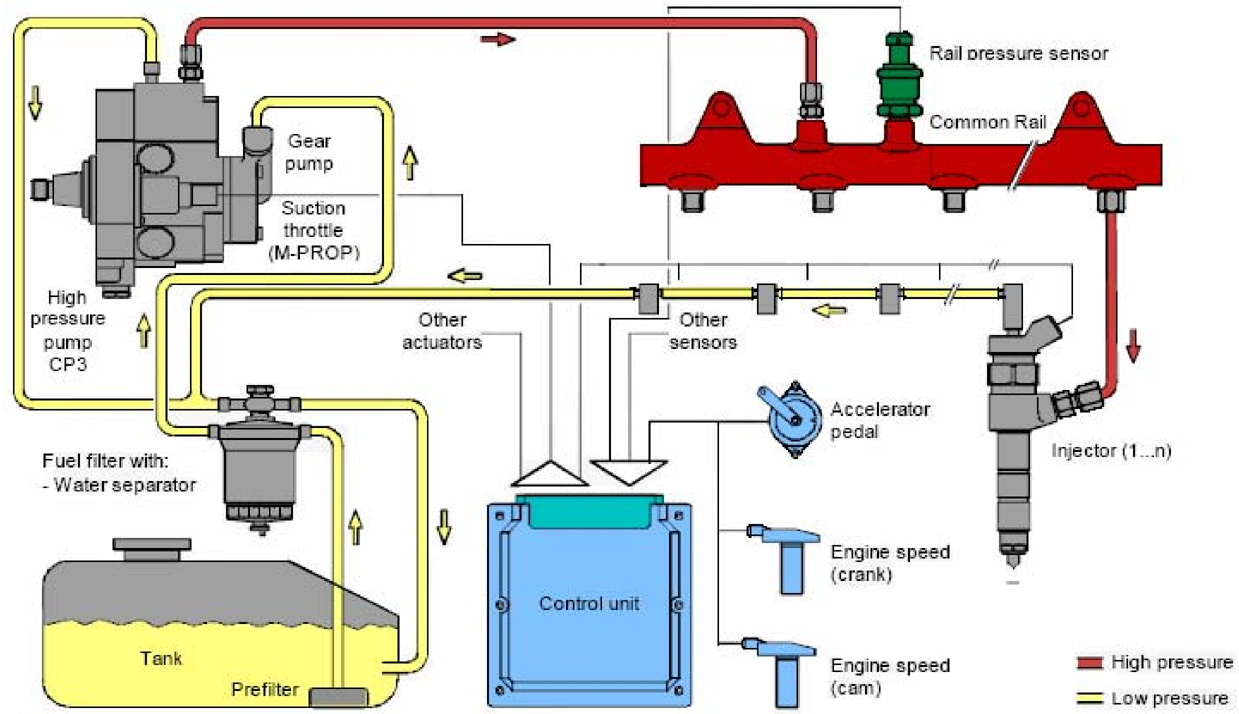
Tightening Torques –

Location	Torque in Nm
Viscous Fan clutch nut	45 ± 5 Nm (33 ± 4 lbf-ft)

Common Rail System

1. Common Rail system

The CRS is briefly given in the schematic sketch:



While trying to explain it in block diagrams it is represented by:

The common rail system can be divided into the following sub-systems:

- Low pressure hydraulic system.
- High pressure hydraulic system.
- Input sensors.
- ECU
- Actuators.

SENSOR INPUT

- ENGINE SPEED
- MASS AIR FLOW
- MANIFOLD AIR TEMP
- RAIL PRESSURE
- CAM PHASE SENSOR

- ACCL. PEDAL SENSOR
- CRUISE CONTROL SWITCH
- COOLANT TEMPERATURE
- VEHICLE SPEED
- BRAKE PEDAL POSITION
- CLUTCH PEDAL POSITION
- DIESEL TEMPERATURE
- A/C REQUEST SWITCH

ACTUATOR OUTPUT

FUEL INJECTOR

EGR

PUMP METERING

TACHOMETER

TEMPERATURE GAUGE

GLOW PLUG RELAY (in Export)

ENGINE CHECK LAMP

System Block

1. **Sensors/Systems & set point generators.** Used for registration of the operating conditions & the desired values. These convert a variety of physical parameters into electrical signals**.**
2. **ECU** for generating the output signal by processing the information using specified arithmetic operations (control algorithms**)**
3. **Actuators** to control the output signal into mechanical parameters**.**

1.The Sensors in the system are:

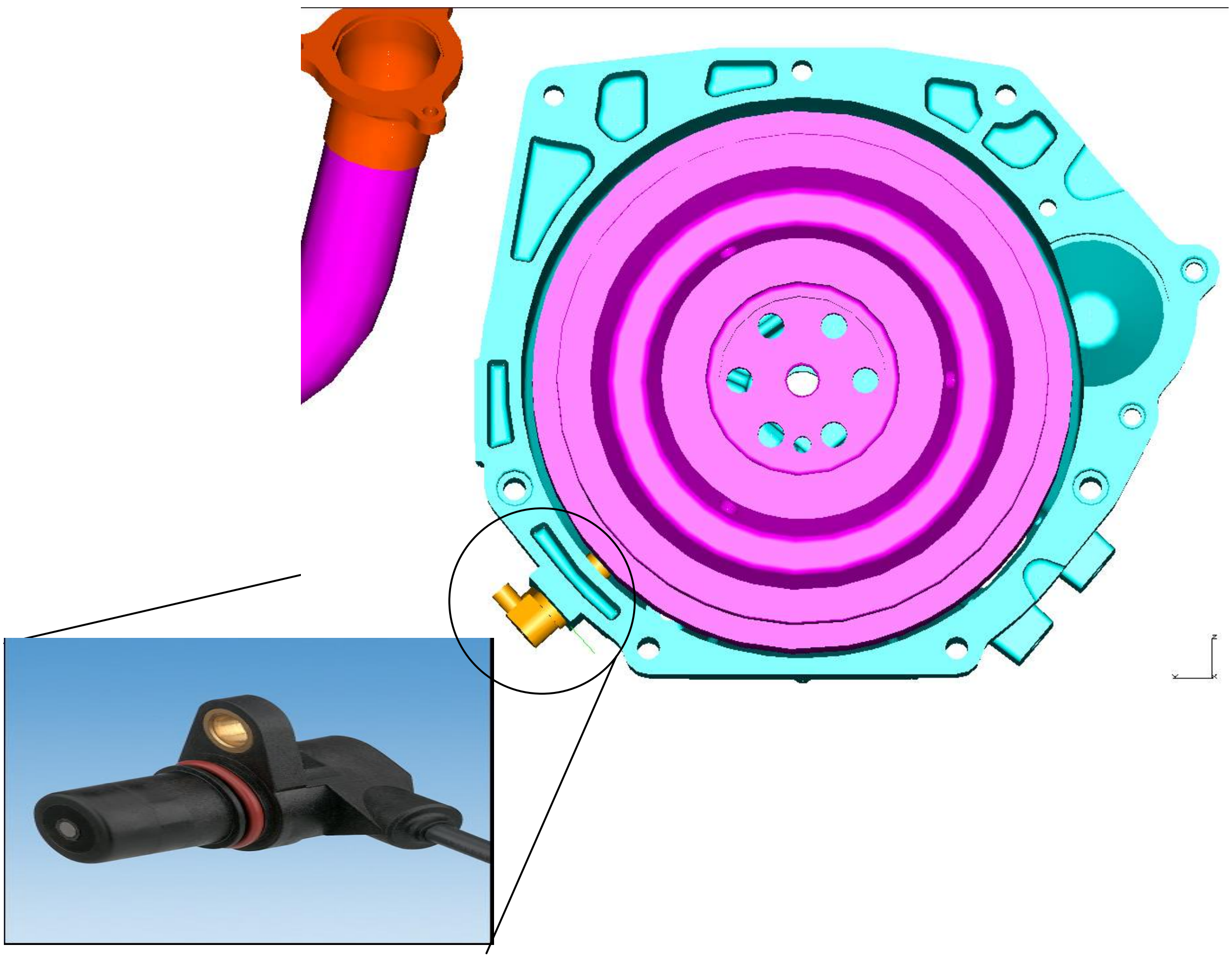
Crankshaft speed sensor / Incremental speed sensor (ISS)
Cam Phase sensor / Segment Speed sensor
HFM Sensor
Coolant temperature sensor
Fuel temperature sensor
Clutch pedal position sensor
Brake position sensor
AC Request sensor.
Accelerator pedal position sensor.

3. The actuators are:

Injector (injector solenoid)
EGR
High Pressure Pump – inlet metering (MPROP)
Temperature Gauge
Tachometer
Glow plug (where applicable)
Engine check lamp

Crankshaft speed sensor:

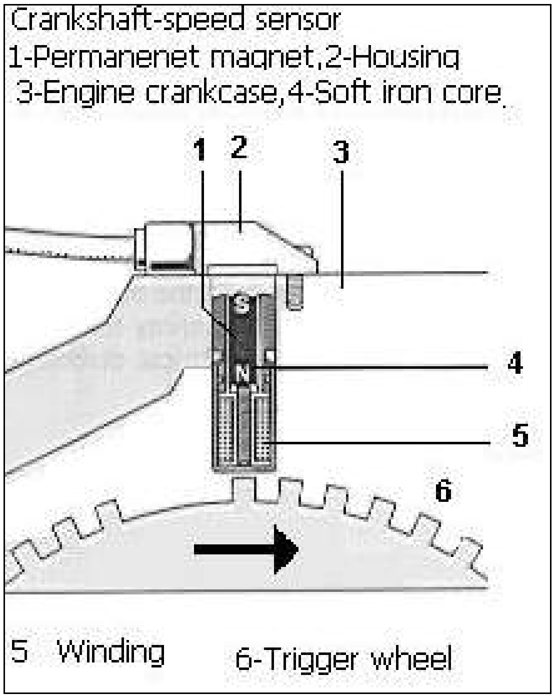
Location: On the clutch housing.



Function: The piston position in the combustion chamber is decisive in defining the start of the injection. All the engine pistons are connected to the crankshaft by con rods. A sensor on the crankshaft thus provides information on the position of all the pistons. The rotational speed defines the crankshaft RPM.

This important input variable is calculated in the ECU using the signal from the inductive crankshaft speed sensor

Signal Generation



A 60 teeth ferromagnetic trigger wheel is attached to crankshaft. Out of the 60 teeth, 2 are missing, so there are 58 teeth. This large gap is allocated to a defined crankshaft position for the cylinder 1.

The crankshaft speed sensor registers the trigger wheels tooth sequence. It comprises a permanent magnet and a soft- iron core with a copper winding.

The magnetic flux in the sensor changes as the teeth and gaps pass by, and a sinusoidal AC voltage is generated, the amplitude of which increases sharply in response to higher engine speeds. Adequate amplitude is already available from speeds as low as 50 min 1

Calculation of the engine speed

The angular relationship between the piston is such that two rotations (720 °

Pass before the start of each new working cylinder. So the angular ignition spacing is = 720 °/4 = 180 °

In other words the CSS scans 30 teeth between two ignitions. The period of time requires is known as segment time and the mean of the crankshaft speed in the segment time is the engine speed.

Do's & Don'ts for the Engine Speed Sensor

Do's

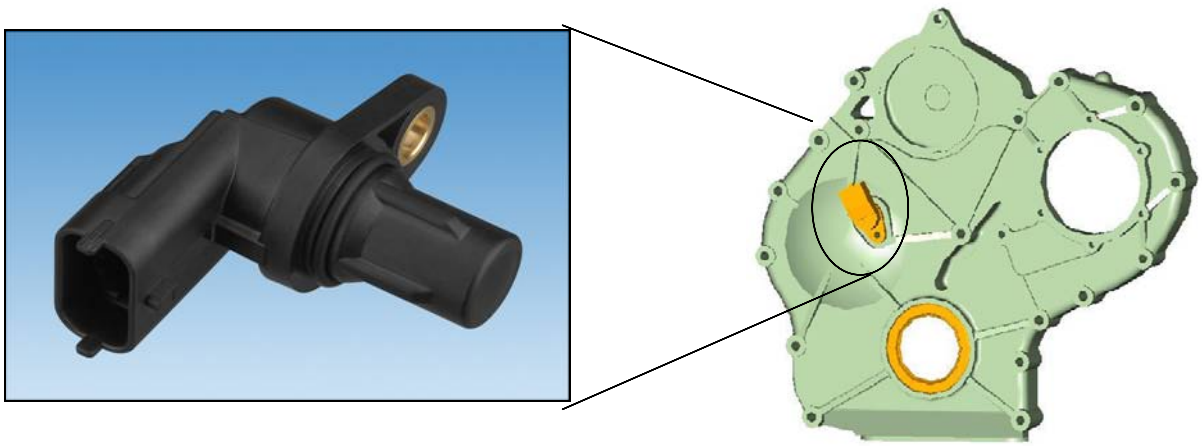
- ✓ Rotational speed sensor must be removed from its packing just prior to installation in the vehicle.
- ✓ Sensor to be mounted by pushing it into place.
- ✓ The first support of wire after connection: Max 250 mm. It should be on the sensor carrier.
- ✓ Replace damaged O-Ring.
- ✓ Clean and grease O-Ring prior to installation with mineral oil-based grease.
- ✓ Fix with only partially self-sealing cylindrical screw M6X12.
- ✓ Tightening Torque specification should be 8 ± 2 Nm.
- ✓ Storage temperature : -20ºC to 50ºC.

Don'ts

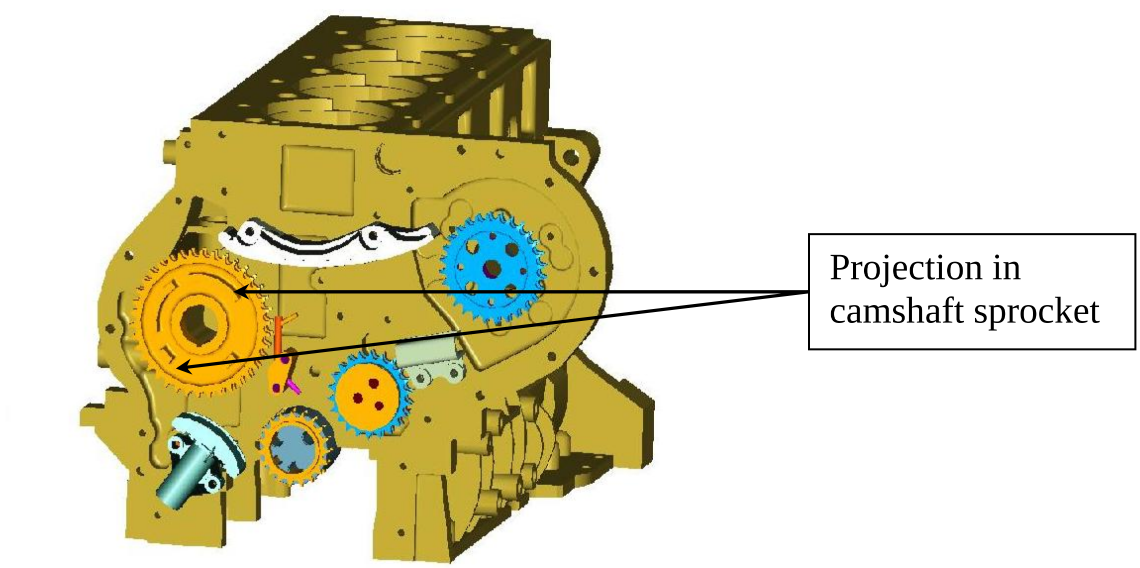
- 5 Don't allow the sensor to fall down.
- 5 Do not hammer the sensor while fitting.
- 5 Do not bend sensor wire with radius less than R = 50 mm.
- 5 The angle between sensor exit and first support of the wire should not be more than 90º.
- 5 Do not short circuit the connector pins while the sensor is functioning.
- 5 Sensor should not be kept near Hot medium or objects with Temp > 120 ºC.
- 5 Sensor should not be kept near any strong Magnetic Materials.
- 5 None of the application guidelines should be deviated (Air gap etc).

Cam Phase sensor/ Camshaft speed sensor

Location: On the timing cover facing the camshaft sprocket.



CRDI - PHASE SENSOR ON FRONT COVER



CRDI - CHAIN LAYOUT

The camshaft controls the engine intake and exhaust valves. It travels at half the engine speed. When a piston travels in the direction of TDC the camshaft position determines whether it is in compression or exhaust phase. This information can not be generated by the crankshaft position in the starting phase. During normal operation on the other hand the information can be generated by the crankshaft sensor suffices to define the engine status. In other word it means that if the

Camshaft sensor will fail while the vehicle is being driven the ECU shall receive information on the engine status from the crankshaft sensor.

The camshaft sensor utilizes the Hall effect for establishing the camshaft position. A tooth of ferromagnetic is attached to the camshaft and rotates with it. When this tooth passes the semiconductor wafer of the camshaft sensor, its magnetic field diverts the electrons in the semiconductor wafer at right angle to the direction of the current flowing through the wafers. This results in a brief voltage signal (Hall voltage) which informs the ECU that cylinder 1 has entered the compression phase.

Do's & Don'ts for the Phase Sensor

Do's

- The Phase Sensor should be unpacked directly before installation.
- Sensor to be mounted by pushing it into place.
- Clean and grease O-Ring prior to installation with mineral oil-based grease.
- The first support of wire after connection: Max 250 mm. It should be on the sensor carrier.
- Sensor terminal pins should be free from water/moisture.
- Fix with only partially micro-capsuled screw M6.
- Tightening Torque specification should be 8 ± 0.5 Nm.

Don'ts

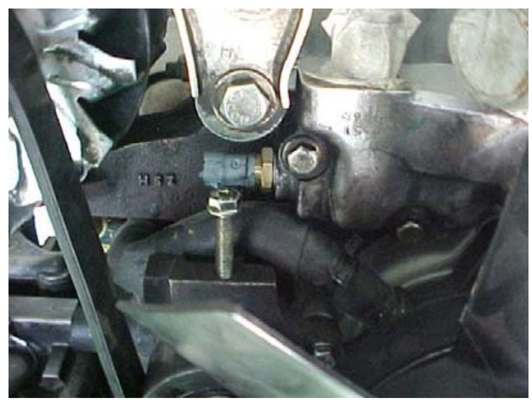
- Don't allow the sensor to fall down.
- Do not hammer the sensor while fitting.
- Do not bend sensor wire between the connection and the first support.
- Do not touch the sensor pins or the wiring harness pins with hand (to avoid ESD i.e. Electro static discharge).
- None of the application guidelines should be deviated (Air gap etc).

5 Sensor should not be kept near hot medium or objects with Temp > 160 ºC.

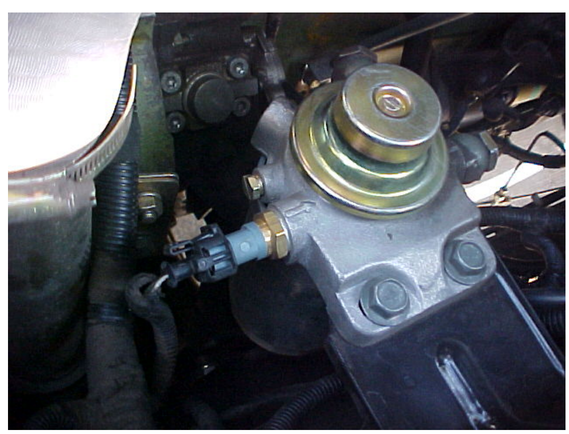
Temperature sensor

Location: Used in two locations.

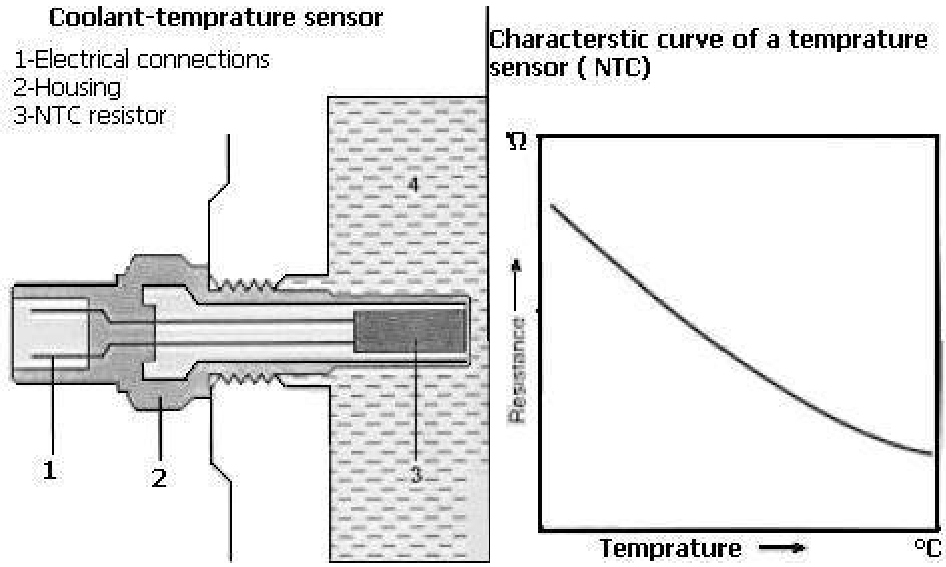
Usage: Coolant temperature sensor
Located On the water outlet, near thermostat.



Usage: Fuel Temperature sensor
Located on the bottom of the fuel filter



Type: Negative Temperature coefficient type (NTC)



In the cooling circuit to establish engine temperature by way of the coolant temperature.

In the fuel return line to measure the fuel temperature. The fuel temperature is used for density correction.

The sensors are equipped with a temperature dependent resistor with a Negative temperature coefficient (NTC) which is part of voltage – divider circuit across which 5 V is applied. The voltage drop across the resistor is inputted into the ECU through an analogue- to – digital converter (ADC) and is a measure for the temperature. A characteristic curve is stored in ECU microcomputer, which defines the temperature as a function of the given voltage.

Automotive Sector

Do's & Don'ts for the Temperature Sensor.

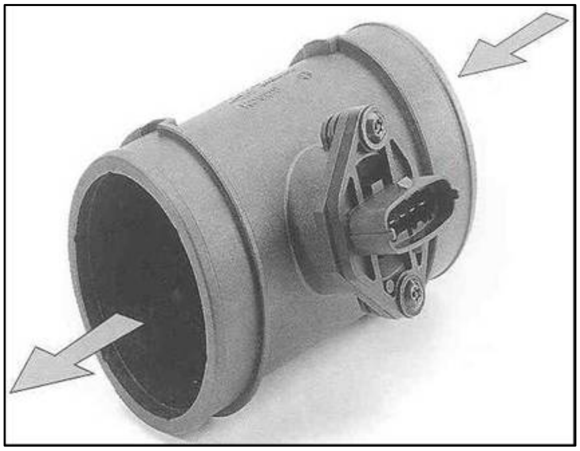
Do's

- During service-After removing temperature sensor, existing Aluminum washer is to be carefully cut (without damaging the brass threading) and taken out.
- Replace the washer with Copper washer (MICO 2916 710 608).

Don'ts

- Don't allow the sensor to fall down.
- Do not exceed the maximum permissible tightening Torque of 18 Nm for copper washer and 25 Nm for aluminum washer.

Hot Film Air mass meter



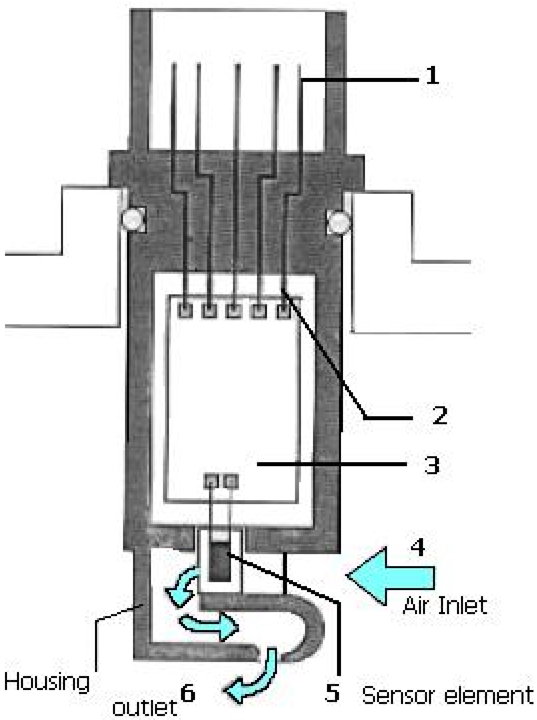
The HFM sensor combines two functions. It monitors the airflow & also monitors the air intake temperature so that the density correction is carried out and also the hot film temperature is maintained.

Particularly during dynamic driving operation, precise compliance with the correct A/F ratio is imperative in order to comply with the exhaust – gas limits as stipulated by the regulations. This makes it necessary to use the sensor, which precisely register the air- mass flow actually being drawn by the engine at a particular moment. This load sensor's measuring accuracy must be completely independent of pulsations, reverse flow, EGR, variable camshaft control and changes in air intake temperature.

A hot film air mass meter was selected for being most suitable for complying with the above stipulations. The hot film principle is based on the transfer of heat from heated sensor element to the air mass flow. A micromechanical measuring system is utilized which permits registration of the air-mass flow and detection of flow direction. Reverse flows are also detected in case of strongly pulsating airflow.

Hot -filmair mass meter

1 Electrical connection, 2 Internal connections
3 Evaluation electronic (hybrid circuit)



The micromechanical sensor element is located in the plug- in sensor's flow passage. The plug in sensor is installed in the outlet of the air cleaner. The signal voltage curve as a function of the air mass flow is divided into signal ranges for forward and reverse flow. In order to increase measuring accuracy the measuring signal is referred to a reference voltage outputted by the engine management. The characteristic curve has been designed so that during diagnosis in the workshop for an open circuit conductor for instance, can be detected with the help of the engine management.

A temperature sensor is also incorporated for measuring the air intake temperature (IAT)

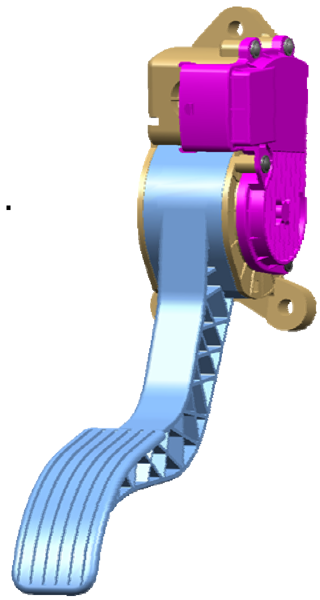
Accelerator pedal sensor

Location – in the accelerator pedal

Type – 6 wire, double track potentiometer

Function – informs ECU about driver's pedal request.

Purpose – to transmit driver's pedal request to ECU



In contrast to the conventional distributor or inline pumps with CRD the driver's acceleration input is no longer directly inputted to injection pump by the Bowden cable. But the motion is registered by an accelerator pedal sensor and is transmitted to the ECU.

A voltage generated across the potentiometer in the accelerator pedal sensor as a function of the accelerator pedal setting. Using a programmed characteristic curve the pedal positions then calculated from this voltage.

There are two tracks called APP1 & APP2. The ECU monitors signals from both the tracks. Even if the relationship between either changes it is registered as a defect.

Do's and Don'ts

Do's

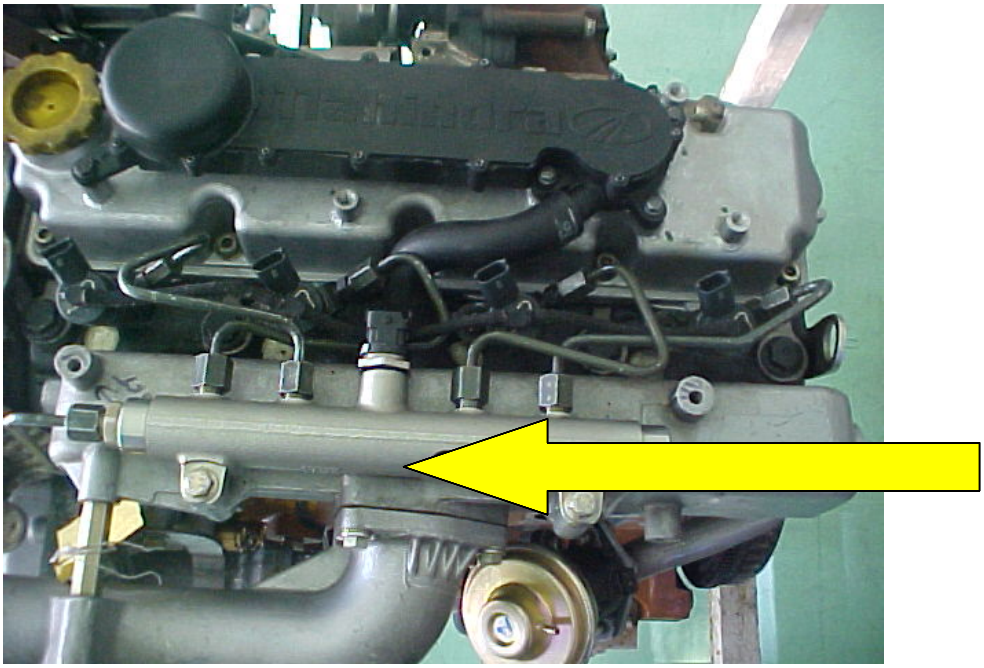
- Tightening Torque of the retaining screws should not exceed 9 ± 1.5 Nm.
- Use only self-locking screws.

4 After damage or in doubt of damage (e.g. dropped APM) the APM has to be separated and scrapped.

Don’t

6 Don’t drop s the sensor.
6 Do not exceed the maximum permissible tightening Torque.
6 Do not dip in any liquid.

Rail pressure sensor



Location - on the fuel common rail

Type -

Function - monitors rail pressure

Purpose – to decide on injector energising time

Caution : The rail pressure sensor has to be changed along with the rail.

VEHICLE SPEED SENSOR(VSS)

Location - on the gear box output shaft

Type - magnetic reed type

Function - Monitors the vehicle speed. ECU,based on this information can deduce the gear in which vehicle is driven.

Purpose - Gear recognition is useful in low speed governing & cruise control

BRAKE PEDAL SWITCH

Location – in the brake pedal

Type – 4 wire, make-break switch

Function – informs ECU about position of brake pedal , operates brake lamp/stop lamp

Purpose – help ECU to identify brake actuation for cruise control

CLUTCH PEDAL SWITCH

Location – in the clutch pedal

Type – 4 wire, make-break switch

Function – Informs engine ECU about position of clutch pedal .Also informs 4WD ECU about position of clutch pedal.

Purpose – help engine ECU to identify clutch actuation for cruiuse control

ECU

Assignment & method of operation:

The ECU evaluates the signal it receives from the external sensors & limits them to permissible voltage level

From this input data, and from stored characteristic maps, the ECU microprocessors calculates the injection times and instants of injection and convert these times to signal characteristic which are adapted to the movements of engine piston & crankshaft. The specified accuracy and the engines high dynamic demands high level of computing power.

The output signal from the ECU microprocessor's is used to trigger driver stages, it also provides adequate power for switching the actuators for rail pressure control and elements switch off. In addition actuators for engine function are triggered (e.g. EGR actuator) as well as those for further auxiliary functions such as blower relay, auxiliary heater relay, glow relay, air conditioner). The driver stages are proof against short circuit and destruction due to brief electrical overloading. Errors of this type and open circuit are reported to the microprocessor. Diagnosis functions in the injector driver stages detect faulty signal characteristic, and in addition a number of the output signal are transferred via interfaces for use in other systems in the vehicle. And within the framework of a special safety concept, the ECU monitors the complete fuel injection system.

Injector triggering particularly places heavy demands on the driver stages. In the injector, the current from the driver stage generates a magnetic force in the triggering element, which is applied to the injector's high-pressure system. In order to ensure very tight tolerances and high reporductiabilty of the injected fuel quantity, these coils must be triggered with steep current flanks. This necessities high voltages being made available in the ECU.

A current control circuit divides the energisation time (injection time) into a pickup current phase and hold phase. It must operate so accurately that the injector guarantees reproducibility injection under all stages. In addition it must reduce the power loss in the ECU & the injectors

Operating conditions

High demands are made on ECU regarding
- The surrounding ambient temperatures (in normal cases from –40°C to +85° C)
- The resistance to fuels and lubricants etc.
- The resistance to humidity and
- Mechanical loading.

Very high demand is also made upon the electromagnetic compatibility and upon the radiation of HF interference signals.

Design & Construction

The ECU has a metal housing. The sensors, the actuators and power supply are connected to the ECU through a multi pole plug in connector. The power components that directly trigger the actuators are integrated in the ECU in such a manner that they can efficiently dissipate their heat to the ECU housing.

Operating state control

In order that the engine operates with optimum combustion in every operating state the ECU in each case calculates the optimum injected fuel quantity. In the process a number of parameters has to be taken into account

Start quantity

For starting, the injected fuel quantity is calculated as a function of the temperature and cranking sped. The start quantity is injected from the moment the starting switch is turned to start till the engine has reached a given minimum speed. The driver has no influence upon the start quantity

Drive Mode

When the vehicle is being driven normally .The injected fuel quantity is calculated from the accelerator pedal setting (accelerator pedal sensor) and the engine speed. Calculation utilizes the driving maps so that the driver inputs and the engine O/P power are optimally matched to each other.

Idle sped control

At idle, fuel consumption depends for the most part on engine efficiency and idle speed. Since a considerable portion of vehicles fuel consumption in dense traffic conditions is attributable to this operating state, it is obvious that the idle speed must be kept to a minimum. The idle speed though must be set so that no matter what the operating conditions, it does not drop so far under load that the engine runs roughly or even stops. This applies for instances when the electrical systems are overloaded, when the AC is switched on, or when the power steering is in operation. In order to regulate the desired idle speed the idle controller varies the injected fuel quantity until the actual speed equals the desired idle speed. Here the selected gear and the engine temperature (coolant temperature sensor) influence the desired idle speed and control characteristic. In addition the external load moments, the internal friction moments must also be taken into account and compensated by the idle speed control. These change minimally but steadily through out the vehicle service life, as well as being highly dependent upon temperature.

Smooth running Control

Due to mechanical tolerances and aging, there are differences in torque generated by the engine's individual cylinders. This leads to rough or irregular running, particularly at idle. The smooth running (cylinder balancing) control measures the engine speed change every time a cylinder has fired and compares them with each other. The injected fuel quantity for each cylinder is then adjusted in accordance with the measured difference in engine speed between the individual cylinders so that each cylinder makes the same contribution to the torque generated by the engine. The smooth running control is only operative in the lower engine speed.

Vehicle speed Controller / Cruise control

The cruise control comes into operation when the vehicle is to be driven at a constant speed. It controls the vehicle speed to that inputted by the driver at the operators unit in the steering wheel.

The injected fuel quantity is increased or decreased until the actual speed equals the set speed. While the cruise control is in operation, the control process is interrupted if the driver presses the brake. If the accelerator pedal is pressed, the vehicle can be accelerated beyond the speed, which has been set with the cruise control. As soon as the accelerator pedal is released the cruise controls regulates the speed back down to previous set speed. Similarly if the cruise control has been switched off, the driver only needs to press the reactivate key in order to again select the last speed which has been set.

Controlling the injected fuel quantity limit --

There are a number of reasons why the fuel quantity desired by the driver must not be injected. These include

- Excessive pollutant emissions
- Excessive soot emissions
- Mechanical overloading due to excessive torques or engines speed.
- Thermal overloading due to excessive coolant temperature.

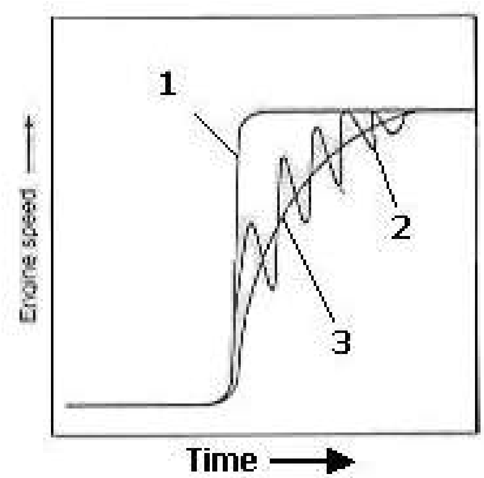
The limit for the injected fuel quantity is formed from the a number of input variables e.g. intake air mass, engine speed, coolant temperature

Active surge damping control -

When the accelerator pedal is abruptly pressed or released. It causes the injected fuel quantity to change rapidly with the result that there is also a rapid change in the torque developed by the engine. These abrupt changes lead to flexible engine mounts and the drive train generating bucking oscillations which result in fluctuation of engine speed.

Active surge damper

1. Sudden accelrator movement



2 Engine speed without active damper
3.With active surge damping control

.

The active surge damper reduces these periodic speed fluctuations by varying the injected fuel quantity at the same frequency as the periodic fluctuations. Less fuel is injected when the speed increases and more when it decreases. This effectively damps the surge movement.

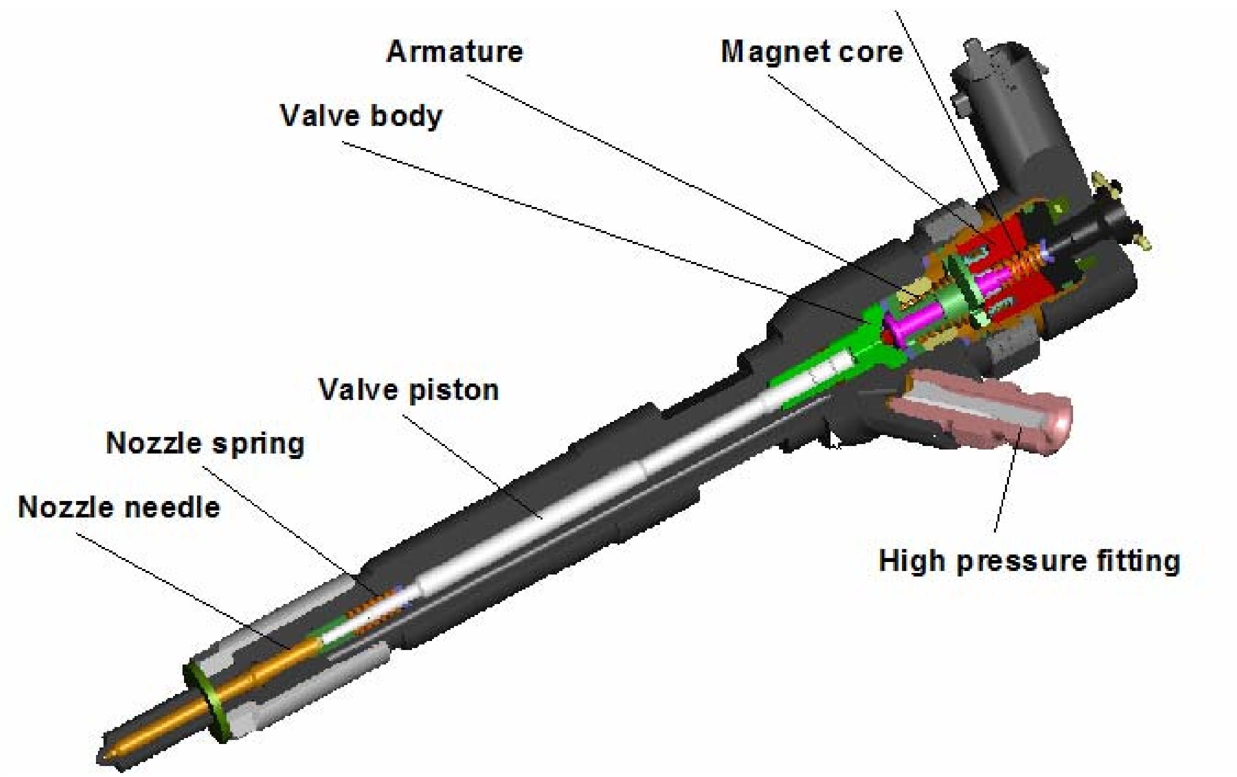
Engine switch off –

The diesel engine operates according to auto ignition principal. This means that it can only be switched off by cutting the fuel supply.

With the CRDi the ECU stipulates injected fuel quantity zero. (The system also features a number of additional – reduntat switch off paths.)

Injectors –

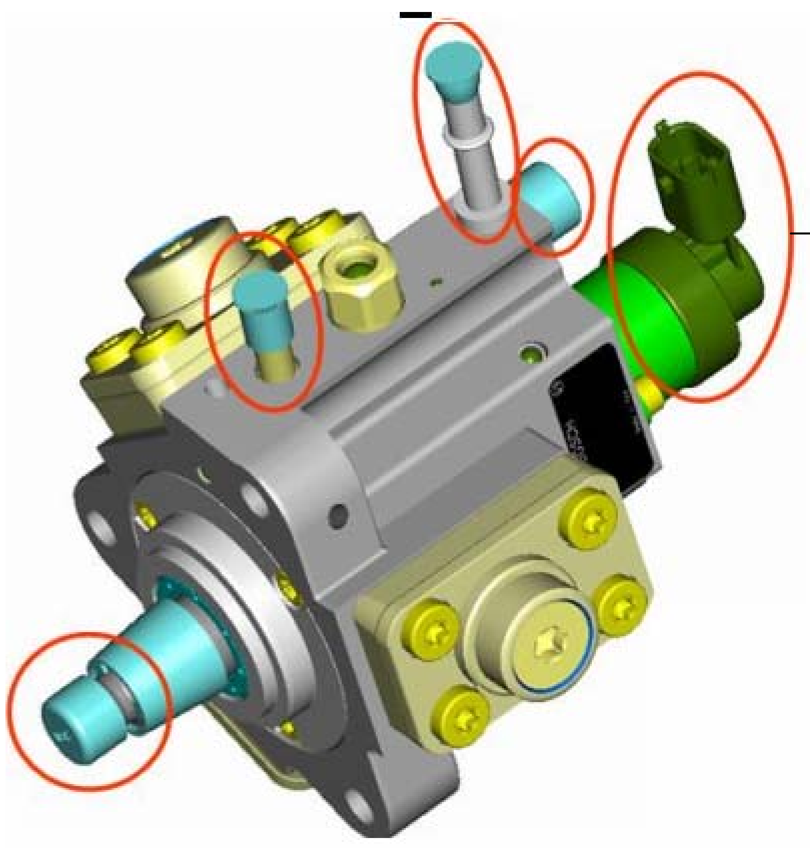
Special injectors with hydraulic servo systems and electrical triggering element
(Solenoid valves) are used in order to achieve efficient start of injection and precise fuel injected fuel quantity. At the start of the injection a high pickup current is applied to the injector so that the solenoid opens quickly. As soon as the nozzle needle has traveled its complete stroke and the nozzle has opened completely. The-energizing current is reduced to lower holding value. The injector opening time & rail pressure now defines the injected fuel quantity. Injection is terminated when the solenoid valve is no longer triggered and closes as a result.

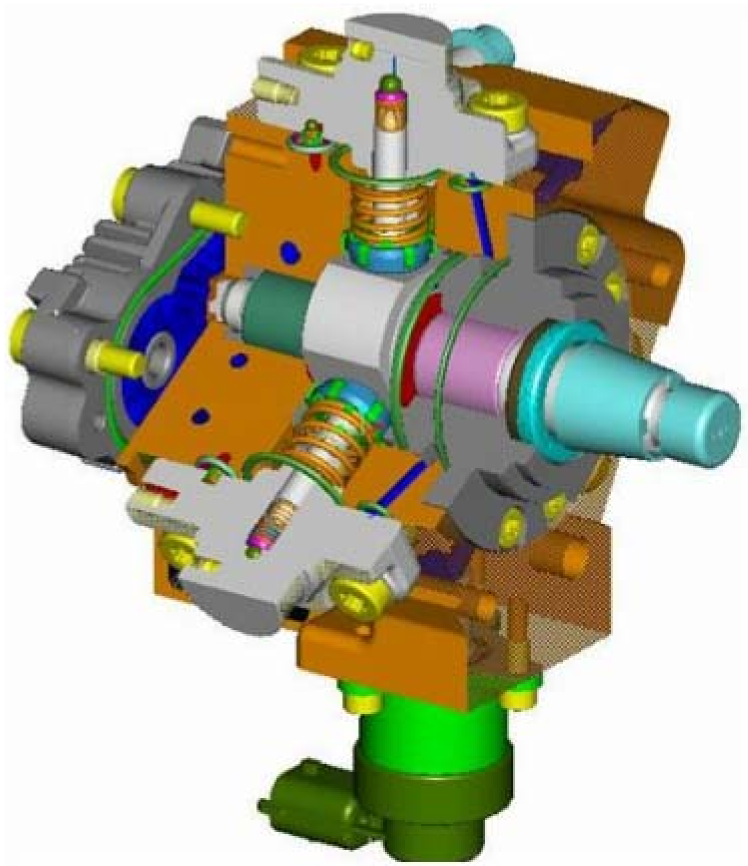


M-PROP

The ECU uses the MPROP control valve to control the rail pressure by controlling the inlet to the high-pressure pump.

It is possible to vary the pressure by pulsing (PWM) the triggering current. The degree to which the pressure control valve is opened or closed depends on the pulse rate (duty cycle)





The High-pressure pump has the following main components:

Gear Pump : its main job is to give continuous and stable feed of LP pump.
Pump housing : It houses the LP & HP circuits along with the inlet, outlet, and backflow valve.

Metering unit with Electric regulation (MPROP) : It ensures inlet metering thus only the needed amount of fuel is compressed ensuring correct inlet of fuel to the rail.

Drive & Pump elements along with the High pressure valve in the cylinder head.

Do's & Donts's

Do's

4 The critical parts which must always be protected are :
Inlet fitting
Backflow fitting
M-PROP
HP connector
Shaft

4 While removing & refitting the pump:

Carefully plug both LP fittings & unscrew HP connector.

4 Verify the integrity of the O ring on pump flange. Replace if broken.
4 Immediately cover all the openings & shaft with protective caps.
4 Handle the pump with extreme care.
4 If the pump falls down, it should not be used (even if looks visually OK).

Don'ts

6 Do not attempt to open the pump or remove the external components (it will invalidate the warranty.)

Glow control unit
(Only for Euro III)

The glow control unit is responsible for ensuring efficient cold starting. It also shortens the warm up period, a fact that is highly relevant for exhaust emissions. The preheating time is a function of the coolant temperature. The further glow phases during the engine start or when the engine is actually running are determined by a number of parameters, which include engine speed and injected fuel quantity. Glow control utilizes a power relay.

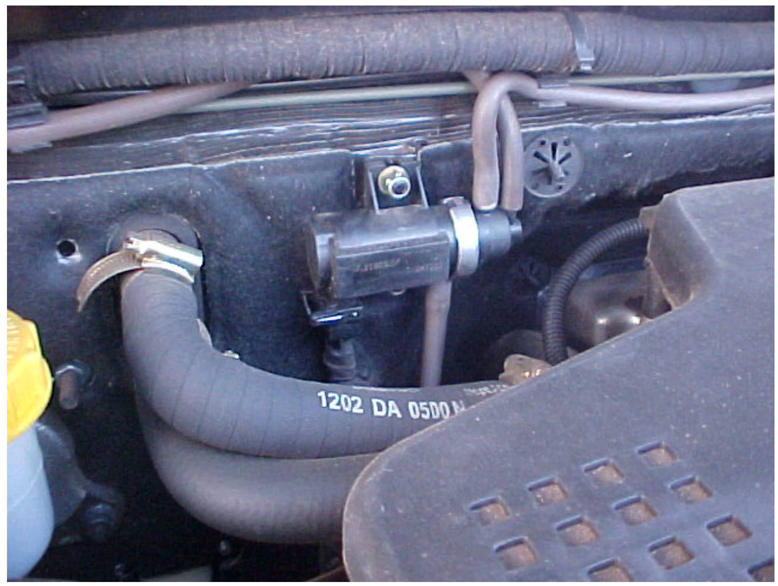
EGR positoner

Depending upon the engines operating point, the air /gas mass drawn into the cylinders can be composed of up to 40% of the exhaust gas.

For ECU control the actual drawn in fresh air is measured at each operating point with the air mass setpoint value. Using her signal generated by the control circuit, the EGR position opens so that exhaust gases flow into the intake tract.

The ECU controls the movement of the modulator.

The modulators controls The amount of vacuum going to the EGR valve , thus varying the lift of the EGR. The variable lift of the EGR changes the amount Of exhaust gas going to the Inlet system.



Air Conditioner

Depending on the engine & driving situation the energy consumption is 1 to 30% of the engine output power.

The target is therefore not so much as improvement of the temperature control, rather the optimum use of the engine torque as soon as the driver accelerates strongly (and thus requires maximum engine torque) the AC compressor is switched off by the EDC

Integrated diagnosis

Sensor monitoring

For sensor monitoring the integrated diagnosis facility checks whetar they are being supplied by power, and whetar the O/P signals are plausible (within the permitted range e.g. temperature between –40 to 150°C. Where possible the reduancy principle is applied for important signals.

That is in case of a malfunction, a switch is made to another similar signal.

Monitoring module –
In addition to the microcontroller the ECU also incorporates a monitoring module. The ECU and the monitoring module monitor each other. If a malfunction is detected, either of them can switch off the injection independent of the other.

Malfunction detection

Malfunction detection is only possible within the monitoring range of a given sensor. A signal path is classified as faulty when an error is present for longer than a predefined period. In such cases, the error is stored in ECU's error memory together with details of the environmental condition which prevailed when the error / malfunction occurred (e.g. coolant temperature, engine speed etc.) For a large number of errors/ malfunction, it is possible for the healed status to be established. Here the signal path must be identified as intact for a defined period of time.

Error procedure

If a sensors permitted output-signal is violated, a switch is made to a substitute value. This procedure is applied for battery voltage
- Coolant, air, and lube temperature
- Atmospheric pressure
- Intake air quantity

In addition in case of non-plausible signals from the accelerator pedal sensor and/or brake as substitute accelerator pedal signal is applied.

ECU Data processing

The actuators and the sensors are the interface between the vehicle and the ECU

Analogue input signals (from analogue sensors; quantity of the air drawn, engine & intake air temperature, battery voltage etc are converted to digital value by an A/D converter in the ECU microprocessor.
Digital input signal (e.g. On/Off switching signals or digital signals such as rotational speed pulse) can be processed directly by the ECU

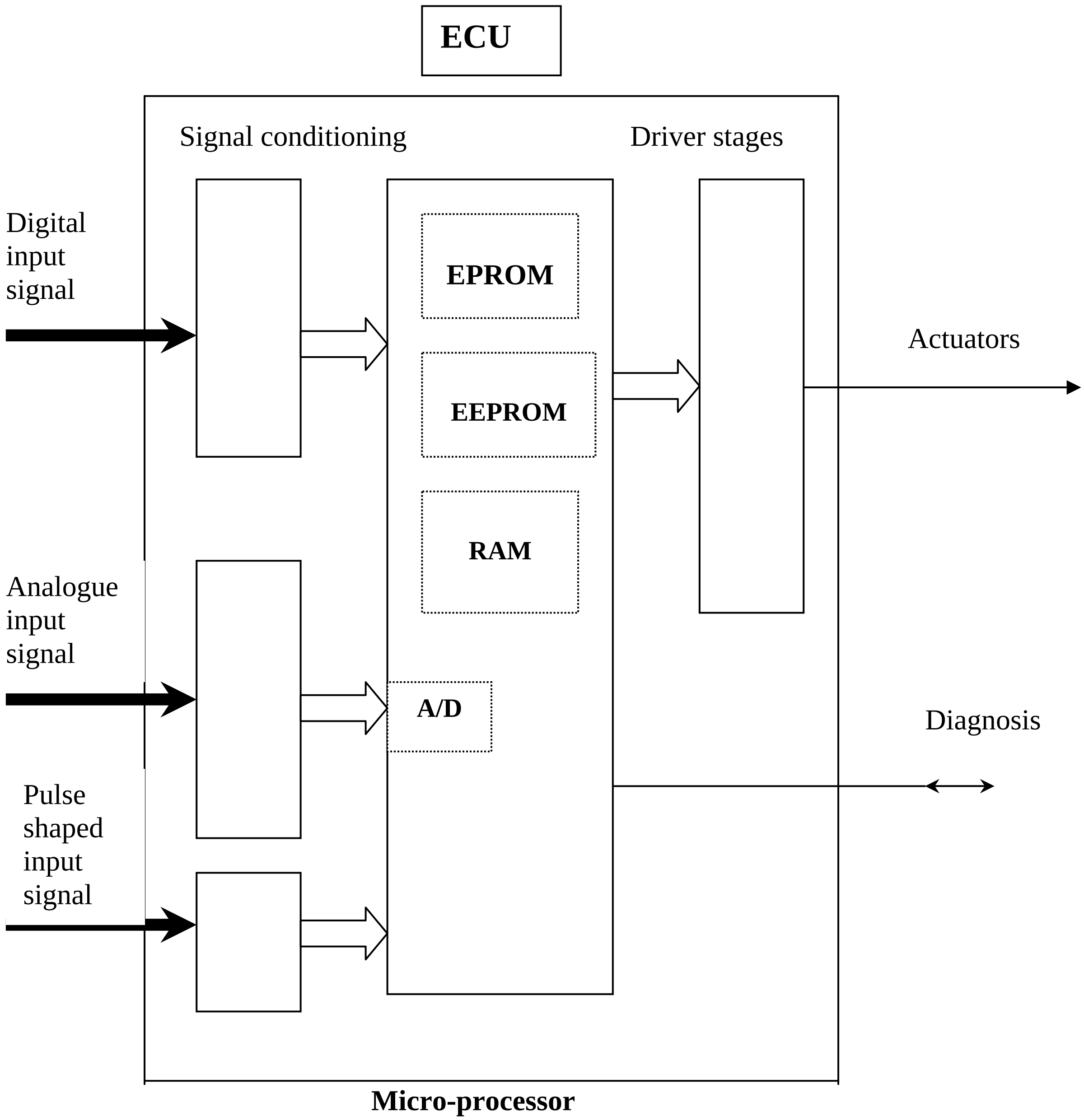
In order to reduce interference pulses the pulse shaped input signal from inductive sensor (crankshaft speed sensor) which carry information on engine speed and reference mark are conditioned by a special circuit in the ECU and converted to square wave form

Some signal conditioning can take place at the sensor end itself.

Signal conditioning

Protective circuitry is used to limit the incoming signals to a maximum voltage level. The effective signal is freed almost completely of superimposed interference signals by means of filtering and is then amplified to match it to the ECU voltage.

Signal Processing in the ECU



The ECU microprocessors mostly process the input signal digitally and therefore need a special program. This program is stored in a Read Only Memory (ROM or Flash-EPROM)

In addition the engine specific curves and engine management maps are stored in a Flash –EPROM.

A volatile random access memory (RAM) is needed to store variable data such as calculation data and signal values. In order to function correctly, the RAM requires a permanent power supply. In other words, it loses its complete data stock when the ECU is switched off via the ignition switch or when the vehicle battery is disconnected. In such cases the adaptation values (values, which have been learnt regarding engine & operating conditions,) would have to be re-established when the ECU is switched on again. To prevent this adaptation values are stored in an EEPROM and not in a RAM

Output signals

With their output signals, the microprocessors trigger output stages, which usually are powerful enough for direct connection to the actuators. The triggering of the individual actuators is dealt with in the particular system description. These output stages are proof against short circuit to ground or to batter voltage, as well as destruction due to electrical overload. Such faults are recognized by the output stages and reported to the microprocessor. This also applies to the conductor open circuit.
In addition a number of output signals are transmitted through interface to the other systems in the vehicle.

Automotive Sector

Clutch

Contents

Description

The clutch disc is a single, dry type with cushion springs in the hub. The clutch disc's friction material is riveted to the hub.

The clutch cover is a diaphragm type with one-piece construction. A 240-mm clutch disc is used.

In the engaged position (when the clutch pedal is not pressed), the diaphragm spring of the clutch cover assembly holds the clutch pressure plate against the clutch disc. This enables the engine torque to be transmitted to the input shaft of the gearbox, without any slip / loss.

The clutch is hydraulically actuated with self-adjusting features. The complete actuation system comprises of a clutch master cylinder with integral reservoir. The master cylinder is connected to the clutch actuation or the slave cylinder by hydraulic pipe. The travel of the push rod results in linear movement of the release bearing through a release fork pivoted on a ball in the clutch housing.

The clutch release bearing pushes the diaphragm spring center towards the flywheel. The diaphragm spring pivots at the fulcrum, relieving the load on the clutch plate. Steel spring straps riveted to the pressure plate cover pulls the pressure plate away from the clutch disc. When the clamping load on the clutch plate is relieved it slides on the splines of the input shaft away from the flywheel thus disengaging the engine torque from the input shaft & enabling the gears to be changed.

<u>Care of the System</u> -

While topping up use the recommended fluid conforming to DOT 3 specifications only. Avoid mixing different brands.

The clutch fluid is hygroscopic fluids hence tend to collect humidity. The humidity along with the brake fluid can cause acidic reaction & seizure of the master & slave cylinders. The clutch fluid should be replaced every 40,000 km or one in a year, whichever is earlier. The master & clutch cylinder seals to be replace every 50,000 Kms

Trouble Shooting –

Unless the cause of a clutch problem is extremely obvious, accurate problem diagnosis will require a road test to confirm that the problem exists. To find out the actual root cause of the problem the clutch will have to be dismantled and the failed parts examined to determine the cause.

During road test, drive the vehicle in normal operating speeds. Shift the gears and observe the clutch action. If chatter, grab, slip or improper release is experienced, remove & inspect the parts. However if problem is noise or hard shift then the problem may not be in clutch only but also the transmission or the driveline.

If the clutch slip is suspected then drive the vehicle in 1st or 2nd gear at the top speed (corresponding to the gear). Keeping the accelerator fully pressed, slowly apply the brake- with your left feet. If the engine stalls then the clutch is not slipping.

Clutch Problem Causes –

Fluid contamination is the most frequent cause of clutch malfunction. Oil, water on the clutch contact surface will cause faulty operation viz. Slip, grab, and judder.

During inspection check if any parts in the clutch are coated with oil or water splash from road.

Oil contamination indicates a leak at either rear main seal or transmission-input shaft. The oil leaks from either of these areas will normally coat the housing interior or clutch cover or flywheel. Heat build up due to slippage between the clutch plate and the flywheel or the pressure plate can result into the leaked oil literally getting baked. Visually this will result in a glazed residue varying from amber to black.

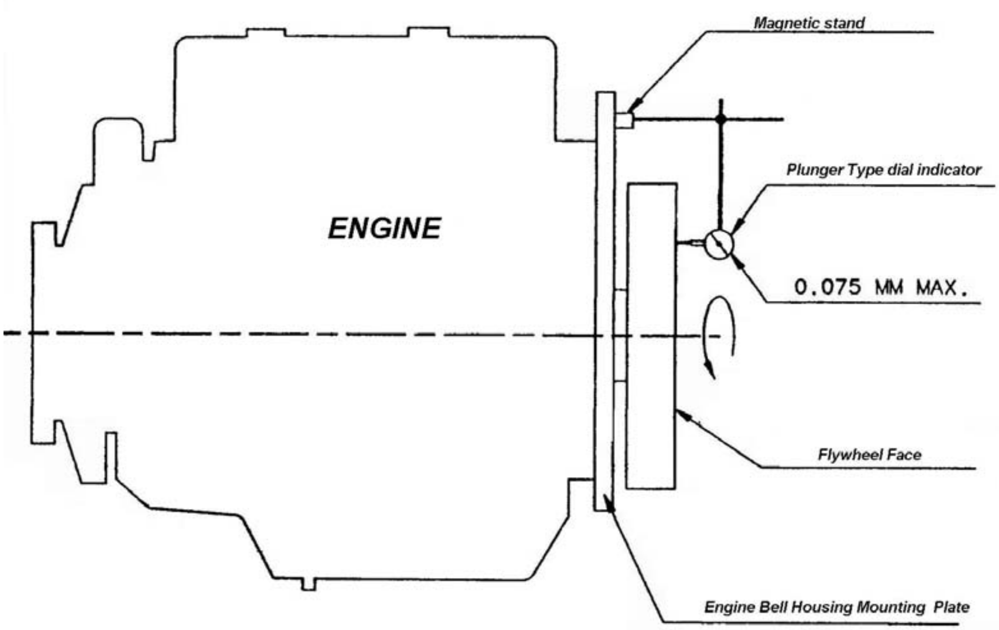
Roads splash contamination will mean that the dirt water is entering the clutch housing either due to loose bolt or torn rubber boot.

Clutch misalignment -

The clutch component i.e. the clutch plate, flywheel and the pressure plate have to be aligned with the crankshaft and the transmission input shaft. Misalignment caused by runouts/ warpage will cause clutch to grab judder as well as improper release (also manifesting as hard gearshift).

Flywheel runout -

The flywheel runout needs to be checked whenever misalignment is suspected. Flywheel runout should not exceed 0.10



mm.
To measure the runout mount the base of the magnetic dial gauge on the block. Locate the dial gauge's needle on the outer surface of the flywheel.

Some of the common reasons for excessive runout are:
- ✓ Heat warpage.

- ✓ Improper machining.
- ✓ Incorrect bolt tightening
- ✓ Foreign material on crankshaft flange or flywheel.
- ✓ Improper seating on crankshaft.

Clutch cover & Disc runout –

A warped cover or diaphragm spring will result in clutch grab and / or incomplete release of clutch plate.

If the clutch alignment tool is not used then the misalignment of the clutch plate can cause distortion of the cover and also disc damage.

The cover can also get misaligned due to improper tightening of the cover onto the flywheel. The only way to avoid is that the bolts must be tightened alternatively (diagonal pattern) and evenly i.e. 2 to 3 thread a time only.

A noisy gearshift operation especially the 1st and 2nd gear can be due to clutch not getting disengaged completely. To check it, jack up the rear axle. Lift the axle till both the wheels are rotating freely.

Press the clutch pedal completely and start the engine, the wheels should not be spinning. Now slowly release the pedal till it has moved about 10 mm, the wheel should still not be spinning. If some spinning is noticed then it indicates improper lift of the pressure plate. First check the bleeding and the pedal travel then check for the pressure plate lift.

Clutch Housing Misalignment –

The clutch housing has to be aligned with the engine so that the input shaft is aligned with the crankshaft. Absence of this alignment results in clutch noise, incomplete release of the clutch plate. It can normally be judged by uneven wear of the finger and pilot bearing. In severe case it can also damage the spline of the input shaft and clutch hub’s well as the clutch splines

- ➢ Normally the clutch housing misalignment is a result of:
- ➢ Incorrect seating on the engine/transmission.

- Missing alignment dowel holes.
- Loose or missing mounting bolt.
- Mounting surfaces that are damaged/ not parallel.

To check the clutch housing misalignment bell housing runout will also need to be checked.

Clutch slippage

Observation	Causes	Remedial action
Disc facing worn out.	1. Normal wear. 2. Clutch riding. 3. Insufficient diaphragm spring clamp load. 4. Faulty release mechanism. 5. Vehicle being driven despite slipping clutch. 6. Bad driving practice of allowing the clutch to slip far too long.	✓ Replace clutch disc ✓ Replace clutch plate ✓ Replace clutch plate & cover assembly. ✓ Replace , and bleed/ ✓ Customer to be informed. ✓ Customer to be informed.
Clutch disc facing contaminated with oil, grease or clutch fluid.	Leak at : 1. Crankshaft rear end oil seal 2. Leak through the input shaft 3. Excess amount of grease applied to the input shaft splines	✓ Replace seal & disc. Clean cover assembly. ✓ Replace seal & disc. Clean cover assembly. ✓ Apply less grease. Replace clutch disc. Clean cover assembly.

Clutch is running partially disengaged.	Release bearing carrier sticky.	✓ Replace bearing / carrier.
Flywheel height incorrect.	1. Improperly machined flywheel. 2. Excess machining done.	✓ Replace flywheel.
Wrong disc or pressure plate used.	Use the correct parts	✓ Replace the parts after comparison.
Clutch disc/ cover or diaphragm spring warped.	1. Improper tightening or loosening procedure. 2. Rough handling of clutch plate or cover assembly	✓ Replace the parts and tighten as per sequence. ✓ Replace the parts, ensure that the rough handling is avoided
Flywheel side clutch facing surface – torn/ nicked/ worn	Flywheel surface ,scored and having light notch	✓ Reduce the scoring and nicks by sand paper. Reduce if scoring deeper.
Clutch disc facing burnt. Excessive glazing of the flywheel & pressure plate.	1. Frequent operation under high loads or hard acceleration conditions 2. Frequent clutch riding by the driver.	✓ Roughen the flywheel face with sandpaper. Replace clutch plate & cover assembly. ✓ The driver has to be alerted to avoid repeat failure.
Clutch facing broken	Improper storage-clutch plate dropped prior to fitting.	✓ Replace.
Fouling marks on the torsion damper.	Improper fitment-assembled the wrong way around	✓ Rectify

Clutch grab/chatter

Observation	Causes	Remedial action
Clutch disc facing contaminated with oil, grease or clutch fluid.	Leak at : 1. Crankshaft rear end oil seal 2. Leak through the input shaft 3. Excess amount of grease applied to the input shaft splines	✓ Replace seal & disc. Clean cover assembly. ✓ Replace seal & disc. Clean cover assembly. ✓ Apply less grease. Replace clutch disc. Clean cover assembly.
Clutch disc / pressure plate warped. Disc facing show unusual wear	1. Incorrect or substandard parts. 2. Improper tightening or loosening procedure. 3. Rough handling of clutch plate or cover assembly	✓ Replace disc and cover with the correct parts. ✓ Replace the parts and tighten as per sequence. ✓ Replace the parts, ensure that the rough handling is avoided.
Partial engagements of clutch disc (One side worn – opposite side glazed and lightly worn.)	1. Clutch pressure plate position setting incorrect or modified 2. Clutch cover, spring or release fingers bent or distorted due to rough handling or improper assembly. 3. Clutch disc damaged or distorted. 4. Clutch misalignment.	✓ Replace clutch cover & clutch plate. ✓ Replace clutch cover & clutch plate. ✓ Replace clutch plate. ✓ Check alignment and runout of flywheel disc

		or cover. ✓ Replace the clutch plate & cover assy (if required. Correct the alignment)
No fault found with clutch components.	Problem related to suspension or driveline components.	✓ Further diagnosis required. Check engine & transmission mounting insulators. U Joint, tyres, body attaching parts.
Clutch master cylinder or slave cylinder piston jammed/ scuffing.	Piston/ bore damaged or corroded	✓ Overhaul the master & slave cylinder.
Tangential strap connecting the pressure plate to the diaphragm cover broken.	1. Incorrect driving practice ✓ Mostly due to tow starting in 1st or 2nd gear **Or** ✓ Incorrect gear selection	✓ Advise the customer of the consequences.
Withdrawal fork worn out	Wear of the fork at pivot end or the release bearing end	✓ Replace the fork..

Improper clutch release

Observation	Causes	Remedial action
Clutch disc warped.	New disc not checked before installation	✓ Check the new disc's runout & replace it.
Clutch plate is binding on the input shaft's splines.	1. Clutch disc hub splines damaged during installation. 2. Input shaft splines rough or damaged. 3. Corrosion or rust formation on splines of disc and input shaft.	✓ Replace the clutch plate. ✓ Replace input shaft is severely damaged. ✓ Replace the clutch plate. Replace the input shaft if the scaling can not be removed.
Clutch disc-facing sticks to flywheel.	Vacuum may form in pockets over rivet head. Occurs as clutch cools down after use.	✓ Drill 1/16 inch diameter hole through rivets and scuff sand the clutch disc facing .
Clutch will not disengage properly.	1. Low fluid in the clutch master cylinder. 2. Air in the hydraulic system 3. Clutch cover loose. 4. Wrong clutch disc. 5. Clutch cover diaphragm spring bent / warped	✓ Top off the fluid and check for leaks. ✓ Bleed & refill the system. ✓ Tighten the bolts. ✓ Replace disc. ✓ Replace the cover assembly.

	during transmission installation. 6. Clutch disc fitted backwards.	 ✓ Fit the clutch plate correctly the hub should be facing the pressure plate side & the flywheel side mark towards the flywheel
Bush worn out / damaged	Vibration / misalignment Clutch misalignment	✓ Fit new bearings & check for misalignments.

Hard gear shift

Observation	Causes	Remedial action
Brake fluid less and or contaminated	1. Leaks 2. Reservoir strainer missing	✓ Replace fluid. ✓ Stop leaks and avoid contamination.
Excessive clutch pedal free plays.	Wrong adjustment or lock nut loosening	Adjust
Clutch plate warpage	1. Warpage due to handling or assembly. 2. Warpage due to misalignment.	Replace

Automotive Sector

In Car Repairs -

[Adjustment of clutch pedal height](#)

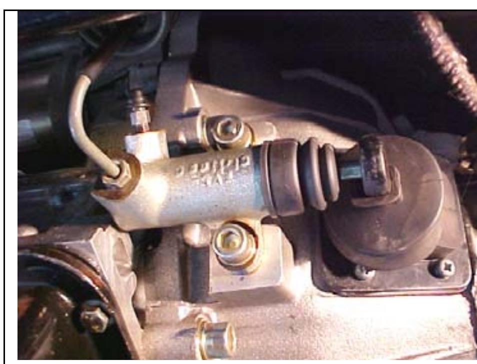
[Clutch bleeding.](#)

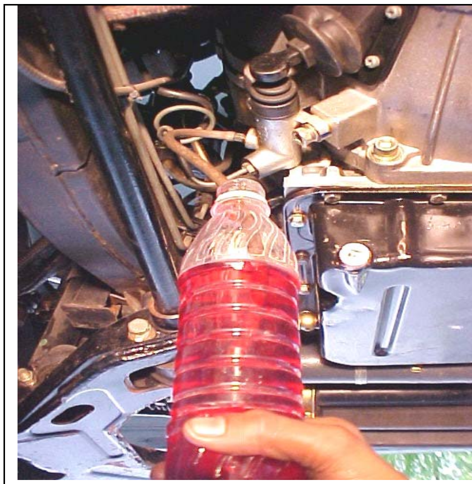
Adjustment of clutch pedal height -

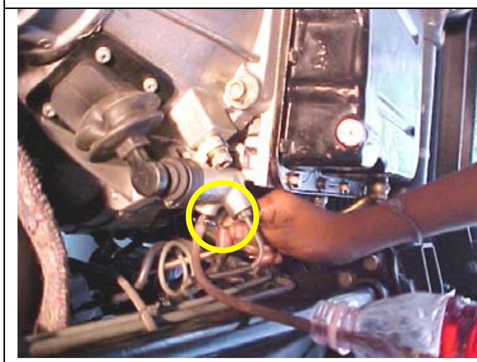
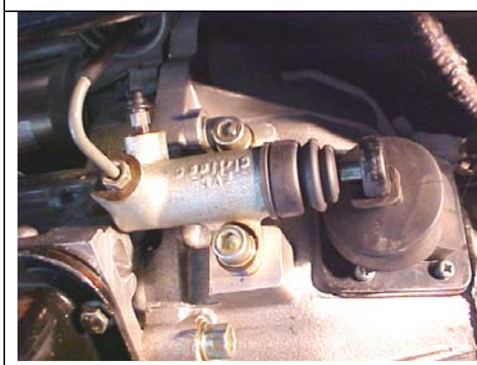
 	Loosen the lock nut of master cylinder's push rod fork.
	Slide backs the dust cover.
	Rotate the master cylinder push rod till desired height of pedal is achieved.

	Tighten the lock nut of push rod fork.
	Screw in pedal stopper bolt completely. Press pedal fully till the pedal bottoms on the floor.
	Now screw out the pedal stopper bolt till it touches the pedal lever, release pedal.
	Screw out the bolt further by one turn. Tighten the locknut.
	Recheck pedal height.

Bleeding the clutch -

	Clean the external areas of the clutch slave cylinder and remove the dust cap of the bleeder screw.
	If the bleeding operation is done by without connecting by a tube and in the open air then the chance of air remaining trapped is high.

	Connect bleeding tube, to bleeding screw on slave cylinder. Ensure that the other end of the tube is fully immersed in the bottle having clean clutch /brake fluid.
	Fill the Reservoir clutch master cylinder up to the top level with recommended clutch fluid.
	Operate clutch pedal 3 or 4 times slowly to the full stroke. Holding the clutch in depressed condition loosen the bleeding screw on slave cylinder by ½ to ¾ turn and allow all the air escape in to the container bottle.
	Repeat the exercise till no air bubbles appears in the bottle.

	During this operation ensure fluid level in reservoir.
	Tighten the bleed screw properly.
	Remove bleeding tube and place the dust cap o bleed screw.
	Check the fluid level in container and need be top up to the ‘max’ level.

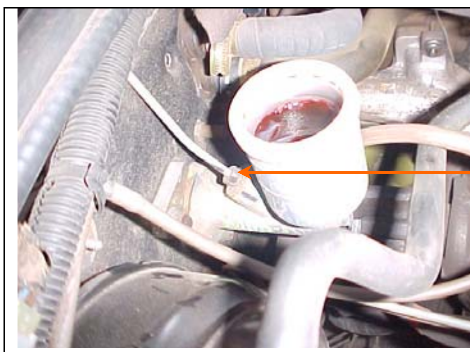
Clutch Actuation Mechanism -

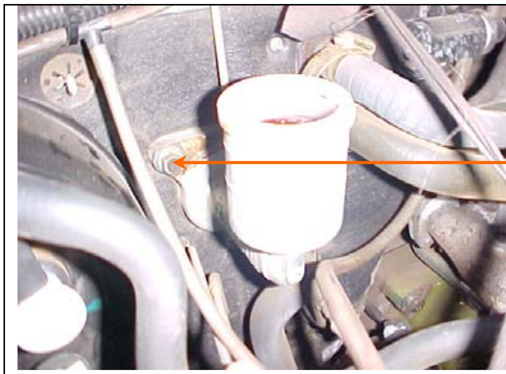
The clutch actuation is hydraulic actuation. The clutch pedal actuates a master cylinder. The hydraulic fluid is transmitted to the slave cylinder through Bundy tubes.

The slave cylinder actuates a fork, which is pivoted on a ball pivot. The other end of the fork; a release bearing on a carrier actuates the diaphragm springs.

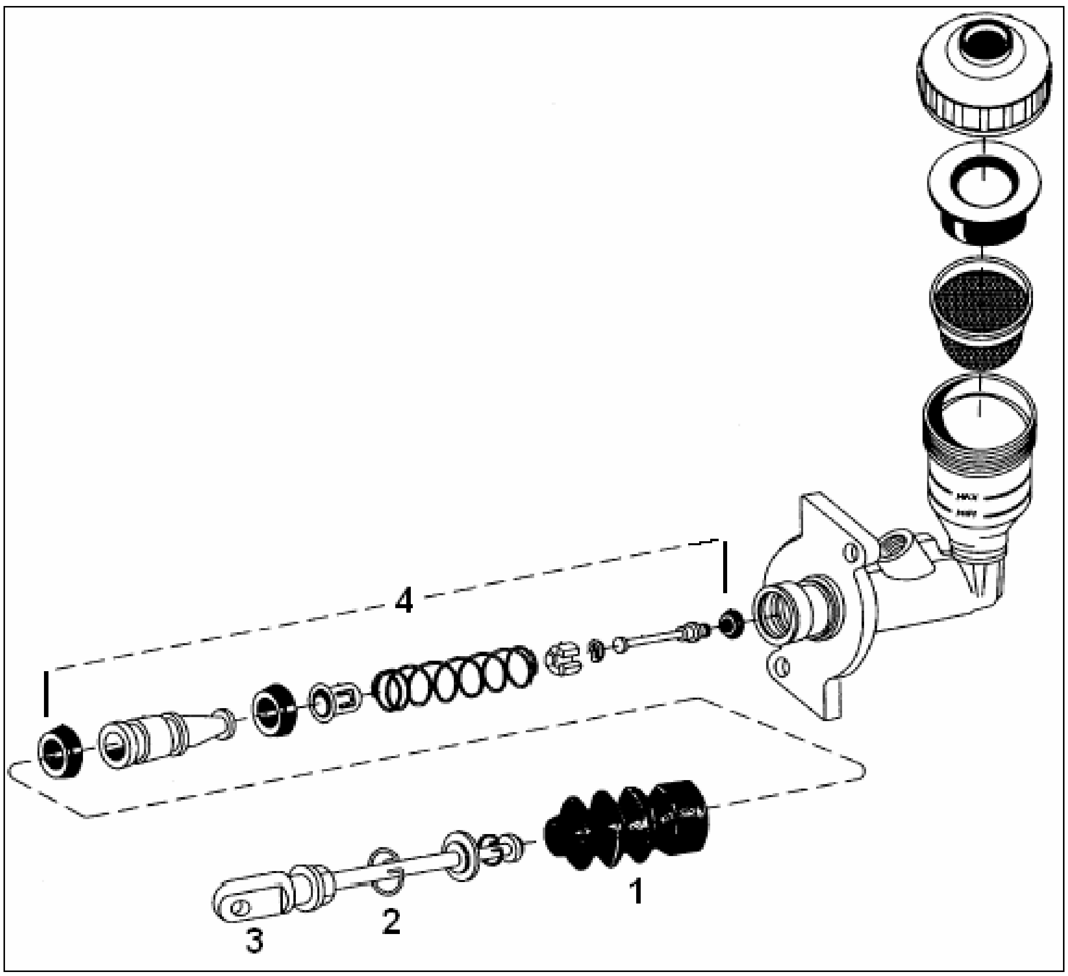
Master cylinder overhaul
Slave cylinder overhaul
Slave cylinder and Concentric bearing Overhaul

Master cylinder overhaul -

	Remove the outlet pipe connection.
	Remove the clevis pin lock & the clevis pin.
	Remove the clutch push rod fork & the clutch pedal.



Remove the master cylinder from the firewall .



1. Pull back the dust cover.

2. Remove circlip.

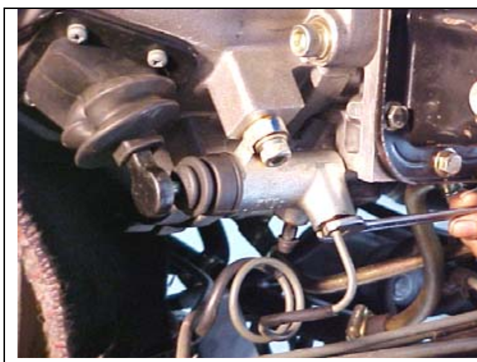
3. Remove the push rod assembly with retainer washer.

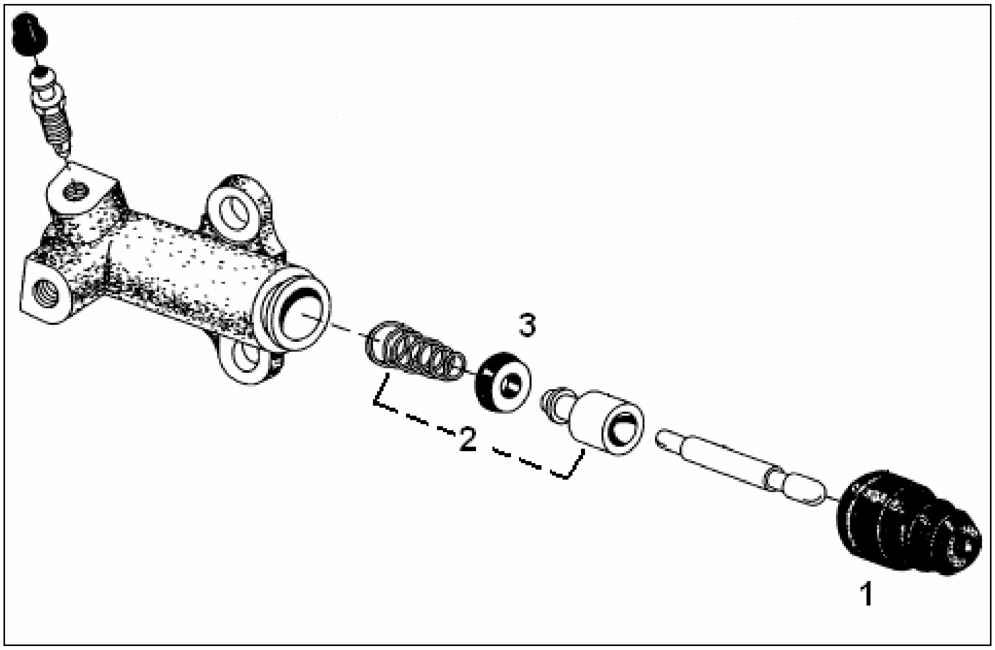
4. Remove the piston assembly by gently tapping the Clutch Master cylinder body on a wooden block.

	Using a screwdriver, lift the leaf spring retainer. Remove spring assembly from plunger.
	Take care, while lifting the spring otherwise the spring and the stem will fall off.
	Compress spring to free valve stem from eccentrically positioned hole in the end face of spring retainer. This will separate spring retainer from valve stem.
	Remove spring, valve spacer and spring washer from the valve stem.
	(While assembling hold the spacer between fingers such that the valve stems hangs down vertically. Pull down the stem downwards as far as possible. Observe if the valve stem has moved freely upwards. If movement is not free replace valve spacer.)

	Remove the valve seal from the valve stem.
	The bore and the plunger should be checked for scoring, scuffing uneven wear marks, corrosion and excessive clearance between plunger & body
	Check the condition of dust cover for cut, deterioration if damaged replace.
	The assembly procedure is the reverse of the dismantling procedure. While fitting the plunger lubricate it with brake fluid.

Slave cylinder overhaul -

	Remove the Bundy pipe from the inlet.
	Remove the slave cylinder from the mounting bracket.

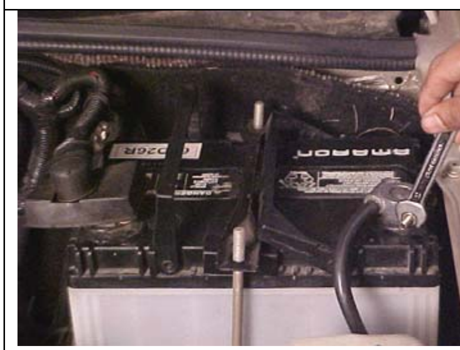


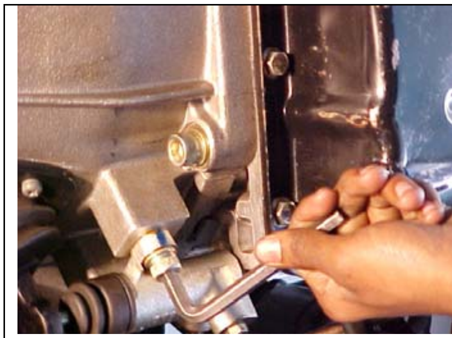
1. Remove dust cover.
2. Remove circlip.
3. Remove plunger with gland seal and plunger spring from body by lightly tapping it on wooden block.
4. Remove gland seal from plunger.

	The bore and the plunger should be checked for scoring, scuffing uneven wear marks, corrosion and excessive clearance between plunger & body
	Check the condition of dust cover for cut, deterioration if damaged replace.
	The assembly procedure is the reverse of the dismantling procedure. While fitting the plunger lubricate it with brake fluid.

!	Make sure that the push rod end is firmly located at the fork.

Clutch overhaul -

	Block the front wheels, so that the vehicle does not move forward.
	Disconnect the negative cable of the battery.
	Remove the electrical connections to the starter motor.
	Remove the starter motor.

	Remove the clutch slave cylinder from the gearbox mounting. Note: Remove the slave cylinder along with the small Bundy tube. Disconnect the Bundy tube from the main tubing.
	Remove the propeller shaft from the gearbox end. Do not allow the propeller shaft to hang. Support it.
	Remove the speedometer cable from the gearbox end
	Remove the electrical connection for the reverse lamp switch.
	Support the engine suitably at rear
	Remove the gearboxes gearshift lever grommet.
	Remove the gearbox lever upper half.
	Support the gearbox using a suitable stand.

	Remove the gearbox mounting insulators.
	Remove the clutch housing mounting screws to the engine rear face & the ladder frame.
	Move the gearbox away from the engine.
	Remove the clutch release bearing with sleeve.
	Remove the clutch fork.
	If the original cover will be reinstalled then mark position of cover on the flywheel for assembly reference. Use paint as a marker for this.
	If the cover assembly may be reused then loosen the cover bolts evenly and in tightening sequence to relive the spring tension equally. The bolts should be loosened few threads at a time – so that the warping is avoided. If the cover assembly is not going to be reused then this precaution is not essential.
	If the pilot bearing has to be removed then the flywheel has to be removed and then the bearing removed using the MST no 543. (To install the bearing MST no 544 has to be used.)
	During assembly use the MST 546 to align the clutch plate while the cover is being tightened.
The assembly sequence is the reverse of the dismantling (except the precautions mentioned.)	

Inspection:

All the components should be inspected for wear. Any components, which are beyond the wear limits, have to be replaced.

Over & above the wear limits: The following points also need to be ensured.

Flywheel runout --

The flywheel runout needs to be checked whenever misalignment is suspected. Flywheel runout should not exceed 0.10 mm

To measure the runout; mount the base of the magnetic dial gauge on the block. Locate the dial gauge's needle on the outer surface of the flywheel.

Some of the common reasons for excessive runout are:
- ✓ Heat warpage.
- ✓ Improper machining.
- ✓ Incorrect bolt tightening
- ✓ Foreign material on crankshaft flange or flywheel.
- ✓ Improper seating on crankshaft.

If the flywheel has been removed for resurfacing or replacing the pilot bearing then while fitting it back ensure that:

- No dirt and grease present on the mounting face (it can cause cocking & run out)

- The flywheel bolts have been replaced.

- Torque tightened as per sequence and also the angular tightening as per the specification is done.

Absence of any of these requirements may result in bolt loosening causing flywheel runout.

Clutch cover & Disc runout --

Check the clutch disc runout before fitting. It should be within the specifications. If it is more than the specification- use a different clutch plate.

A warped cover or diaphragm spring will result in clutch grab and / or incomplete release of clutch plate.

If the clutch alignment tool is not used then the misalignment of the clutch plate can cause distortion of the cover and also disc damage.

The cover can also get misaligned due to improper tightening of the cover onto the flywheel. The only way to avoid is that the bolts must be tightened alternatively (diagonal pattern) and evenly i.e. 2 to 3 thread a time only.

Clutch Housing Misalignment –

The clutch housing has to be aligned with the engine so that the input shaft is aligned with the crankshaft. Absence of this alignment results in clutch noise, incomplete release of the clutch plate. It can normally be judged by uneven wear of the finger and pilot bearing. In severe case it can also damage the spline of the input shaft and clutch hub's well as the clutch splines

- Normally the clutch housing misalignment is a result of:
- Incorrect seating on the engine/transmission.
- Missing alignment dowel holes.
- Loose or missing mounting bolt.
- Mounting surfaces that are damaged/ not parallel.

Before fitting the clutch housing ensure that no dirt, debris or foreign parts are trapped between the mating surface of the transmission & the clutch housing.

Flywheel --

If the flywheel is found to be having minor scoring then it can be resurfaced. However the maximum allowed cut is 0.076 mm. If scoring is deeper than 0.0076 than the flywheel has to be changed. (Excessive material removal will cause the flywheel to either crack/ warpage after installation/ drop in clamping load and will affect the proper clutch release as the travel of release bearing gets affected.)

If the flywheel has been removed for resurfacing or replacing the pilot bearing then while fitting it back ensure that:

- No dirt and grease present on the mounting face (it can cause cocking & run out)

- The flywheel bolts have been replaced.

- Torque tightened as per sequence and also the angular tightening as per the specification is done.

Absence of any of these requirements may result in bolt loosening causing flywheel runouts.

Starter ring replacement: Unless the provision of properly heating & fitting is available. It is not recommended to replace the starter ring. It is worthwhile to replace the ring along with the flywheel.

Caution: If the starter ring is only going to be replaced then :-

- Do not use a gas flame to cut. It can cause local overheating of flywheel.

- The ring gear has to be heated in a oven to get
  uniform expansion. (Nearly 191°C)

- Do not use flame to heat the ring – it can cause
  annealing of the ring teeth and premature failure.

Automotive Sector

Specifications & Wear Limits -

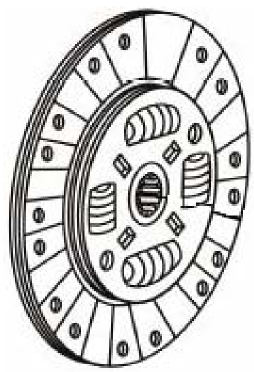
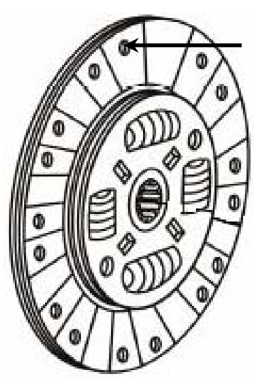
Figure	Description	Value
	Clutch control type-	Hydraulic- self adjusting
	Pressure plate	Diaphragm
	**Clutch Disc** **Outer Dia (mm)** **Inner Dia (mm)**	240±1 160± 1
	Disc Thickness (mm)	8.8 mm (free)
	Clutch disc run out	0.8 mm Max
	**Minimum thickness from outer face to rivet head.**	0.4 mm
	Clutch pedal	Suspended Type
	Clutch pedal Ratio	7.4

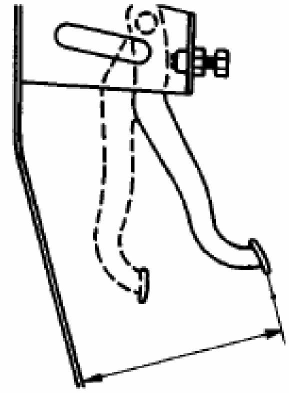
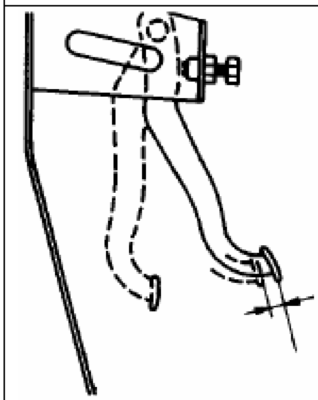
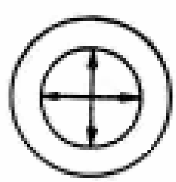
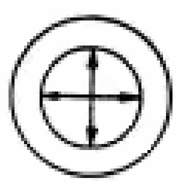
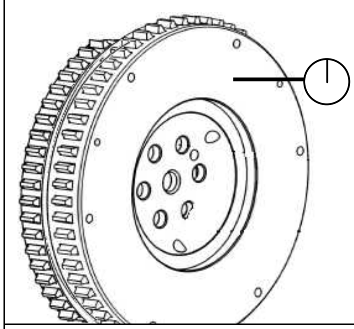
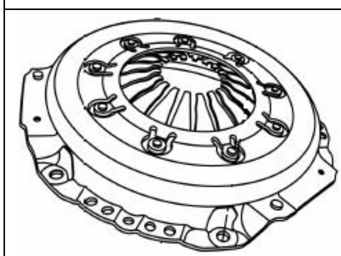
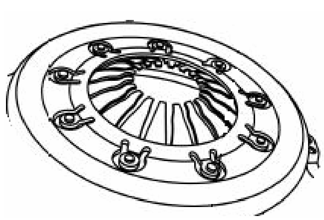
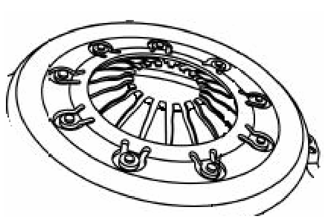
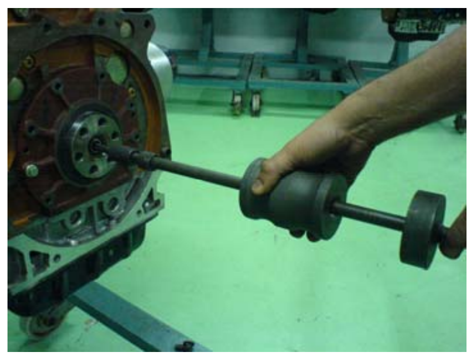
Figure	Description	Value
	**Clutch Pedal Height above carpet thickness of 10 mm.** **Normal** **Under full depression.**	172 mm 165 mm.
	**Clutch pedal free play (including push rod play at pedal top)**	5 to 6 mm
	**Master Cylinder Bore diameter**	19.05 mm
	**Slave Cylinder Inner diameter**	22.22 mm
	Clearance between The piston & the bore (Both cylinders)	0.13 mm

Figure	Description	Value
	**Flywheel** **Flatness** **Runout**	Standard Service Limit $\leq$ 0.05 0.1 $\leq$ 0.05 0.1
	Flywheel **Width from Mounting face to clutch face**	35±0.13
	Clutch release point from pedal full stroke end position	25 mm from Bottom position
	**Pressure plate finger height (mm)**	47.6 ± 1.0 mm
	**Diaphragm spring tip non alignment.(Max)**	0.8 mm (finger to finger)
	**Diaphragm spring finger wear**	Max depth 0.5 mm Max width 5 mm

Tightening Torques -

Location	Torque Nm (Lbft)
Pressure plate bolts	32.5 ± 2.5 Nm (24 ± 2 Lb-ft)
Clutch pedal position Switch lock nut	25 Nm (18 Lb-ft)
Clutch master cylinder nut	25 Nm (18 Lb-ft)
Clutch slave cylinder bolts	45 Nm (33 Lb-ft)
Flywheel Bolts	90 Nm + 60° (66 Lbft + 60°)
Clutch pedal pivot bolt and nut	27.5 ± 2.5 Nm (20 ± 2 Lb-ft)

List of the MSTs -

Description / Part No. / Sketch	Usage View
Master clutch plate assembly-diesel (aligner) **MST 546** 	
Extractor Flywheel bearing **MST 543** 	
Drift Flywheel bearing **MST 544** 	

Lubricant -

Specification: DOT 3

Hindustan Petroleum: HP Super Duty Brake Fluid

Castrol: Girling Brake Fluid

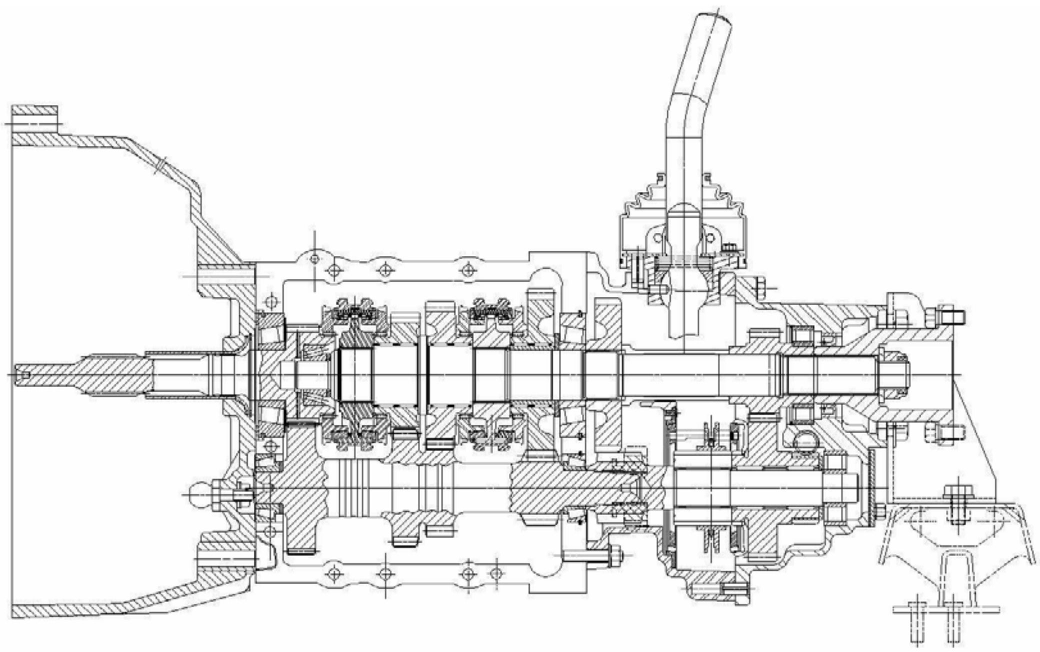
Indian Oil: Servo Brake fluid Super HD

Automotive Sector

NGT 530-2 WD

Contents

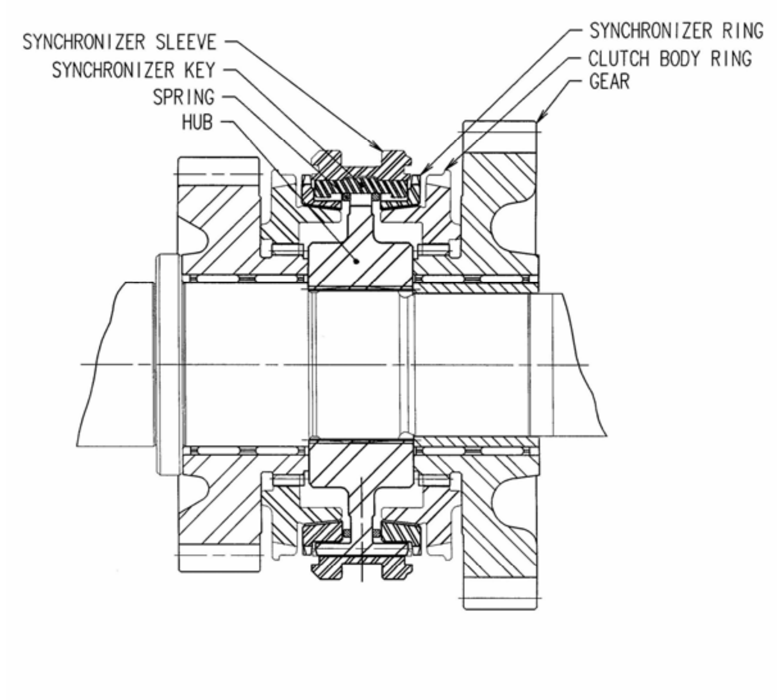
Description -



It is a 5-speed gearbox. All the forward speed is using baulk ring type synchronizer. The reverse gear is sliding mesh type with synchro brake.

The gear selection is by a direct shift lever operating a 3-rail system. The accidental operation of two gears is avoided by an interlocking mechanism. To avoid vibrations passing on to the shift lever. The shift lever is a two-piece with rubber isolation provided on to the top half.

The gearbox housing is aluminium 3 piece with split housing. The Gearbox is mounted directly on the flywheel through the integral clutch housing and supported at bottom below the rear housing using a bracket.



Care of the transmission -

The lubricant level should be checked every 10000 Kms. with the vehicle un-laden and in a level ground. The lubricant level should be at the lower edge of the filler plug. Use lubricant meeting oils specification of GL 4 & viscosity 80W90.The brand names have been specified in the Operators Manual. The other optional grade is 80 W90 Synchro oil. This grade is particularly suitable for cold weather operation.

The lubricant should be changed at 5000 Kilometers, then at 20000 Kilometer's and subsequently every 20000-Kilometer's.

Service Diagnosis -

A low transmission lubricant level is generally the result of a leak, inadequate lubricant fill, or an incorrect lubricant level check.

Leaks can occur at the mating surface of the gear case, intermediate plate and adapter or extension housing or from the front/rear seals. A suspected leak could also be result of an overfill condition.

Leaks at the rear of the extension or adapter housing will be from the housing oil seal. Leaks at component mating surface will probably be the result of inadequate sealer, gaps in sealer, incorrect bolt tightening, or the use of a non-recommended sealer.

A leak at the front of the transmission will be from either the front bearing retainer. Lubricant may be seen dripping from the clutch housing after extended operation. If the leak is severe, it may also contaminate the clutch disc causing slip, grab and chatter.

A correct lubricant level check can be made only when the vehicle is level, use a two post or a four post hoist to ensure this. Also allow the lubricant to settle for a minute or so before checking. These recommendations will ensure that an accurate check and avoid an under fill or overfill conditions.

Hard Shifting

Hard shifting is usually caused by low lubricant level, improper or contaminated lubricants, component damage, and incorrect clutch adjustment or by a damaged clutch pressure plate or disc.

Substantial lubricant leak can result in gear, shift rail, synchro and bearing damage. If a leak goes undetected for an extended period the first indications of a problem are usually hard shifting and noise.

Incorrect or contaminated lubricants can also contribute to hard shifting. The consequence of using non-recommended lubricants is noise, excessive wear, internal bind and hard shifting.

Improper clutch release is one of the most frequent causes of hard shifting. Incorrect adjustment of a worn damaged pressure plate or disc can cause incorrect release. If the clutch problem is advanced then it can result in gear clash during shifts. Incomplete travel of the clutch pedal due to restrictions at the end of stroke (upturned carpet, extra carpet or cover or bend clutch linkage can also cause improper clutch release and hard shift.)

Worn or damaged synchro rings can cause gear clash when shifting any forward gear. In some new or rebuilt transmissions, new synchro rings may tend to stick slightly causing hard or noisy shifts. In most conditions this will decline as the rings wear in.

Transmission noise

Most manual transmissions make some noise during normal operation. Rotating gears can generate slight whine that may only be audible at extreme speeds.

Severe obviously audible transmission noise is generally the result of a lubricant problem. Insufficient, improper or contaminated lubricant can promote rapid wear of gears, synchros, shift rail, forks and bearing's. The overheating caused by a lubricant problem can also lead to gear breakage.

Summarizing the common faults and their cause:

PROBLEM	POSSIBLE CAUSES	CORRECTION
Gear Whine	Low oil level Worn teeth gears Worn bearings	Top up oil. Replace gears Replace bearings.
Knocking or ticking	Chipped gear teeth Foreign matter inside transmission. Defective bearings.	Replace gears. Remove the foreign matter and locate how the foreign matter came inside e.g. missing breather and rectify that also to avoid recurrence. Check drain plug for metal particles. Replace the bearings.
Jumping out of gear	Defective detent springs. Worn out grooves in shift rail. Shaft misalignment. Worn dog teeth in gear Worn out fork pads Worn out synchronizer body.	Replace the detent springs. Replace the shift rails. Replace the gears Replace the fork assembly Replace the synchro

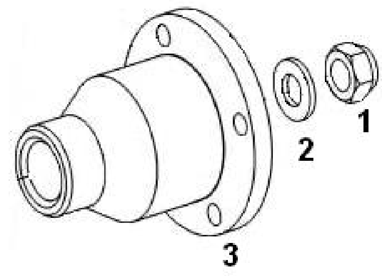
	Gear shift lever fouling with vehicle on vehicles cut-out for lever.	pack Find out the reason for the fouling, correct them.
Unable to select gear	Clutch defective Worn out selector mechanism	Rectify the clutch/ clutch withdrawal mechanism Rectify the gear selector mechanism
Hard gear shifting	Clutch defective Improper or contaminated lubricants	Rectify the clutch/ clutch withdrawal mechanism Replace the lubricant with the specified lubricant. (80 W 90 Synchro Oil)

A: - IN VEHCILE ADJUSTEMENT & REPAIR -

The rectifications in transmission that can be done without removing from the vehicle are:

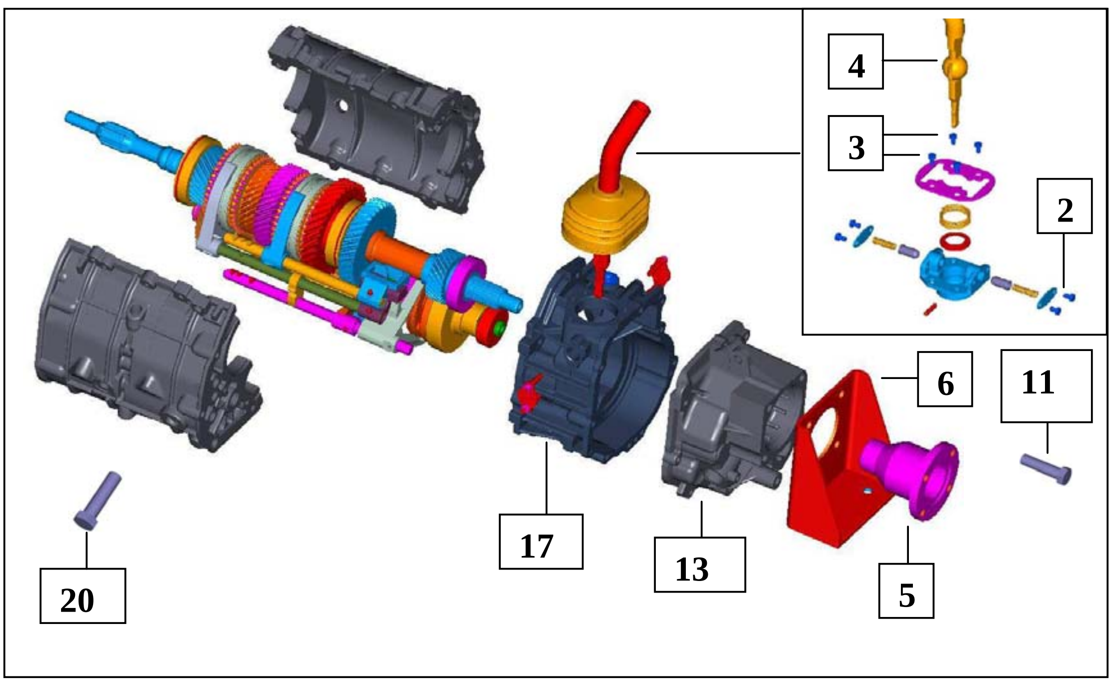
1) Replacement of output shaft seal -

Sketch / Photo	Description
	Remove the propeller shaft from the companion flange
	Lock the companion flange.

	1. Unlock the output shaft nut 3. Remove the companion flange

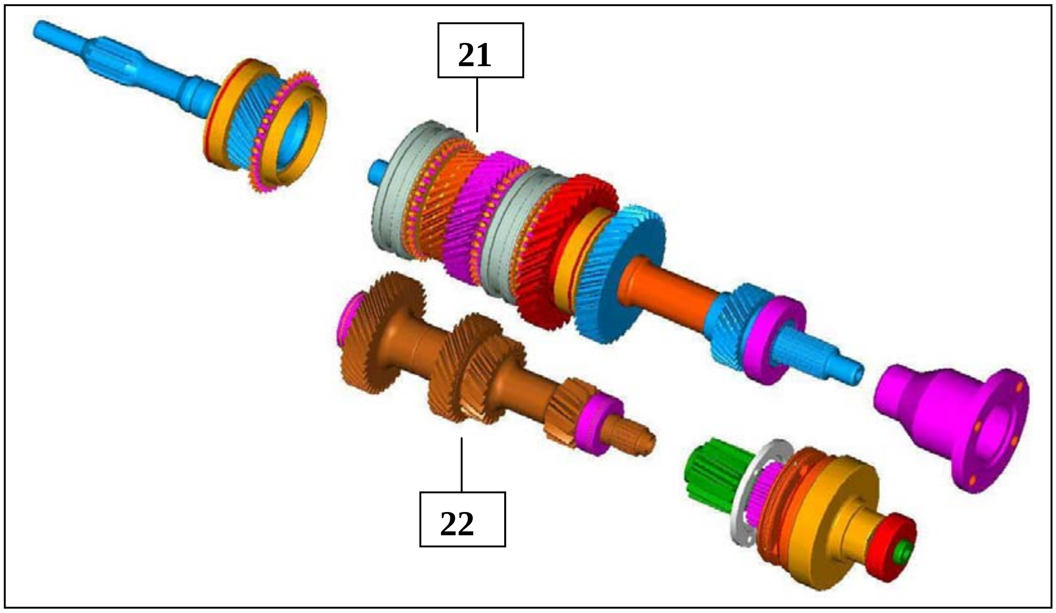
Note: Unless otherwise specified the assembly procedure / guidelines is the reverse of the disassembly procedure

DISMANTLING -



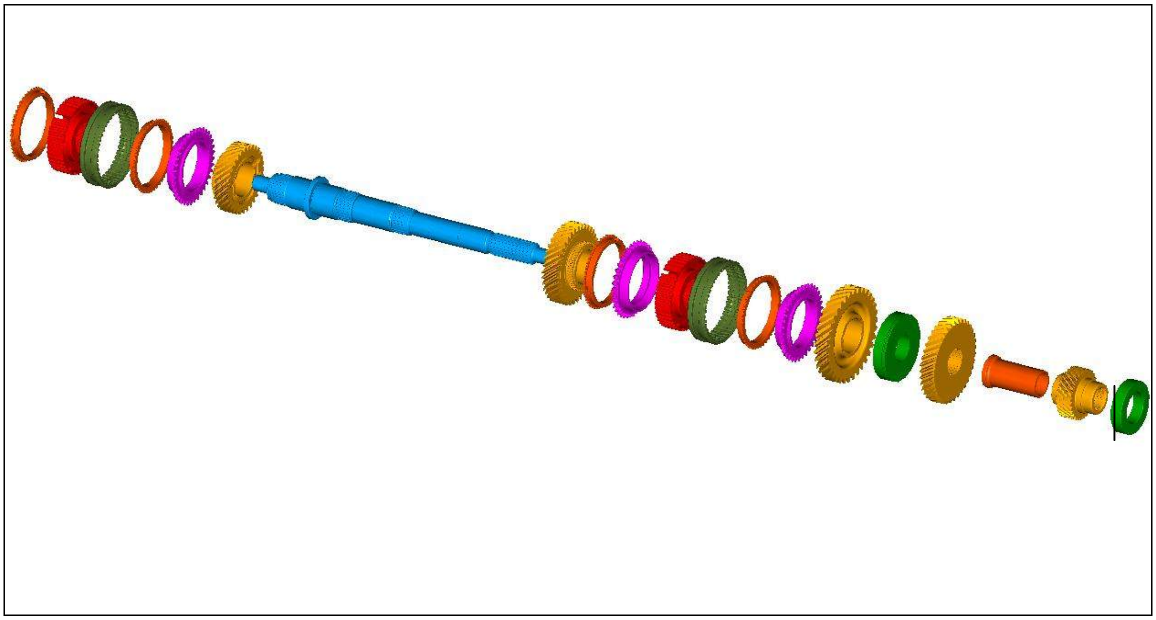
1) Remove Clutch Release bearing & fork.
2) Remove biasing cover plate bolts & springs. – 4 nos. (Check Point A)
3) Remove Lever retention bolts – 3 nos.
4) Put the selector mechanism in neutral & remove lever assembly along with nylon bush & spring.
5) Loosen & Remove the rear companion flange nut & remove the Flange using **MST 203**.

6) Remove the mounting bracket.
7) Loosen & remove the locking bolt & remove the speed sensor.
8) Using the **MST 514** remove the speedometer driven gear. (Check Point B)⟺
9) Remove the reverse light switch.
10) Place the gear box on a wooden block such as the bell housing rests on the block.
11) Loosen & remove rear-housing bolts. (7 Nos.)
12) Remove the plate - cover by unscrewing three nos. bolts & fit the **MST 513** on the rear housing.
13) Tighten the **MST 513** center bolt gently to pull out the rear housing. Gently tap on the rear housing using a soft mallet to make the extraction uniformly from the gearbox. (Check Point C)⟺
14) Remove 5th driven gear using **MST 523** (Check point D)⟺
15) After shifting into the 5th gear install the retaining plate **MST 503** over 5th gear selector fork shaft.
16) Remove rail pins from 5th – Reverse fork. & remove the 5th - reverse fork & synchro pack.
17) Loosen & remove intermediate housing (4 nos. bolts & 3 nos. nuts). By gently tapping remove intermediate housing.
18) Place the gearbox on Gear Box mounting stand **MST 522**. (Check Point E)⟺



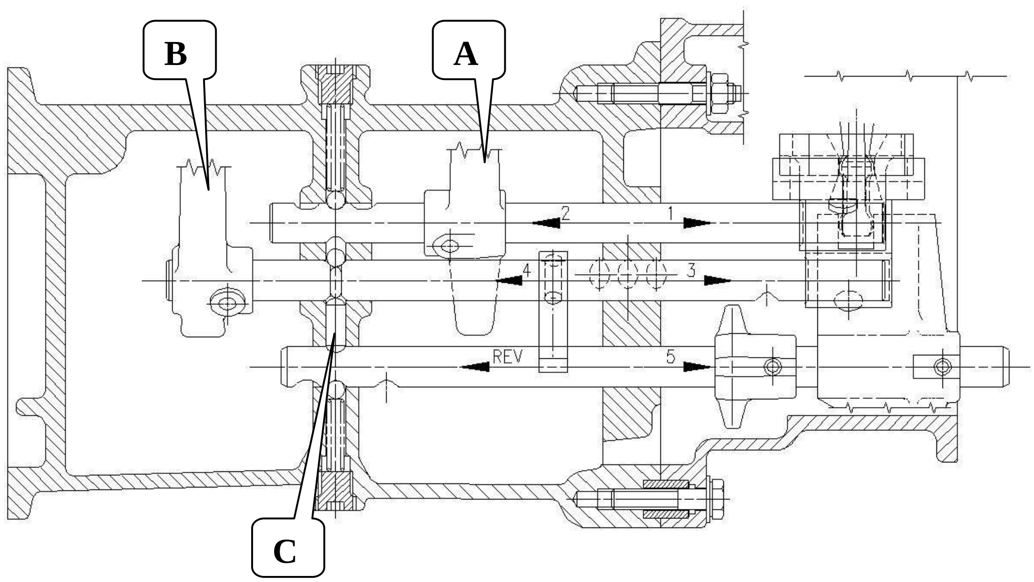
20) Loosen & remove the split housing bolts (12 Nos.) & remove housing.
21) Remove the main shaft assembly & MD gear assembly.
22) Remove the counter shaft assembly.

Dismantling -- Main Shaft Assembly –



1) Remove circlip & remove taper roller bearing, 3rd-4th synchro unit,
2) & 3rd gear.
3) Remove 5th driven gear using MST 523.
4) Remove distance sleeve & reverse main gear.
5) Place the main shaft on mechanical press with **MST 511**.
6) Remove spacer, 1st gear, 1st – 2nd synchro unit & 2nd gear.

Shift Mechanism -

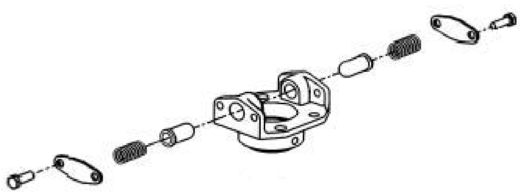
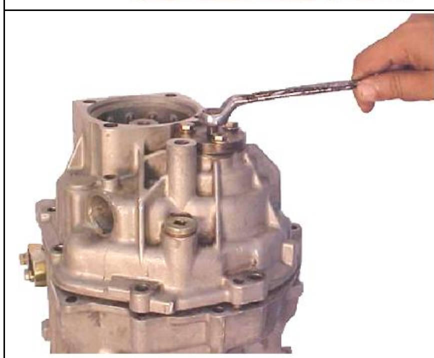


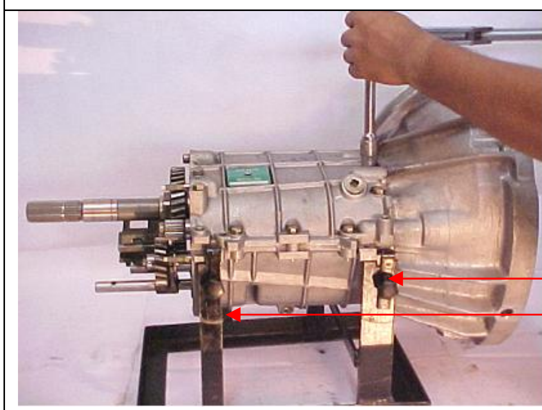
Note :

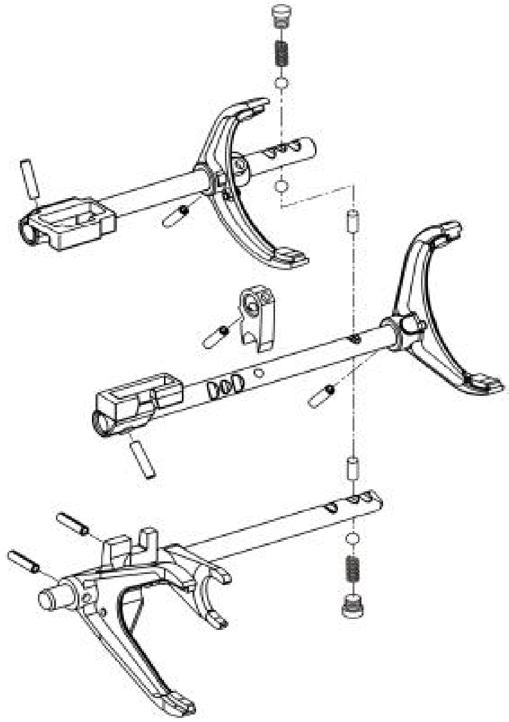
A : 1st / 2nd fork boss is facing towards rear.
B: 3rd/4th fork boss is facing towards front.
C : The position of the interlock pin.

Suggestion : While assembly lightly smear the interlock pin & the detent spring & the balls with grease, so that they do not fall. (Check Point F)

Check Points -

	**A)** Springs towards 1^{st} / 2^{nd} gear position is softer than 5^{th} / reverse position.
	**B)** Use MST 514 to pull out the speedo drive.
	**C)** While tightening the centre bolt of the special tool ; tighten it gently. To make the extraction easier tap the rear cover using a soft mallet.

	**D)** Use MST 523 to remove the 5th Gear. All the legs should be locked properly. Care must be taken not to damage the roller bearing.
	**E)** While mounting the gear box on support stand the orientation to be ensured as shown in photograph. **<u>Lock on only one support leg.</u>** **<u>Lock on both the support legs.</u>**

	**F)** Please note the fitment of the balls & the interlock pins. It is recommended that while assembly lightly smear the pin & balls with grease. This will avoid the ball or the pin falling down while assembly
	Caution : **The split portion of the spilit pin should be along the axis of the rail. That is in the same direction of the rail travel.** **If fitted facing the fork then during shifting , due to compression the pin can fall down.**

Adjustments

The adjustments are required to achieve the following parameters:

The shimming which is done at the 4^{th} gear is done so that the position of the 4^{th} gear synchro cone is correct. Wrong / improper setting will lead to 4^{th} gear slip.

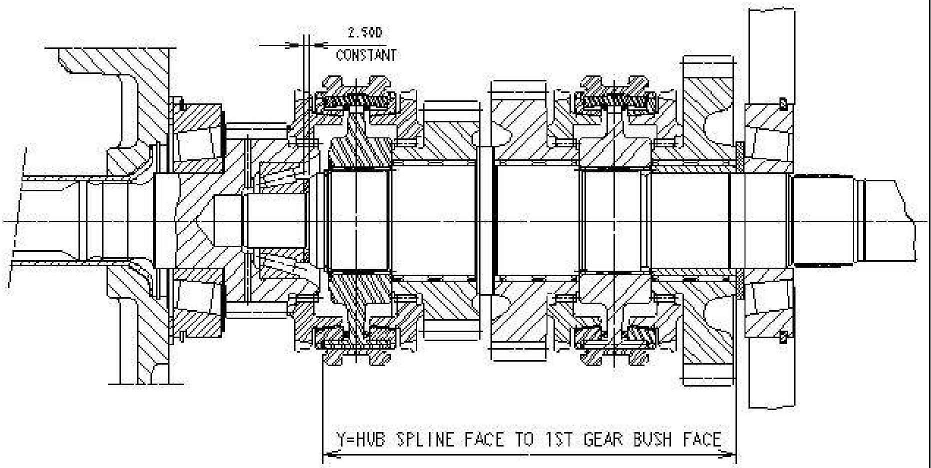
It is advisable to use the same shims.

The shaft re-shimming is only required if either of the components are changed:

- Main shaft
- 1^{st}/2^{nd} hub.
- 3^{rd}/4^{th} hub.
- Needle bearing of 1^{st} or 2^{nd} gear.
- Bush 1^{st} gear.

The shimming sketch & available shims are shown in the sketch.

SHIMMING OUTPUT SHAFT



DIMN 'Y'		SPACER THICKNESS
Y MAX(>=)	Y MIN(<)	
149.375	149.425	3.35
149.425	149.475	3.3
149.475	149.525	3.25
149.525	149.575	3.2
149.575	149.625	3.15
149.625	149.675	3.1
149.675	149.725	3.05
149.725	149.775	3.00
149.775	149.825	2.95
149.825	149.875	2.9
149.875	149.925	2.85
149.925	149.975	2.8
149.975	150.025	2.75
150.025	150.075	2.7
150.075	150.125	2.65
150.125 AND ABOVE		2.60

Cleaning & Inspection –

Clean the transmission parts in solvent.
Dry the housing gear mechanisms & shafts with compressed air.

Do not use the compressed air to clean / dry the bearings. It can cause damage to raceways and rollers.

Inspect the -

A. Bearings for:
Excessive pitting
Brinelling
Flaking
Overheating of raceways

B. Gears for:
Teeth breakage
Teeth pitting

C. Synchronizer rings:

Check for excessive wear. The lubrication grooves should be present.

D. Clutch body ring:

Check for excessively worn out tooth.

E. Sliding sleeve:

Check for excessive wear of the groove & wear of the teeth.

F. Forks:

Check for excessive wear causing excess play when they are located in the sleeve.

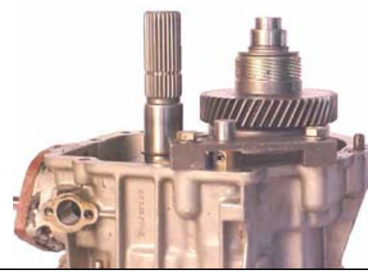
G. Shift rails:

Check for wear in the poppet groove.

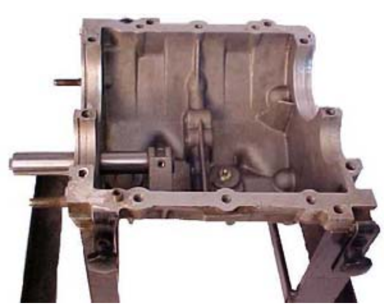
Tightening Torques -

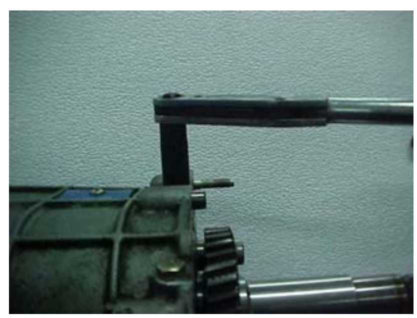
Description	Torque Nm (lbf-ft)
Companion Flange nut	183 ± 20 (135 ± 15 lbf-ft)
Plugs for shift rail poppet spring	12.5 ± 2.5 Nm (9 ± 2 lbf-ft)
Ft. housing bolts (split housing) M7 bolts	10 ± 2.5 Nm (7 ± 2 lbf-ft)
Ft. housing bolts (split housing) M 8 bolts	15 ± 2.5 Nm (11 ± 2 lbf-ft)
Drain plug	27.5 ± 2.5 Nm (20 ± 2 lbf-ft)
Filler plug	27.5 ± 2.5 Nm (20 ± 2 lbf-ft)
Reverse light switch	27.5 ± 5 Nm (20 ± 4 lbf-ft)
Clutch housing bolts M10	30 ± 5 Nm (22 ± 4 lbf-ft)
Intermediate Housing bolts M8	17.5 ± 2.5 Nm (13 ± 2 lbf-ft)
Rear Housing bolts M8	15 ± 2.5 Nm (11 ± 2 lbf-ft)
Bolt - Mounting Brackets	27.5 ± 2.5 Nm (20 ± 2 lbf-ft)
Rear housing cover plate	8 ± 2 Nm (6 ± 1 lbf-ft)
Biasing bolt M6x1s	8 ± 2 Nm (6 ± 1 lbf-ft)

Special Tools --

Description/ Part No./ Sketch	Usage View
Press Plate 5th Gear Removal **MST - 502** 	
BA10 5th Rev. Rail Ret. Plate **MST - 503** 	
Press Block 5th Gear Removal **MST - 505** 	
Output Shaft Roller Bearing Press **MST - 507** 	

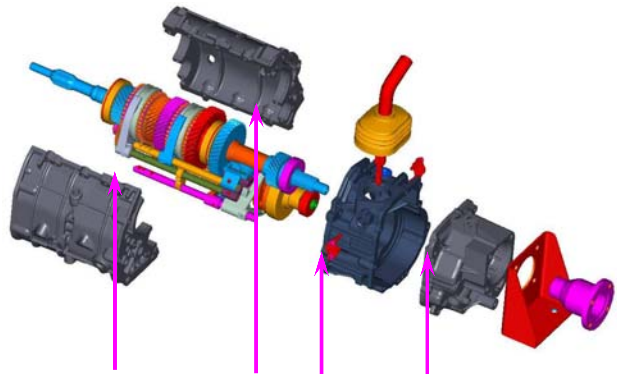
Description/ Part No./ Sketch	Usage View
5th/Rev Sub Shaft Bearing Installer **MST - 508** 	
Press Plate For Input Shaft **MST - 511** 	
Rear Housing Seal Installing Ring **MST - 512** 	
Extractor Rear Housing. **MST - 513** 	

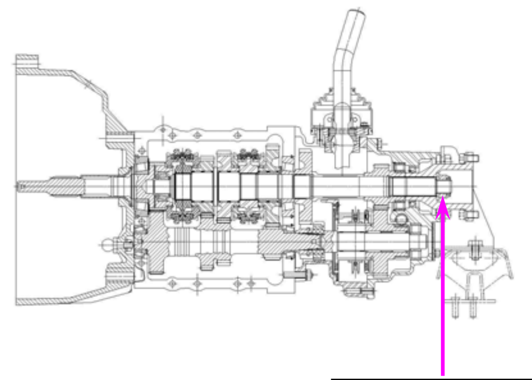
Description/ Part No./ Sketch	Usage View
BA10 Circlip Plier For Speedo **MST – 514** 	
Dial Indicator Support **MST – 515** 	
BA10 Drift **MST – 517** 	 

Description/ Part No./ Sketch	Usage View
Socket **MST - 518** 	
Socket Hex Hd M8 3/8 Sq Drive **MST - 519** 	
Socket Hex Hd M7 3/8 Sq Drive **MST - 520** 	
Support Transmission **MST - 522** 	

Description/ Part No./ Sketch	Usage View
BA10 Fix. To Extract 5th Gear **MST - 523** 	
BA10 Extractor For Reverse Sub Shaft Bearing **MST - 524** 	
Extractor For Roller Bearing On 5th **Gear MST - 525** 	

SEALANTS: -





Serial number	Location	Sealant / Thread Locks	Applicability
			NGT 530
1	Clutch Hsg. / Split Hsg. / Intermediate Hsg. / Rear Hsg.	Rhodoseal 5632 Option 1 – CAF 33 Option 2 – Pidiseal 3P Option 3 – Loctite 574	✓
4	Breather	Loctite 648 Option 1 – Anabond 413 Option 2 – ANR 138	✓
5	Pivot locking	RTV Sealant Metlock 920 Option 1 Rhodoseal Option 2 Pidiseal 3 P	✓
6	Companion Flange Lock Nut (Output Shaft Thd.)	Anabond 111	✓
7	Speedo Sleeve Thd.	Pidilite 171	✓

9	Clutch release bearing support sleeve	Loctite 510	✓
10	Poppet plug M12x1.25	Loctite 542 Option 1 – Anabond 612	✓

Specifications -

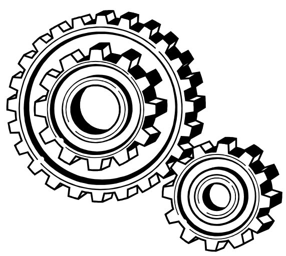
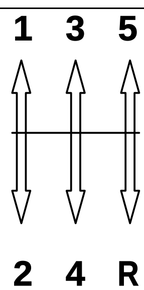
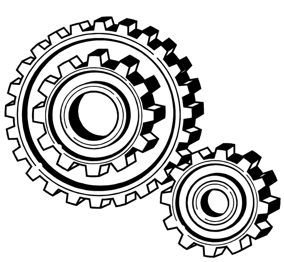
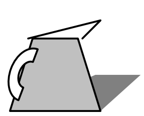
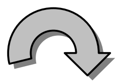
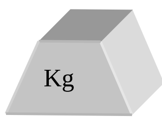
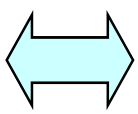
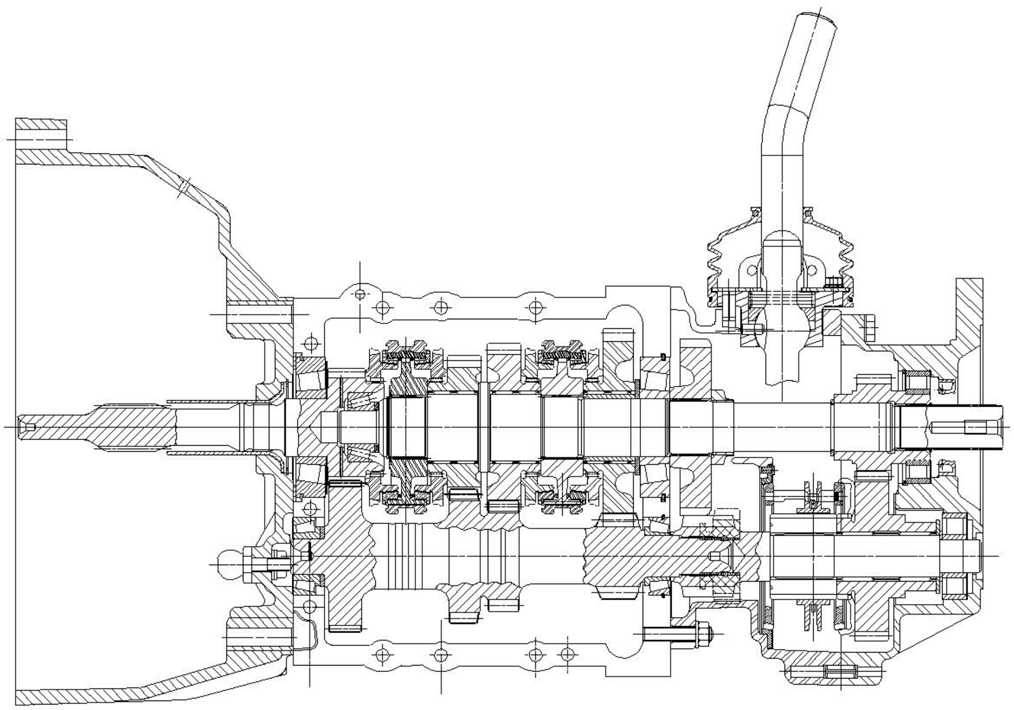
Figure	Description	Value
	Type	Mechanical
	Description	NGT 530
	Gears	5 Forward and one reverse gear
	Gear shift	Direct shift with rubberized lever
	**Gears**	Helical- tooth
	**Gear Engagement**	Block ring type synchronizer on ½, ¾; pin type on 5th
	**Gear Ratio** **1st** **2nd** **3rd** **4th** **5th** **Reverse**	Scorpio CRDe, (V4) 3.78 2.09 1.38 1.00 0.79 3.52
	**Oil grade/ quantity**	80 W90; GL 4 or 80 W90 Synchro GL4 Fill Quantity: 2.0 liters

Figure	Description	Value	
	Counter shaft bearing	Taper roller bearing.	
	**Input Torque capacity**	27 Kg – m	
	**Weight (With clutch housing)**	42.5 Kgs W/O Oil	
	**Play**	Limit (mm)	Service limit(mm)
	1st	0.175	0.375
	2nd	0.175	0.375
	3rd	0.175	0.375
	4th	0.175	0.375
	5th	0.18	0.3
	Fork to groove clearances	0.1 to 0.4	

NGT 530 4WD

Contents

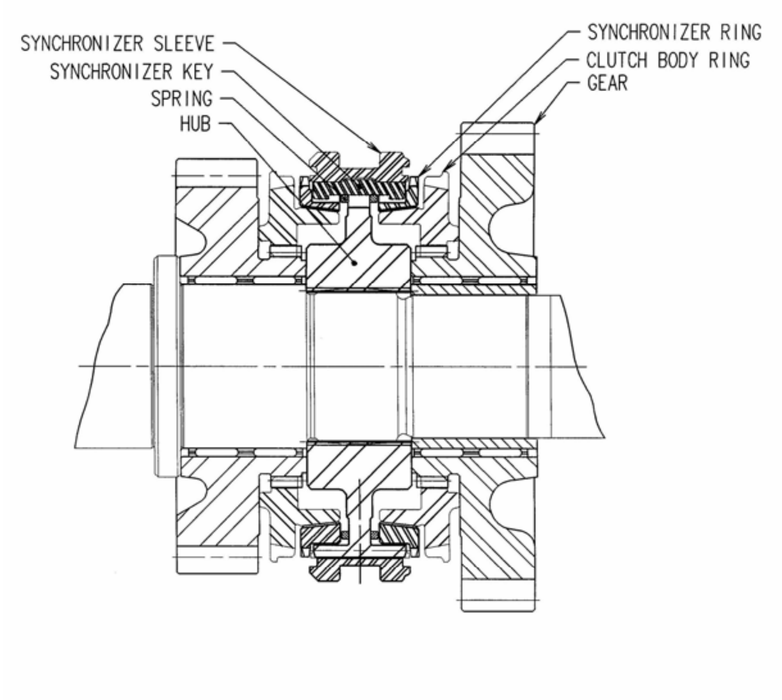
Description --



It is a 5-speed gearbox. All the forward speed is using baulk ring type synchronizer. The reverse gear is sliding mesh type with synchro brake.

The gear selection is by a direct shift lever operating a 3-rail system. The accidental operation of two gears is avoided by an interlocking mechanism. To avoid vibrations passing on to the shift lever. The shift lever is a two-piece with rubber isolation provided on to the top half.

The gearbox housing is aluminum 3 piece with split housing. The Gearbox is mounted directly on the flywheel through the integral clutch housing and supported at bottom below the rear housing using a bracket.



Care of the transmission --

The lubricant level should be checked every 10000 Kms. with the vehicle unladen and in a level ground. The lubricant level should be at the lower edge of the filler plug. Use lubricant meeting oils specification of GL 4 & viscosity 80W90.The brand names have been specified in the Operators Manual. The other optional grade is 80 W90 Synchro oil. This grade is particularly suitable for cold weather operation.

The lubricant should be changed at 5000 Kilometers, then at 20000 Kilometer's and subsequently every 20000-Kilometer's.

Service Diagnosis –

A low transmission lubricant level is generally the result of a leak, inadequate lubricant fill, or an incorrect lubricant level check.

Leaks can occur at the mating surface of the gear case, intermediate plate and adapter or extension housing or from the front/rear seals. A suspected leak could also be result of an overfill condition.

Leaks at the rear of the extension or adapter housing will be from the housing oil seal. Leaks at component mating surface will probably be the

result of inadequate sealer, gaps in sealer, incorrect bolt tightening, or the use of a non-recommended sealer.

A leak at the front of the transmission will be from either the front bearing retainer . Lubricant may be seen dripping from the clutch housing after extended operation. If the leak is severe, it may also contaminate the clutch disc causing slip, grab and chatter.

A correct lubricant level check can be made only when the vehicle is level, use a two post or a four post hoist to ensure this. Also allow the lubricant to settle for a minute or so before checking. These recommendations will ensure that an accurate check and avoid an under fill or overfill conditions.

Hard Shifting

Hard shifting is usually caused by low lubricant level, improper or contaminated lubricants, component damage, and incorrect clutch adjustment or by a damaged clutch pressure plate or disc.

Substantial lubricant leak can result in gear, shift rail, synchro and bearing damage. If a leak goes undetected for an extended period the first indications of a problem are usually hard shifting and noise.

Incorrect or contaminated lubricants can also contribute to hard shifting. The consequence of using non-recommended lubricants is noise, excessive wear, internal bind and hard shifting.

Improper clutch release is one of the most frequent causes of hard shifting. Incorrect adjustment of a worn damaged pressure plate or disc can cause incorrect release. If the clutch problem is advanced then gear clash during shifts can result. Incomplete travel of the clutch pedal due to restrictions at the end of stroke (upturned carpet, extra carpet or cover or bend clutch linkage can also cause improper clutch release and hard shift.)

Worn or damaged synchro rings can cause gear clash when shifting any forward gear. In some new or rebuilt transmissions, new synchro rings may tend to stick slightly causing hard or noisy shifts. In most conditions this will decline as the rings wear in.

Transmission noise

Most manual transmissions make some noise during normal operation. Rotating gears can generate slight whine that may only be audible at extreme speeds.

Severe obviously audible transmission noise is generally the result of a lubricant problem. Insufficient, improper or contaminated lubricant can promote rapid wear of gears, synchros, shift rail, forks and bearing's. The overheating caused by a lubricant problem can also lead to gear breakage.

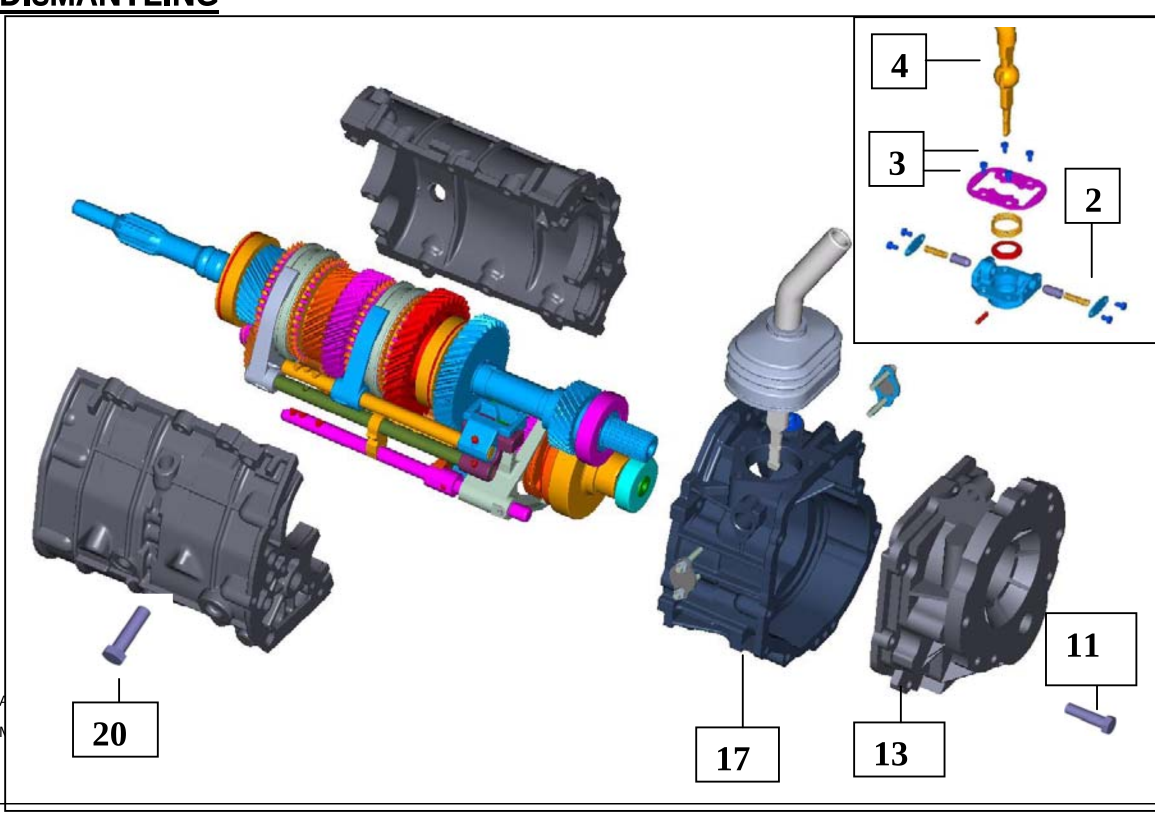
Summarizing the common faults and their cause:

PROBLEM	POSSIBLE CAUSES	CORRECTION
Gear Whine	Low oil level Worn teeth gears Worn bearings	Top up oil. Replace gears Replace bearings.
Knocking or ticking	Chipped gear teeth Foreign matter inside transmission. Defective bearings.	Replace gears. Remove the foreign matter and locate how the foreign matter came inside e.g. missing breather and rectify that also to avoid recurrence. Check drain plug for metal particles. Replace the bearings.
Jumping out of gear	Defective detent springs. Worn out grooves in shift rail. Shaft misalignment.	Replace the detent springs. Replace the shift rails.

	Worn dog teeth in gear Worn out fork pads Worn out synchronizer body. Gear shift lever fouling with vehicle vehicles cutout for lever.	Replace the gears Replace the fork assembly Replace the synchro pack Find out the reason for the fouling, correct them.
Unable to select gear	Clutch defective Worn out selector mechanism	Rectify the clutch/ clutch withdrawal mechanism Rectify the gear selector mechanism
Hard gear shifting	Clutch defective Improper or contaminated lubricants	Rectify the clutch/ clutch withdrawal mechanism Replace the lubricant with the specified lubricant. (80 W 90 Synchro Oil)

Note: Unless otherwise specified the assembly procedure / guidelines is the reverse of the disassembly procedure

DISMANTLING –

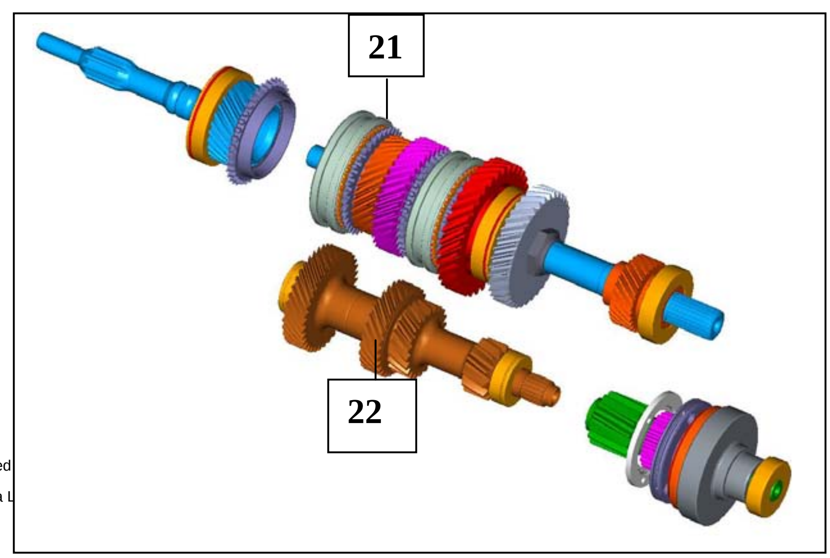


1) Remove Clutch Release bearing & fork.
2) Remove biasing cover plate bolts & springs. – 4 nos. (Check Point A)
3) Remove Lever retention bolts – 3 nos.
4) Put the selector mechanism in neutral & remove lever assembly along with nylon bush & spring.

5) Remove the mounting bracket.

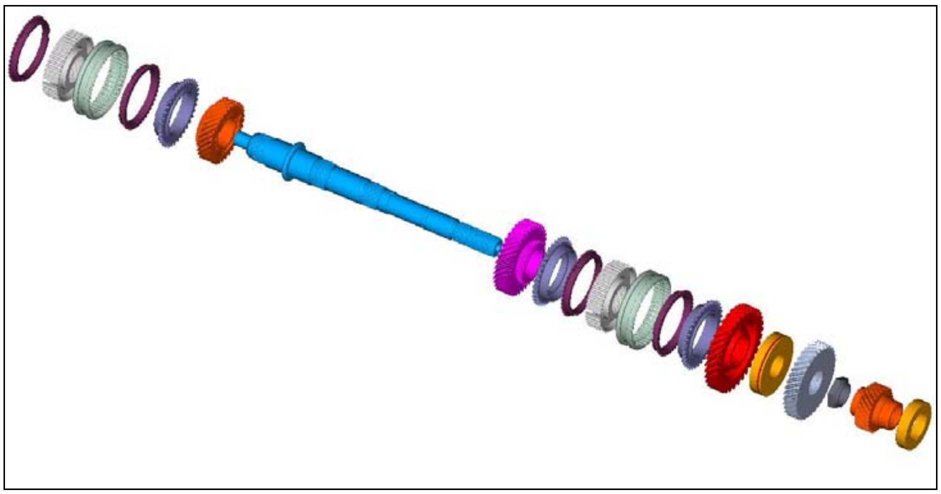
6) Using the **MST 514** remove the speedometer driven gear. (Check Point B)
7) Remove the reverse light switch.
8) Place the gear box on a wooden block such as the bell housing rests on the block.
9) Loosen & remove rear-housing bolts. (7 Nos.)

10) Remove 5th driven gear using **MST 523** (Check point D)
11) After shifting into the 5th gear install the retaining
12) plate **MST 503** over 5th gear selector fork shaft.
13) Remove rail pins from 5th – Reverse fork. & remove the 5th - reverse fork & synchro pack.
14) Loosen & remove intermediate housing (4 nos. bolts & 3 nos. nuts). By gently tapping remove intermediate housing.
15) Place the gearbox on GearBox mounting stand **MST 522**. (Check Point E)



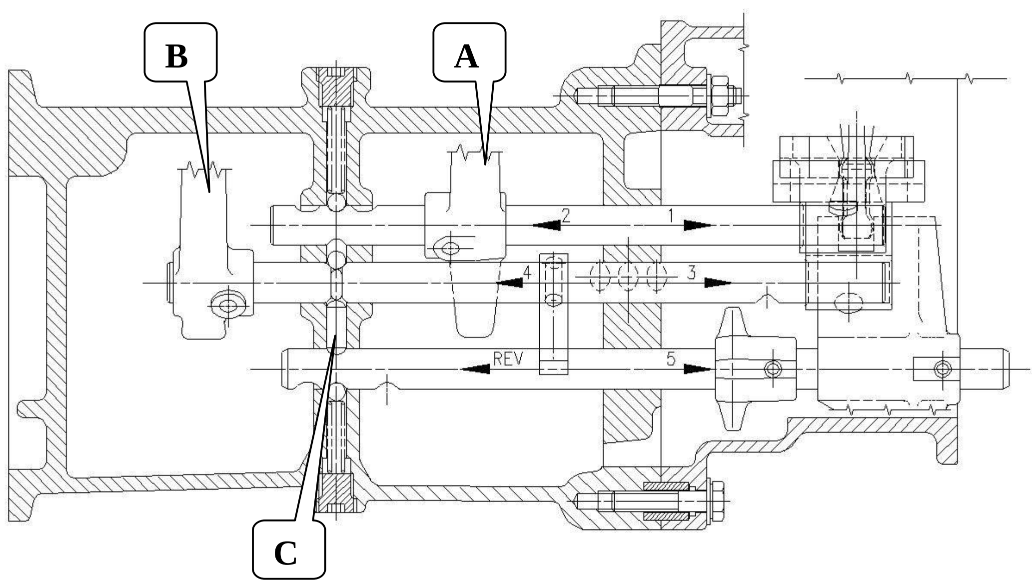
16) Loosen & remove clutch housing bolts (7 Nos.) & the housing.
17) Loosen & remove the split housing bolts (12 Nos.) & remove housing.
18) Remove the main shaft assembly & MD gear assembly.
19) Remove the counter shaft assembly.

Dismantling -- Main Shaft Assembly -



1) Remove circlip & remove taper roller bearing, 3rd-4th synchro unit, & 3rd gear.
2) Remove 5th driven gear using MST 523.
3) Loosen & Remove the nut & reverse main gear.
4) Place the main shaft on mechanical press with **MST 511**.
5) Remove spacer, 1st gear, 1st – 2nd synchro unit & 2nd gear.

Shift Mechanism -

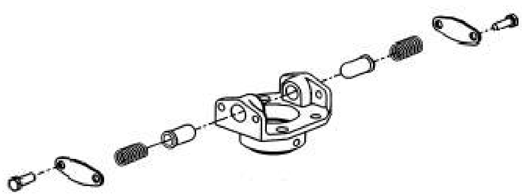
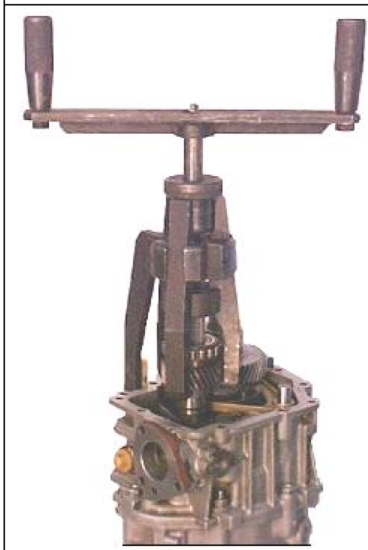
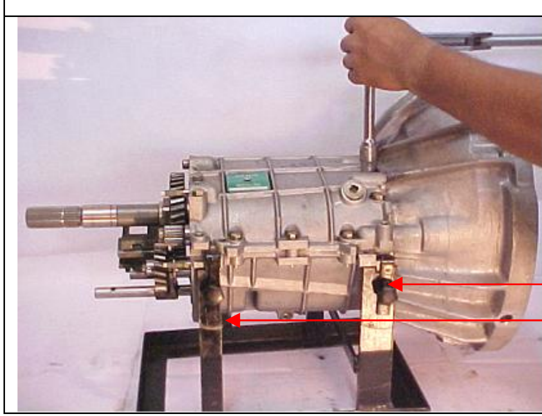


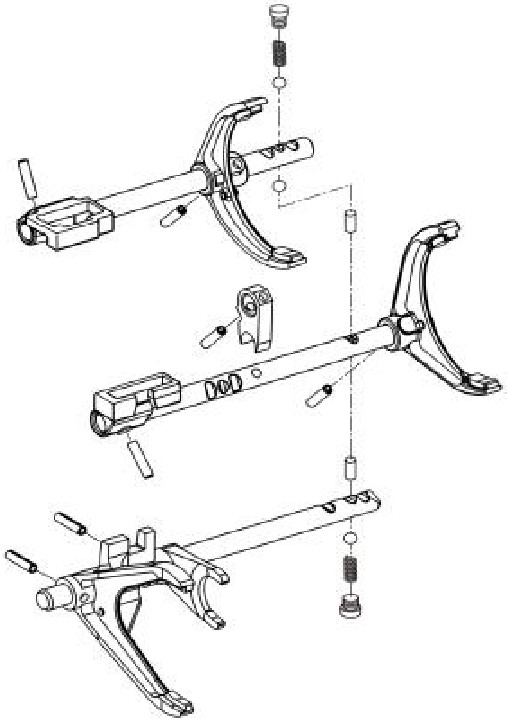
Note :

A : 1^{st} / 2^{nd} fork boss is facing towards rear.
B: 3^{rd}/4^{th} fork boss is facing towards front.
C : The postion of the interlock pin.

Suggestion : While assmbly lightly smear the interlock pin & the detent spring & the balls with grease, so that they do not fall. (Check Point F)

Check Points -

	**A)** Springs towards 1st / 2nd gear position is softer than 5th / reverse position.
	**D)** Use MST 523 to remove the 5th Gear. All the legs should be locked properly. Care must be taken not to damage the roller bearing.
	**E)** While mounting the gear box on support stand the orientation to be ensured as shown in photograph. **<u>Lock on only one support leg.</u>** **<u>Lock on both the support legs.</u>**



F) Please note the fitment of the balls & the interlock pins.

It is recommended that while assembly lightly smear the pin & balls with grease.

This will avoid the ball or the pin falling down while assembly

Caution :

The split portion of the spilit pin should be along the axis of the rail. That is in the same direction of the rail travel.

If fitted facing the fork then during shifting , due to compression the pin can fall down.

Adjustments

The adjustments are required to achieve the following parameters:

The shimming which is done at the 4th gear is done so that the postion of the 4th gear synchro cone is correct. Wrong / improper setting will lead to 4th gear slip.

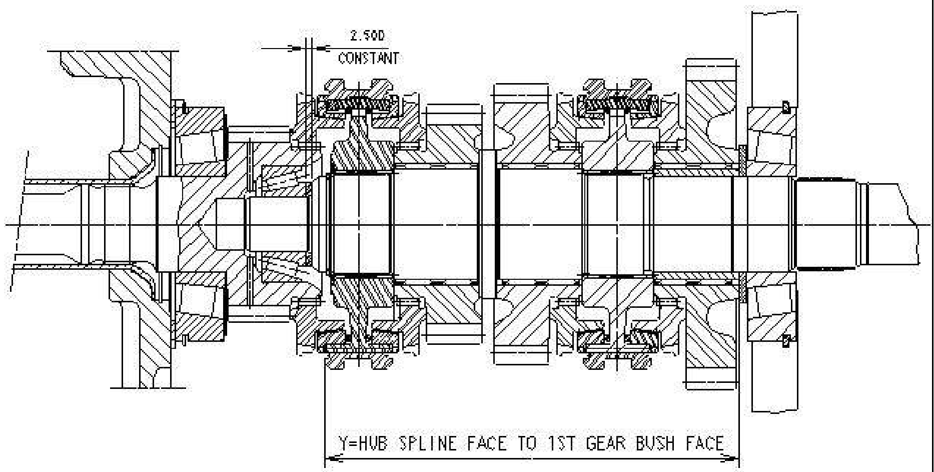
It is advisable to use the same shims.

The shaft reshimming is only required if either of the comonnets are changed:

- Main shaft
- 1st/2nd hub.
- 3rd/4th hub.
- Needle bearing of 1st or 2nd gear.
- Bush 1st gear.

The shimming sketch & available shims are shown in the sketch.

SHIMMING OUTPUT SHAFT



DIMN 'Y'		SPACER THICKNESS
Y MAX(>=)	Y MIN(<)	
149.375	149.425	3.35
149.425	149.475	3.3
149.475	149.525	3.25
149.525	149.575	3.2
149.575	149.625	3.15
149.625	149.675	3.1
149.675	149.725	3.05
149.725	149.775	3.00
149.775	149.825	2.95
149.825	149.875	2.9
149.875	149.925	2.85
149.925	149.975	2.8
149.975	150.025	2.75
150.025	150.075	2.7
150.075	150.125	2.65
150.125 AND ABOVE		2.60

Cleaning & Inspection –

Clean the transmission parts in solvent.
Dry the housing gear mechanisms & shafts with compressed air.

Do not use the compressed air to clean / dry the bearings. It can cause damage to raceways and rollers.

Inspect the –

A. Bearings for:
Excessive pitting.
Brinelling
Flaking.
Overheating of raceways.

B. Gears for:
Teeth breakage.
Teeth pitting.

C. Synchronizer rings:

Check for excessive wear. The lubrication grooves should be present.

D. Clutch body ring:

check for excessively worn out tooth.

E. Sliding sleeve:

Check for excessive wear of the groove & wear of the teeth.

F. Forks:

Check for excessive wear causing excess play when they are located in the sleeve.

G. Shift rails:

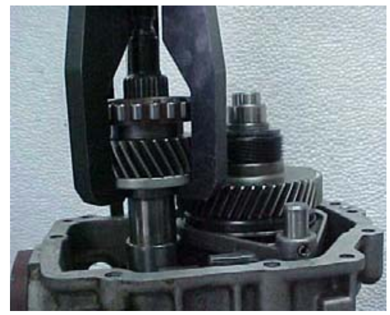
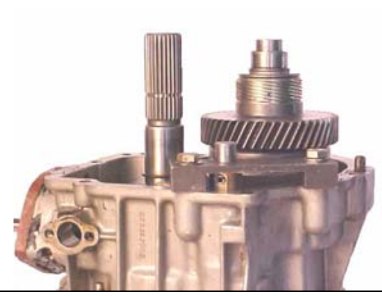
Check for wear in the poppet groove.

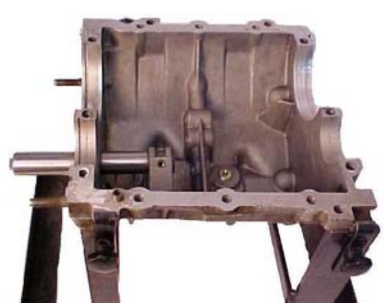
Tightening Torques -

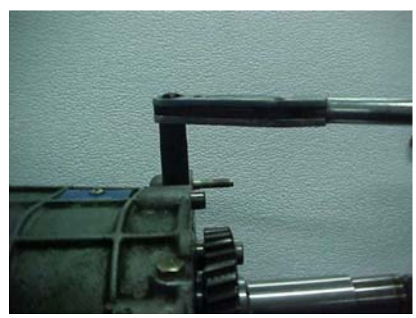
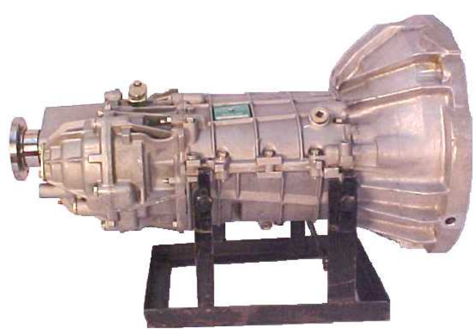
Description	Torque Nm (lbf-ft)
Plugs for shift rail poppet spring	**12.5 ± 2.5 Nm (9 ± 2 lbf-ft)**
Ft. housing bolts (split housing) M7 bolts	**10 ± 2.5 Nm (7 ± 2 lbf-ft)**
Ft. housing bolts (split housing) M8 bolts	**15 ± 2.5 Nm (11 ± 2 lbf-ft)**
Drain plug	**27.5 ± 2.5 Nm (20 ± 2 lbf-ft)**
Filler plug	**27.5 ± 2.5 Nm (20 ± 2 lbf-ft)**
Reverse light switch	**27.5 ± 5 Nm (20 ± 4 lbf-ft)**
Clutch housing bolts M10	**30 ± 5 Nm (22 ± 4 lbf-ft)**
Intermediate Housing bolts M8	**17.5 ± 2.5 Nm (13 ± 2 lbf-ft)**
Rear Housing bolts M8	**15 ± 2.5 Nm (11 ± 2 lbf-ft)**
Bolt – Mounting Brackets	**27.5 ± 2.5 Nm (20 ± 2 lbf-ft)**
Rear housing cover plate	**8 ± 2 Nm (6 ± 1 lbf-ft)**
Biasing bolt M6x1s	**8 ± 2 Nm (6 ± 1 lbf-ft)**

Automotive Sector

Special Tools --

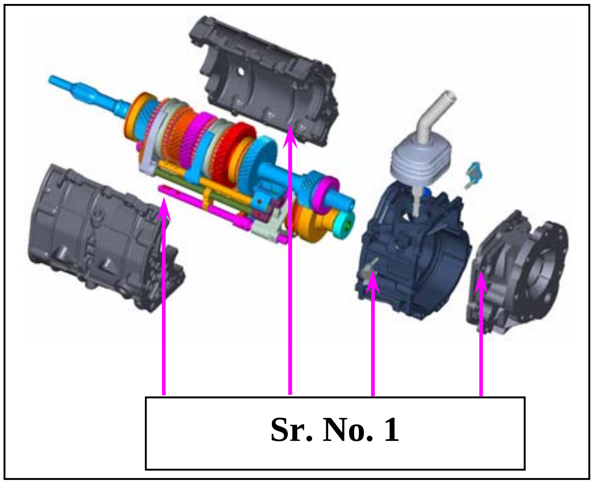
Description/ Part No./ Sketch	Usage View
Press Plate 5th Gear Removal **MST - 502** 	
BA10 5th Rev. Rail Ret. Plate **MST - 503** 	
Press Block 5th Gear Removal **MST - 505** 	
Press Plate For Input Shaft **MST - 511** 	

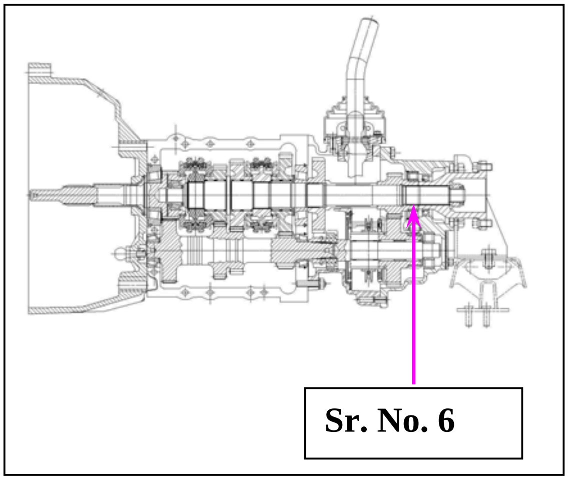
Description/ Part No./ Sketch	Usage View
Rear Housing Seal Installing Ring **MST - 512** 	
Dial Indicator Support **MST - 515** 	
BA10 Drift **MST - 517** 	 

Description/ Part No./ Sketch	Usage View
Socket **MST - 518** 	
Socket Hex Hd M8 3/8 Sq Drive **MST - 519** 	
Socket Hex Hd M7 3/8 Sq Drive **MST - 520** 	
Support Transmission **MST - 522** 	

<table>
<tr><th>Description/ Part No./ Sketch</th><th>Usage View</th></tr>
<tr><td>BA10 Fix. To Extract 5th Gear
MST - 523
</td><td></td></tr>
<tr><td>BA10 Extractor For Reverse Sub Shaft Bearing
MST - 524
</td><td></td></tr>
<tr><td>Extractor For Roller Bearing On 5th Gear MST - 525
</td><td></td></tr>
</table>

SEALANTS: -





Serial number	Location	Sealant / Thread Locks	Applicability
			NGT 530
1	Clutch Hsg. / Split Hsg. / Intermediate Hsg. / Rear Hsg.	Rhodorseal 5632 Option 1 – CAF 33 Option 2 – Pidiseal 3P Option 3 – Loctite 574	
4	Breather	Loctite 648 Option 1 – Anabond 413 Option 2 – ANR 138	
5	Pivot locking	RTV Sealant Metlock 920 Option 1 Rhodoseal Option 2 Pidiseal 3 P	
6	Companion Flange Lock Nut (Output Shaft Thd.)	Anabond 111	
7	Speedo Sleeve Thd.	Pidilite 171	
9	Clutch release bearing support sleeve	Loctite 510	
10	Poppet plug M12x1.25	Loctite 542 Option 1 – Anabond 612	

Specifications -

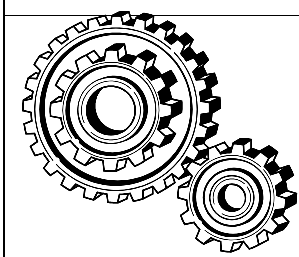
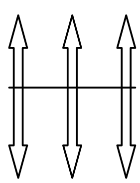
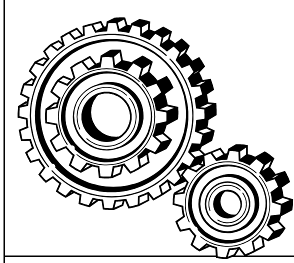
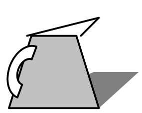
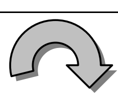
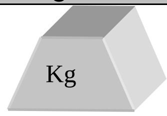
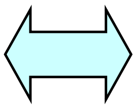
Figure	Description	Value
	Type	Mechanical
	Description	NGT 530 - 4WD
	Gears	5 Forward and one reverse gear
	Gear shift	Direct shift with rubberized lever
	Gears	Helical- tooth
	Gear Engagement	Block ring type synchronizer on ½, ¾; pin type on 5th
	Gear Ratio	Scorpio CRDe, (V1)
	1st	3.78
	2nd	2.24
	3rd	1.43
	4th	1.00
	5th	0.79
	Reverse	3.52
	Oil grade/ quantity	80 W90; GL 4 or 80 W90 Synchro GL4 Fill Quantity: 2.0 litres.
	Counter shaft bearing	Taper roller bearing.
	Input Torque capacity	27 Kg - m

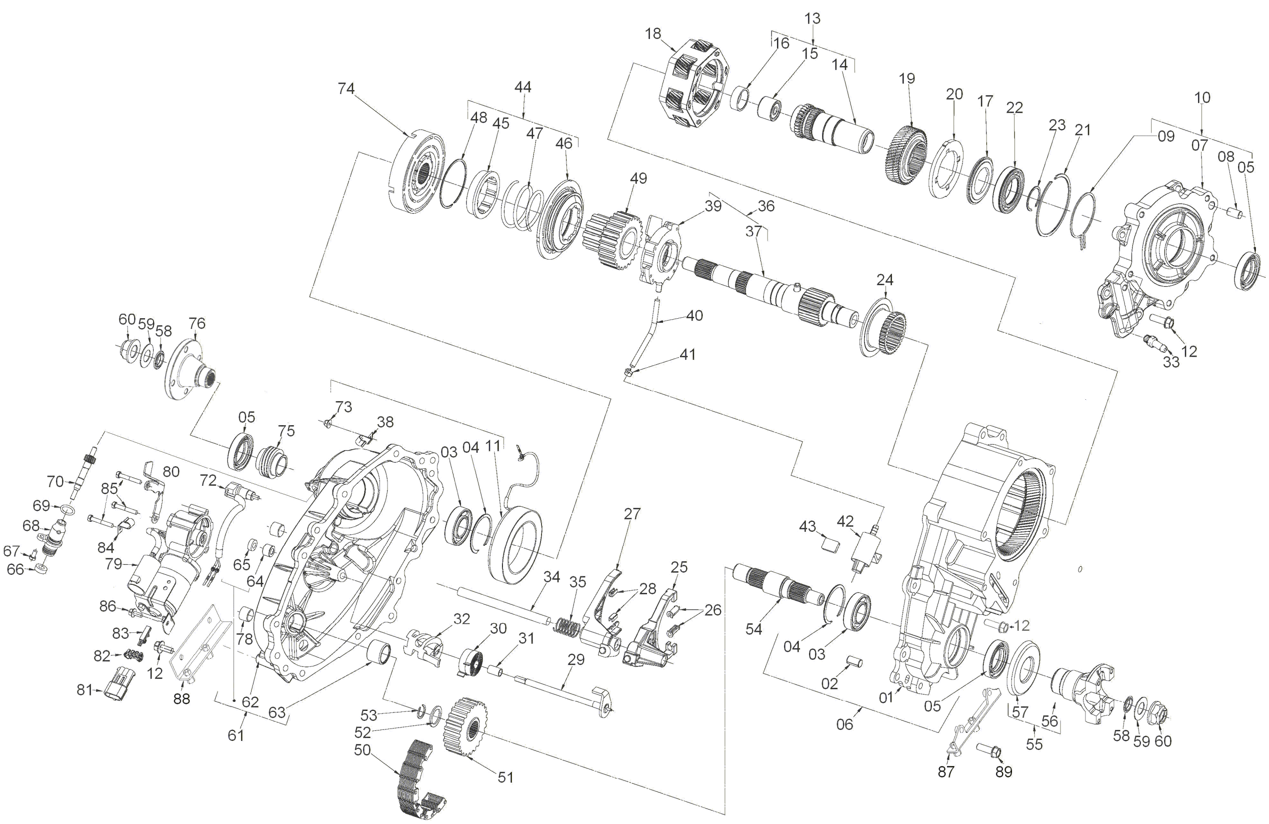
Figure	Description	Value	
	**Weight (With clutch housing)**	**42.5 Kgs W/O Oil**	
	**Play**	**Limit (mm)**	**Service limit(mm)**
	1st	**0.175**	**0.375**
	2nd	**0.175**	**0.375**
	3rd	**0.175**	**0.375**
	4th	**0.175**	**0.375**
	5th	**0.18**	**0.3**
	Fork to groove clearances	**0.1to 0.4**	

Automotive Sector

Transfer Case - Electric Shift

Contents

Description –



Divgi-Warner’s 4555 Transfer case is a two-speed, part-time electrical shift transfer case. The transfer case operates in a system. The system consists of:

1. Transfer case with Shift Motor, Speed sensor and Electric clutch.
2. Electronic Control Unit (ECU)
3. Mode selector switch and Indicator lights 4WH and 4WL on dash board
4. Harness to connect the above parts and power input.

The power is received by input shaft, which is coupled with output shaft of transmission gearbox by matching splines. There are two outputs, one for rear wheels and one for front wheels. Four selector positions are provided as follows –

Position	Speed Ratio	Operation
2H - Two high position	1: 1	Only the two rear wheels are driven at 1: 1 speed ratio
4WH - Four high position	1: 1	All four wheels are driven at 1: 1 speed ratio
4WL – Four low position	2.48:1	All four wheels are driven at 2.48: 1 speed ratio

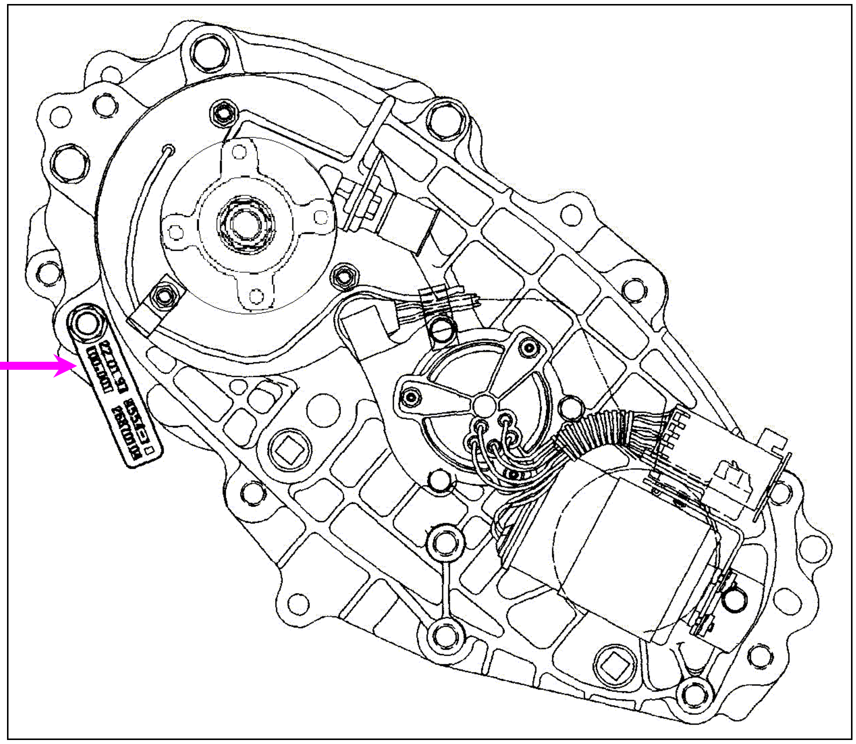
Construction & Operation –

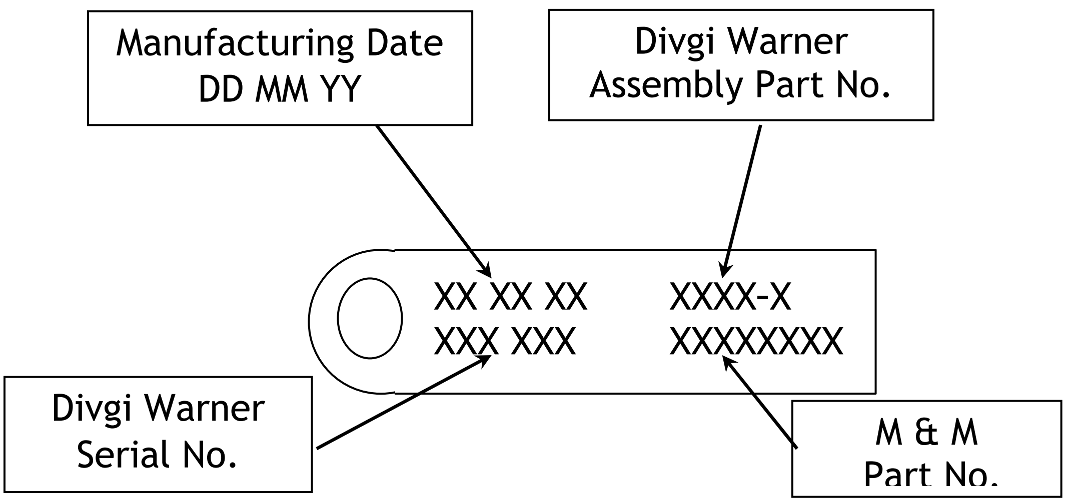
Planetary gear set provides gear reduction. Power is transferred to the front wheel drive through a Morse HY-VO chain drive. Unit operates in an oil bath. An oil pump is used to provide positive lubrication to the planetary gear set and other upper output shaft components.
The different modes are obtained by rotating selector switch for selection. This in turn gives signal to Electronic Control Unit (ECU). ECU intelligently controls operations. It senses the conditions and shift transfer case in to the mode selected.
The control over the operations is obtained using Electronic Control Unit (ECU). It is housed below the driver's or co-driver's seat in .Rotary switch is provided for selection of different modes –

2H – Two wheel high
4H – Four wheel high
4L – Four wheel low

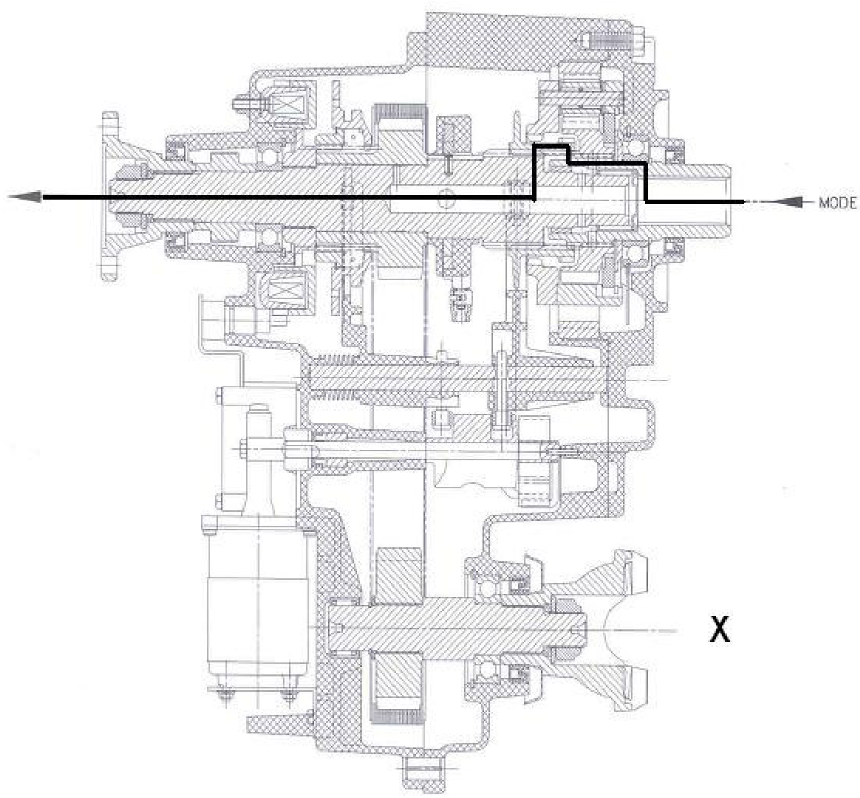
Identification -

Identification Tag





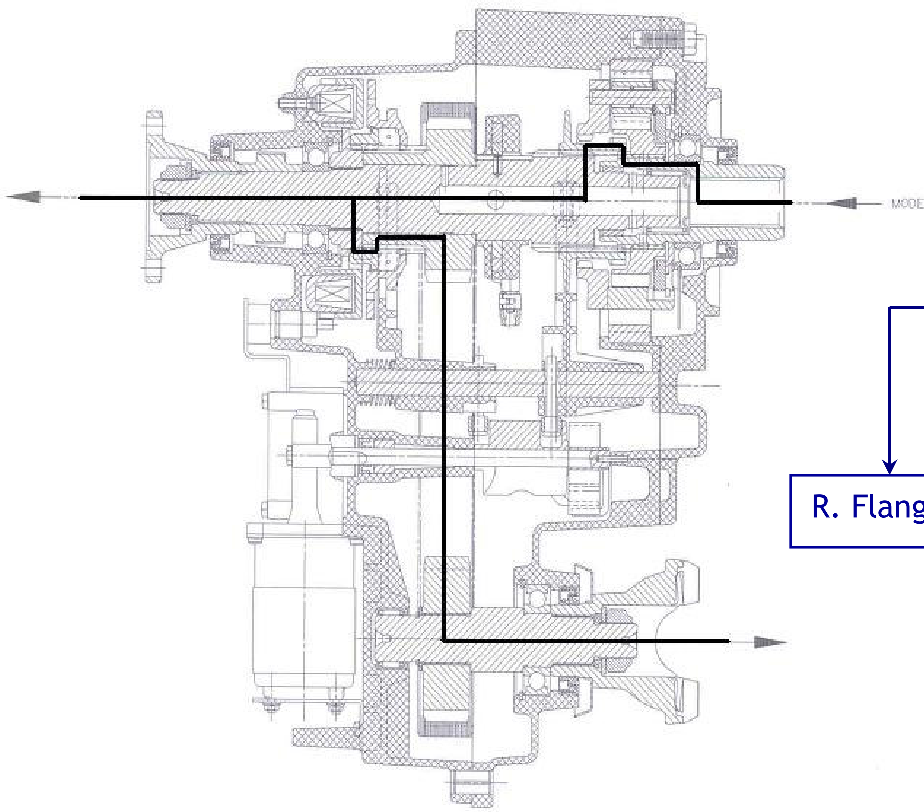
- **Electric Shift Transfer Case in 2H Mode**



Input Shaft → Reduction Hub → Output Shaft → Rear Output Flange

Only the two rear wheels are driven at 1: 1 speed ratio

- **Electric Shift Transfer Case in 4H Mode**



Input Shaft → Reduction Hub → Output Shaft → Lockup Assembly → Drive Sprocket → Chain → Driven Sprocket → Lower Output Shaft → Front Yoke

Output Shaft → R. Flange

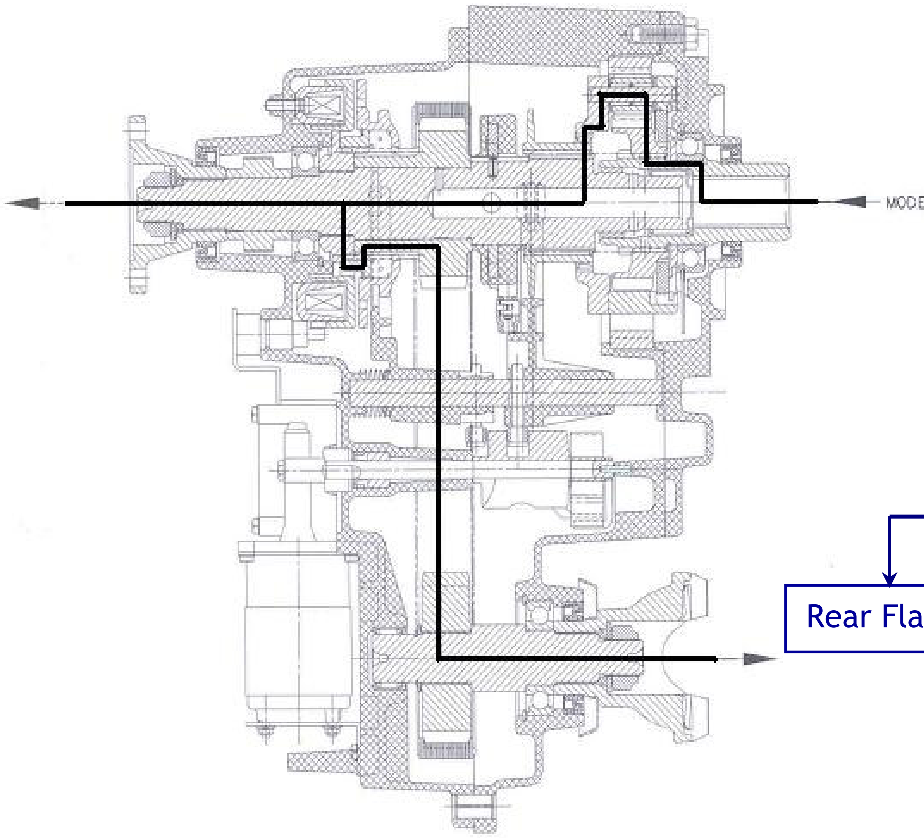
➢ **Shifting from 2WD to 4WD**

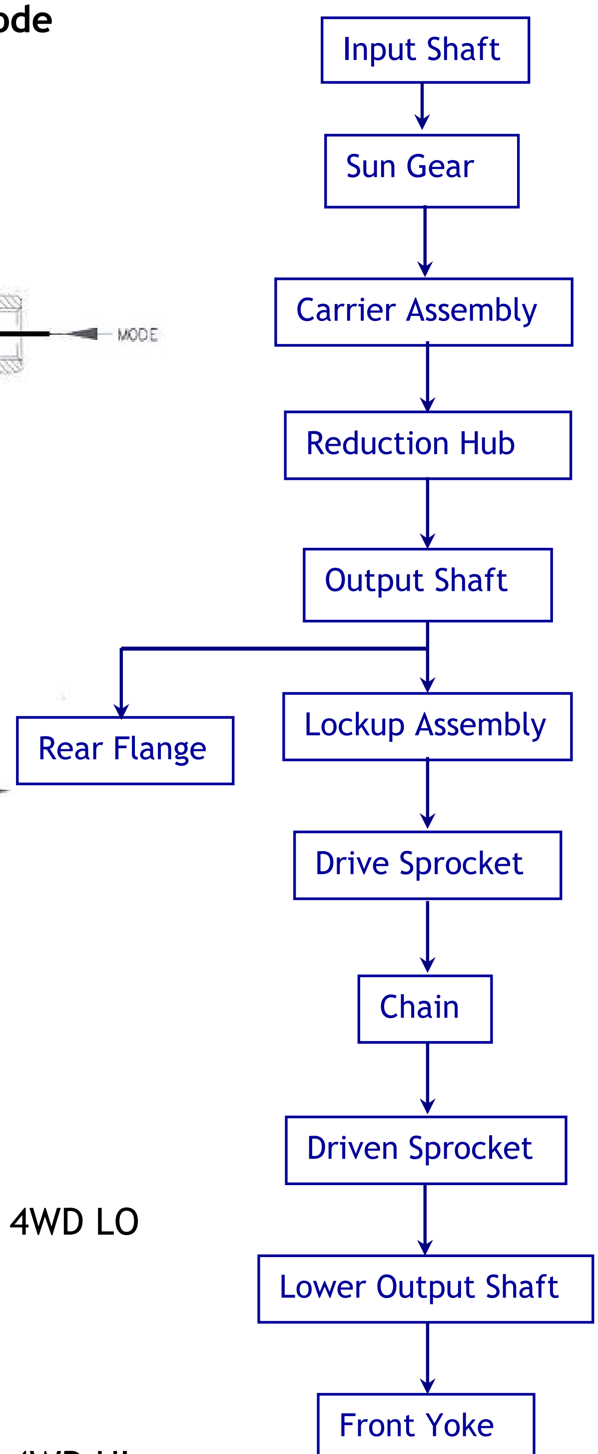
- Shift selector switch mode from 2H to 4H. 4WD HI indicator light will turn On.
- Shifting is possible during driving.

➢ **Shifting from 4WD to 2WD**

- Shift selector switch mode from 4H to 2H. 4WD HI indicator light will turn Off
- Shifting is possible during driving

- **Electric Shift Transfer Case in 4L Mode**





- **Shifting from 4H to 4L**
- Stop the vehicle
- Apply clutch paddle
- Shift selector switch mode from 4H to 4L. 4WD LO indicator light will turn On
- **Shifting from 4L to 4H**
- Stop the vehicle
- Apply clutch paddle.
- Shift selector switch mode from 4L to 4H. 4WD HI indicator light will turn On

Trouble Shooting -

Symptom	Causes	Remedial action
Electric shift problems	1. Faulty or damaged ECU, speed sensor, clutch or internal wiring 2. Damaged or worn shift cam, hub, fork and rail shaft	✓ Refer to self diagnosis ✓ Overhaul and check for wear and damage. Replace if necessary
No front wheel drive when Shifted to 4WD.	1. Broken drive chain	✓ Check internal parts and replace if necessary
Noise in 4WD operation. Make sure noise is coming from Transfer case and not from clutch, transmission, drive shaft, Automatic locking hubs or other Components.	Oil level lower than minimum required. Loosened bolts or mounting parts Noisy transfer case bearings Noisy gears Worn or damaged sprockets or drive chain Incorrect tyre pressure.	Drain old oil and replace with Specified oil. Re-tighten as specified. Disassemble bearings and parts and check for wear or damage. Replace if necessary. Check for wear and damage Including speedometer gear and replace if necessary Disassemble and check for wear and damage. Replace if necessary Adjust tyre pressure.

Transfer case oil leakage	Cracked transfer case. Leakage from other parts. Breather clogging. Oil level higher than required or improper brand of oil being used. Loosened sealing bolts. Improper brand of sealant or improperly applied sealant Worn or damaged oil seal	Replace the case. Clean case and parts and check for leakage. Remove breather barb and clean it. Replace if necessary. Use specified oil. Adjust oil level Re-tighten. Use specified sealant and retighten. Replace oil seal

Care of the System -

Oil level Check – Every 10,000 Kms.
Oil replacement interval - Every 40,000 Kms.

Checking the Oil Level -

- Clean the oil level plug and surrounding area.
- Remove the oil level plug and check whether oil is dripping out.
- If oil is not dripping out, oil level must be below the required level. Add specified oil to bring it to the level when it starts dripping out.
- Tighten the oil level plug.

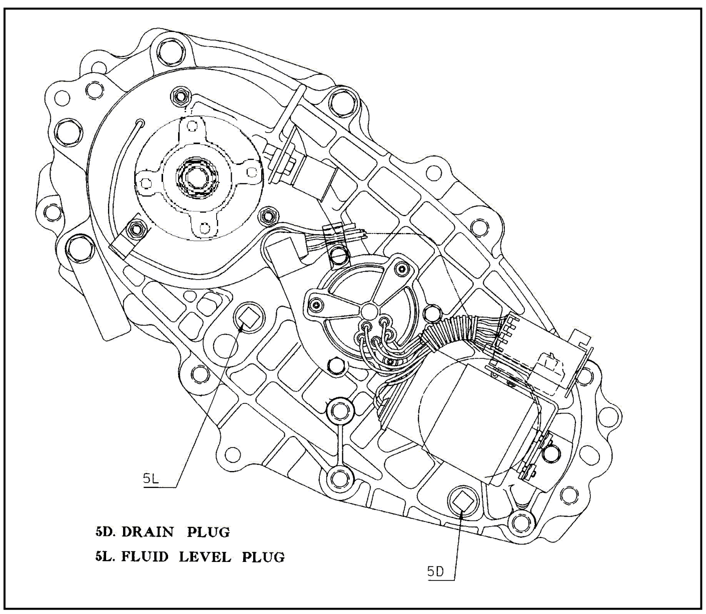
Precautions –

Before checking or removing the oil, warming up the transfer case is necessary. This should be done by driving the vehicle for some time.

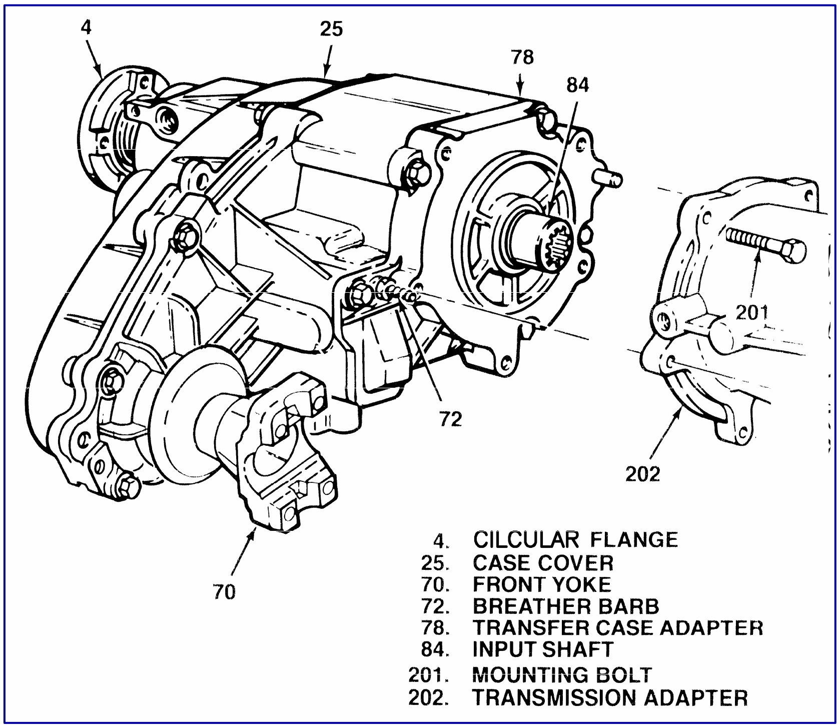
Do not use an impact wrench to open or tighten the drain and oil level plugs. This may damage the threads in the transfer case.

Changing the Oil –

- Clean the oil level plug, drain plug and surrounding area.
- Place a container to collect oil, under the transfer case.
- Remove the drain plug.
- Remove the oil level plug.
- Let the oil drain out.
- Tighten the drain plug.
- Fill new oil through oil level plug, till it begins to drip out.
- Tighten the oil level plug.

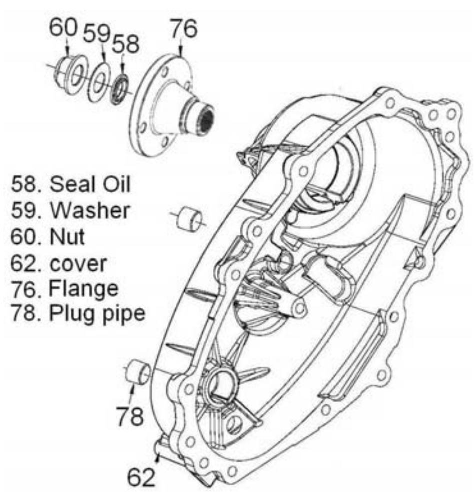


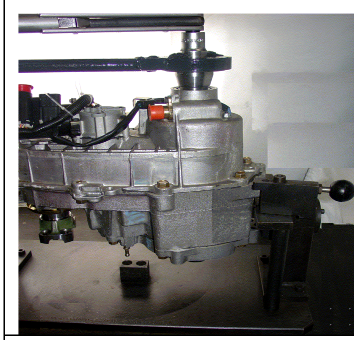
Removal & fitting on the vehicle –



1. Disconnect the wiring harness connection from the T/case
2. Lift up the vehicle.
3. Remove transfer case drain and fluid plugs. Drain all fluid and reinstall plugs.
4. Remove the breather tube.
5. Disconnect speedometer cable connector and switch connector.
6. Support the transfer case with the jack and disconnect the front and rear propeller shafts from the transfer case
7. Remove the transfer case by removing the mounting nuts, attaching the transfer case to transmission.
8. Remove the tuner assembly & tuner brackets.

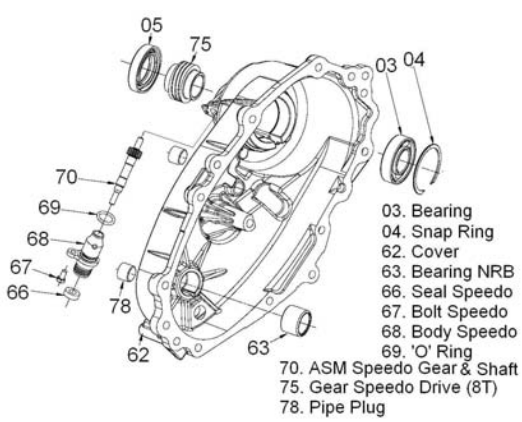
Dismantling –





Disassembly – Rear Flange.

- Position the Transfer case on repair fixture.
- Holding the flange by flange holder, remove the nut and washer and then remove the flange with the help of puller.
- Remove the oil seal from the shaft.
- Remove the two oil plugs from the cover.



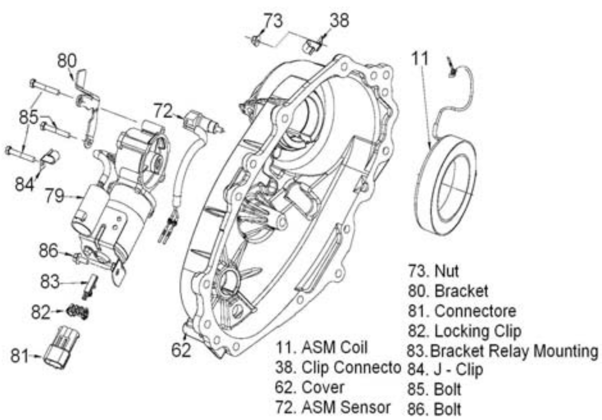
Disassembly - Assembly Cover (Motor, Speed sensor, Clutch coil and Speedo Gear.

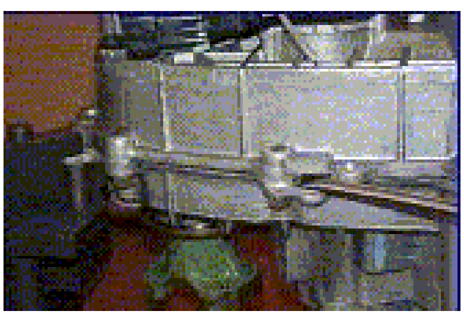
- Remove bolts and remove Assembly Motor, Speed sensor bracket and speed sensor.
- Separate clutch coil wire terminal from the connector and pull out from the sleeve.
- Remove the bolt and remove Speedo body and separate Assembly Speedo driven gear & shaft and Speedo body.

<table>
<tr>
<td></td>
<td>

- Remove oil seal and Speedo drive gear.

</td>
</tr>
<tr>
<td>

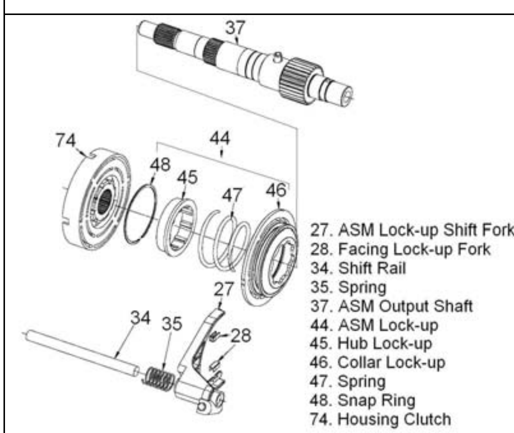




</td>
<td>

- Remove the 9 bolts and identification tag.
- Pry at the bosses provided on the cover and the case to break the sealant bond of the cover and the transfer case in such a way that the metal surface is not damaged.
- Remove the snap ring and pull out the ball bearing from the cover.
- Remove clutch coil from the cover.
- Pull out the needle bearing from the cover.
- Remove the magnet from the slot in the case.
- Remove the return spring.
- Clean and remove the sealant of the cover and case. Be careful not to damage the metal surface.

</td>
</tr>
<tr>
<td>

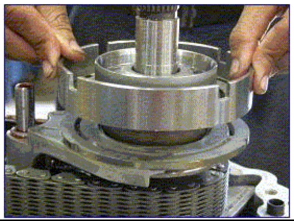
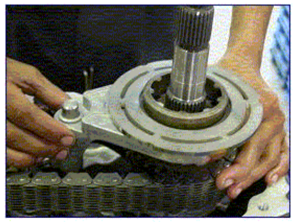


</td>
<td>

Disassembly – Lock – up Shift Part

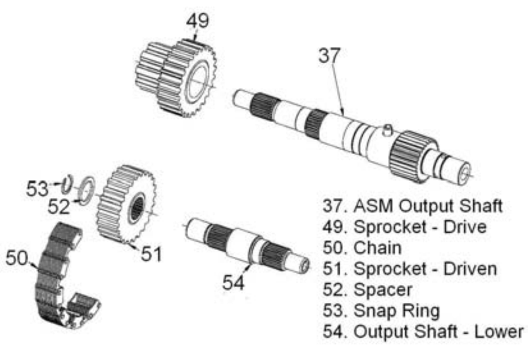
- Remove clutch housing from output shaft.
- Together slid 2W-4W lock up assembly and lock up fork from output shaft and separate fork assembly and Remove the two shift fork facings from the shift fork

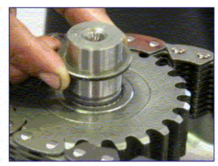
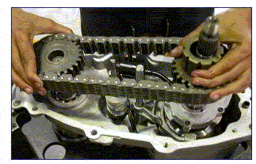
</td>
</tr>
</table>

assembly, if required.

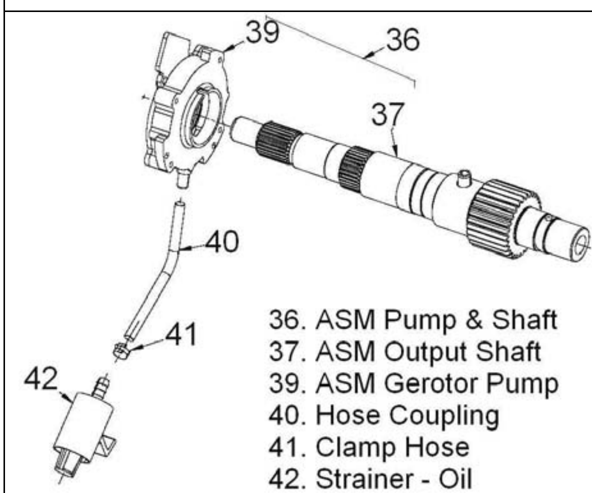
- To dismantle 2W-4W lockup assembly remove snap ring, lock up hub return spring from lock up collar.



Disassembly – Chain Drive

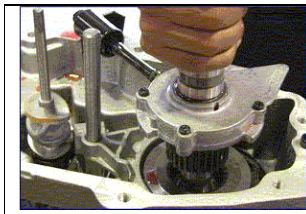
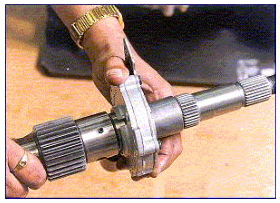
- Remove snap ring and spacer from the output shaft.
- Remove drive chain, driven sprocket and drive sprocket from the output shaft at a time.
- Separate the chain and sprocket when removing the assembly.



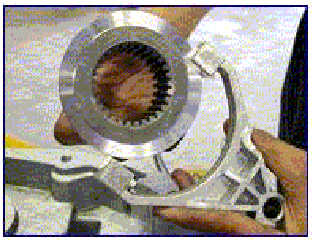
Disassembly – Gerotor Pump

- Remove the coupler from the case.
- Remove Assembly output shaft and gerotor pump.
- Loosen the hose clamp and remove the hose coupling from the pump housing
- Remove hose clamp, hose coupling and strainer

- Slide the Gerotor pump of the

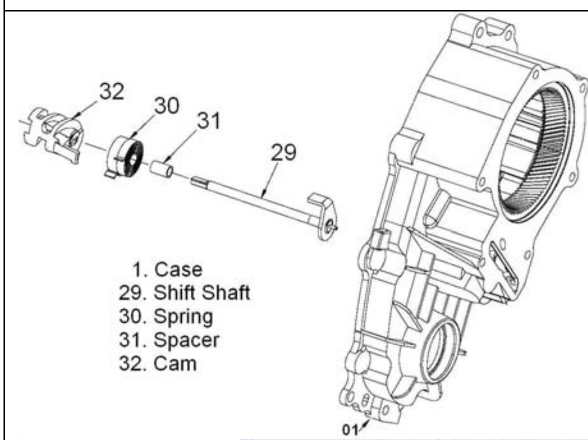



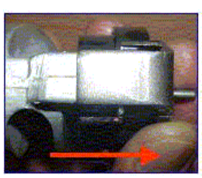
output shaft and remove the output shaft.




Disassembly – Reduction Shift Parts

- Remove rail shaft from the case.
- Remove the reduction hub and reduction fork assembly from the case
- Remove the two shift fork facings from the shift fork assembly, if required.



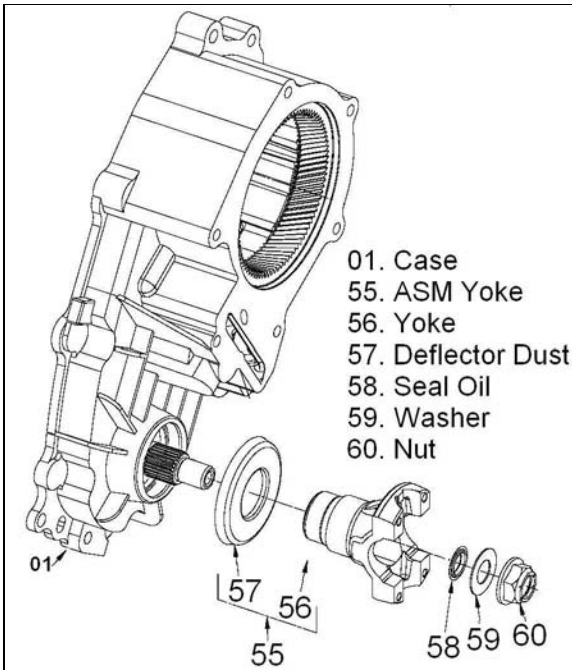


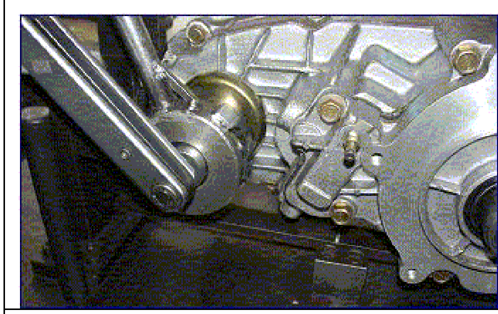

Disassembly – Electrical Shift Cam Parts

- Remove ASM shift shaft from the case.
- Separate Cam, spring, Spacer and shift shaft by pulling outward.

Disassembly – Yoke & Output Shaft

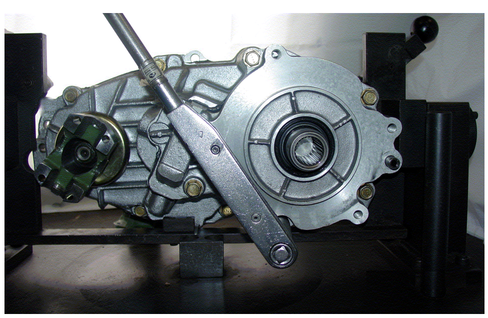
- Holding the end yoke with the yoke holder remove the nut,





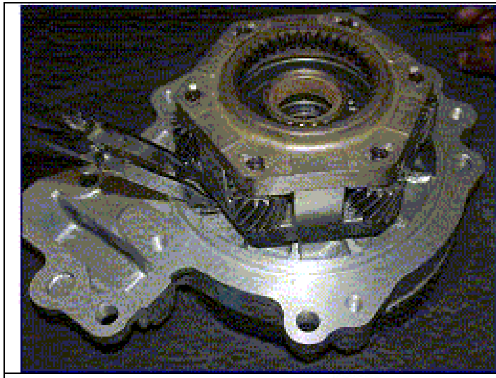
washer and then pull out the front yoke assembly. Remove seal oil.

- Remove the out put shaft.
- Press deflector from the yoke only if replacement is required.



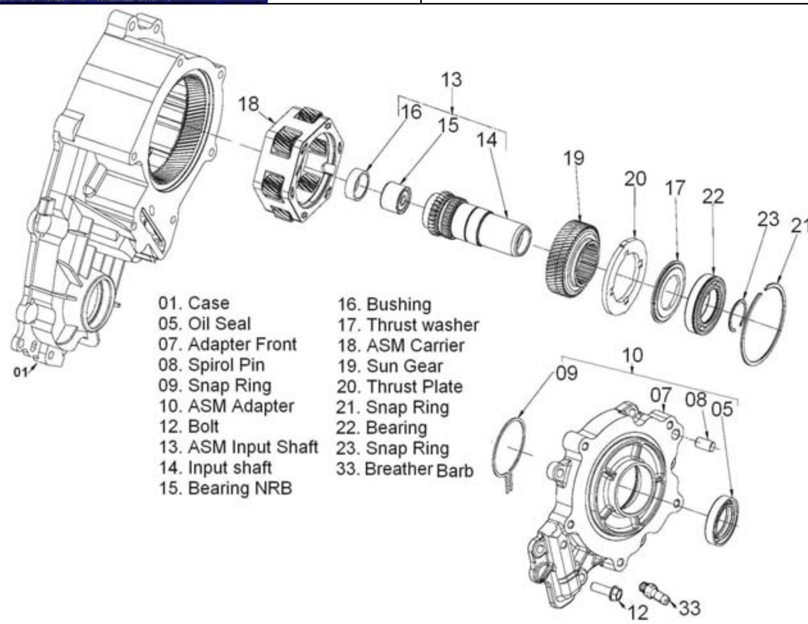
Disassembly – Adaptor , Input Shaft & Carrier Assembly

- Remove the breather barb.
- Remove the six bolts of adapter.
- Remove the adapter by separating the adapter sealer bond (pry front adapter, take care not to damage the adapter or the case).
- Remove the adapter assembly, input shaft assembly and carrier gear

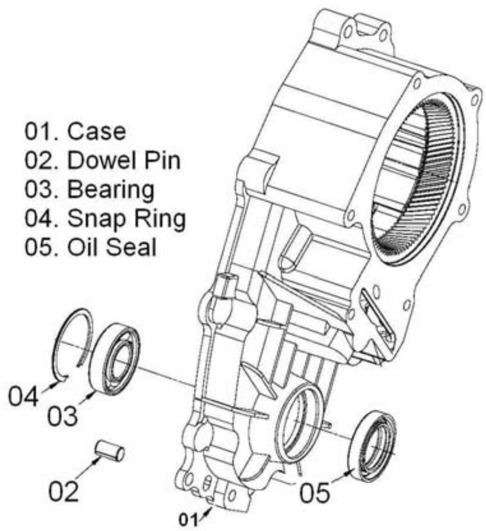


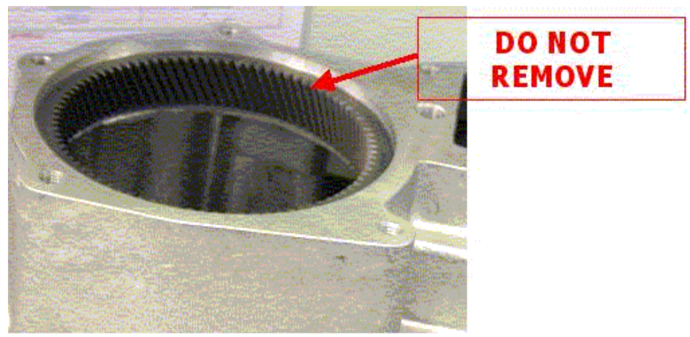
assembly. (Expanding long ends of the snap ring ; separate the carrier and input shaft assembly from the adapter.).

- Remove snap ring and oil seal from front adapter.



1. Remove snap ring and pull out Assembly Input shaft and sun gear from Assembly Carrier.
2. After removing retaining ring, pull out the bearing and thrust washer from input shaft.
3. Remove the needle bearing and sleeve bearing from input shaft assembly, if required.





Disassembly - Case

- Remove the oil seal.
- Remove the retaining ring and bearing.
- Remove the dowel pins from transfer case, if required.
- Do not remove ring gear from the case.

Cleaning –

Note: Before cleaning, check the magnet for the presence of metal particles, which indicate internal chipping of the transfer case.

- Using a cleaning solvent, clean the old oil and dirt deposits
- After cleaning dry the parts with low-pressure (20 psi maximum) compressed air.
- Lubricate the ball bearings and needle bearing with ATF oil.
- Protect lubricated bearings from dust.

Inspection –

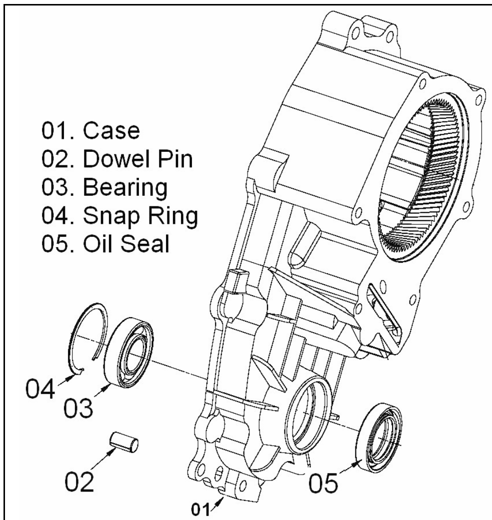
Note: Always replace the hose coupling, O-ring and oil seal with new parts.

- Visually check all the parts for damage.
- Referring to normal gear tooth face, specifically inspect the uneven wear and chips of gear tooth. Replace or repair if necessary.

Assembly –

CAUTION

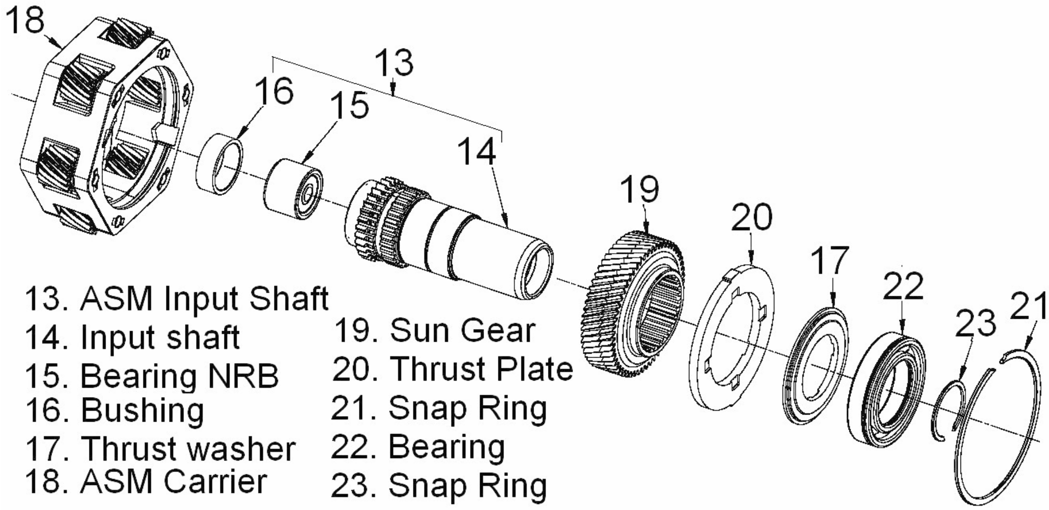
Do not use hammer to drive in the oil seal and bearing. Use special tools for assembly.
Use a Torque Wrench to tighten threaded parts.
Torque values are specified in the torque chart.
Lubricate bearings, oil seals, O-rings, bushings and matching metal parts before assembly (with oil).



Assembly – Case

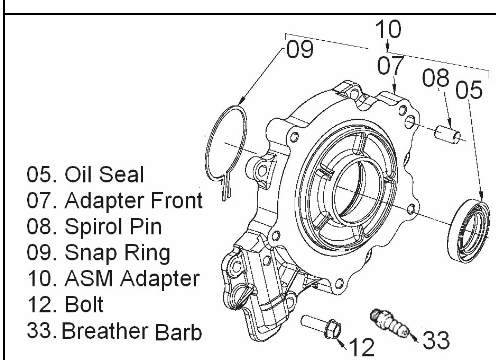
- Insert the two new dowel pins.
- Press the ball bearing into the case and install the retaining ring (snap ring).
- Install the new oil seal, by pressing it into the case.

Make sure that all parts are correctly and firmly installed into the case.



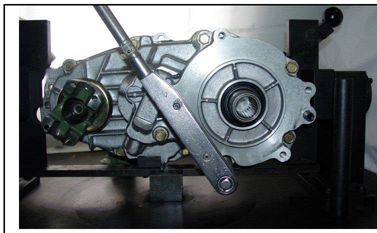
Assembly – Adaptor, Input Shaft & Carrier Assembly

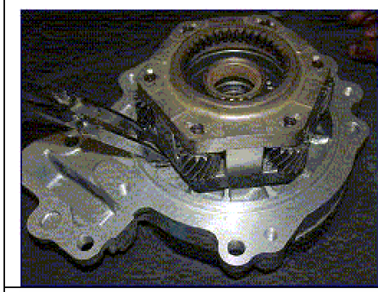
- Press the needle bearing and the new sleeve bearing into the input shaft (if removed).
- Install the sun gear onto the input shaft and put thrust plate, thrust washer and press the bearing onto the input shaft.
- After pressing the bearing, install the retaining ring.
- Insert the above assembly into the planet carrier. (Ensure that planet carrier assembly on the work bench is such that the retaining rings' mounting groove faces upward).
- Install the retaining ring to the planet carrier.



Assembly – Adaptor, Input Shaft & Carrier Assembly

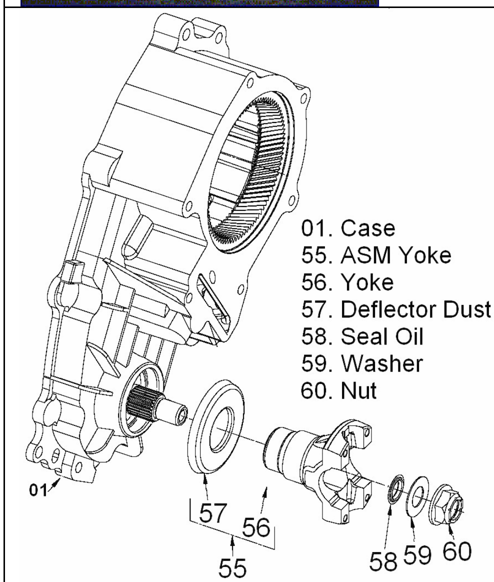
- Press the spiral pin into the front adapter.
- Press the oil seal into the front adapter.
- Invert front adapter assembly. Install snap ring by make sure that snap ring is correctly installed into the groove.
- Position the input shaft assembly over front adapter

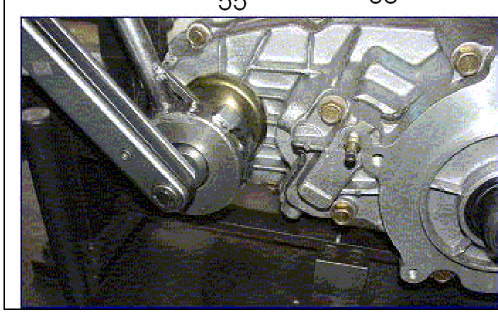




and engage into bearing groove by expanding the ends of snap ring (Push Input shaft and carrier assembly in to the front adapter.).

- Apply 1.6 mm bead of sealant on the mounting face for the transfer case and tighten the six bolts.
- Install the breather barb.

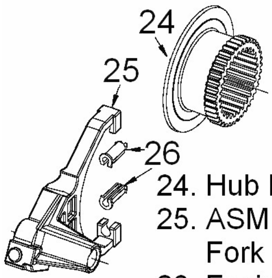




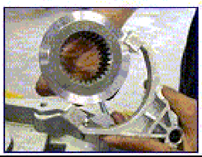
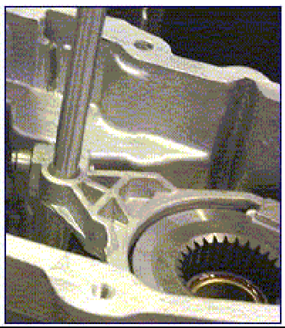
Assembly – Yoke

- Position the output shaft in transfer case and install the end yoke assembly, seal, washer and nut.
- Holding the end yoke with the help of yoke holder, tighten the nut.
- Turn the fixture for further assembly.

Mahindra
Automotive Sector

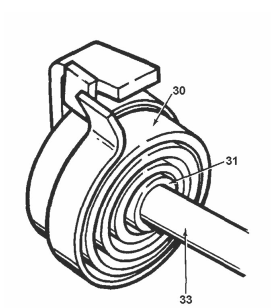


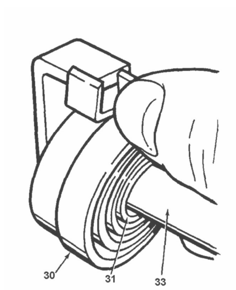
24. Hub Reduction
25. ASM Reduction Shift Fork
26. Facing Reduction Shift Fork

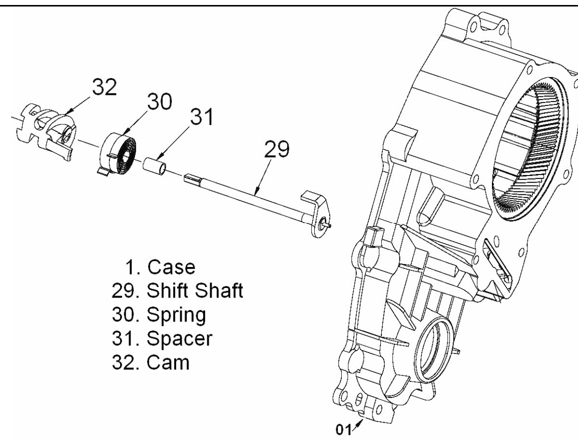




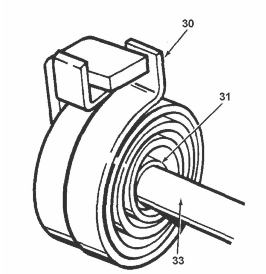
Assembly – Reduction Shift Parts

- Install the two forks facing on the reduction shift fork assembly.
- Install the reduction hub in to the fork.
- Install reduction hub and fork in to the planet carrier.
- Insert shift rail in reduction fork bore, to match with case bore.







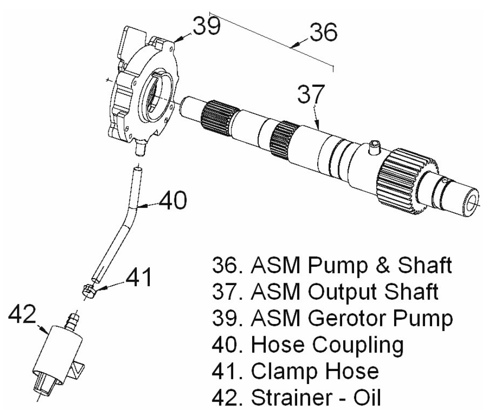


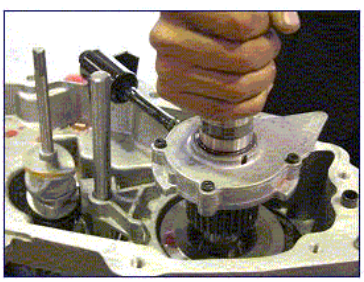
Assembly – Electrical Shift Cam Parts

- Insert spacer into torsion spring ,insert the shift shaft into the spacer. Slide electric cam on to the shift shaft.
- Slide the torsion spring and spacer to the right of the shift shaft and

position the end of the first spring to fix on the drive tang.

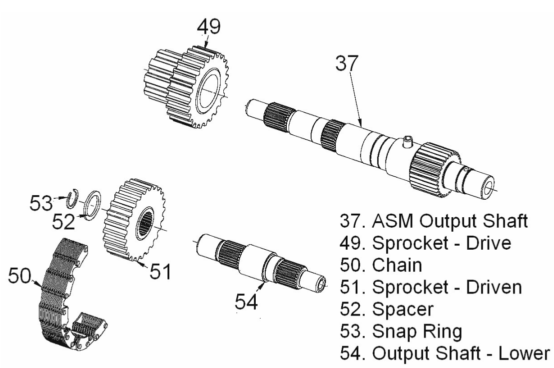
- Position the cam on the second spring and rotated anticlockwise. Push the end of the second spring to left with cam and fix it on the drive tang.
- Install the electric shaft cam in to the case.





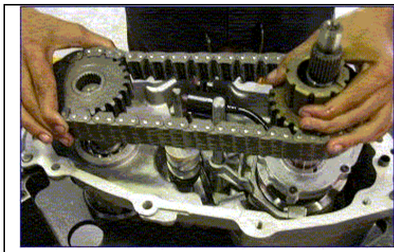
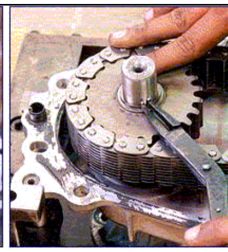
Assembly – Assembly Output Shaft & Gerotor Pump

- Align rotor slot of the pump and slot of the pump body in line.
- Slide the pump assembly on the output shaft over pump pin.
- Slip hose clamp over free end of hose coupling with strainer and push onto hose barb on pump and tighten.
- Install the output shaft splines into the reduction hub and engage the output shaft end with input shaft bearing.
- Couple strainer with case and insert the magnet into the transfer case slot.

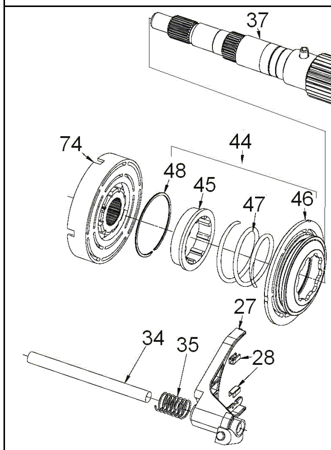


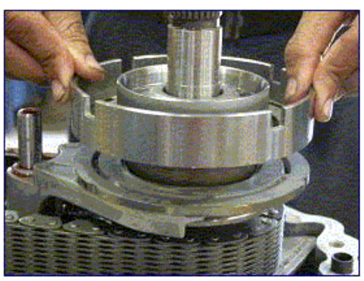
Assembly – Chain Drive

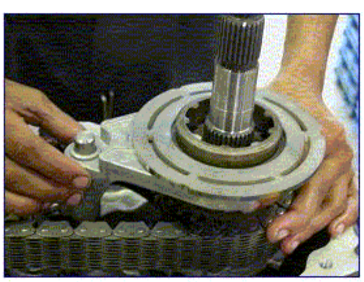
- Position the drive sprocket to the rear output shaft end and driven sprocket to the front output shaft end.
- Install the drive chain onto the sprockets.
- Holding each sprocket with drive chain tight and parallel with transfer case, install the drive chain assembly to the output shafts.

- Rotate the driven sprocket slightly to engage splines on the front output shaft.
- Install the spacer to the front output shaft and insert snap ring into the groove over spacer.

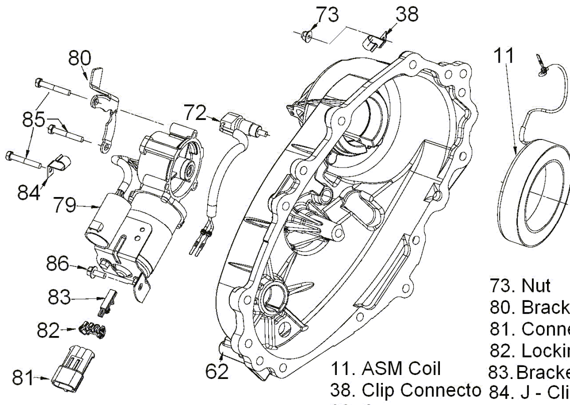






Assembly – Lock-up Shift Part

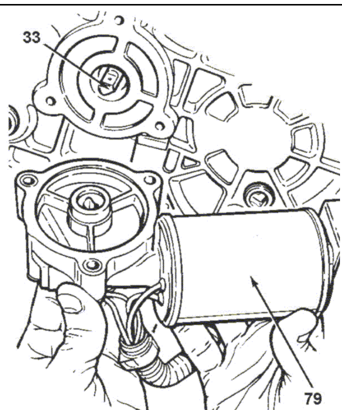
- Install the lockup hub and return spring to the lock up collar and insert the snap ring.
- Install two new facings to the fork.
- Engage the lockup fork in groove in 2WD-4WD lock up assembly and slide this group down over drive sprocket and rail shaft.
- Install clutch housing on out put shaft.



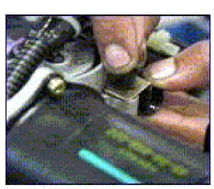
73. Nut
80. Bracket
81. Connectore
82. Locking Clip
83. Bracket Relay Mounting
84. J - Clip
85. Bolt
86. Bolt
11. ASM Coil
38. Clip Connecto
62. Cover
72. ASM Sensor

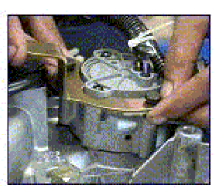
Assembly – Assembly Cover

- Position the cover with the open end facing up on the table.
- Position the end of needle bearing with the identification mark up and press into the cover (If removed).
- Press the ball bearing in to cover and install snap ring.
- Install the clutch coil assembly inside the cover, put wire bracket and tighten three nuts.
- Install speed sensor assembly to the cover.



33. Shift Shaft
79. Shift Motor

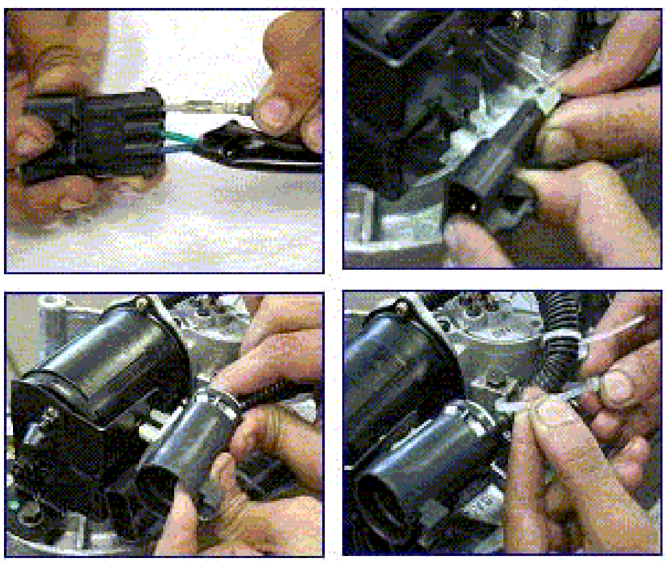




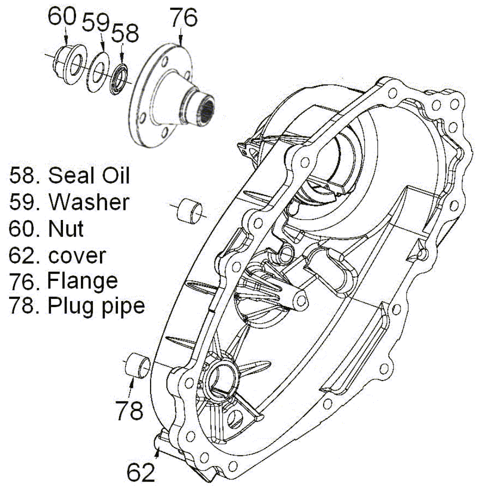
Assembly – Assembly Cover

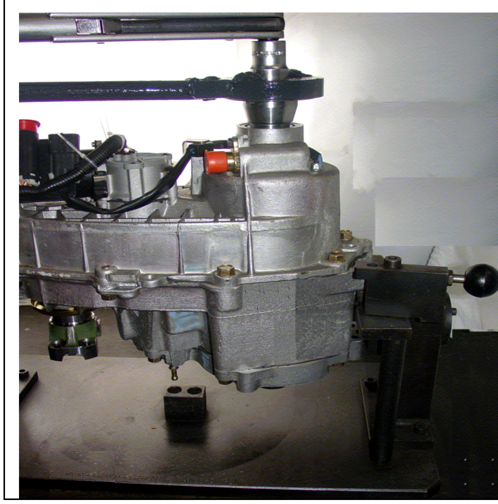
- Align the cover holes with the transfer case dowel pins
- Align the cover bearings with output shafts
- Align shift shaft with cover boss.

- Align the cover blind hole with rail shaft and make sure that return spring is not cocked.
- Tighten nine bolts positioning identification tag.
- Align the motor with shift shaft and position the motor assembly on to the cover.
- Install the motor to the shift shaft and contact cover. Rotate the motor clockwise direction to check correct engagement.
- Install the bracket to the motor assembly and tighten three bolts.
- Tighten motor bracket bolt.
- Install to oil plug to the cover.



- Pass clutch coil wire through sensor wiring sleeve, connect clutch coil terminal with the connector.
- Install motor connector and sensor connector to the motor bracket.
- Insert wiring in the respective Clip and crimp it properly.
- Install the Speedo gear over output shaft splines in the cover assembly.
- Press the new oil seal into the cover assembly.





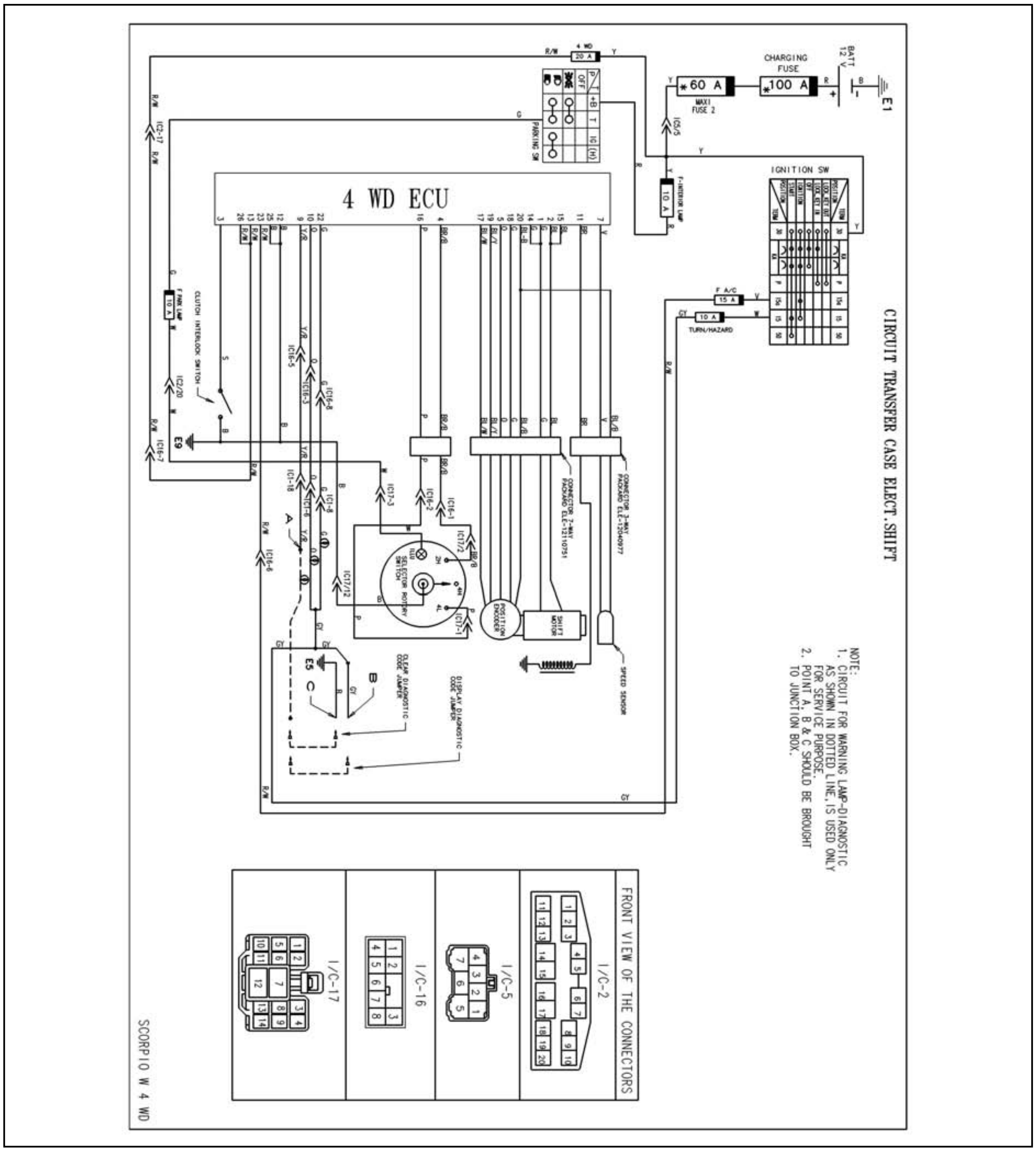
Assembly – Rear Output Flange
Position the circular flange on the upper output shaft in transfer case and install the flange, seal, washer and nut.
Holding the flange, tighten the nut.

<u>Electronic Control Unit and Self Diagnosis –</u>

- **Electronic Control Unit**

Electronic Control Unit (ECU) is located under the co-driver's seat or under dashboard. Driver operates a selector switch to shift the vehicle from two-wheel drive to four-wheel drive (and vice versa). Shifting is possible during driving (only in 2H to 4H mode).
Interconnections between ECU and other system blocks are as shown in the circuit diagram for Scorpio & Bolero –

<u>Scorpio</u> 4 WD Electric shift Circuit Diagram – Refer the wiring diagram shown below -



Note : In case of malfunctioning in shifting, the 4WD HIGH and 4WD LOW indicator lights will flash.

Self diagnosis of ECU :

ECU detects transfer case system malfunctions and indicates malfunctioning part(s) through flashing indictor lights. The operator will be alerted of fault condition by continuous illumination of both 4WD HI and 4WD LO lights on dashboard when ignition is On.

A service connector is provided to indicate the fault codes in binary. Connect one end to the pin hole number 9 in ECU connector, and other end to the ignition switch. The flashing of indicator light will show the defective code (as illustrated in the table). Identify the malfunctioning part and replace it.

L1	L2	L3	Binary code	Decimal equivalent	Fault with
Off	Off	On	001	1	ECU Module
Off	On	Off	010	2	Shift Motor
Off	On	On	011	3	Synchronizer Clutch
On	Off	Off	100	4	Speed Sensor
On	On	Off	110	6	Selector switch
On	On	On	111	7	Motor Position Switch

Note –

Before replacing the malfunctioning parts with defective codes, check the wires and connectors for proper condition.

Use only 12v 3-watt bulb for diagnostic purpose.

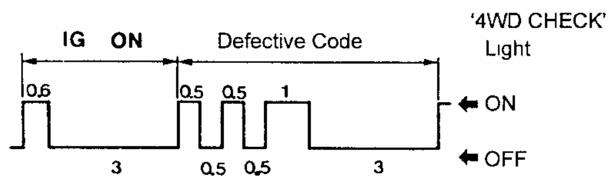
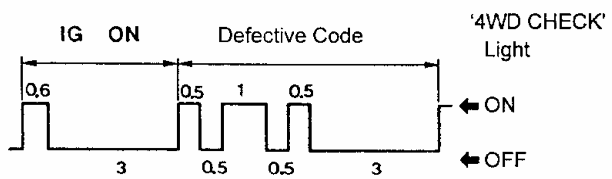
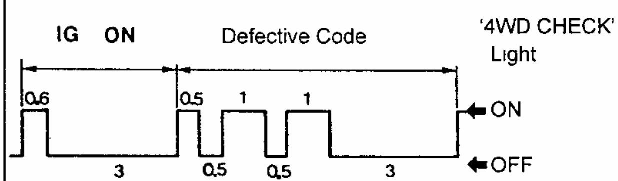
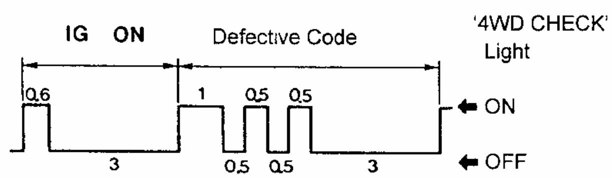
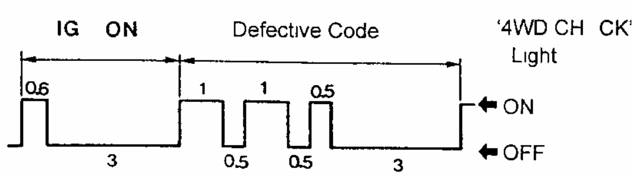
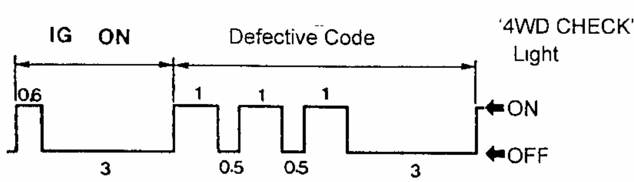
If only one part is malfunctioning, the indicator light will display defective code three times continuously. If more than two parts are malfunctioning, the first malfunctioning part will be displayed three times and then the other malfunctioning parts will be displayed.

After repair, clear the fault stored in the memory. Ground the service connector and keep ignition 'On' for five seconds continuously to erase defective code.

Self diagnosis of ECU –

Connect a service connector as described earlier. Turn the ignition switch On. 4WD CHECK indicator will turn On for 0.6 seconds and turn Off for 3 seconds. Then it will display a defective code 3 times continuously.

The chart for the defect codes is enclosed -----

No.	Defective Code	Malfunctioning Part
1		E C U
2		Shift Motor
3		Synchronizer Clutch
4		Speed Sensor
6		Selector Switch
7		Motor Position Sensor

Mahindra

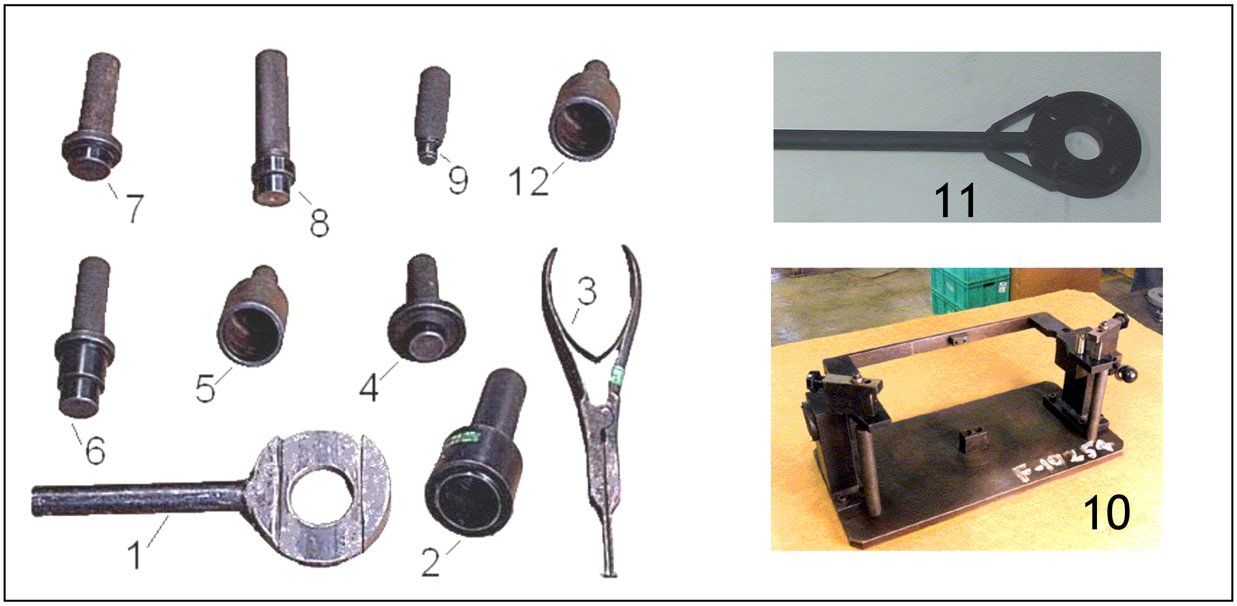
Automotive Sector

Tightening Torques -

Bolt location	Torque Values
Level & Drain Plug	35 ± 7 Nm (26 ± 5 lbf-ft)
Flange Nut	365 ± 15 Nm (269 ± 11 lbf-ft)
Front Yoke Nut	225 ± 25 Nm (166 ± 18 lbf-ft)
Case Bolts	35 ± 7 Nm (26 ± 5 lbf-ft)
Motor bolts, and coil nuts	9.5 ± 1.5 Nm (7 ± 1 lbf-ft)
Speedo body bolt	9.5 ± 1.5 Nm (7 ± 1 lbf-ft)
Breather Barb	14 ± 5 Nm (10 ± 4 lbf-ft)

Automotive Sector

Special Tools -



Description	Borg Warner Part No.
Yoke Holder - **1**	T-10001
Seal Driver - **2**	T-10003
Snap ring plier Adapter - **3**	T-10007
Snap ring plier - **4**	T-10006
Drift ball bearing - **5**	T-10053
Drift ball bearing Input shaft - **6**	T-10056
Drift NRB fitting Input shaft - **7**	T-10054
Drift Bush fitting Input shaft - **8**	T-10055
Drift NRB fitting Cover- **9**	T-10057
Repair Fixture - **10**	T-10037
Flange Holder - **11**	T-10012
Dust Deflector Press Tool - **12**	T-10188

Automotive Sector

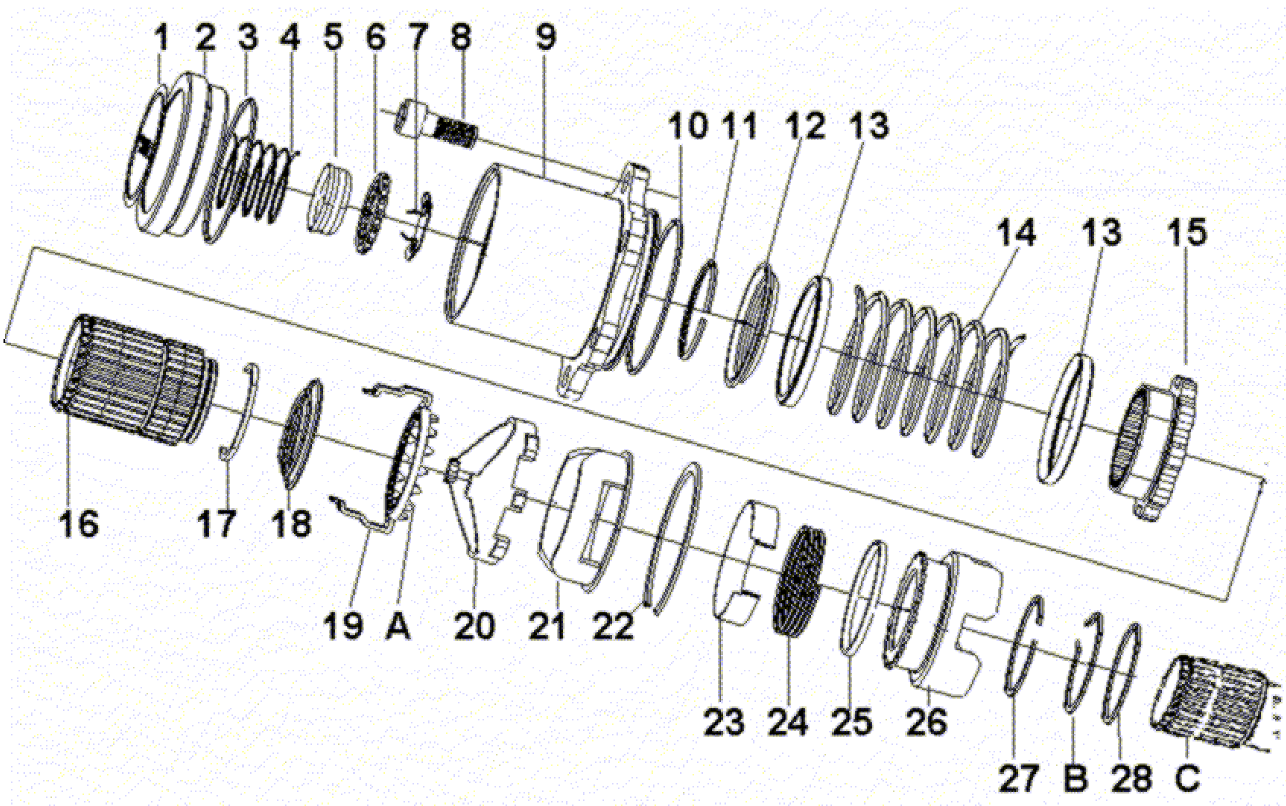
Specifications - Transfer Case 4555 (Electrical Shift)

Configuration	Part time, Single Offset
Rear Output Configuration	Circular flange
Front Output Configuration	Fixed Yoke
Input Configuration	Female Splines
Offset hand	Right hand
Lubrication System	Force lubrication by Gerotor pump
Lubricating Fluid Type	Castrol ATF - TQ, IOC- Servo Transfluid A Chemoleium -A HPCL ATF - A
Housing Material	Aluminum
Dry Weight in Kgs.	30 Kgs. Approx.
Fluid Capacity in liter	1.2 Approx.
Shift Pattern	2H – 4H – 4L
Shift Control	Selector Switch
4WDH Shift -on the Fly	Yes

Automatic Locking Hub -

When 4-wheel drive is selected, the automatic hub locks the axle shaft to the wheel hub. This occurs when the vehicle is driven in either forward or reverse direction. The hub unlocks when 2-wheel drive is selected, and the vehicle is driven in the opposite direction for a few feet.

Construction -



The 4 Tanged washers are held in place on the Wheel Spindle. The cut-outs on the drag sleeve (26) fit over the tangs on the washer, preventing the drag sleeve from rotating. The brake band (24) fits over the serrated portion of the drag sleeve. The tangs of the brake band are fitted through the window in the steel inner cage (21). The plastic outer cage (20) fits over the inner cage. Each tang of the brake band fits through each cutout in the outer cage. The cam follower (19) is attached to the clutch gear (15). The follower profile on the cam follower (A) ride against the cam faces or ramps of the steel inner cage. The clutch gear slides on the splines

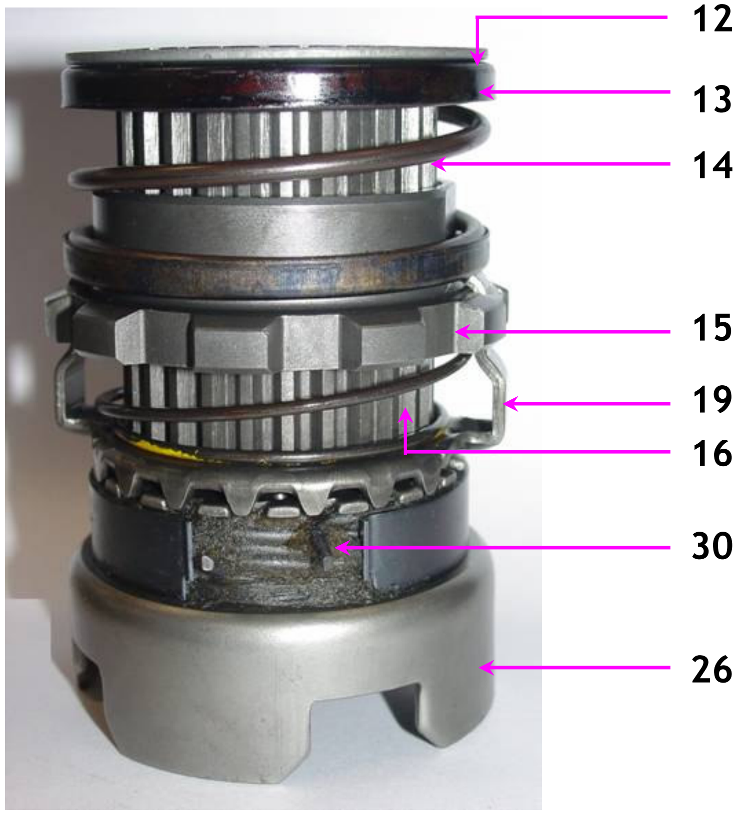
on the out side the hub sleeve (16). The axle shaft(C) is splined to the inside of the hub sleeve. The large teeth on the outside of the clutch gear can engage the teeth inside the outer clutch housing (9).The outer clutch housing is bolted to the wheel hub. An End Cap (2) fits over the hub lock assembly. The end cap contains a bearing assembly (6) that supports the other end of the hub sleeve. The End Cap is fitted with an Aluminium Decorative Plate(1) for better aesthetics.

Briefly, this is what happens when the hub locks -
The clutch gear (15) and cam follower (19) rotate up the cam face of the inner cage (21). This causes the clutch gear to move outward on the hub sleeve (16). The out side teeth of the clutch gear engage the inside teeth of the outer clutch housing (9), locking the wheel hub to the axle shaft.
When the hub un-locks,

The clutch gear and cam follower rotate in the opposite direction, back down the cam face of the inner cage. Spring pressure forces the clutch gear inward, unlocking the wheel hub from the axle shaft.

<u>Operation</u> –

Now, let's see how the hub operates in detail. When 4-wheel drive is engaged (and vehicle starts to move), the axle shaft starts to turn the hub sleeve (16), clutch gear (15) and cam follower (19). The steel inner cage (21) and plastic outer cage (20) also start to turn. (Remember, the drag sleeve (26) is fixed to the wheel spindle and doesn't rotate) When the inner cage window hits the first brake band tang (30) the band tightens up on the drag sleeve. This stops the inner cage. The cam follower (19) is forced up the ramp of the inner cage (21).



Now, let's see how the hub operates in detail. When 4-wheel drive is engaged (and vehicle starts to move), the axle shaft starts to turn the hub sleeve (16), clutch gear (15) and cam follower (19). The steel inner cage (21) and plastic outer cage (20) also start to turn. (Remember, the drag sleeve (26) is fixed to the wheel spindle and doesn't rotate) When the inner cage window hits the first brake band tang (30) the band tightens up on the drag sleeve. This stops the inner cage. The cam follower (19) is forced up the ramp of the inner cage (21).

As the cam follower moves up the ramp of the inner cage, it is moved outward along the hub sleeve (16), pushing the clutch gear (15) into engagement with the outer clutch housing. The cam follower (19) also pushes against the lugs of the outer cage (20). The outer cage tang contacts the second brake band tang (30). This unlocks the brake band and allows it to turn freely on the drag sleeve serration's.

When 2-wheel drive is selected to disengage the hubs, and the vehicle is driven in the opposite direction for a few feet, the rotating front wheel turns the outer clutch housing, clutch gear (15) and cam follower (19) in the opposite direction. The cam follower moves down the ramp of the inner cage (20). The return spring (14) pushes the clutch gear (15) along the hub sleeve (16) and out of engagement with the outer clutch housing.

Trouble shooting –

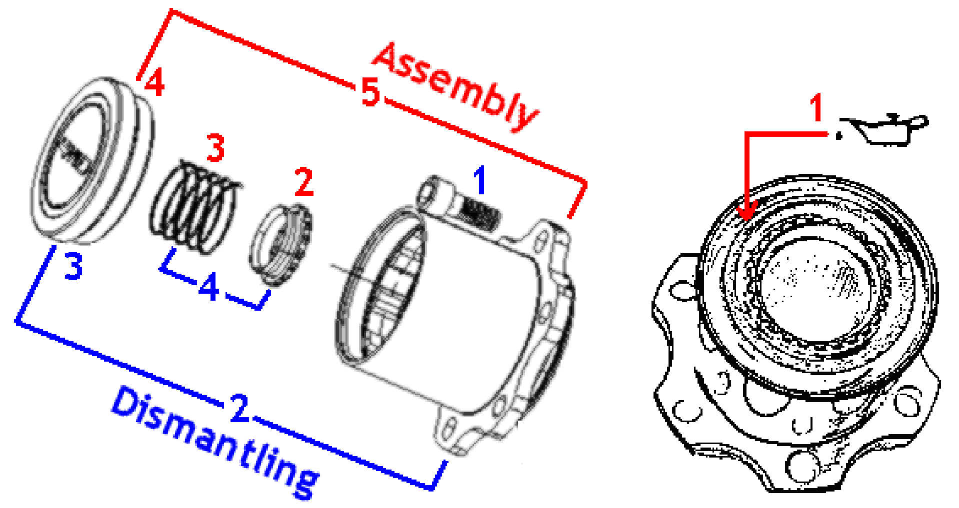
Symptoms	Causes	Remedial Action
Oil Leakage Make sure that a suspected oil leak is actually coming from the hub. Oil leaks can originate in the axle shaft (oil seal).	A cracked or porous or improper fitment of protective end cap. Damaged or missing “O” rings. Incorrectly installed or damaged sealing ring of the End Cap and outer clutch housing.	Replace the end cap. Fit a new ‘O’ ring. Fit properly
Does not engage or Disengage. Before disassembly of a locking hub, be sure the problem is caused by the hub and not another component in the drive train.	Transfer case not engaging or disengaging front axle shaft. Viscosity of front differential lubricant too high (i.e. due to cold weather). Front differential pre-load too high. Seized front axle shaft bearing.	Rectify Check & fill proper lubricant. Rectify Rectify / Replace

Noisy Operation –

A broken or missing 4 tanged washer can cause problems in 2 or 4 - wheel drive.
A broken or missing washer will allow the drag sleeve to rotate with the brake band . If the hub are not engaged , the brake band is unable to lock on the drag sleeve and initiate the locking action of the clutches. If the hubs are engaged, the brake band can not be released to allow the clutch gear to disengage.
A broken or missing brake band cannot lock the inner cage to engage the hub or be unlocked by the outer sleeve to allow the clutch gear to disengage.
If both brake band tangs are touching the centre post of the outer sleeve, there cannot be proper locking or unlocking action of the brake band through the movement of the inner cage and outer cage. The centre post of the outer cage and the window of the inner cage move relative to each other when the hub is locking or unlocking. If the cages are not rotating freely over each other, the hub may fail to engage or disengage.
A sticking clutch gear can cause the hub to bind in either the engage or the disengage position. A broken return spring will cause the hub to remain in the engaged position.
In each case, the defective component should be replaced with the correct part or assembly. Always check the most recent parts list for the correct part numbers and available assemblies for the type of the hub you are servicing.

Lubrication –

The automatic hub lock should be lubricated at every 40000 Kms. OR one year whichever is earlier.



Dismantling –

- Remove wheel hub cover and loosen the ALH End Cap of Automatic Locking Hub **(ALH)** with the help of pin spanner (Borg Warner Special Tool - T – 10068).

1. Remove 6 Nos. mounting bolts of ALH with the help of special Allen key (Borg Warner Special Tool - T-10099).
2. Pull out the ALH assembly.
3. Turn open the ALH end cap & check the 'O' ring.
4. Remove spring and assembly bearing race and keep aside.

Lubrication & Assembly –

1. Put the ALH sub-assembly resting on the mounting flange in a clean tray. Pour ATF Oil (Qty. Approx. 100 ml) on the cam & follower assembly.
   2. Invert the ALH assembly so that the excess oil drains off.

3. Smear the bearing assembly with wheel hub bearing grease- Maximile LCG – 3 / Castrol LCG-2 (Qty. Approx. 15 Gms).
4. Place the ALH sub-assembly on the table resting on the mounting flange (drag sleeve side facing down). Install bearing in to the ALH and put spring on the assembly bearing.
5. Install end cap on to the ALH.

- Install ALH on the wheel hub. Make sure that the slots on the drag sleeve are engaging with the 4 Tanged Washer.

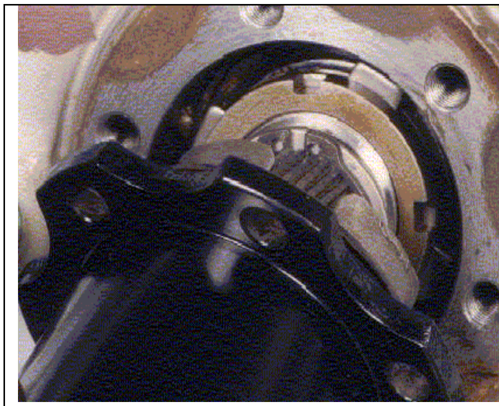
- Tighten the 6 bolts - Torque 60 ± 5 Nm.

- Tighten the end cap with the help of pin spanner.

Removal & Installation of Automatic Locking Hub -

Removal -

	Loosen the end cap with the help of pin spanner
	Remove 6 nos. bolts

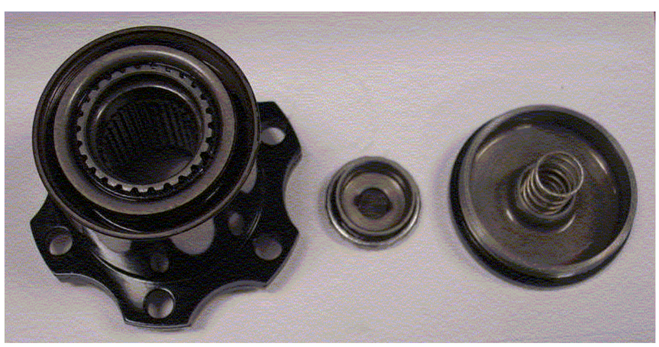


Pull out ALH from the wheel hub.

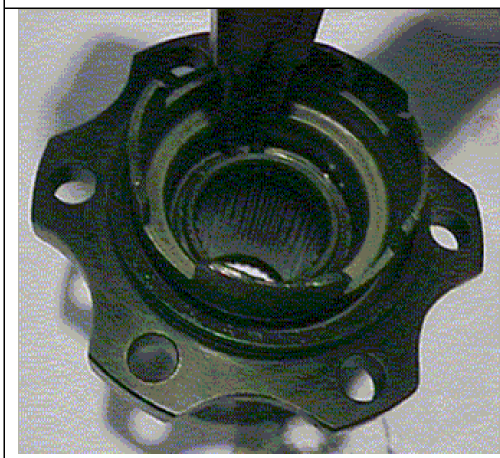
Installation of Automatic Locking Hub -

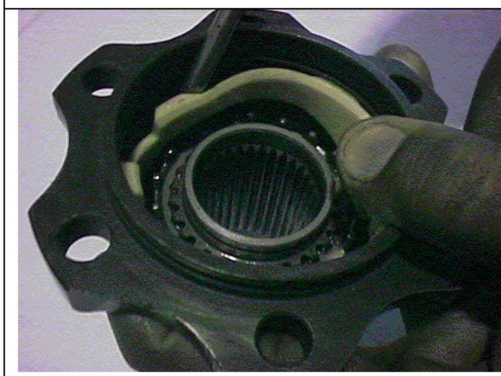
1. Make sure that the snap ring and spacer is installed on the axle shaft.
2. Make sure that the slots on the Drag Sleeve are engaging with the 4-tanged washer. Install the Hub Lock in the wheel hub.
3. Rotate the Hub Lock to match the threaded holes of the wheel hub. Put 6 nos. bolts face to face.
4. Tighten 6 nos. bolts with the help of special Allen key to 5.5 to 6.5 kg-m torque using Torque Wrench.
5. Tight the end cap with the help of pin spanner.

Disassembly of Automatic Locking Hub -



Remove the end cap and bearing race spring. Remove the bearing inner race and retainer.

	Invert assembly vertically so the drag sleeve comes up.
	Remove the snap ring with suitable plier. Exercise caution while removing the snap ring.
	Remove the drag sleeve with brake band. To lift out the drag sleeve, rotate it slightly to release the brake band tangs from the sleeves and tilt it up on the side opposite the tangs.
Note the position of the components for correct assembly.	
	The clip doesn't need to be removed for the normal servicing. However, if it's damaged, remove it using thumbnail force only to avoid stretching or distorting it. **<u>Do not remove the brake band for normal servicing.</u>**
	Remove the large snap ring from the outer clutch housing.

	Remove the steel inner cage by pressing it over the tang of the outer cage (in the window). Lift the inner cage straight out, don't tilt it.
	Remove the plastic outer cage by prying one lug out of the large groove in the outer clutch housing. Hold the lug and go on to the next one. It's easiest to start with the lugs opposite the one that fits into the window of the steel inner cage.
	Slide the cam & follower assembly out of the outer clutch housing.

Cleaning -

- Using a cleaning solvent, clean the all the parts except DRAGE SLEEVE since it is permanently lubricated with **Darmex** grease.

- After cleaning dry the parts with low pressure (20 psi maximum) compressed air.

- Lubricate the bearings race with light wheel bearing grease and cam & follower assembly with ATF oil. Protect lubricated parts from dust.

Inspection -

- Visually check all the parts for damage.

- Examine the protective end cap for cracks, O - ring.

- Brake band for damage or distortion.

- Also, inspect the teeth on the cam follower, clutch gear and outer clutch housing for wear or damage.

When diagnosing a “ratcheting” hub, remember that the noisy hub is “NOT” always the defective one. It depends on whether the hubs have just been disengaged. Let’s examine why.
If only one hub disengages after 2-wheel drive is selected, the faulty hub transmits the wheel rotation to the axle shaft. The mechanical situation is like a conventional axle raised off the ground. The axle shaft drives the differential pinions through the side gear. The ring gear and cage are not turning, so the other side gear and axle shaft are driven in the opposite direction to the first one. The axle shaft tries to engage the hub against the direction of the wheel rotation, causing the noise from the hub. In this case, the faulty hub is not making the noise. The non-noisy hub should be checked. If 4-wheel drive is selected and only one hub engages, there may not be any noise from the hub, depending on the malfunction. The only

symptom might be a loss of drive at that hub. If the hub is “ratcheting” in 4-wheel drive, it should be inspected.

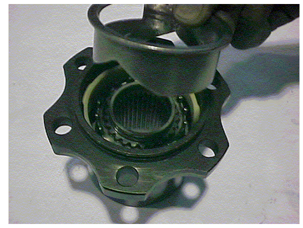
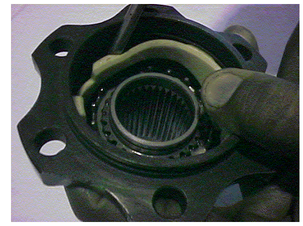
Assembly –

Following assemblies are to be replaced as sub-assemblies only-- **(if replacement is needed)**

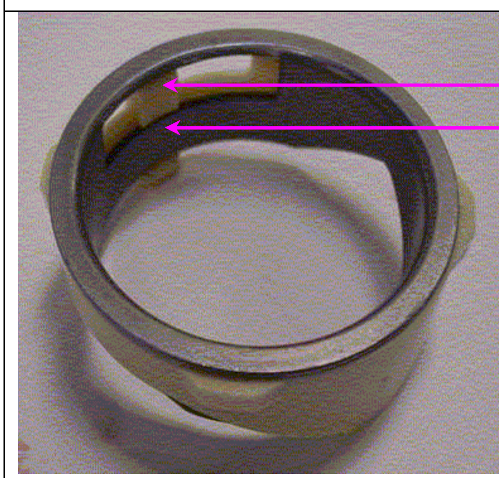
Assembly Cam & Follower

Assembly Drag Sleeve

	Install the cam & follower assembly into the outer clutch housing from the inside.

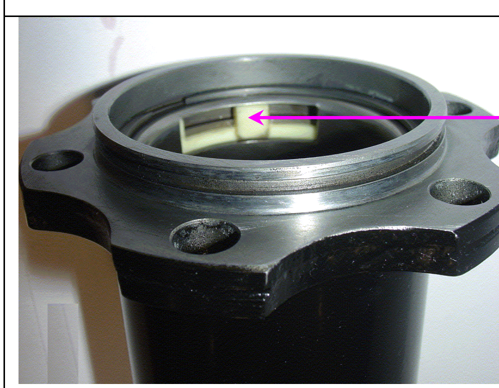
Install the plastic outer cage into the large groove in the outer clutch housing. The cage may be easier to install if the tangs on the each side of the cutout are installed first.



B
A

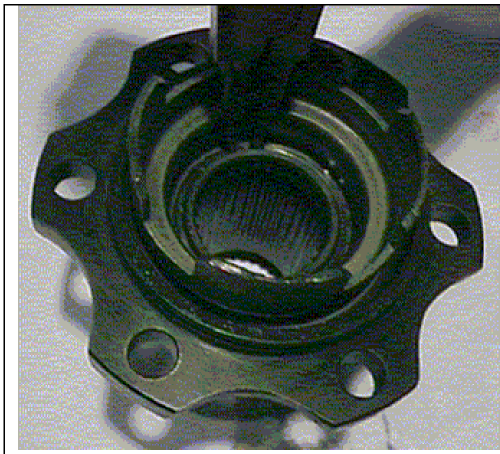
Install the steel inner cage inside the plastic outer cage. (For clarity, the cages on the right are shown outside the hub.) The window (A) must engage the tang (B) of the outer cage for correct positioning.

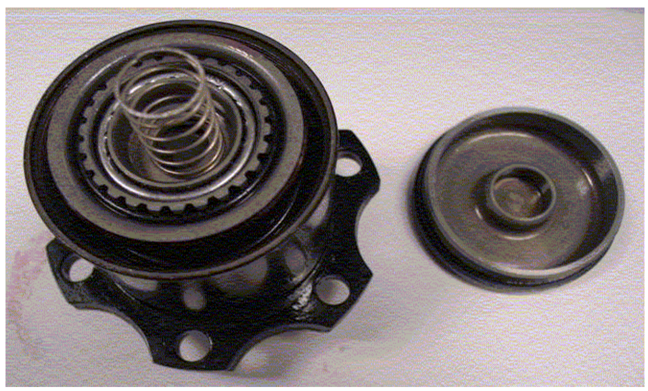
Install the large snap ring in the top groove of the outer clutch housing.



C

Install the drag sleeve assembly in the inner cage, so that the tangs of the brake band are located on each side of the outer cage tang (C)and in the window of the inner cage. Tilt the drag sleeve slightly to engage the tangs, but be careful not to cock the hub sleeve.

	Install the snap ring to the hub sleeve.



Install the outer bearing assembly, with the retainer and bearing facing the interior of the hub and the cap facing out.

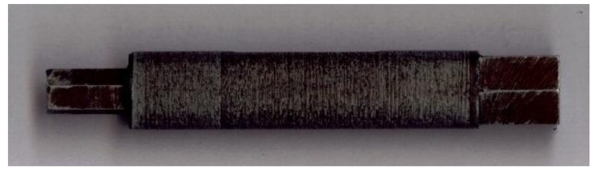
Install the assembly end cap with the bearing race spring.

	Ensure that the ALH is in ‘Unlock ‘ mode while installing on the wheel hub.

Tightening Torques –

Description	Torque Value
Allen Bolts (6 Nos.)	59 ± 5 Nm (43 ± 4 lbf-ft)

Special Tools –



Description	Borg Warner Part No.
Pin Spanner - **1**	T 10068
Special Allen for M10 Bolts - **2**	T 10099

Specifications –

Input Configuration	Female Splines
Output Configuration	Bolted Flange (M10 X 25MM, 6Nos.Bolts)
Location	74 mm dia and ‘O’ Ring for water resistance
Working Principle	Automatic Locking
Projected Length over from the face of the wheel hub	74.0 mm (Nominal)
Lubricant :	
Assembly Drag Sleeve -	Darmex grease
Assembly Cam & Follower-	ATF Castrol -TQ or Dexron II
Assembly Bearing Race -	Light wheel bearing grease
Locking & Unlocking in degrees	90^0 Deg. (Clockwise & Counter Clockwise)
Gross Weight	1.75 Kgs. Approx.
Appearance	Black Powder Coated with Aluminium Decorative Plate

Mahindra
Automotive Sector

Propeller shaft

Contents

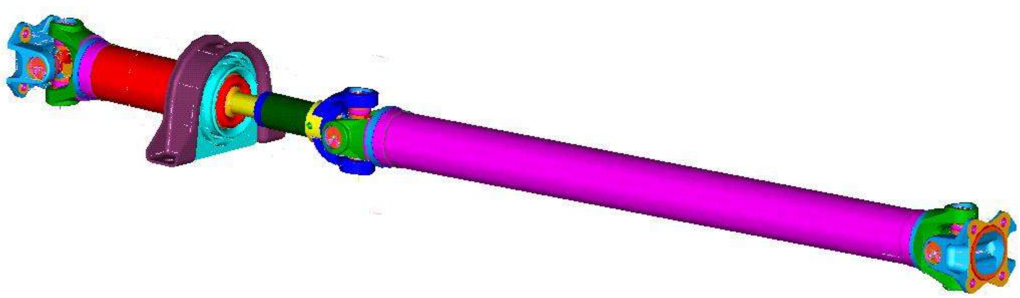
Description

The function of the propeller shaft is to transmit power from one point to another. The shaft is designed to transmit torque from transmission / transfer case to the axle.

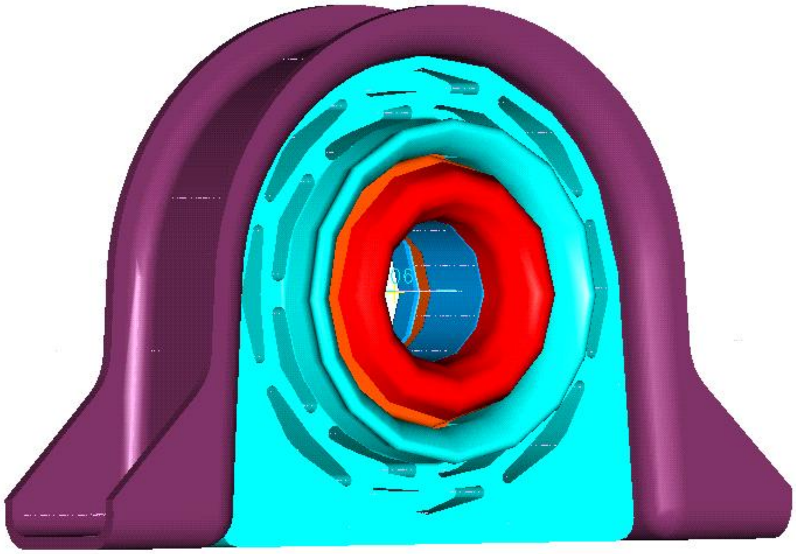
The propeller shaft has to operate through constantly changing length while transmitting torque. The axle rides suspended by spring in floating motion. The propeller shaft must be able to change the transmission angle when going through the various road surfaces. This is done through Universal joints which permit the propeller shaft top operates at different angles. The slip joint or the yokes allow the cotntratction or expansion of the propeller shaft thus allowing the length to change.

The propeller shaft is built with the yoke lugs in line with each other, which is called phasing. This design produces the smoothest running condition. An out of phase shaft can cause a vibration.

The propeller shaft is 2 piece with a centre bearing construction.
The view of the split propeller shaft is shown below.



The details of the centre bearing are shown below.



While assembling the split propeller shaft –

1. Locate the centre bearing assembly- keep the bolts loose in the slot of the chassis.
2. Locate & tighten the propeller shaft flange at the gearbox end.
3. Tighten the centre bearings mounting bracket bolts.
4. Fit the rear propeller shaft.

This procedure is important; in order to avoid straining the centre bearing Failure to do so will result in transmission noise and premature failure of the centre bearing

<u>Trouble shooting</u> –

Tyres that are out of round or wheels that are out of balance cause a low frequency vibration.
Brake drums that are unbalanced cause a harsh low frequency vibration.
Driveline vibrations can also result from loose or damaged engine mountings.

Propeller shaft vibrations will keep on increasing as the vehicle speed increase. The propeller shaft does not cause a vibration that is present only in a narrow speed range.

Drive condition	Possible cause	Correction
Propeller shaft	1. Undercoating or other foreign on the shaft.	Clean exterior of shaft & wash with solvent.
	2. Loose companion flange mounting bolts.	Tighten the mounting bolts.
	3. Worn out yoke/slip joint.	Replace the joint/yoke.
	4. Excessive runout.	Check runout- replace shaft.
	5. Incorrect drive line angularity.	Correct angularity.
	6. Worn UJ bearings.	Replace the UJ.
	7. Propeller shaft damaged or bent.	Replace the propeller shaft.
	8. Broken rear springs.	Replace the rear springs.
	9. Excessive runout or unbalanced condition.	Reindex the propeller shaft by 180°, test and correct as required.
	10. Excessive pinion shaft runout.	Reindex the propeller shaft by 180°, test and correct as required
Universal Joint Noise	UJ worn out	Replace the UJ

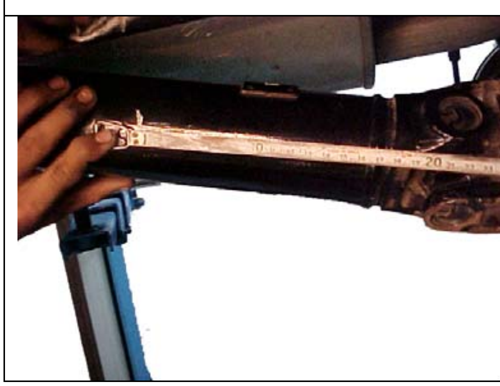
<u>In car repairs</u> -

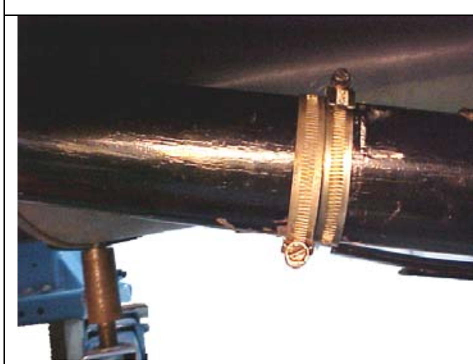
<u>Unbalance</u>
<u>Runout</u>

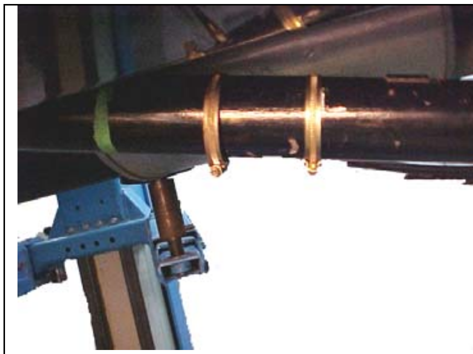
Unbalance –

If the propellers shaft unbalance is suspected then it can be verified by the following procedure.

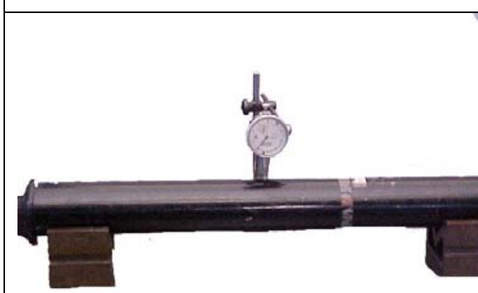
Removing & rendering the propeller shaft by 180° may eliminate some vibrations.

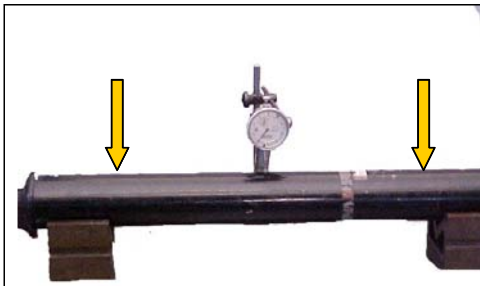
	Clean all the foreign material from propeller shaft and the universal joint.
	Inspect the propeller shaft for missing balance weight, broken welds and bent areas. If the propeller shaft is bent then it must be replaced.
	Ensure that the propeller shaft is not worn, are properly installed and are correctly aligned with the propeller shaft
	Check the companion flange mounting bolts.
	Raise the vehicle.
	Remove the wheel & tyres.
	Install the wheel nuts to lock the brake drum.
	Mark & number the shaft 6 inches from pinion end at four positions 90° apart.

	Run and accelerate the engine until vibration occurs. Note the intensity & the speed at which the vibration occurs.
	Install a screw clamp at position “1”
	Start the engine and recheck for vibrations. If there is little or no change in vibrations then move the clamp or of the other 3 positions.
If there is no difference in vibration at the other position then the vibration is not due to the propeller shaft imbalance.	
	If the vibration decreases, install a second clamp and repeat the test.
	If the clamps cause an additional imbalance, separate the clamp (¼ inch above & below the mark.). Repeat the vibration test.

	Increase the distance between the clamps until the vibration is at the lowest level.
	At this position bend the slack end of the clamp so that it does not loosen.
	Install the wheel & tyres. Lower the vehicle.
If the amount of the vibration remains unacceptable then repeat the exercise at the Gearbox end.	

Runout

	Remove dirt, rust, paint & undercoating from the propeller shaft surface.
	The dial indicator must be installed perpendicular to the shaft surface.



Measure the runout at the center and at the ends – away from the weld.

Replace the propeller shaft if the runout is beyond the specified limit.

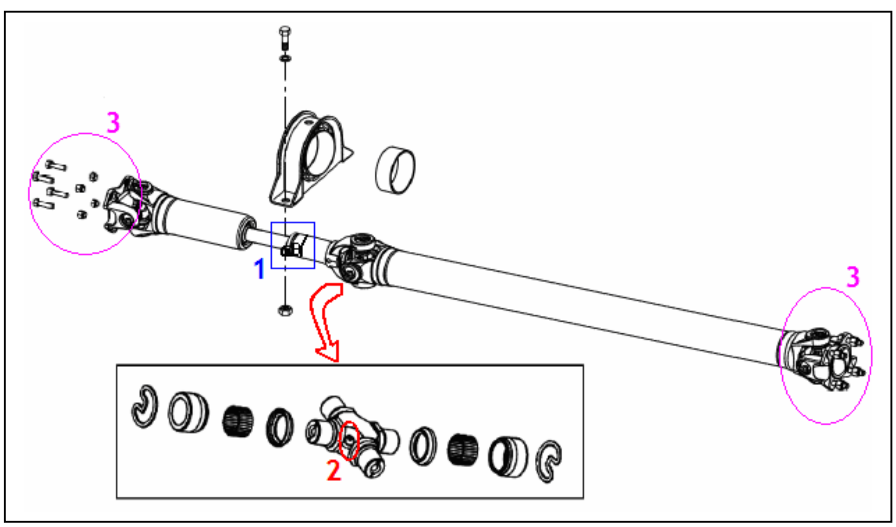
<u>Care of the system</u> --

Caution:
Before undercoating a vehicle with any underbody protection. The propeller shaft and the UJ's should be covered. This will prevent the undercoating from causing an unbalanced condition and vibration.

Use the exact replacement hardware for attaching the propeller shafts. The specified torque's must always be applied when tightening the mounting bolts.

- ✓ The UJ to be greased at every service.
- ✓ The slip joint should be lubricated every 10,000 Kms.

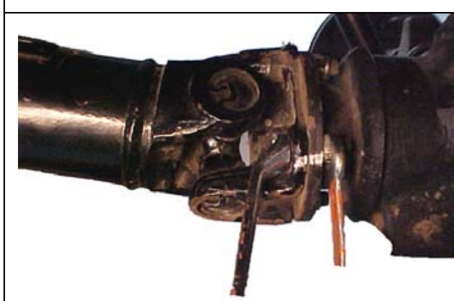
The procedure of greasing is as follows –



1. Inspect the Sliding yoke for Grease & play; fill the grease through the grease nipple with pressurized gun.

2. Inspect the Universal Joint for Grease & play; fill the grease through the grease nipple with pressurized gun.

Repairs --

	Lift the vehicle
	Put aligning marks on the flange, UJ and propeller shaft before removal. Do not use a punch to mark impression.
	Remove the mounting bolts at the pinion end
	Remove the mounting bolts at the gearbox end.
	It is important to protect the machined, external surface of the yoke from damage after propeller

	shaft removal. Any damage in the machined surface will lead to damage of the seal and cause a leak.
	Remove the circlips holding the UJ in place.
	Applying the socket wrench on the outside of the propeller shaft flange, force out one end of UJ using a vice as shown. (One end 32 mm socket to receive other end 21-mm socket to push.)
	While assembling- insert both ends then hold & press fit them with special tool.

Specification & Wear Limits -

Description	2WD	4WD
Length (Joint to Joint) x O.D x thickness in mm		
Rear	1023.5x70x2	727.5x70x2
Front (Diesel)		479.6x 44.45x3.25
Rear (GB -c/brg)-Split propeller	132.8x 63.5x2.1	
Rear (centre brg to axle) Split propeller	761.4x63.5x2.1	
Runout Diesel	0.5 mm TIR at centre	

Tightening Torques -

Location	Torque Nm (lbf-ft)
Flange bolt	60 ± 5 Nm (44 ± 4 lbf-ft)
Center bearing mounting bracket	87 ± 15 Nm (65 ± 12 lbf-ft)
Companion Flange nuts at Transmission & Axle end	60.5 ±5.5 Nm (45 ± 4 lbf-ft)

Automotive Sector

Rear Axle

Contents

Description

The rear axle is of the hypoid, semi-floating type using shim adjustment to obtain bearing pre-loads. The differential case with Crown wheel and the drive pinion are mounted in opposed taper roller bearing in one-piece rear axle carrier.

The rear axle pinion receives its power from the engine through the Transmission and driveshaft. The drive pinion rotates the differential case through the engagement with the crown wheel, which is bolted, to the differential case flange. Inside the differential cages are four differential pinions mounted on the differential pinion shaft which is splined to the housing. These gears are engaged with the side gears, to which the axle shafts are splined. Therefore as the differential housing turns, it rotates the axle shaft and the rear wheel. When it is necessary for one wheel to rotate faster than the other is, the faster turning gear causes the pinion to roll on slower turning gear to allow differential action between the two axle shafts.

The axle shafts are held in the housing by the bearings and the retainers at the housing outer end. *Axle shaft endplay is pre set and not adjustable. The hub bearings are prepackaged for life.*

ⓘ All operations other than the removal of the axle shafts and the replacement of the wheel bearing oil seal should be carried out with the axle removed from the vehicle.

<u>Trouble Shooting</u> -

Certain rear axle and driveline trouble symptoms are also common to the engine, transmission, tyres and other parts of the Vehicle. For this reason be sure that the cause of the trouble is in the rear axle before adjusting, repairing or replacing any of the axle parts.

Rear Axle Noise Diagnosis -

Basic characteristics in a rear axle are more difficult to diagnose and repair than mechanical failures. Slight axle noise heard only at certain speed or under particular conditions must be considered normal. Axle noise tend to peak or be more pronounced at particular speeds and the noise is in now way a sign of the trouble in the vehicle.

Where noise is present in objectionable form (Loud and/ or at all speeds) the first effort should be to isolate the noise.

Isolation of noise in any one unit requires care and experience and an attempt to eliminate a slight noise may baffle even the most experienced mechanic/ technician.

Axle noise fall into two basic categories: gear noise and/ or bearing noise.

Axle Noise **Gear Noise**
Bearing Noise
Others

Gear Noise –

The most important characteristic of the gear noise is that it is usually sensitive to accelerator position. E.g. noise audible under drive condition will often disappear under coast condition (i.e. driving in neutral with the clutch released and engine running) at the same vehicle speed and vice versa.

Axle gear noise whine will always occur at the same road speed and throttle setting i.e. drive or coast (i.e. driving in neutral with the clutch released and engine running). Gear whine is usually a fairly high pitched pure tone as opposed to a low-pitched rumble caused by a spalled bearing.

Some noises, which can be confused with axle gear whine, are: -

…. Whine from an engine component; this will always occur at the same engine speed irrespective of which transmission gear is used

…. Whine from an indirect Transmission gear (e.g. 5th gear on some vehicles produces a whine comparable with axle whine) however this will disappear when the direct transmission ratio is selected.

…. Whine from tyres or wind noise from a rack or aerial. These noise generally occur over a very broad speed range and do not change with driving mode i.e. drive or coast (i.e. driving in neutral with the clutch released and engine running)

Remember

Before diagnosing the whine as axle gear noise, ensure that the whine:

(a)Occurs in direct transmission ratio (4th gear)

(b) Changes with throttle/ accelerator variations (drive and coast) (i.e. driving in neutral with the clutch released and engine running)

(c)Always occur at the same road speed and not engine speed,

(d) Occurs over a limited vehicle speed. (This can vary over a wide band should the axle be in extremely bad condition.)

Bearing Noise –

Bearing noise is inclined to be less throttle sensitive than gear noise and frequently occurs over a wide speed range. Bad cases of faulty bearings can, in fact be detected from walking speed, building up in pitch as speed increases and is not directly affected by changing from drive to coast (i.e. driving in neutral with the clutch released and engine running) and visa versa

(a)Rear wheel bearing noise tends to be low pitched grumble, which can normally be detected and confirmed when driving on a smooth road at constant speed, with the noise most audible while swerving sharply from left to right. If the noise increases or decreases as the car is swerved, it is probable that a wheel bearing is faulty. Driving close to a wall or a curb at a suitable speed can carry out a further check for wheel bearing noise.

(b) Differential bearing noise is usually similar to in pitch to wheel bearing noise but is not affected by the swerve check referred to previously.

(c) Pinion bearing noise is normally at a higher pitch than wheel or differential bearings and is often slightly sensitive to throttle position, although not to the same extent as gear noise.

Other:

1. A further condition, which can exist, is due to a worn bearing that allows the gear set to move out of its correct mesh cause gear noise. This condition is usually throttle sensitive, with the noise frequently disappearing on a "drive" condition.

   Any amount of or endplay in either the pinion bearings or differential carrier bearings are detrimental to the gears and bearings and will cause axle noise.

2. A high spot sometimes occur on either the ring gear or the drive pinion; this shows up as a ticking or light knocking noise over a restricted range of throttle position. The frequency of the noise will indicate whether the high spot is on the pinion (drive shaft frequency) or on the ring gear. The severity of the noise indicates the size of the defect. A light "tick " is seldom detrimental and usually occurs in new axle and will normally disappears once the axle has been run in.

3. Louder noise usually indicate a more serious defect and a knock occurring in an axle which was previously free from this type of noise must always be investigated.

Care of the axle -

The lubricant level should be checked every 10000 Kms with the vehicle unladen and in a level ground. The lubricant level should be at the lower edge of the filler plug. Use lubricant meeting oils specification of GL 5 and viscosity of SAE 90 .The brand names have been specified in the lubricant section.

Note: Unless otherwise specified the assembly procedure / guidelines is the reverse of the disassembly procedure

IN VEHCILE ADJUSTEMENT & REPAIR -

The works in axle that can be done without removing from the vehicle are:

Replacement of pinion seal

~~Backlash adjustment~~

Replacement of Pinion seal

	Remove the propeller shaft from the companion flange

	Using the MST 216, Lock the companion flange.
	Unlock the pinion nut
	Remove the companion flange along with the dust cover
	Using screwdriver take out the old oil seal- take care not to damage the seating / contact areas/
	Fit the new seal using the dolly. Apply oil on lip and ensure that seating are has been wiped clean and free of burrs

~~Backlash adjustment.~~

The backlash adjustment should not be done on the vehicle. This is due to the fact that the spreader usage in vehicle is difficult if the vehicle isn't being attended in a pit. Further after adjustment it may be necessary to adjust pinion height. (Any change in backlash indicates wear- hence though shim adjustment may compensate for gear teeth wear. It will not compensate the pinion wear and pinion bearing wear and loss of preload)

However it is suggested that the tooth contact be checked on the vehicle

before taking decision to open/ overhaul. It is recommended that after draining the oil and opening the rear cover. Put paint marks in four different places. Then push the vehicle forward and backwards at least 15 feet. This will give a much better tooth contact under load. (It should be remembered that with load the tooth contact moves away from toe to heel). The tooth contact without load is given in the specification sheet.)

Rear axle Overhaul –

Comprises of the following major steps

1. **Removal & Refitment of the axle from the vehicle.**
2. **Removal of the Refitment of the hub and the brake carrier and oil seal.**
3. **Removal of the differential assembly**.
4. **Pinion height adjustment and preloading of pinion bearings**
5. **Assembly of the crown wheel.**

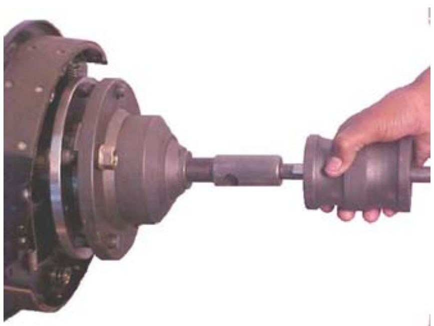
1) Removal and Refitment of the axle assembly from the vehicle

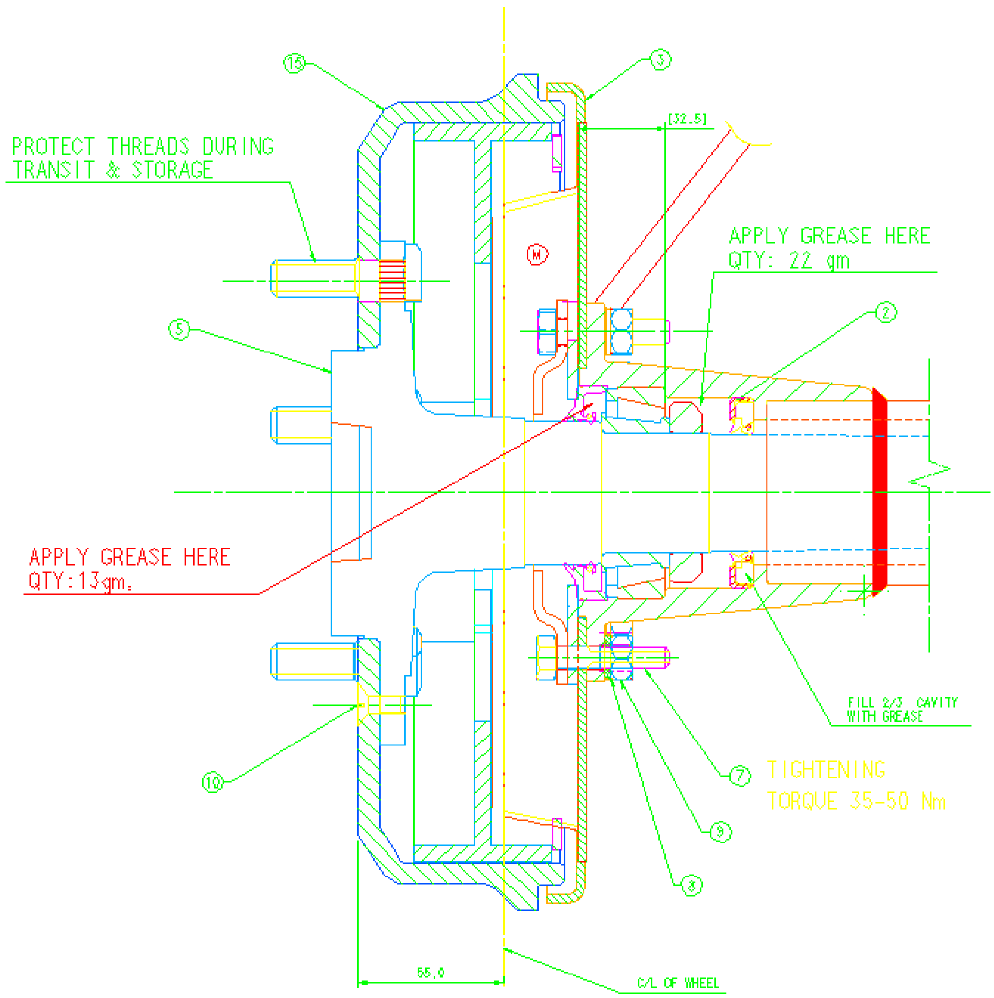
	Support the body on stand and remove the tyres.
	Remove the shock absorber.
	Remove the brake pipe T clamp from axle
	Remove the LSPV spring from axle

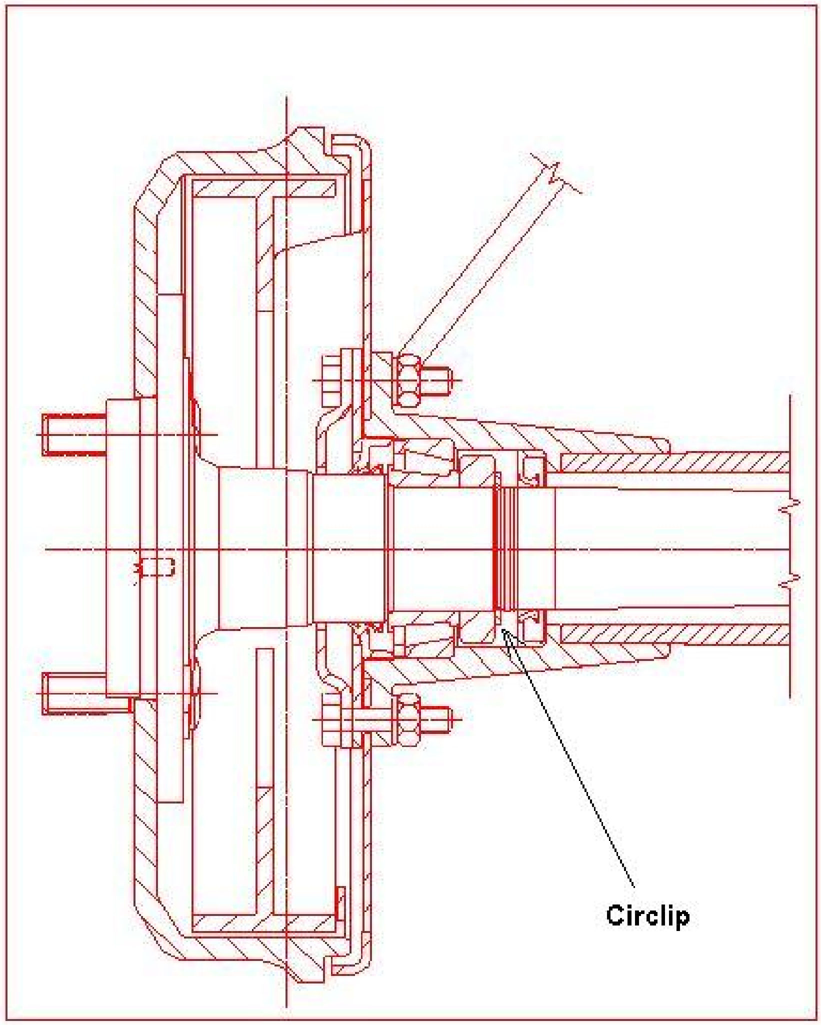
	end
	Loosen suspension links. Axle to be supported & should not fall
Remove the axle from the vehicle	

2) Removal & Refitment of the rear axle shaft & hub

	Remove the brake drum after loosening the two screws
	Remove the parking brake locking

	Loosen the 6 screws holding the retainer.
	Using the MST576 and the sliding hammer MST 577. Pull out the hub integral with the axle shaft, prepackaged bearing, retainer ,oil seal and carrier
	For removal of the bearing the locking collar has to be cut using a drill. It should be cut up to the end and then using the chisel it should be snapped open
	Remove bearing using the hydraulic press and the MST.
	While assembly use the MST 578 to support the bearing & tube MST 579 for pressing


PROTECT THREADS DURING
TRANSIT & STORAGE
APPLY GREASE HERE
QTY: 22 gm
APPLY GREASE HERE
QTY: 13gm.
FILL 2/3 CAVITY
WITH GREASE
TIGHTENING
TORQUE 35-50 Nm
[32.5]
55.0
C/L OF WHEEL
15
3
5
2
10
7
9
3
M



The assembly section is shown in the sketch attached. Please note the bearing direction the circlip

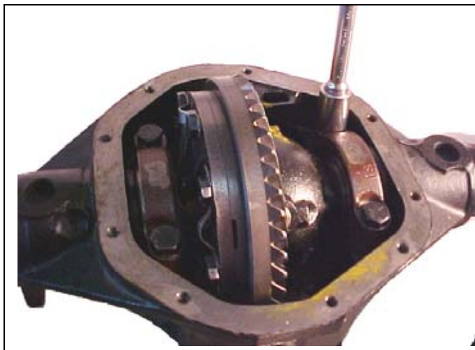
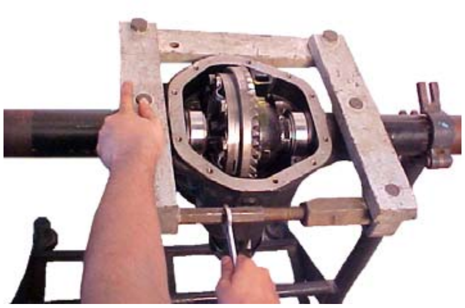
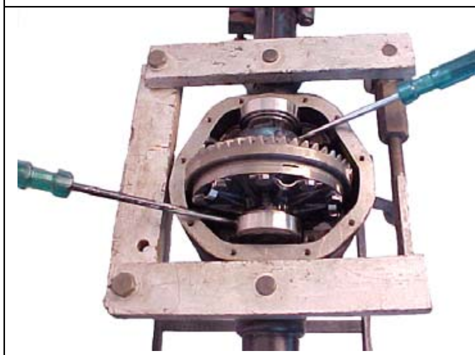
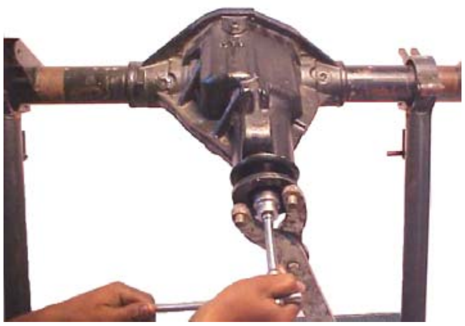
DO NOT ATTEMPT TO FIT THE LOCKING COLLAR BY HEATING.

THE COLLAR IS HARDENED AND TEMPERED.HEATING & PRESSING MAY CAUSE IT TO LOOSEN IN SERVICE CAUSING MAJOR FAILURE

	While reassemble use the hole in axle shaft flange to tighten the retainer bolts. Please ensure that the hydraulic press is capable of at least 10 tons load and it has a adequate stroke.

3) Removal of the Centre assembly

	After draining the oil - remove the differential cover set screws.
	Remove the differential side bearing bolts

	Remove the side bearing caps,
	Using MST 205, expand the differential.
	Pull out the crown along with the bearings
	Using MST 216, lock the companion flange.

	Unlock the pinion nut.
	Remove the companion flange along with the dust cover
	Tap the pinion along with bearings,

4) Assembly of the Centre assembly

<u>Using the special tool</u>

<u>Without the special tool</u>

<u>Preloading of the crown wheel and backlash adjustment.</u>

<u>The pinion preload setting and tooth contact setting can be done by using</u>:

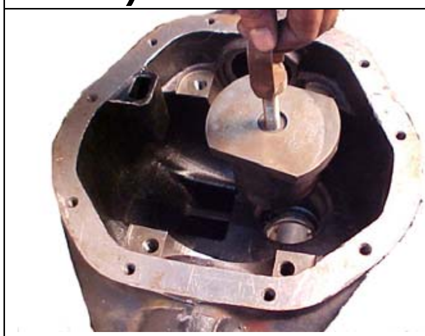
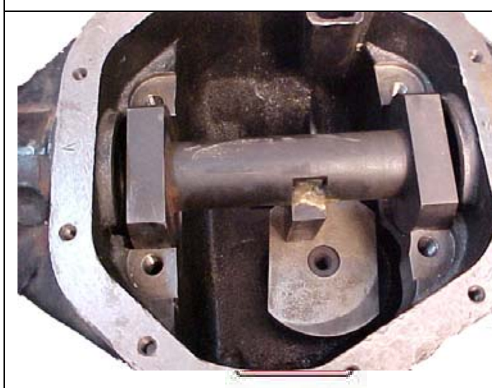
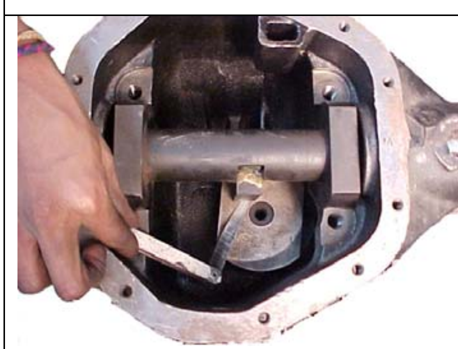
a) **Special Tool**. The special tool and gauges are strongly recommended in either of the scenario

- new axle housing is used or
- the bearing seating surface has worn out.

b) **Without the use of special tools**. This can be done only if the crown wheel & pinion is being replaced in the existing housing and the crown wheel bearing seating and the pinion inner bearing seating area is not worn.

4 a) Assembly Using the Special Tools

	If the pinion bearings are having pitting, flaking or spalling of the

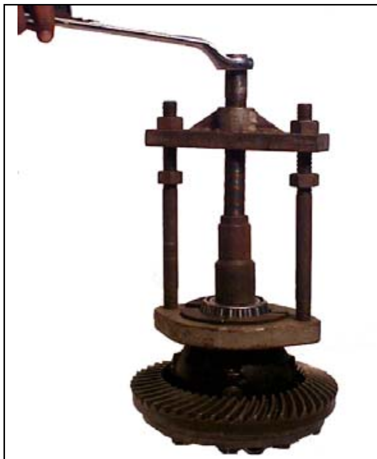
	raceway then they have to be replaced. Remove the outer race using the MST (For Fitting use MST 200)
To measure the Z value (distance of pinion apex from the carrier center)	
	Place the setting gauge (MST 581) in the carrier (the pinions inner bearing outer race & shim should be removed) Please note that the lifting handle should be removed after placing it in position
	Place the setting gauge 2 – MST 582 (in the crown wheel bore)
	Measure the gap between the setting gauge 1 and 2 using a feeler gauge.
	Ensure that the gauge 582's face is parallel to the differential case. (Use a level gauge)

	For example if the thickness measured X is 12 thou
	The value etched in pinion is Y Then the shim value is X-Y In this example it will become 12-5= 7 thou
	Place the 7thou shim below the bearing seating area.
	After that cross check the gap between the gauge and the new pinion. It should be the same as the Z mark punched. In this case 5 thou (tolerance ± 1 thou)
	In case the Z value is –ve then the gap has to be checked between the bore & MST 582.
This will ensure that the tooth contact of the Crown wheel and pinion is accurate **<u>However this shim also affects the distance between the two pinion bearings and thus will affect the pinion bearing preload</u>**.	
	Suppose 10 thou of shims were the thickness originally present (at the height adjusting end and the new value is 12 thou.)
	Hence to maintain the pinion bearing preload equal amount of shims at the outer bearing end will have to be

	adjusted Since the shim thickness at the inner bearing has increased by 2 thou hence add 2 thou of shims from the other end.
	If the pinion preload is not as per the specifications after assembly then add or remove shims from the outer bearing end.
	Please note that if the shims are removed or added at the outer end for adjusting the preload then do not add or remove shims at the height adjusting end- that will disturb the contact.
	Before inserting the companion flange at the end- apply **Loctite 638** in the splines so that the loosening can be avoided.

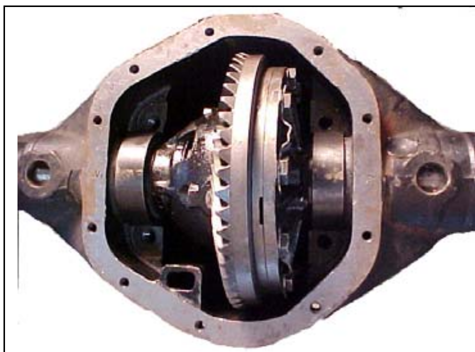
4 b) **Only if the crown wheel & pinion are being replaced – no wear on seating surfaces is present**

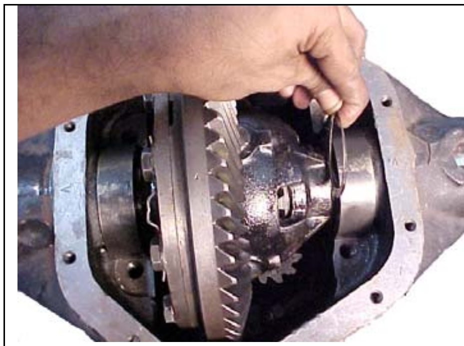
	If the pinion bearings are having pitting, flaking or spalling of the raceway then they have to be replaced. Remove the outer race using the MST (For Fitting use MST 200)

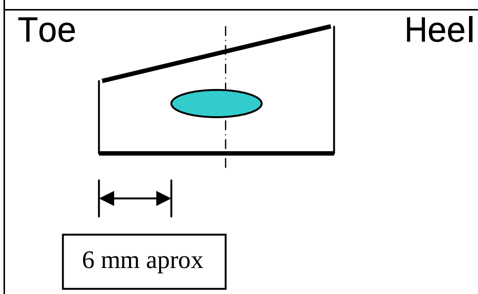
	If the crown wheels bearings are having pitting, flaking or spalling of the raceway then they have to be replaced. For removal of the bearing use MST 202 (For fitting the crown wheels side bearing use the MST
	Note the Z value etched on top of the old pinion (O) and the Z value etched on the top of the new pinion (N)
	The correct shim thickness = O-N (Old-New) If the value is + then shims have to be added and if – then shims have to be removed. These shims are between the pinion inner bearing outer race & the housing.
	This will ensure that the tooth contact of the Crown wheel and pinion is accurate
	However this shim also affects the distance between the two pinion bearings and thus will affect the pinion bearing preload.
	Suppose 2 thou of shims are adjusted. E.g + 2 added
	Then to maintain the pinion bearing preload equal amount of shims at the outer bearing end will have to be adjusted

	Since the shim thickness at the inner bearing has increased by 2 thou hence add 2 thou of shims at the other bearing
	If the pinion preload is not as per the specifications after assembly then add or remove shims from the outer bearing end.
	Please note that if the shims are removed or added at the outer end for adjusting the preload then do not add or remove shims at the height adjusting end- that will disturb the contact.

Adjustments of the crown preload & tooth backlash

	Install the crown, in the carrier. Instead of using the bearings use MST 583, - one on each side. The advantage of using the MST instead of bearings while setting is that as the outer race does not keep getting tilted hence we get accurate reading further the bearings do not get damaged when they are removed after checking the values of shims required.
	Push the crown assembly towards the pinion so that the backlash is zero.

	In this position find the shim pack which has to be inserted on right (Back of crown) side. And also on the teeth side.
	Move shims from teeth side to back of the crown side so that the backlash is achieved.
	Add an additional 0.075mm (0.003")- of shim on the both the side so that the crown teeth get preloaded.
	Take out the assembly, keep the selected shim packs correctly.
	Remove the MST 583.
	Insert the bearing assembly along with the selected shim pack. Use MST 205 to spread the carrier.
	While using the spreader ensure that the expansion is not more than 0.5 mm. If more it can cause permanent deformation of the carrier.
	While assembling the caps ensure that the markings match. Torque- 9.6 to 12.5 Mkg (70 to 90 Lbft)

	Check the backlash, if less or more then the shims should be moved from one side to the other. Note: Approximately 5 thou shim is equal to 3 thou of backlash.
	Check the backlash. 0.13 to 0.25 mm (0.005"-0.010")
	Check the runout in four places it should be less than 0.15 mm (0.006")
	After the backlash has been achieved, check the tooth contact on both the drive and the reverse side. Note since the crown wheel is without load hence the contact should not be exactly at center but as shown in the sketch.

Specifications -

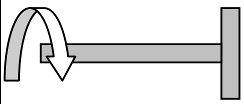
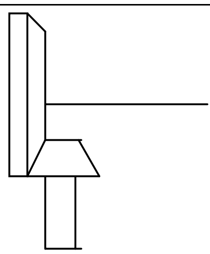
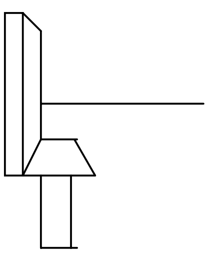
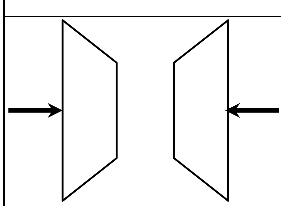
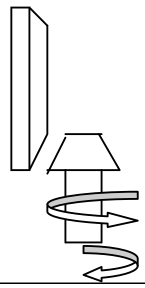
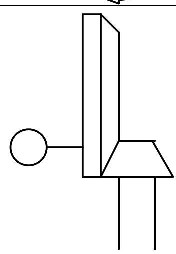
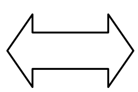
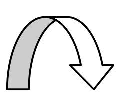
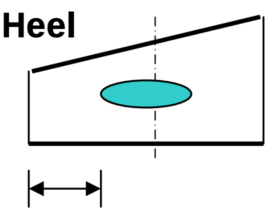
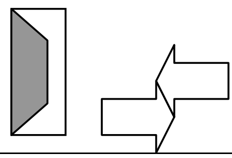
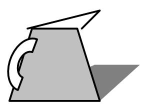
Figure	Description	Value		
	Semi floating single reduction without diff. lock			
		High end/Petrol	Mid range	Low range
	No of teeth on crown N1	48	50 (45 opt)	
	No of teeth on pinion N2	10	11	
	Axle reduction ratio N1/N2	4.88	4.55(optional)	4.09
		From Sl no 32 K 90710 (All models except Rev 116)		
	No of teeth on crown N1	43		
	No of teeth on pinion N2	10		
	Axle reduction ratio N1/N2	4.3		
	Pinion Pre load	23 to 45 Kgcm		
	Preloading of differential bearings	0.075 mm (0.003”		

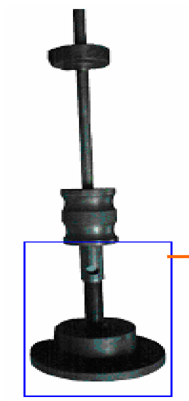
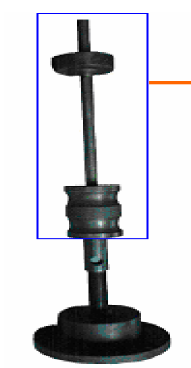
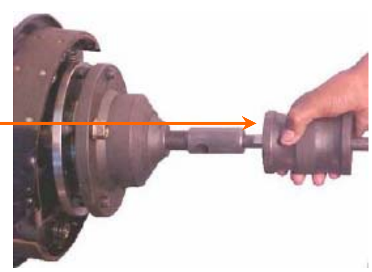
Figure	Description	Value
	**Crown-pinion backlash** **Maximum variation of backlash in a crown**	**(0.005 to 0.008”** **(0.003”)**
	**Run out of the ring gear / crown wheel**	**0.15 mm (0.006”)**
	**Hub end play**	**Max 0.3 mm (0.0012”)**
	**Hub rotational torque**	**Not applicable**
Toe **Heel**  6 mm aprox	**Check for correct tooth contact on both the forward and reverse direction**	**Check on both the driving & reverse flank. This contact is for checking without load.**
	Clearance between and side(sun) gears and diff case	**0.20 mm (0.008”)**

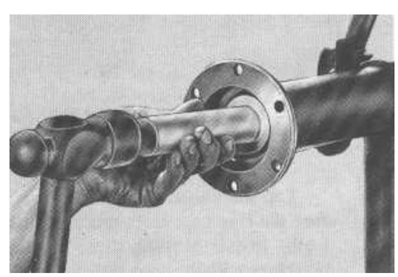
	Rotational torque of differential case with sun & pinion gears	**5 Kg cm**
Figure	**Description**	**Value**
	**Inner race interference Outer race clearance**	**0.125 mm (0.005 to 0.007”)**
	**Oil grade/ Viscosity/ Quantity**	**GL 5/ SAE 90/ 1.65 liters**

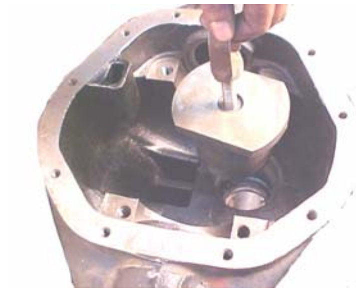
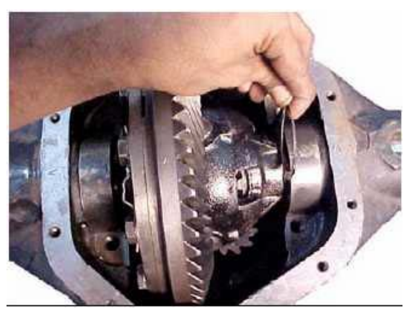
Tightening Torque’s –

Location	Torque in Nm (Lbft)
Brake carrier mounting bolts	33.8 to 47.45 (25 to 35 LB FT)
Pinion nut	217 to 244 (160 to 180 LB FT)
Crown mounting nuts	54 to 68 (40 to 50 Lb Ft)
Differential side bearing bolts	95 to 122 (70 to 90 LB FT)
Differential disc cover bolts	16 to 20(12 to 15 LB FT)

Special Tools --

Description / Part No. / Sketch	Usage View
Puller rear axle shaft MST 576 	
Sliding Hammer MST 577 	
Ring Rear axle collar support. MST 578	

	
Description / Part No. / Sketch	**Usage View**
Tube-Rear axle collar pressing MST 579 	
Installer Inner Oil seal Rear axle tube MST 580 	
Rear axle Pinion Height setting	

Gauge (1) MST 581 	
Description / Part No. / Sketch	**Usage View**
Rear axle Pinion Height setting Gauge (2) MST 582 	
Differential side bearing setting gage MST 583 	

Recommended Lubricants -

Specification: GL 5; SAE 90

Brands

Maximile : Recommended	Maximile DO
Other options	
IOC	SERVOGEAR HP 90
HP	HP GEAR OIL XP 90
BPCL -	BHARAT SPIROL HD 90
BHARAT SHELL -	SPIRAX HD 90
CHEMOLEUMS -	CHEMOLEUMS TURBO GL5 SAE 90
GULF	MP GO 90
CALTEX	THUBAN GL5-90
VEEDOL	VEEDOL MULTI GEAR 90 HD
CASTROL -	CASTROL HYPOY B 90

Sealant -

Differential cover sealant : Loctite 587 / Gasket

Automotive Sector

Mahindra
Automotive Sector

Rear Axle

Contents

Description

The rear axle is of the hypoid, semi-floating type using shim adjustment to obtain bearing pre-loads. The differential case with Crown wheel and the drive pinion are mounted in opposed taper roller bearing in one-piece rear axle carrier.

The rear axle pinion receives its power from the engine through the Transmission and driveshaft. The drive pinion rotates the differential case through the engagement with the crown wheel, which is bolted, to the differential case flange. Inside the differential cages are four differential pinions mounted on the differential pinion shaft which is splined to the housing. These gears are engaged with the side gears, to which the axle shafts are splined. Therefore as the differential housing turns, it rotates the axle shaft and the rear wheel. When it is necessary for one wheel to rotate faster than the other is, the faster turning gear causes the pinion to roll on slower turning gear to allow differential action between the two axle shafts.

The axle shafts are held in the housing by the bearings and the retainers at the housing outer end. *Axle shaft endplay is pre set and not adjustable. The hub bearings are prepackaged for life.*

ⓘ All operations other than the removal of the axle shafts and the replacement of the wheel bearing oil seal should be carried out with the axle removed from the vehicle.

Trouble Shooting -

Certain rear axle and driveline trouble symptoms are also common to the engine, transmission, tyres and other parts of the Vehicle. For this reason be sure that the cause of the trouble is in the rear axle before adjusting, repairing or replacing any of the axle parts.

Rear Axle Noise Diagnosis -

Basic characteristics in a rear axle are more difficult to diagnose and repair than mechanical failures. Slight axle noise heard only at certain speed or under particular conditions must be considered normal. Axle noise tend to peak or be more pronounced at particular speeds and the noise is in now way a sign of the trouble in the vehicle.

Where noise is present in objectionable form (Loud and/ or at all speeds) the first effort should be to isolate the noise.

Isolation of noise in any one unit requires care and experience and an attempt to eliminate a slight noise may baffle even the most experienced mechanic/ technician.

Axle noise fall into two basic categories: gear noise and/ or bearing noise.

Axle Noise **Gear Noise**
Bearing Noise
Others

Gear Noise -

The most important characteristic of the gear noise is that it is usually sensitive to accelerator position. E.g. noise audible under drive condition will often disappear under coast condition (i.e. driving in neutral with the clutch released and engine running) at the same vehicle speed and vice versa.

Axle gear noise whine will always occur at the same road speed and throttle setting i.e. drive or coast (i.e. driving in neutral with the clutch released and engine running). Gear whine is usually a fairly high pitched pure tone as opposed to a low-pitched rumble caused by a spalled bearing.

Some noises, which can be confused with axle gear whine, are: -

…. Whine from an engine component; this will always occur at the same engine speed irrespective of which transmission gear is used

…. Whine from an indirect Transmission gear (e.g. 5th gear on some vehicles produces a whine comparable with axle whine) however this will disappear when the direct transmission ratio is selected.

…. Whine from tyres or wind noise from a rack or aerial. These noise generally occur over a very broad speed range and do not change with driving mode i.e. drive or coast (i.e. driving in neutral with the clutch released and engine running)

Remember

Before diagnosing the whine as axle gear noise, ensure that the whine:

(a) Occurs in direct transmission ratio (4th gear)

(b) Changes with throttle/ accelerator variations (drive and coast) (i.e. driving in neutral with the clutch released and engine running)

(c) Always occur at the same road speed and not engine speed,

(d) Occurs over a limited vehicle speed. (This can vary over a wide band should the axle be in extremely bad condition.)

Bearing Noise –

Bearing noise is inclined to be less throttle sensitive than gear noise and frequently occurs over a wide speed range. Bad cases of faulty bearings can, in fact be detected from walking speed, building up in pitch as speed increases and is not directly affected by changing from drive to coast (i.e. driving in neutral with the clutch released and engine running) and visa versa

(a) Rear wheel bearing noise tends to be low pitched grumble, which can normally be detected and confirmed when driving on a smooth road at constant speed, with the noise most audible while swerving sharply from left to right. If the noise increases or decreases as the car is swerved, it is probable that a wheel bearing is faulty. Driving close to a wall or a curb at a suitable speed can carry out a further check for wheel bearing noise.

(b) Differential bearing noise is usually similar to in pitch to wheel bearing noise but is not affected by the swerve check referred to previously.

(c) Pinion bearing noise is normally at a higher pitch than wheel or differential bearings and is often slightly sensitive to throttle position, although not to the same extent as gear noise.

Other:

1. A further condition, which can exist, is due to a worn bearing that allows the gear set to move out of its correct mesh cause gear noise. This condition is usually throttle sensitive, with the noise frequently disappearing on a “drive” condition.

   Any amount of or endplay in either the pinion bearings or differential carrier bearings are detrimental to the gears and bearings and will cause axle noise.

2. A high spot sometimes occur on either the ring gear or the drive pinion; this shows up as a ticking or light knocking noise over a restricted range of throttle position. The frequency of the noise will indicate whether the high spot is on the pinion (drive shaft frequency) or on the ring gear. The severity of the noise indicates the size of the defect. A light “tick “ is seldom detrimental and usually occurs in new axle and will normally disappears once the axle has been run in.

3. Louder noise usually indicate a more serious defect and a knock occurring in an axle which was previously free from this type of noise must always be investigated.

<u>Care of the axle</u> -

The lubricant level should be checked every 10000 Kms with the vehicle unladen and in a level ground. The lubricant level should be at the lower edge of the filler plug. Use lubricant meeting oils specification of GL 5 and viscosity of SAE 90 .The brand names have been specified in the lubricant section.

Note: Unless otherwise specified the assembly procedure / guidelines is the reverse of the disassembly procedure

IN VEHCILE ADJUSTEMENT & REPAIR -

The works in axle that can be done without removing from the vehicle are:

Replacement of pinion seal

~~**Backlash adjustment**~~

Replacement of Pinion seal

	Remove the propeller shaft from the companion flange

	Using the MST 216, Lock the companion flange.
	Unlock the pinion nut
	Remove the companion flange along with the dust cover
	Using screwdriver take out the old oil seal- take care not to damage the seating / contact areas/
	Fit the new seal using the dolly. Apply oil on lip and ensure that seating are has been wiped clean and free of burrs

~~Backlash adjustment.~~

<u>The backlash adjustment should not be done on the vehicle.</u> This is due to the fact that the spreader usage in vehicle is difficult if the vehicle isn't being attended in a pit. Further after adjustment it may be necessary to adjust pinion height. (Any change in backlash indicates wear- hence though shim adjustment may compensate for gear teeth wear. It will not compensate the pinion wear and pinion bearing wear and loss of preload)

However it is suggested that the tooth contact be checked on the vehicle

before taking decision to open/ overhaul. It is recommended that after draining the oil and opening the rear cover. Put paint marks in four different places. Then push the vehicle forward and backwards at least 15 feet. This will give a much better tooth contact under load. (It should be remembered that with load the tooth contact moves away from toe to heel). The tooth contact without load is given in the specification sheet.)

<u>Rear axle Overhaul</u> –

Comprises of the following major steps

1. **Removal & Refitment of the axle from the vehicle.**
2. **Removal of the Refitment of the hub and the brake carrier and oil seal.**
3. **Removal of the differential assembly**.
4. **Pinion height adjustment and preloading of pinion bearings**
5. **Assembly of the crown wheel.**

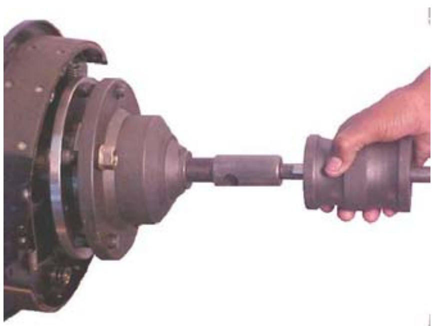
1) Removal and Refitment of the axle assembly from the vehicle

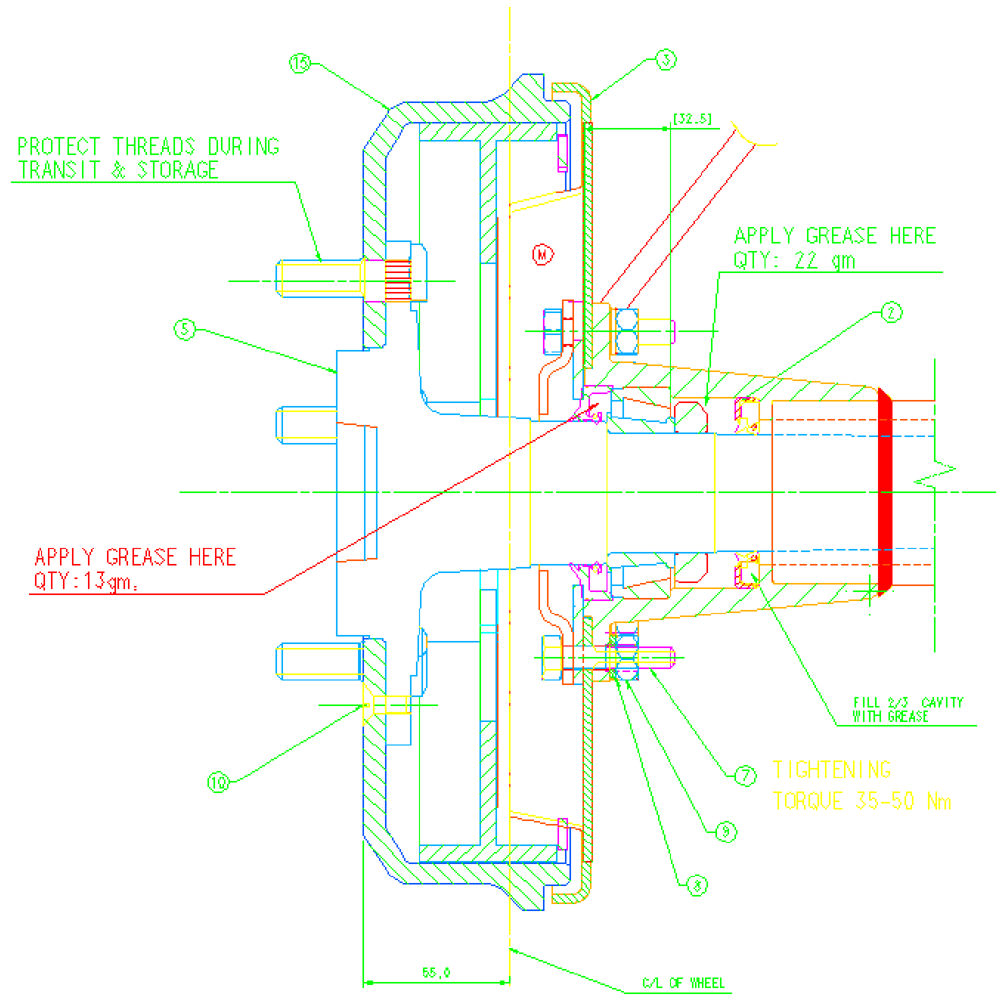
	Support the body on stand and remove the tyres.
	Remove the shock absorber.
	Remove the brake pipe T clamp from axle
	Remove the LSPV spring from axle end

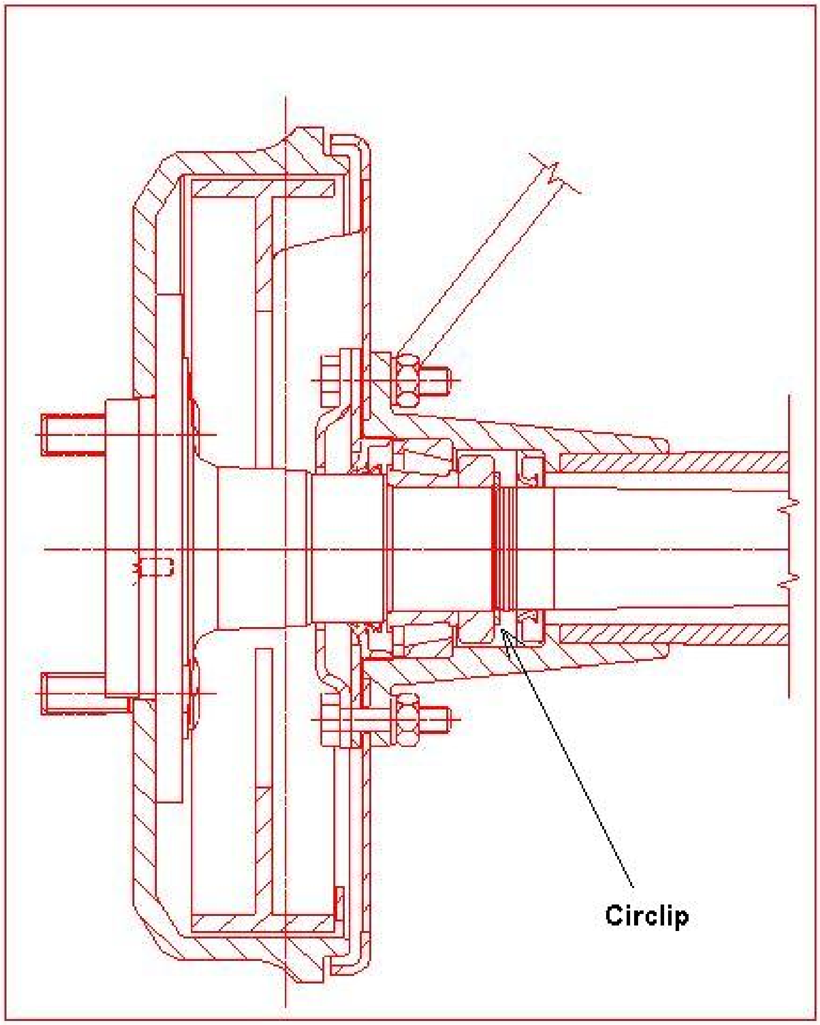
	Loosen suspension links. Axle to be supported & should not fall
Remove the axle from the vehicle	

2) Removal & Refitment of the rear axle shaft & hub

	Remove the brake drum after loosening the two screws
	Remove the parking brake locking

	Loosen the 6 screws holding the retainer.
	Using the MST576 and the sliding hammer MST 577. Pull out the hub integral with the axle shaft, prepackaged bearing, retainer ,oil seal and carrier
	For removal of the bearing the locking collar has to be cut using a drill. It should be cut up to the end and then using the chisel it should be snapped open
	Remove bearing using the hydraulic press and the MST.
	While assembly use the MST 578 to support the bearing & tube MST 579 for pressing


15
3
[32.5]
PROTECT THREADS DURING TRANSIT & STORAGE
APPLY GREASE HERE QTY: 22 gm
2
M
5
APPLY GREASE HERE QTY:13gm.
FILL 2/3 CAVITY WITH GREASE
10
7
TIGHTENING TORQUE 35-50 Nm
9
8
55.0
C/L OF WHEEL



The assembly section is shown in the sketch attached. Please note the bearing direction the circlip

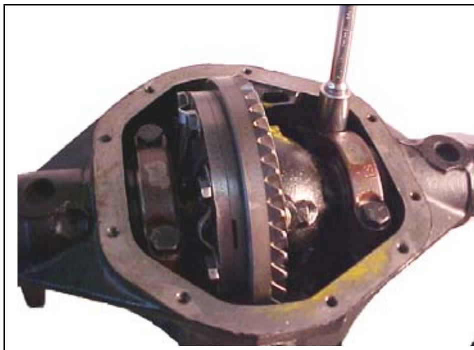
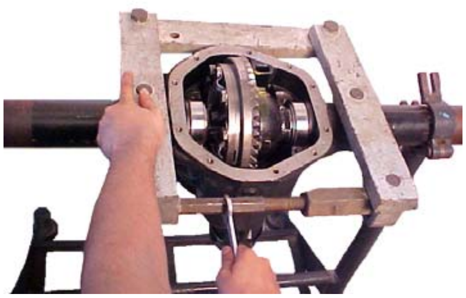
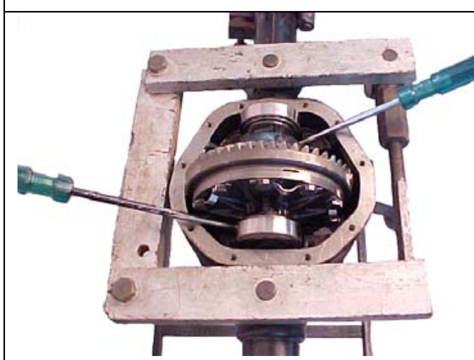
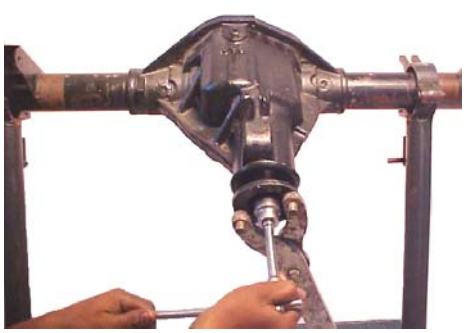
DO NOT ATTEMPT TO FIT THE LOCKING COLLAR BY HEATING.

THE COLLAR IS HARDENED AND TEMPERED.HEATING & PRESSING MAY CAUSE IT TO LOOSEN IN SERVICE CAUSING MAJOR FAILURE

	While reassemble use the hole in axle shaft flange to tighten the retainer bolts. Please ensure that the hydraulic press is capable of at least 10 tons load and it has a adequate stroke.

3) Removal of the Centre assembly

	After draining the oil - remove the differential cover set screws.
	Remove the differential side bearing bolts

	Remove the side bearing caps,
	Using MST 205, expand the differential.
	Pull out the crown along with the bearings
	Using MST 216, lock the companion flange.

	Unlock the pinion nut.
	Remove the companion flange along with the dust cover
	Tap the pinion along with bearings,

4) Assembly of the Centre assembly

<u>**Using the special tool**</u>

<u>**Without the special tool**</u>

<u>**Preloading of the crown wheel and backlash adjustment.**</u>

<u>The pinion preload setting and tooth contact setting can be done by using</u>:

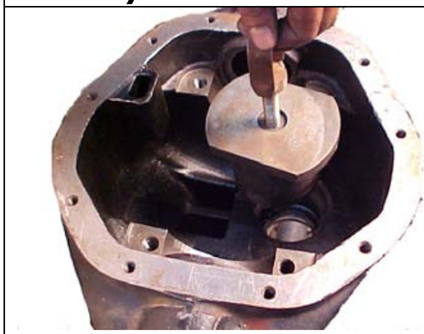
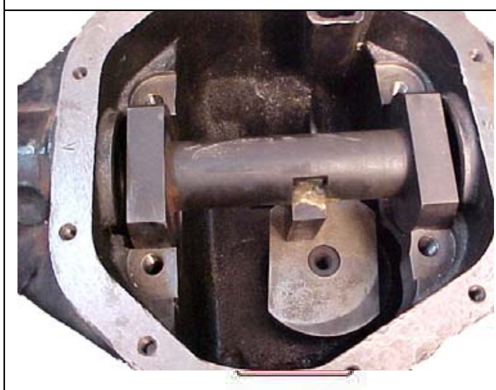
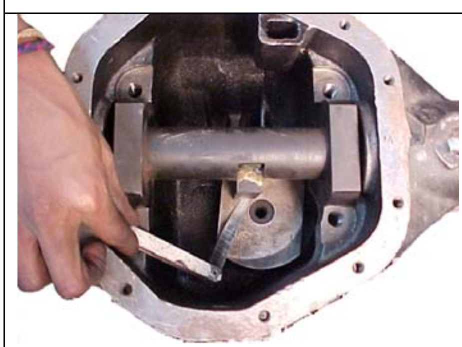
a) **Special Tool**. The special tool and gauges are strongly recommended in either of the scenario

- new axle housing is used or
- the bearing seating surface has worn out.

b) **Without the use of special tools**. This can be done only if the crown wheel & pinion is being replaced in the existing housing and the crown wheel bearing seating and the pinion inner bearing seating area is not worn.

4 a) Assembly Using the Special Tools

	If the pinion bearings are having pitting, flaking or spalling of the raceway then they have to be

	replaced. Remove the outer race using the MST. (For Fitting use MST 200)
To measure the Z value (distance of pinion apex from the carrier center)	
	Place the setting gauge (MST 581) in the carrier (the pinions inner bearing outer race & shim should be removed) Please note that the lifting handle should be removed after placing it in position
	Place the setting gauge 2 – MST 582 (in the crown wheel bore)
	Measure the gap between the setting gauge 1 and 2 using a feeler gauge.
	Ensure that the gauge 582's face is parallel to the differential case. (Use a level gauge)

	For example if the thickness measured X is 12 thou
	The value etched in pinion is Y Then the shim value is X-Y In this example it will become 12-5= 7 thou
	Place the 7thou shim below the bearing seating area.
	After that cross check the gap between the gauge and the new pinion. It should be the same as the Z mark punched. In this case 5 thou (tolerance ± 1 thou)
	In case the Z value is –ve then the gap has to be checked between the bore & MST 582.

This will ensure that the tooth contact of the Crown wheel and pinion is accurate

<u>However this shim also affects the distance between the two pinion bearings and thus will affect the pinion bearing preload</u>.

	Suppose 10 thou of shims were the thickness originally present (at the height adjusting end and the new value is 12 thou.)
	Hence to maintain the pinion bearing preload equal amount of shims at the outer bearing end will have to be adjusted Since the shim thickness at the inner bearing has increased by 2 thou

	hence add 2 thou of shims from the other end.
	If the pinion preload is not as per the specifications after assembly then add or remove shims from the outer bearing end.
	Please note that if the shims are removed or added at the outer end for adjusting the preload then do not add or remove shims at the height adjusting end- that will disturb the contact.
	Before inserting the companion flange at the end- apply **Loctite 638** in the splines so that the loosening can be avoided.

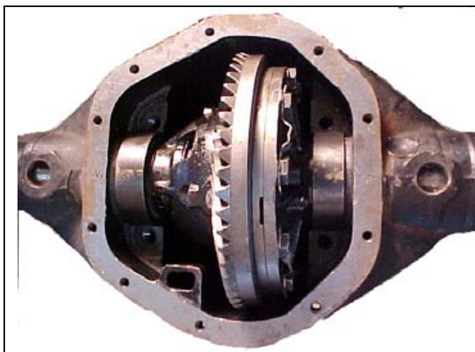
4 b) **Only if the crown wheel & pinion are being replaced – no wear on seating surfaces is present**

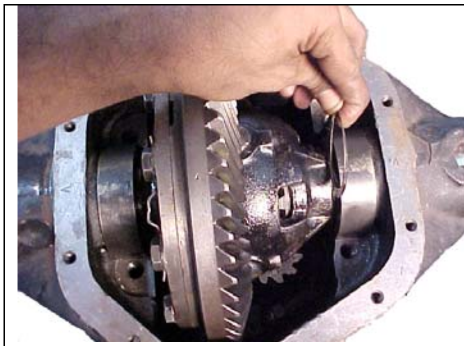
	If the pinion bearings are having pitting, flaking or spalling of the raceway then they have to be replaced. Remove the outer race using the MST. (For Fitting use MST 200)

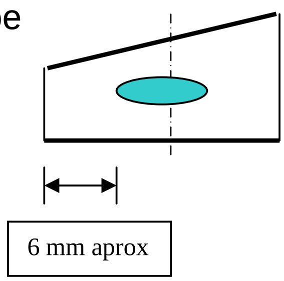
	If the crown wheels bearings are having pitting, flaking or spalling of the raceway then they have to be replaced. For removal of the bearing use MST 202 (For fitting the crown wheels side bearing use the MST
	Note the Z value etched on top of the old pinion (O) and the Z value etched on the top of the new pinion (N)
	The correct shim thickness = O-N (Old-New) If the value is + then shims have to be added and if – then shims have to be removed. These shims are between the pinion inner bearing outer race & the housing.
	This will ensure that the tooth contact of the Crown wheel and pinion is accurate
	However this shim also affects the distance between the two pinion bearings and thus will affect the pinion bearing preload.
	Suppose 2 thou of shims are adjusted. E.g + 2 added
	Then to maintain the pinion bearing preload equal amount of shims at the outer bearing end will have to be adjusted

	Since the shim thickness at the inner bearing has increased by 2 thou hence add 2 thou of shims at the other bearing
	If the pinion preload is not as per the specifications after assembly then add or remove shims from the outer bearing end.
	Please note that if the shims are removed or added at the outer end for adjusting the preload then do not add or remove shims at the height adjusting end- that will disturb the contact.

Adjustments of the crown preload & tooth backlash

	Install the crown, in the carrier. Instead of using the bearings use MST 583, - one on each side. The advantage of using the MST instead of bearings while setting is that as the outer race does not keep getting tilted hence we get accurate reading further the bearings do not get damaged when they are removed after checking the values of shims required.
	Push the crown assembly towards the pinion so that the backlash is zero.

	In this position find the shim pack which has to be inserted on right (Back of crown) side. And also on the teeth side.
	Move shims from teeth side to back of the crown side so that the backlash is achieved.
	Add an additional 0.075mm (0.003")- of shim on the both the side so that the crown teeth get preloaded.
	Take out the assembly, keep the selected shim packs correctly.
	Remove the MST 583.
	Insert the bearing assembly along with the selected shim pack. Use MST 205 to spread the carrier.
	While using the spreader ensure that the expansion is not more than 0.5 mm. If more it can cause permanent deformation of the carrier.
	While assembling the caps ensure that the markings match. Torque- 9.6 to 12.5 Mkg (70 to 90 Lbft)

	Check the backlash, if less or more then the shims should be moved from one side to the other. Note: Approximately 5 thou shim is equal to 3 thou of backlash.
	Check the backlash. 0.13 to 0.25 mm (0.005”-0.010”)
	Check the runout in four places it should be less than 0.15 mm (0.006”)
Toe  Heel	After the backlash has been achieved, check the tooth contact on both the drive and the reverse side. Note since the crown wheel is without load hence the contact should not be exactly at center but as shown in the sketch.

<u>Limited Slip Differential</u> –

Description

A conventional differential transmits all of the ring gear torque through the differential side gears to the axle shafts. Torque is at all times equal on the axle shafts and if one wheel slips, the other wheel can only put out as much torque as the slipping wheel. The Limited slip differential is similar, except that part of the torque from the ring gear is transmitted through clutch packs between the side gears and differential case. The multiple disc clutches with radial grooves on the plates and concentric grooves on the discs are engaged by a preload from Belleville Springs, plus separating forces from the side gears, as torque is applied through the ring gear.
The limited slip differential construction permits differential action when required for turning corners and transmits equal torque to both wheels

when driving straight ahead. However, when one wheel tries to spin due to leaving the ground, a patch of ice , etc . , the clutch packs automatically provide more torque to the wheel which is not trying to spin. The limited slip differential resists wheel spin on bumpy roads and provides more pulling power when one wheel tries to slip. In many cases of differences in traction, pulling power will be automatically provided until both wheels start to slip. It is important to know two things :

1. If, with unequal traction, both wheels slip , the Trac-Lok has done all it can possibly do.

2. In extreme cases of differences in traction, the wheel with the least traction may spin after the limited slip differential has transferred as much torque as possible to the non slipping wheel.

Trouble shooting –

If noises or roughness, such as chatter,are present in turning corners , the probable cause is incorrect lubricant can and should be determined.If the vehicle manufacturer recommends a lubricant additive for chatter complaints, add the specified type and amount of additive and recheck for chatter by warming the axle up, and then making a minimum of ten (10) figure eight turns.

If this is unsuccessful, or no lubricant additive is specified, a complete lubricant drain, flush, and refill with the specified Limited Slip Differential lubricant will usually correct chatter.

The following procedure is recommended to ensure flushing the system of old lubricant –

1. Warm the lubricant by vehicle road operation or five (5) minutes of operation in gear at 48 kmph with both rear wheels off the ground on a hoist.

CAUTION : NEVER PLACE THE TRANSMISSION IN GEAR WITH THE ENGINE RUNNING WHEN ONLY ONE WHEEL OF A LIMITED SLIP DIFFERENTIAL EQUIPPED VEHICLE IS RAISED. THE VEHICLE MIGHT DRIVE ITSELF OF THE JACK AND CAUSE DAMAGE OR INJURY.

2. Drain lubricant while warm. Remove drain plug or cover plate to drain

completely. If cover plate is removed it may be necessary to replace gasket at this time.

3. Refill axle with specified Limited Slip Differential lubricant.

4. Operate vehicle for approximately ten (16) kms., making at least ten (10) figure 8 turns to flush the old lubricant out of the clutch packs.

5. Repeat Steps 2,3, and 4, making sure to replace the cover gasket, if required, in Step 2.

6. It is possible that slight chatter, requiring additional vehicle operation may remain after Step 5 above, disassembly and repair will be necessary. Follow procedures for disassembly and assembly as illustrated in the manual.

UNIT INOPERATIVE –

Proper performance and capabilities of Limited Slip Differentials are often misunderstood. No precise methods of measuring Limited Slip Differential performance are generally available in the field. A functioning unit can be determined by these relatively simple vehicle operational tests.

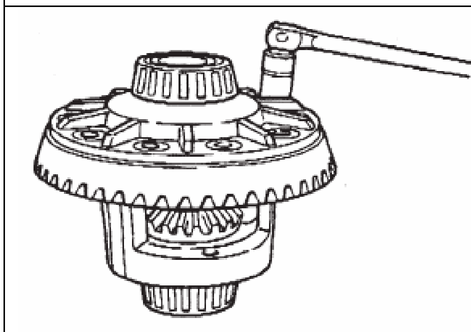
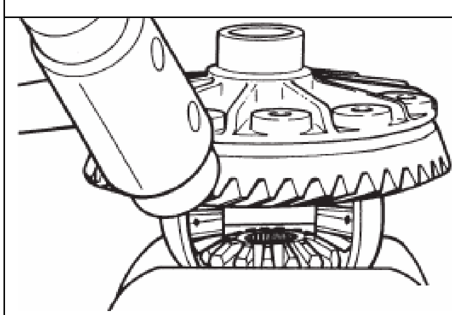
1. Place one wheel on good dry pavement and the other on ice, mud, snow, etc.

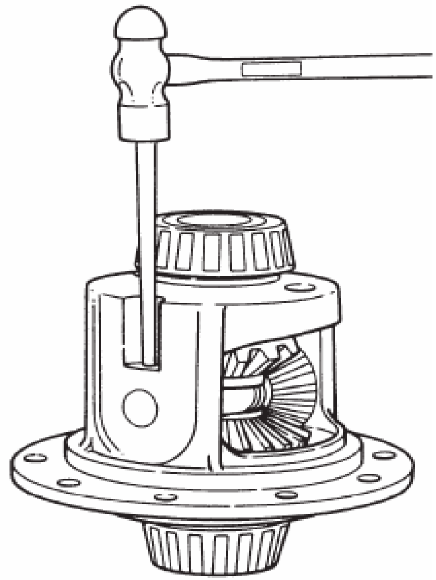
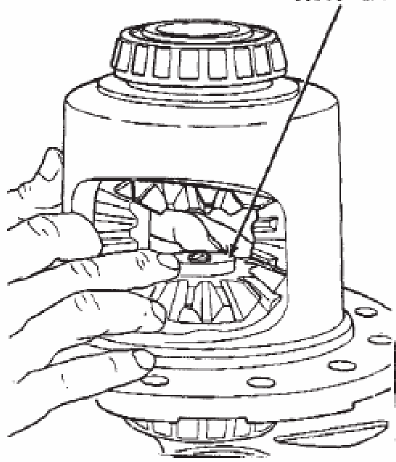
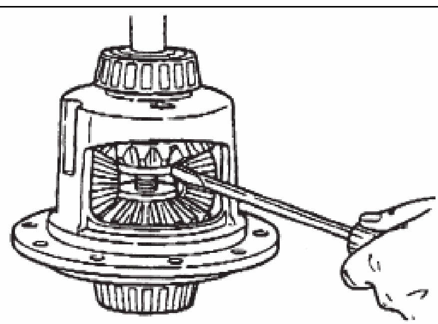
2. Gradually open the throttle to obtain maximum traction prior to "break-away". The ability to move the vehicle effectively will demonstrate proper performance.

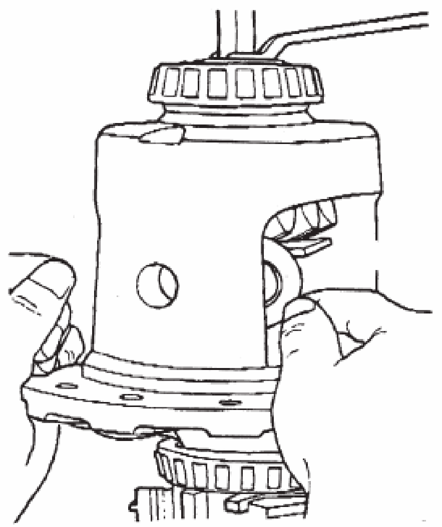
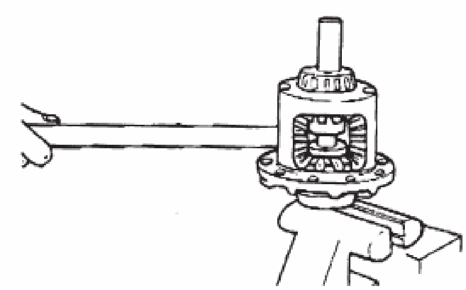
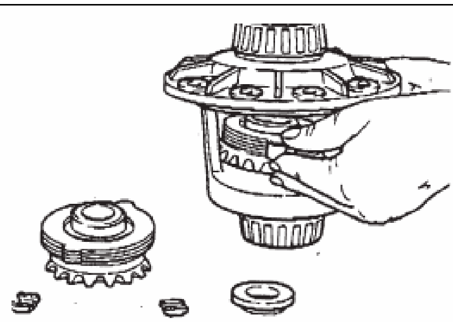
3. If extremely slick surfaces such as ice are used, some question may exist as to proper performance at Step 2. In the extreme cases , a properly performing Limited Slip Differential will provide greater " pulling power " by lightly applying the parking brake.

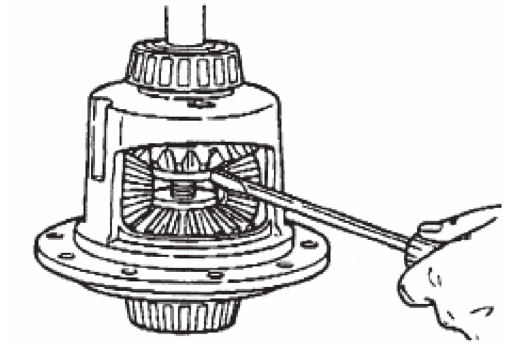
Disassembly Of Limited Slip Differential –

On Dana Spicer limited slip differentials it is recommended that the complete axle assembly be removed from the vehicle when it becomes necessary to remove the centre assembly from the housing.

	Remove Wheels, Brake drums, Brake Backing plate screws and Axle Shafts. Brake back plates can normally be wired to frame without loosening the hydraulic brake line connection at the wheel cylinder if desired. Use caution to avoid damage to brake line.
	Remove axle assembly and place in rack or stand to serve as a holding device.
	Remove cover plate screws, cover plate.
	Place a few shop towels over vice to prevent any damage during disassembly of ring gear. Assemble the differential on the axle shaft with the ring gear screw heads up. Assembling the differential onto the shaft will serve as a holding device to remove the ring gear and to disassemble the internal parts of the case. Remove the ring gear screws.
	Remove ring gear. It will be necessary to remove the ring gear to allow clearance for the removal of the cross pin. Tap ring gear with mallet to free it from case.

	Remove differential case from the axle shaft and remove ring gear.
	To remove the roll pin, use a small drift to remove the roll pin retaining the cross shaft. Remove the cross pin. Use a hammer and punch as shown to remove the cross pin from the case.
	Assemble the adapter plate into the bottom side gear. Apply a small amount of grease to the centring hole of the adapter plate. Lubricate threads of threaded adapter and forcing screw. Assemble threaded adapter into top side gear. Threaded forcing screws into threaded adapter until it becomes centred into adapter plate.
	Use a small screwdriver, position it in slot of threaded adapter. This will prevent the adapter from turning. Torque forcing screw until it becomes slightly tight. This will collapse the Belleville washers and allow a loose condition between the side gears and pinion mate gears.

	Remove both pinion mate spherical washers. Use a shim stock of .030" (.76 mm) thickness or an equivalent tool to push out the spherical washers.
	Relieve the tension of the Belleville washers by loosening the forcing screw. Insert small O.D. end of turning bar into cross pin hole of case. Pull on bar and the case will rotate until the pinion mate gears can be removed from opening. It might be necessary to adjust the forcing screw slightly to allow the case to rotate.
	Remove top side gear and clutch pack. Keep the stack of plates and discs intact in exactly the same position while they are being removed.
	Remove the retainer clips from both clutch packs to allow separation of the plates and discs. Keep the stack of plates and discs exactly as they were removed.



Hold top clutch pack with one hand and remove the tool. It might be necessary to hold threaded adapter with screwdriver as shown.

Remove the case from the axle shaft. Turn case with the flange or ring gear side up and allow the step plate, side gear and clutch pack to be removed from the case.

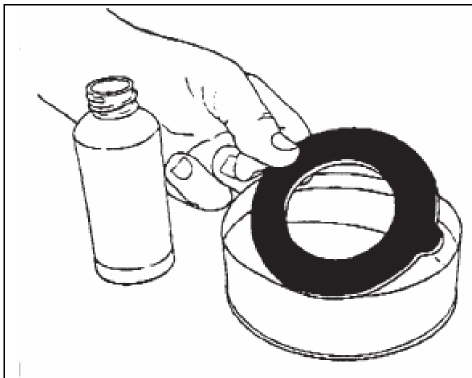
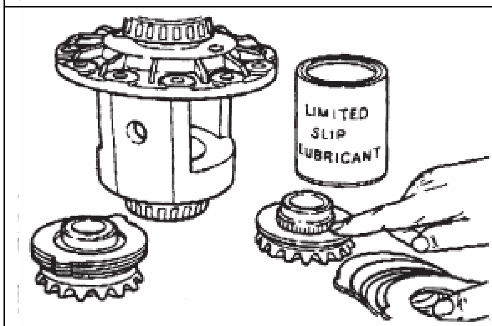
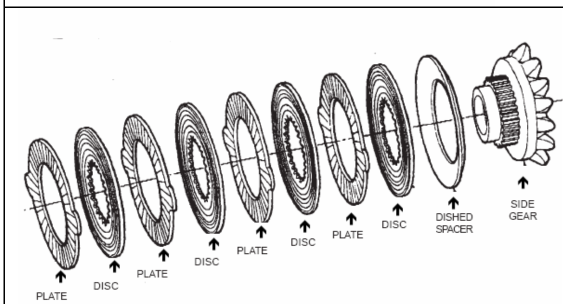
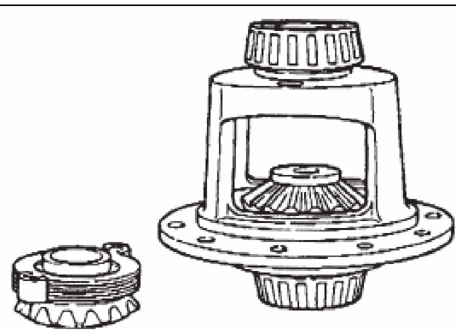
INSPECTION -

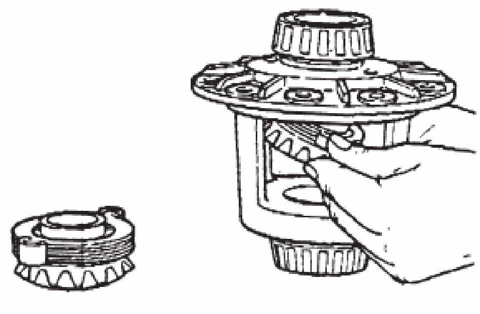
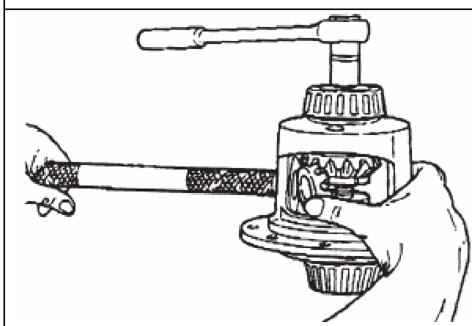
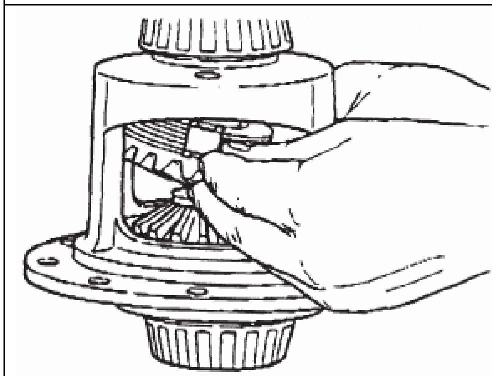
Plates and discs - If any one component of either stack shows evidence of excessive wear or scoring, the complete stack is to be replaced on both sides.
Side gears and pinion mate gears -- The gear teeth of these parts should be checked for extreme wear and possible cracks. The external teeth of the side gear, which retain the concentric groove discs, should also be checked for wear or cracks.
If replacement of one gear is required due to wear, etc., then both the side gears, pinion mate gears and washers are to be replaced.

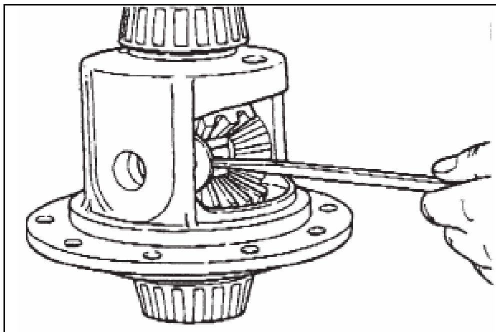
Cross Pin - If excessive wear is evident, the cross pin should be replaced.
Clutch Retainer Clips - If wear is evident on any one of the retainer clips, all four clips must be replaced.

Differential Case - If scoring, wear or metal pick-up is evident on the machined surfaces, then replacement of the case is necessary.

REASSEMBLY -

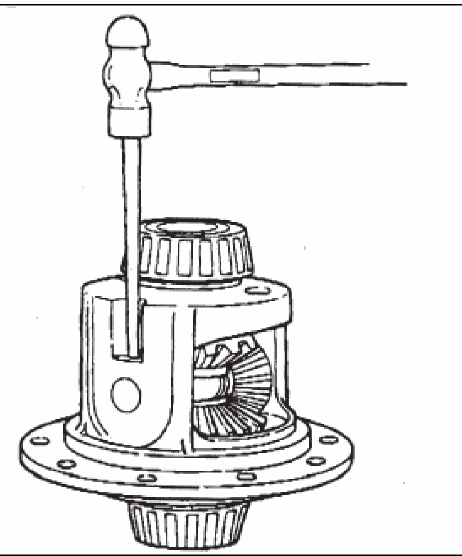
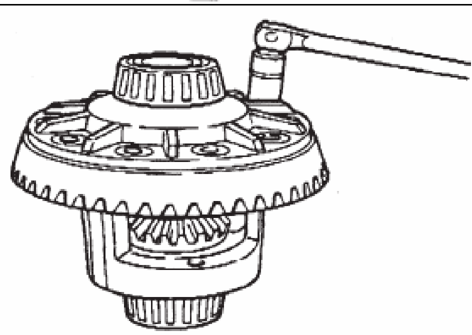
	Prior to assembly, pre – lubricate each disc and plate Friction with Modifier by pre-soaking for a minimum of 20 minutes.
	Pre - lubricate the thrust face of the side gears and the plates and discs.
	Assemble plates and discs in exactly the same position as they were removed, regardless of whether they are new parts or the original parts. Be sure lubricant that is used is of the specified lubricant.
	Assemble the retainer clips to the ears of the plates. Make sure both clips are completely assembled or seated onto the ears of the plates.

	With the differential case positioned as shown, assemble the clutch pack and side gear into the case. Make sure the clutch pack stays assembled to the side gear splines and that the retainer clips are completely seated into the pockets of the case.
	Hold the clutch pack in position and insert the threaded adapter into top side gear, insert forcing screw. Tighten forcing screw into bottom plate. This will hold both clutch packs in position. With tools assembled into the case, position case onto the axle shaft by aligning the splines of the side gear with those of the shaft.
	Loosen forcing screw slightly. Assemble both pinion mate gears. Hold gears in position by hand. While holding gears in place, insert turning bar into case. Pull on bar to rotate case allowing gears to turn. Make absolutely sure that the holes of the pinion mate gears are in alignment with holes of the case.
	Assemble the adapter plate into the side gear. Apply a small amount of grease into the centring hole of the steps plate. Assemble the other clutch pack and side gear as shown. Make sure the clutch pack stays assembled to the side gear splines, and that the retainer clips are completely seated into the pockets of the case.

	Pre-lubricate spherical washers. Torque forcing screw until it is tight. This will collapse the Belleville washers and allow clearance between gears. Assemble spherical washers into case. Use a small screwdriver to push washers into place.

CAUTION:

BE SURE THE HOLES OF THE WASHERS AND GEARS ARE LINED UP EXACTLY WITH THOSE OF THE CASE.

	When roll pin bottoms out, stake (peen) a little metal over the edges in two places 180^0 degrees apart.
	Remove case from axle shaft. Assemble ring gear to case. Line up the ring gear screw holes with those of the case. USE NEW RING GEAR SCREWS.

Specifications -

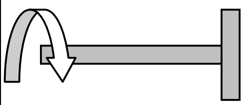
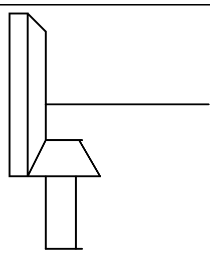
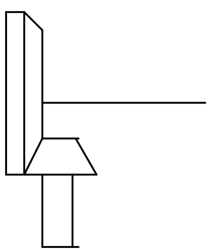
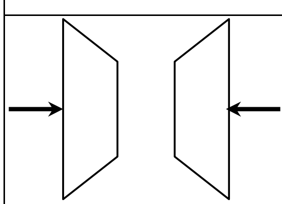
Figure	Description	Value		
	Semi floating single reduction without diff. lock			
		High end/Petrol	Mid range	Low range
	No of teeth on crown N1	49	43	
	No of teeth on pinion N2	10	10	
	Axle reduction ratio N1/N2	4.90	4.30	
		From Sl no 32 K 90710 (All models except Rev 116)		
	No of teeth on crown N1	43		
	No of teeth on pinion N2	10		
	Axle reduction ratio N1/N2	4.3		
	Pinion Pre load	23 to 45 Kgcm		
	Preloading of differential bearings	0.075 mm (0.003”		

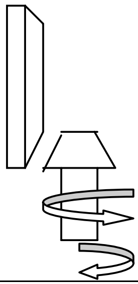
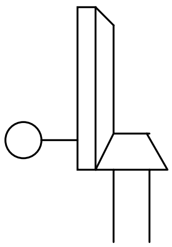
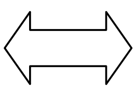
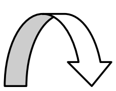
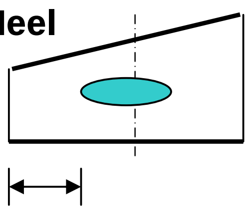
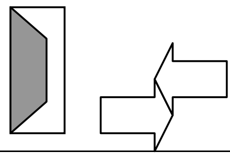
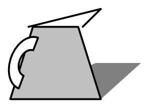
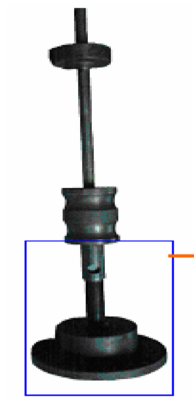
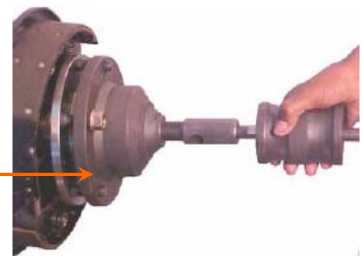
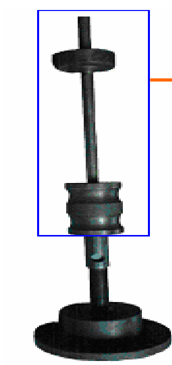
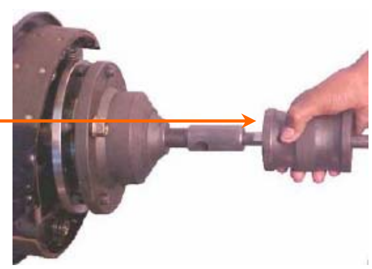
Figure	Description	Value
	**Crown-pinion backlash** **Maximum variation of backlash in a crown**	**(0.006 to 0.010” - 0.150 to 0.250 mm)** **(0.003” - 0.075 mm)**
	**Run out of the ring gear / crown wheel**	**0.15 mm (0.006”)**
	**Hub end play**	**Max 0.3 mm (0.0012”)**
	**Hub rotational torque**	**Not applicable**
Toe **Heel**  6 mm aprox	**Check for correct tooth contact on both the forward and reverse direction**	**Check on both the driving & reverse flank. This contact is for checking without load.**
	Clearance between and side(sun) gears and diff case	**0.20 mm (0.008”)**
	Rotational torque of differential case with sun & pinion gears	**5 Kg cm**

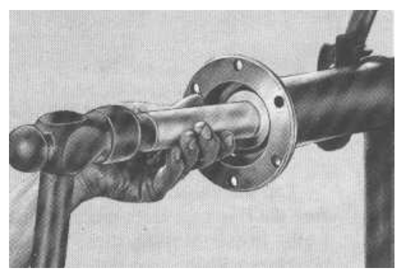
Figure	Description	Value
	**Inner race interference Outer race clearance**	**0.125 mm (0.005 to 0.007")**
	**Oil grade/ Viscosity/ Quantity**	**Total Fina Elf's - Transmission DA oil**

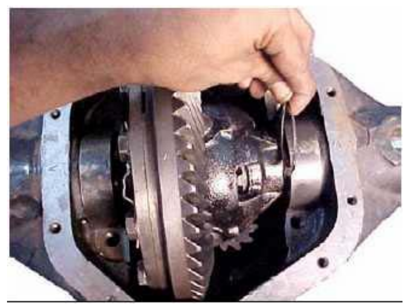
<u>Tightening Torque's</u> –

Location	Torque in Nm (Lbft)
Brake carrier mounting bolts	33.8 to 47.45 (25 to 35 LB FT)
Pinion nut	217 to 244 (160 to 180 LB FT)
Crown mounting nuts	54 to 68 (40 to 50 Lb Ft)
Differential side bearing bolts	95 to 122 (70 to 90 LB FT)
Differential disc cover bolts	16 to 20(12 to 15 LB FT)

Special Tools --

Description / Part No. / Sketch	Usage View
Puller rear axle shaft MST 576 	
Sliding Hammer MST 577 	
Ring Rear axle collar support. MST 578 	

Description / Part No. / Sketch	Usage View
Tube-Rear axle collar pressing MST 579 	
Installer Inner Oil seal Rear axle tube MST 580 	
Rear axle Pinion Height setting Gauge (1) MST 581 	

Description / Part No. / Sketch	Usage View
Rear axle Pinion Height setting Gauge (2) MST 582 	
Differential side bearing setting gage MST 583 	

Automotive Sector

Recommended Lubricants -

Specification: GL 5; SAE 90

Brands

Maximile : Recommended	Maximile DO
Other options	
IOC	SERVOGEAR HP 90
HP	HP GEAR OIL XP 90
BPCL -	BHARAT SPIROL HD 90
BHARAT SHELL -	SPIRAX HD 90
CHEMOLEUMS -	CHEMOLEUMS TURBO GL5 SAE 90
GULF	MP GO 90
CALTEX	THUBAN GL5-90
VEEDOL	VEEDOL MULTI GEAR 90 HD
CASTROL -	CASTROL HYPOY B 90

Sealant -

Differential cover sealant : Loctite 587 / Gasket

Automotive Sector

Front Axle

Contents

Description -

The front axle is of the hypoid, semi-floating type using shim adjustment to obtain bearing pre-loads. The differential case with Crown wheel and the drive pinion are mounted in opposed taper roller bearing in one-piece rear axle carrier.

The rear axle pinion receives its power from the engine through the Transmission and driveshaft. The drive pinion rotates the differential case through the engagement with the crown wheel, which is bolted, to the differential case flange. Inside the differential cages are four differential pinions mounted on the differential pinion shaft which is splined to the housing. These gears are engaged with the side gears, to which the axle shafts are splined. Therefore as the differential housing turns, it rotates the axle shaft and the rear wheel. When it is necessary for one wheel to rotate faster than the other is, the faster turning gear causes the pinion to roll on slower turning gear to allow differential action between the two axle shafts.

The axle shafts are held in the housing by the bearings and the retainers at the housing outer end. *Axle shaft endplay is pre set and not adjustable. The hub bearings are pre-packaged for life.*

ⓘ All operations other than the removal of the axle shafts and the replacement of the wheel bearing oil seal should be carried out with the axle removed from the vehicle.

Trouble Shooting -

Certain rear axle and driveline trouble symptoms are also common to the engine, transmission, tyres and other parts of the Vehicle. For this reason be sure that the cause of the trouble is in the rear axle before adjusting, repairing or replacing any of the axle parts.

Front Axle Noise Diagnosis -

Basic characteristics in a rear axle are more difficult to diagnose and repair than mechanical failures. Slight axle noise heard only at certain speed or under particular conditions must be considered normal. Axle noise tend to peak or be more pronounced at particular speeds and the noise is in now way a sign of the trouble in the vehicle.

Where noise is present in objectionable form (Loud and/ or at all speeds) the first effort should be to isolate the noise.

Isolation of noise in any one unit requires care and experience and an attempt to eliminate a slight noise may baffle even the most experienced mechanic/ technician.

Axle noise fall into two basic categories: gear noise and/ or bearing noise.

Axle Noise **Gear Noise**
Bearing Noise
Others

Gear Noise –

The most important characteristic of the gear noise is that it is usually sensitive to accelerator position. E.g. noise audible under drive condition will often disappear under coast condition (i.e. driving in neutral with the clutch released and engine running) at the same vehicle speed and vice versa.

Axle gear noise whine will always occur at the same road speed and throttle setting i.e. drive or coast (i.e. driving in neutral with the clutch released and engine running). Gear whine is usually a fairly high pitched pure tone as opposed to a low-pitched rumble caused by a spalled bearing.

Some noises, which can be confused with axle gear whine, are: -

…. Whine from an engine component; this will always occur at the same engine speed irrespective of which transmission gear is used

…. Whine from an indirect Transmission gear (e.g. 5th gear on some vehicles produces a whine comparable with axle whine) however this will disappear when the direct transmission ratio is selected.

…. Whine from tyres or wind noise from a rack or aerial. These noise generally occur over a very broad speed range and do not change with driving mode i.e. drive or coast (i.e. driving in neutral with the clutch released and engine running)

Remember -

Before diagnosing the whine as axle gear noise, ensure that the whine:

(a)Occurs in direct transmission ratio (4th gear)

(b) Changes with throttle/ accelerator variations (drive and coast) (i.e. driving in neutral with the clutch released and engine running)

(c)Always occur at the same road speed and not engine speed,

(d) Occurs over a limited vehicle speed. (This can vary over a wide band should the axle be in extremely bad condition.)

Bearing Noise —

Bearing noise is inclined to be less throttle sensitive than gear noise and frequently occurs over a wide speed range. Bad cases of faulty bearings can, in fact be detected from walking speed, building up in pitch as speed increases and is not directly affected by changing from drive to coast (i.e. driving in neutral with the clutch released and engine running) and visa versa

(a)Rear wheel bearing noise tends to be low pitched grumble, which can normally be detected and confirmed when driving on a smooth road at constant speed, with the noise most audible while swerving sharply from left to right. If the noise increases or decreases as the car is swerved, it is probable that a wheel bearing is faulty. Driving close to a wall or a curb at a suitable speed can carry out a further check for wheel bearing noise.

(b) Differential bearing noise is usually similar to in pitch to wheel bearing noise but is not affected by the swerve check referred to previously.

(c) Pinion bearing noise is normally at a higher pitch than wheel or differential bearings and is often slightly sensitive to throttle position, although not to the same extent as gear noise.

<u>Other</u> -

1. A further condition, which can exist, is due to a worn bearing that allows the gearset to move out of its correct mesh cause gear noise. This condition is usually throttle sensitive, with the noise frequently disappearing on a “drive” condition.

   Any amount of or endplay in either the pinion bearings or differential carrier bearings are detrimental to the gears and bearings and will cause axle noise.

2. A high spot sometimes occur on either the ring gear or the drive pinion; this shows up as a ticking or light knocking noise over a restricted range of throttle position. The frequency of the noise will indicate whether the high spot is on the pinion (drive shaft frequency) or on the ring gear. The severity of the noise indicates the size of the defect. A light “tick “ is seldom detrimental and usually occurs in new axle and will normally disappears once the axle has been run in.

3. Louder noise usually indicate a more serious defect and a knock occurring in an axle which was previously free from this type of noise must always be investigated.

<u>Care of the axle</u> -

The lubricant level should be checked every 10000 Kms with the vehicle unladen and in a level ground. The lubricant level should be at the lower edge of the filler plug. Use lubricant meeting oils specification of GL 5 and viscosity of SAE 85W140 .The brand names have been specified in the lubricant section.

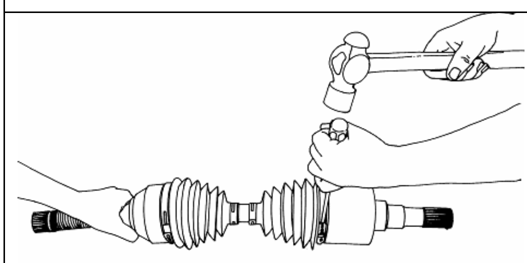
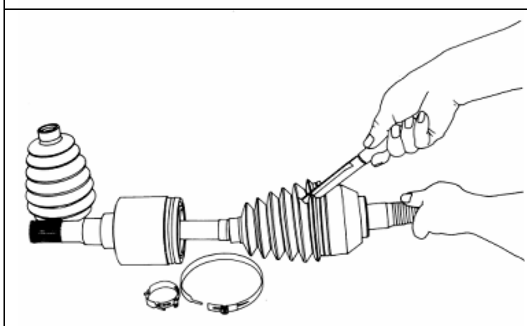
Note: Unless otherwise specified the assembly procedure / guidelines is the reverse of the disassembly procedure

IN VEHCILE ADJUSTEMENT & REPAIR -

The works in axle that can be done without removing from the vehicle are:

CV joint servicing -

Remove the upper ball joint & tilt the corner assembly.
Now remove the CV joints from the vehicle.

	Mark the position of small end of boot on shaft for reassembly purpose.
	Remove the boot clamps & discard.
	Cut the rubber boots & discard.
	Inspect the grease. If presence of water , grit or metal particles or any other contaminant found the CV joint should be replaced.

	Wipe away excess grease so that the snap ring in the inner race is visible. Remove the snap ring by expanding it with a snap ring plier.
	Remove the shaft by tapping on the outer race with a brass hammer.
	Place the CV joint in vice jaws with teflon or plastic protectors to prevent damage to the splines.
	Assemble the disassembly tool set to the joint.
	Tilt the inner race from side to side in a crisscross or star pattern.
	Remove all steel balls from the cage, one at a time using a star pattern.
	Pivot cage & remove the inner race assembly from outer race assembly.
	Pivot inner race & remove from the cage.

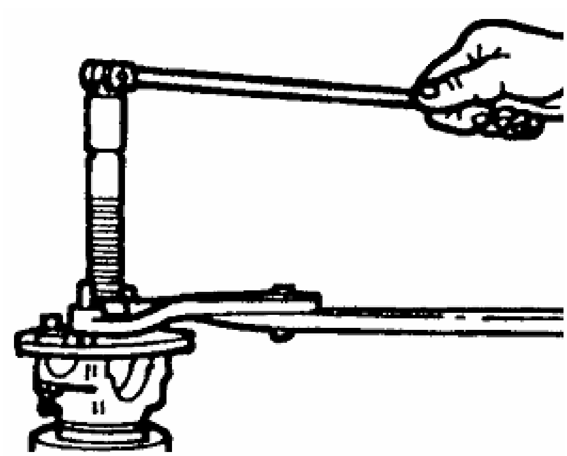
Inspect all parts for wear or damage. Wear or damage to any part indicates replacement of CV joint is necessary.

While reassembly; following sequence should be followed –

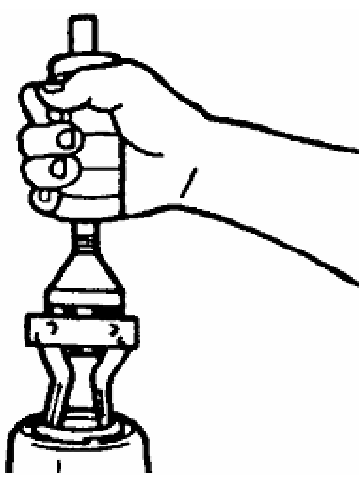
- Clean CV joint components & boot area on shafts. DO NOT USE PETROL.
- Apply tape to shaft splines to protect boot during installation.
- Slide new small circlip & boot on one side of the shaft having one circlip groove.
- Lightly coat inner & outer race with lithium grease.
- The assembly sequence for CV joint is in the reverse order of disassembly.

- Install new snap ring in inner race.
- Completely pack CV joint with grease.
- Allign CV joint splines with shaft splines. Gently rock the CV joint while pushing onto the shaft untill click sound is heard.
- Position the boot & clamp over CV joint (large end) & secure with the clamp.
- Insert blunt edged screwdriver between shaft & small end of the boot to equalise air. Allign boot marks on shaft. Install & tighten the small clamp.

Pinion Seal Replacement –



Pinion nut removal



Oil seal removal

~~**Backlash adjustment.**~~

The backlash adjustment should not be done on the vehicle. This is due to the fact that the spreader usage in vehicle is difficult if the vehicle isn't being attended in a pit. Further after adjustment it may be necessary to adjust pinion height. (Any change in backlash indicates wear- hence though shim adjustment may compensate for gear teeth wear. It will not compensate the pinion wear and pinion bearing wear and loss of preload)

However it is suggested that the tooth contact be checked on the vehicle before taking decision to open/ overhaul. It is recommended that after draining the oil and opening the rear cover. Put paint marks in four different places. Then push the vehicle forward and backwards at least 15 feet. This will give a much better tooth contact under load. (It should be remembered that

with load the tooth contact moves away from toe to heel). The tooth contact without load is given in the specification sheet.)

<u>Front axle Overhaul</u> –

Comprises of the following major steps

1. **<u>Removal & Refitment of the axle from the vehicle</u>**

2. **<u>Removal of the Refitment of the hub and the brake carrier and oil seal</u>**

3. **<u>Removal of the differential assembly</u>**

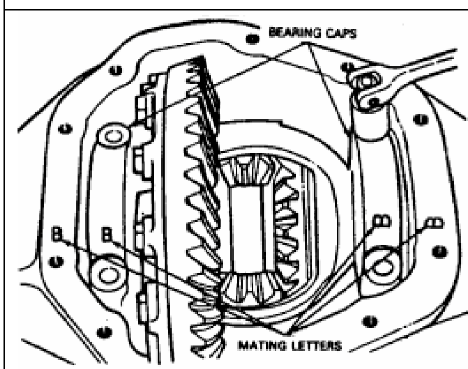
4. **<u>Pinion height adjustment and preloading of pinion bearings</u>**

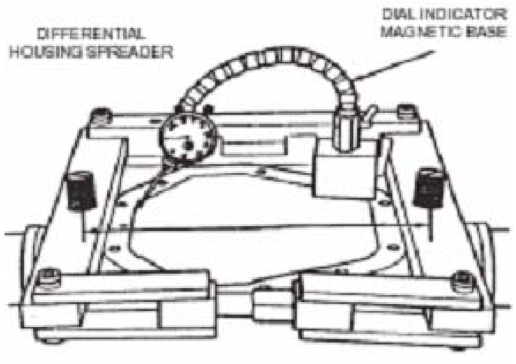
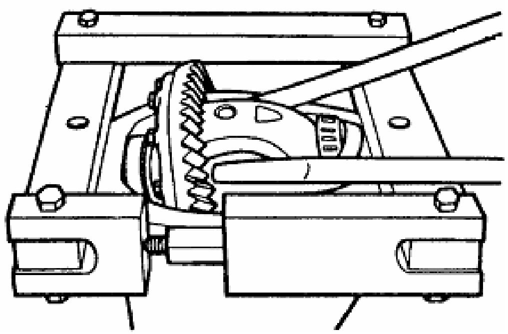
5. **<u>Assembly of the crown wheel</u>**

1) Removal and Refitment of the axle assembly from the vehicle

	Support the body on stand and remove the tyres.
	Remove the shock absorber.
	Axle to be supported & should not fall
Remove the axle from the vehicle	

2) Removal of the Center assembly

	After draining the oil - remove the differential cover set screws.
	Remove the side bearing caps, note mating letters stamped on caps & carrier.

	Using special tool expand the differential. Do not spread carrier over 0.58 mm.
	Pry differential case from carrier with pry bars. After differential case has been removed; remove the spreader.
	Lock the companion flange.
	Unlock the pinion nut.
	Remove the companion flange along with the dust cover.

3) Assembly of the Centre assembly

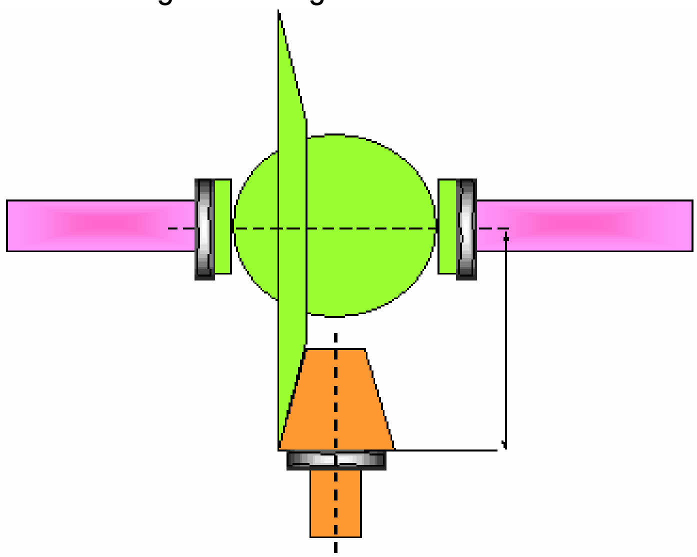
Using the special tool

4 a) Assembly Using the Special Tools

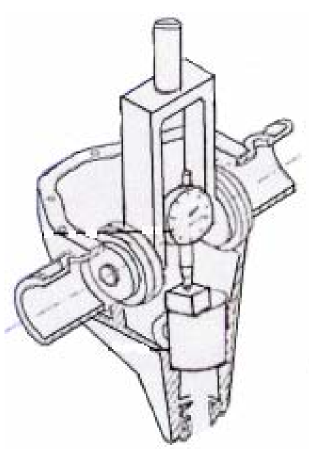
The setting can be divided into three phases.

Pinion height setting .
Pinion preload.
Crwon preloading.
Crown backlash setting.

Pinion height setting.



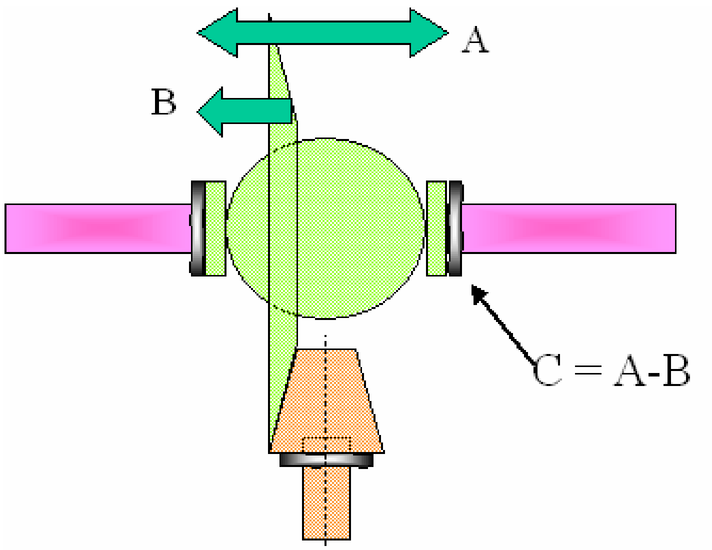
The tool used to do the same is



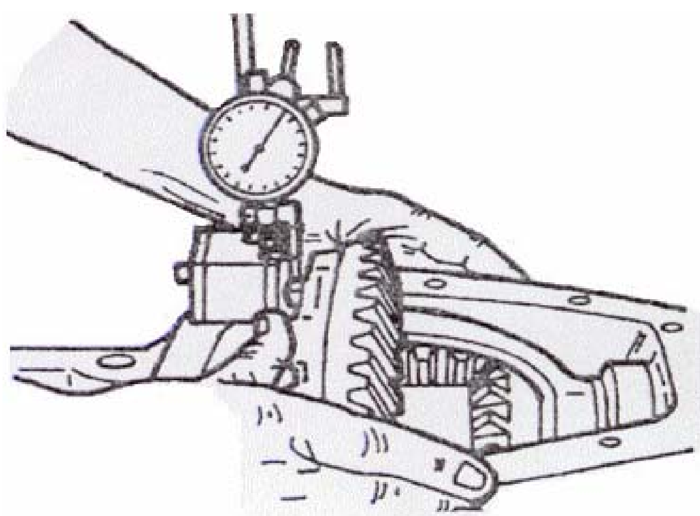
Pinion preloading :

The pinion preloading is done by the collapsible spacer.
Note : In case the pinion nut is opened then the spacers need to be changed.

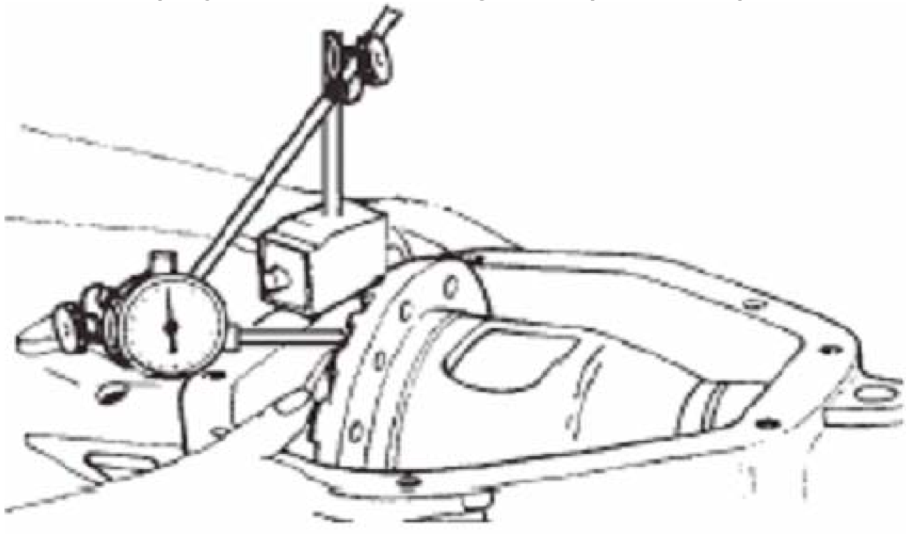
Crown Wheel Preload & backlash



First the play of the diff cage or crown wheel with diff cage but without the pinion in place is checked. This play is A



Then the play B with the Diff gear & pinion in place is measured



The right hand play is C
C= A-B

To get the preload on both LH & RH side 3thou shims are added.

Now to get the backlash 6 thou shims are added on RH side & 6 thou shims are removed from LH

(Recommended preload- 3 thou. Backlash- 6thou)

An example of the working is given below :

WORKSHEET FOR CALCULATING RING GEAR BACKLASH AND DIFFERENTIAL BEARING PRELOAD SHIMS

Total play observed (Without crown wheel)	= A
Left hand play (With crown wheel)	= B
Right hand play = (A - B)	= C

This is just an exmple for understanding the calculation with values rounded off to nearest decimal

Case 1.

Suppose A = 0.070" (1.75 mm)
B = 0.040" (1.01 mm)
C = 0.070" - 0.040" = 0.030" (0.74)

Blacklash Calculations -

	LH Side	RH Side
A	B	C
0.070" (1.75 mm)	0.040" (1.0160 mm)	0.030" (0.762mm)
Preload	+ 0.003" (0.0762mm)	+ 0.003" (0.0762mm)
Blacklash	- 0.006" (0.1524mm)	+ 0.006" (0.1524mm)
Shim Size	**0.037" (0.9398mm)**	**0.039" (0.9906 mm)**

Case 2.

Suppose A = 0.085" (2.159 mm)
B = 0.055" (1.397 mm)
C = 0.085" - 0.055" = 0.030" (0.762mm)

Blacklash Calculations -

	LH Side	RH Side
A	B	C
0.085" (2.159 mm)	0.055" (1.397 mm)	0.030" (0.762 mm)
Preload	+ 0.003" (0.0762mm)	+ 0.003" (0.0762mm)
Blacklash	- 0.006" (0.1524mm)	+ 0.006" (0.1524mm)
Shim Size	**0.052" (1.3208mm)**	**0.039" (0.9906mm)**

Tightening Torque's -

Location	Torque in Nm (Lbft)
Brake carrier mounting bolts	33.8 to 47.45 (25 to 35 LB FT)
Pinion nut	217 to 244 (160 to 180 LB FT)
Crown mounting nuts	54 to 68 (40 to 50 Lb Ft)
Differential side bearing bolts	95 to 122 (70 to 90 LB FT)
Differential disc cover bolts	16 to 20(12 to 15 LB FT)

Recommended Lubricants -

Specification: GL 5; SAE 85 W 140

Sealant -

Differential cover sealant : Loctite 587 / Gasket

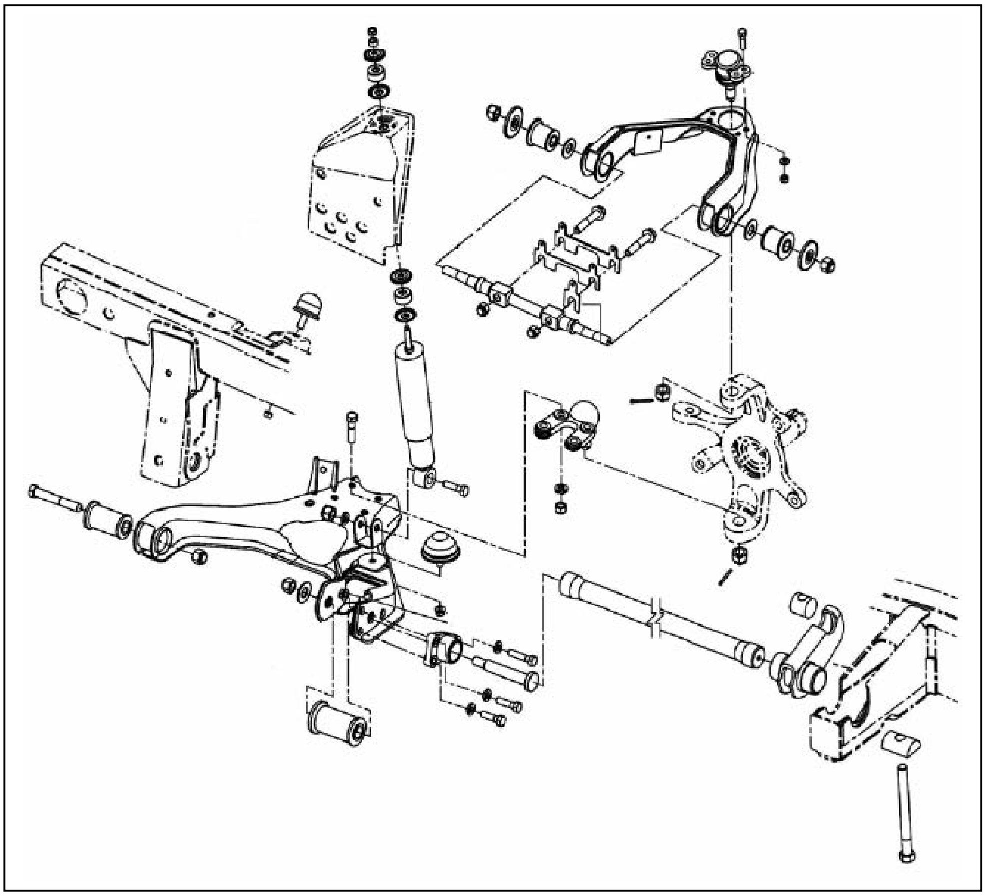
Mahindra
Automotive Sector

Front Suspension

Contents

Description -

In the 4WD vehicles, the suspension is torsion bar type with hydraulic dampener.



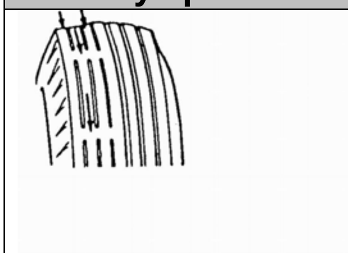
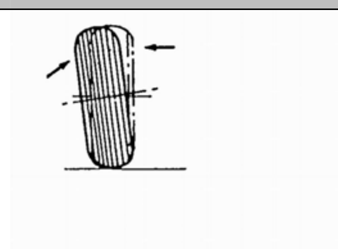
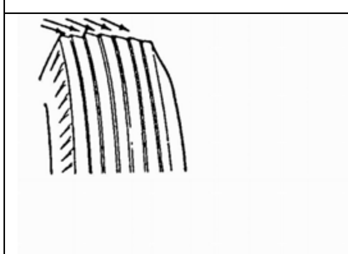
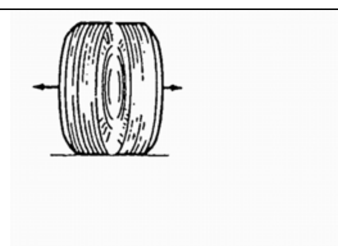
Trouble Shooting -

A squeak noise from the shock absorber can be produced if movement between the rubber bushing and metal occurs. Tightening the attaching parts can usually stop this noise. If the squeak noise persist then inspect for worn or damaged bushings and attaching components. Repair as necessary if any thing found amiss.

Squeak also happen due to relative movement from suspension arm's bush inner sleeve (serration end) and chassis bracket. This situation happens, if torque is not as per specs. Torque tightening the LCA & UCA bolts normally resolves the issue.

The shock absorber bushings do not require any kind of lubrication. Do not lubricate the bushings to reduce bushing noise. Grease or mineral oil base lubricants will deteriorate the bushing.

The shock absorbers are not refillable or adjustable. If a malfunction occurs, the shock absorber must be replaced. To test a shock absorber hold it upright in fully extended position for 10 minutes. Then force the piston in and out of the cylinder four or five times. The action throughout each stroke should be smooth and even.

Symptom	Causes	Remedial action
 **One Edge Wear**	 *Excessive camber*	✓ Check and adjust: ✓ Hub end play ✓ Camber to be checked and adjusted.
 **Feathered Edge Wear**	 *Incorrect Toe In*	✓ Check & correct Toe In ✓ Check the chassis bend ✓ If tyre rotation not carried out as per schedule. Do the tyre rotation.
Excessive Vehicle rolling	*1. Body Mounts loose.* *2. Suspension mounting loose.* *3. Broken or*	✓ Tighten the body mounts. ✓ Tighten the suspension mounts. ✓ If broken stabilizer bar-

	deteriorated stabilizer 4. *Worn stabilizer bush* 5. *Malfunctioning shock absorber*	replace ✓ Replace the bushes & tighten to the specified torque, ✓ Replace the shock absorber.
Vehicle inclined	*Broken or deteriorated coil spring*	✓ Replace the coil spring
Noise	1. *Parts worn or loose* 2. *Broken coil spring* 3. *Malfunctioning shock absorber*	✓ Tighten the parts or replace ✓ Replace the coil spring ✓ Replace the shock absorber

Caution: Do not lubricate the suspension bushes/joints.

Care of the system -

- ✓ The first wheel alignment should be carried out at 5000 Kms then at every 10,000 Kms.
- ✓ Torque tighten the LCA & UCA bolts to the required torque. (Upper arm 110-130 Nm , LCA front 150-180 Nm; LCA rear 110-130 Nm)
- ✓ First at 5000 Kms then subsequently every 10,000 Kms.
- ✓ Check the shock absorber for leaks every 10,000 Kms.
- ✓ Check the rubber bushes for the mounting of the shock absorber, stabilizer bar and links every 20,000 Kms or once in a year

In Car repairs -

a) Wheel alignment
b) Wheel hub greasing

a) Wheel alignment

The sequence of the wheel alignment, which should be followed, is:

Carry out the runout compensation when using the computerized equipment

1. *Steering Wheel Centralize- cross check & adjust.*
2. Castor checking & adjustment (Computerized / *Manual*)
3. Camber checking & adjustment(Computerized / *Manual*)
4. Toe in checking & adjustment. (Computerized / *Manual*)
5. *Wheel Turning Angle*, checking and adjustment. (Computerized / Manual)
6. *Check* the centralization of the Steering wheel as the final operation

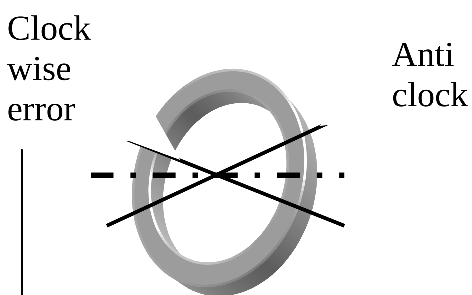
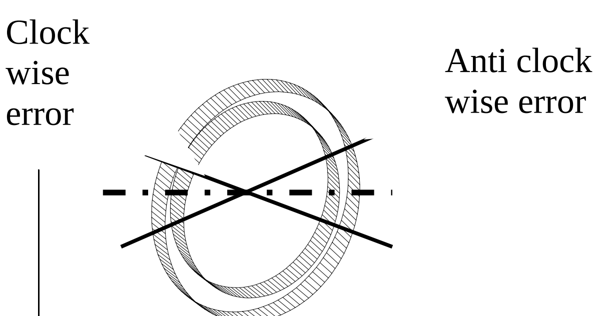
Caution: In order to obtain the correct values and avoid complaints. Please note that that the following parameters have to be adhered to without fail:

- **The tyre pressures in all the four wheels are as per the specifications.**
- **Vehicle should be unladen and parked on level surface**
- **Ensure that the wheel hub play is correct.**
- **Check that the chassis and the underbody are not coated with mud. If in doubt get the vehicle cleaned before doing the checking.**
- **Check the ride height variation as per the specification.**
- **Replace the parts of suspension if found badly damaged**
- **Before starting the measurement, ensure that the parking brakes are applied and the rear wheels are blocked**
- **Before doing the wheel alignment – ensure that the linkages i.e. the ball joint are not worn or loose. Check the free play in the steering.**
- **All the tyres and the wheel disc should be of the same type.**

Caution: This procedure for centralizing the Steering wheel is valid only if the misalignment of the spokes is less than 10 degrees. In other words this procedure is only for fine-tuning the steering wheel position not for glaring error. If it is more 10 degrees then remove the steering wheel and initially realign to less than 10 degrees.

Steering Wheel Centralization –

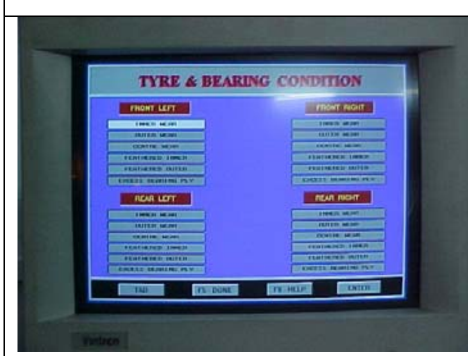
	To check for the centralization of the steering wheel. Drive the vehicle on a level road surface; note the angular position

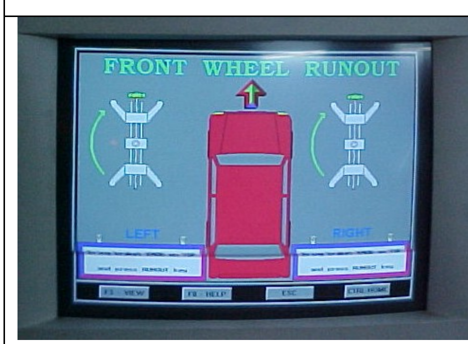
	(misalignment of the steering wheel spokes.
	Raise the vehicle. Keep the wheels in Straight Ahead Position.
	Mark the position of the track rods and the track rod ends
	Slacken the track rod end lock nuts and also remove the gaiter outer retaining clips.
	Rotate both track rods in the same direction approximately 30 degrees for every 1-degree of steering misalignment error.
	If the steering wheel has an anti clockwise angular error then both track rods must be rotated clockwise- when viewed from the left – hand side of the vehicle.
	If the steering wheel has an clockwise angular error then both track rods must be rotated anticlockwise- when viewed from the left – hand side of the vehicle

With the computerized wheel alignment gauges ; the checking procedure may vary slightly. However the sequence of checking and the adjustment procedure remains the same. The most common error made while doing the wheel alignment using the computerized equipment is that the wheel run out compensation procedure is not carried. That is one of the reasons of poor repeatability

The computerized wheel alignment machines, which have been approved by M&M, are of Precision or Manatec make. It is mandatory that the wheel alignment machine be calibrated at regular interval specified by the individual Manufacturer.

Wheel alignment using computerised gauge (Photos are with Manatec)

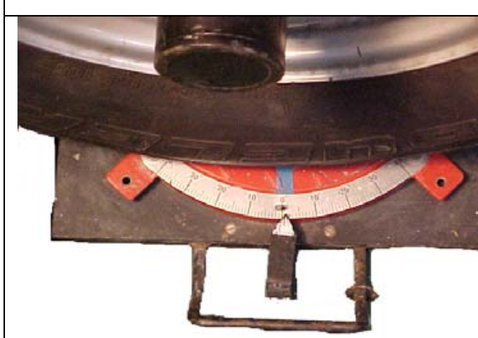
	Start the computerised alignment machine. Move the cursor to the alignment name and press enter.
	Enter the details of the details as displayed on the screen, the vehicle code can be selected from the list by pressing the F3 button on the key board. For moving to the other details press “enter” or “tab”. Press “F5” when all the details are entered.
	State the tyre and the bearing condition. The condition can be selected by moving the up or down arrow keys. For selecting particular condition press enter. For going to the next tyre condition press “tab” key. When the conditions are selected press “F5” key

	From the alignment menu select two wheel Alignment, since our vehicle have fixed alignment at the rear.
	Fix the sensors on the rear as well as front wheels. Caution: While fitting the sensors ensure that the clamps are properly tightened. The right sensors are in place, sensors are marked with right and left side.
	Ensure that the bubble in the spirit level of the rear sensor is set in the center of the marking made on it. Jack up the front wheels. Loosen the knob on the sensor.
	For the runout press the runout key on the sensor as shown in the figure.

Move the tyre in the direction as shown on the screen by holding the sensor, after completing half rotation press the run out key on the sensor complete the remaining rotation.

Caution : Move the tyre slowly and smoothly.

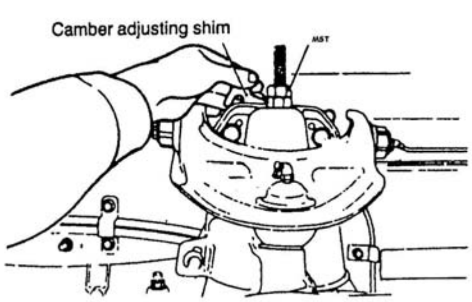
The front wheel run out will be displayed, press “enter” key to continue.



Remove the lock-pins of the turning table

	For achieving the straight ahead position move the steering wheel slowly to the directions as displayed on the screen first to the right and the to the left. Hold for some time at the end, for the computer to acquire data. Hold for some time at the centre position. Fix the steering lock at that position. Press “enter” key to continue.
	Press “enter” key to continue. The values of Castor, camber, and toe will appear.
	The castor & the camber are adjusted by addition or removal of The Toe is changing the track rod end distance. When done press “enter” key.
	The sequence of adjustment which have to be carried is Castor Camber Toe in adjustment
For adjusting the Castor	
	The values should be within 2.75 °±1.00 (2°45’± 1.0°)
	The difference between the two wheels should be within ±45'
	The adjusting shims are available in

	1.6, 0.4-mm thickness. *Addition of shims in front between the fulcrum lever and the chassis bracket will reduce the castor* *Addition of shims in rear between the fulcrum lever and the chassis bracket will increase the castor* *0.4 mm = 9'(0.15°)* *1.6 mm = 37'(0.62°)*
	Loosen the lower arm mounting bolts ,and the upper arm side nuts so that the lower arm movement is free.
	Remove the front apron cover.
	Compress the spring by moving the lower arm, using a jack
	Loosen the fulcrum mounting bolts
	Add or remove shims as required
	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Also refer to the Torque chart.
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. As per the Torque chart **Before tightening shake the vehicle by compressing the front and rear of the vehicle alternatively by hand.**
For adjusting the Camber	
	The value for any given wheel should be 0°14' ± 0°30' and the maximum difference between the two wheels should be ± 30'
	The shims are available in thickness of 3.2, 1.6, 0.8 mm

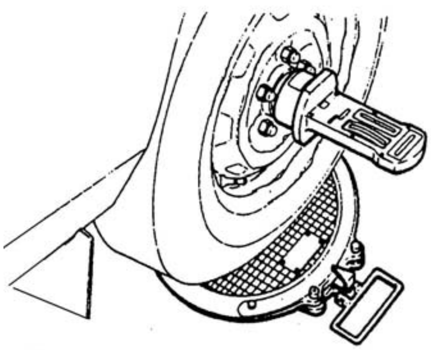
	Addition of shim between the fulcrum and the chassis bracket will decrease the camber. *0.8mm =0.15* °(9') *1.6 mm = 0.32* °(19') *3.2 mm = 0.62°*(37') To increase the camber – remove the shims
	Loosen the lower arm mounting bolts, and the upper arm side nuts. so that the lower arm movement is free
	Take out the apron cover behind the wheel by carefully removing the plastic fasteners
	Compress the spring by moving the lower arm, using a jack.
	Loosen the fulcrum mounting bolts
	Add or remove shims as required
	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Refer to the torque chart
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. **Before tightening shake the vehicle by compressing the front and rear of the vehicle alternatively by hand.**
	Cross-confirm the camber value.
For adjusting the Toe In	
	Adjust by moving the tie rod. The tie

	rods should be adjusted equally on both sides. The variation between left and right side of the tie rods should be maximum one turn. (If it is more than the centralization of the steering wheel will also be affected.)
Adjusting the Wheel tuning angle	
	Bring the Wheels in Straight Ahead Position (SAP). At this position confirm that the turntables Zero are also showing Zero
	Turn the steering wheel to Right Hand Side so that the wheel turns through 36±0.5° **(Please refer the specifications)**
	Check the condition of the stopper bolt of LH side It should touch the bracket on the lower arm assy.
	If it is not touching or the wheel is not able to turn through 36±0.5° then loosen the lock nut adjust the bolt and then lock the bolt with locknut.
	Turn the steering now towards the Left-hand side and then adjust the stopper on the right hand side.
	For print out press "F10" key to save press "ctrl" and the "home" key together.

	Take print out of the final sheet as displayed in the figure in which all details will be available.
	To exit press ctrl and home.
	The data will be stored in the computer and can be retrieved as and when required.

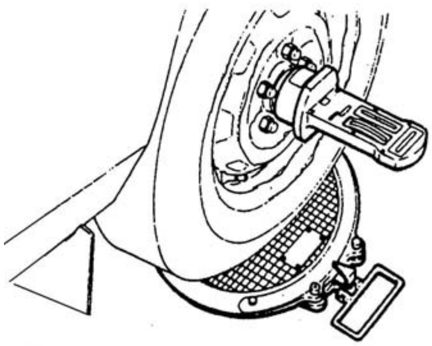
Even if the manual gauge is used please ensure that it is having high accuracy and also repeatability.

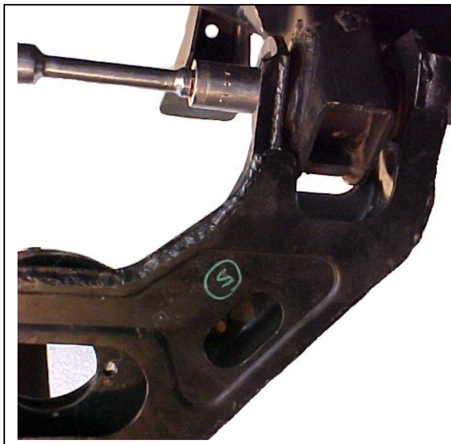
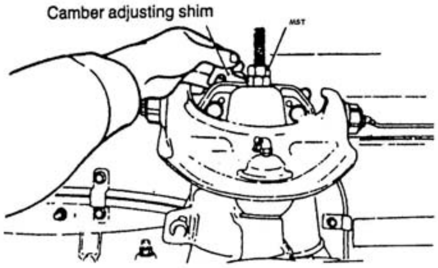
<u>Castor checking (With the bubble type gauge)</u> -

	Confirm that the bubble is set at Zero and also that the turntable is also set to zero.
	Remove the turn tables locking pin
	Rotate the steering so that the wheel turns inwards by 20 degrees.
	Set the castor scale to zero
	Turn the steering wheel in opposite direction so that it turns outwards by 20 degrees
	The value in the castor scale gives the castor value.

	The values should be within 2.75 °±1.00 (2°45'± 1.0°)
	Repeat on the other side
	The difference between the two wheels should be within ±45'
	The adjusting shims are available in 1.6, 0.4-mm thickness. *Addition of shims in front between the fulcrum lever and the chassis bracket will reduce the castor* *Addition of shims in rear between the fulcrum lever and the chassis bracket will increase the castor* *0.4 mm = 9'(0.15°)* *1.6 mm = 37'(0.62°)*
	Loosen the lower arm mounting bolts ,and the upper arm side nuts so that the lower arm movement is free
	Remove the front apron cover.
	Compress the spring by moving the lower arm, using a jack
	Loosen the fulcrum mounting bolts
	Add or remove shims as required
	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Also refer to the Torque chart.
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. As per the Torque chart **Before tightening shake the vehicle by compressing the front and rear of the vehicle alternatively by hand.**
	Cross-confirm the castor value.

Camber checking (With the bubble type gauge) -

	Keep the front wheel in straight-ahead condition. (SAP) Clean the hub assembly for any dirt or mud. Remove the front wheel hubcap.
	Install the magnetic base of the gauge in such a way that the center pin of the gauge aligns with stub axle center drill and gauge is sitting squarely on the hub. By turning the gauge bring the spirit level to read " ZERO ". The value in the camber scale at this point is the Camber reading. Note the reading
	Repeat the same procedure on the other wheel.
	The value for any given wheel should be 0°14' ± 0°30' and the maximum difference between the two wheels should be ± 30'
	The shims are available in thickness of 3.2, 1.6, 0.8 mm *Addition of shim between the fulcrum and the chassis bracket will decrease the camber.* *0.8mm =0.15* °(9’) *1.6 mm = 0.32* °(19’) *3.2 mm = 0.62°*(37’) *To increase the camber – remove the shims*

	Loosen the lower arm mounting bolts ,and the upper arm side nuts. so that the lower arm movement is free
	Take out the apron cover behind the wheel by carefully removing the plastic fasteners
	Compress the spring by moving the lower arm, using a jack
	Loosen the fulcrum mounting bolts
	Add or remove shims as required

	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Refer to the torque chart
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. **Before tightening shake the vehicle by compressing the front and rear of the vehicle alternatively by hand.**
	Cross-confirm the camber value.
	Replace the apron and the hub cover.

Caution:

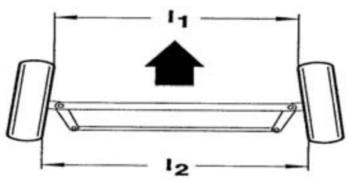
Ensure that while the hubcap is being fitted back the Anabond RTV sealant 673 has been applied. The sealant should be applied in the mounting face as well as the inner dia.

Do not fill grease in cavity.

Failure to do so will result in premature wheel bearing failure and tyre wear.

Toe in checking (With manual gauge) -

	Mark the center of the tyre treads. Do it for both the tyres
	Adjust the height of the pointer so that it touches the marked line in line with the center of the axle spindle/ hubcap.
	Place the gauge in front of the vehicle

	so that the pins touch the center of either the treads/ or the inner edge of the wheel disc at the flat-machined area.
	Note the value in the scale
	Take the gauge to the back of the wheel and take measurement at 180 degrees backward
	Note the value in the scale
	The difference in the value gives the toe in.
	The total difference should be between 1 to 3 mm. (0.15° to 0.45°).
	Adjust by moving the tie rod. The tie rods should be adjusted equally on both sides. with only max. The variation between left and right side of the tie rods should be maximum one turn. (If it is more than the centralization of the steering wheel will also be affected.)

<u>Wheel Turning Angle (With manual gauge)</u> -

	Bring the Wheels in Straight Ahead Position (SAP). At this position confirm that the turntables Zero are also showing Zero
	Turn the steering wheel to Right Hand Side so that the wheel turns through -(Please refer the specifications

	Check the condition of the stopper bolt of LH side It should touch the bracket on the lower arm assy.
	If it is not touching or the wheel is not able to turn through 36±0.5° then loosen the lock nut adjust the bolt and then lock the bolt with locknut.
	Turn the steering now towards the Left-hand side and then adjust the stopper on the right hand side.

Check the Steering Wheel Centralization -

One of the most common complaints / perceptions is that after the Wheel Alignment the Steering wheel is not centralized. Though strictly speaking it does not constitute wheel alignment but if the steering wheel is centralized then a lot of customer dissatisfaction will be avoided.

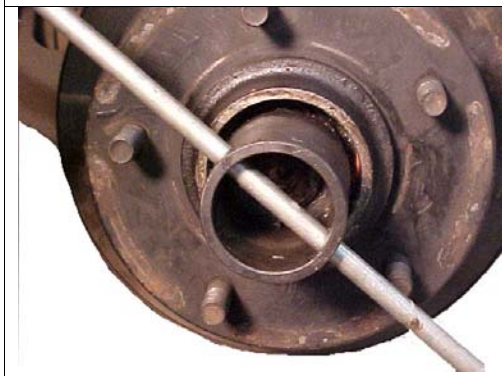
Caution: This procedure for centralizing the Steering wheel is valid only if the misalignment of the spokes is less than 10 degrees. In other words this procedure is only for fine-tuning the steering wheel position not for glaring error. If it is more 10 degrees then remove the steering wheel and initially realign to less than 10 degrees.

Adjust the **Steering wheel centralization**

	Cross check the Wheel **Toe** In after this operation, before releasing the vehicle.

Wheel hub greasing --

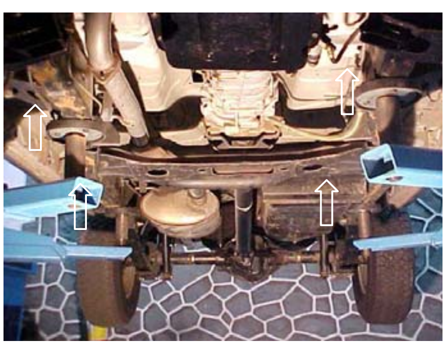
	Remove the caliper assembly without disconnecting the brake hose. Caution: Ensure that the brake hoses

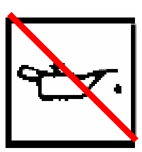
	are not stretched/ damaged. Put the caliper without straining the brake tube.
	Loosen & remove allen bolts & the automatic hub lock.
	Using the MST 571, remove the outer locknut
	Remove the lock washer and the inner nut.
	Pull out the hub along with the bearings.
	Inspect the rollers and the inner races of the bearings for pitting/ brinelling or spalling.
	If any damage is noticed – inspect the outer races also.
	To remove and refit the outer races, use MST.

	Caution: **Never clean the bearings in water.** **Never rotate the bearings with compressed air.** **Never tap the bearing's to clean out the trapped dust.**
	DO: *Clean with kerosene and a hard brush.* *Wrap up the cleaned bearings with polythene to avoid water, humidity affecting the bearings.* *Do remember that the dust and water are the 2 main reasons for bearing failures*
	If the outer race / cup is found to be loose in the housing then it is advisable to replace the hub. Trying to recondition the hub bore is not recommended.
	If the bearing seating area or the oil seal seating area in the spindle is worn then replace the spindle.
	Caution : Ensure that the hub assembly is being rotated while the inner nut is being tightened **This is essential to ensure that the roller centralize themselves and also so that they abut properly.** **Failure to do so causes two complaint- excessive loading on few rollers and also increase/ variation in hub endplay after running.**

	Fill the grease in the bearing.
	Locate the inner bearing cone & press the oil seal using the MST 574.
	Note: The lip of the oil seal should be coated with grease. Also fill grease in the cavity where the oil seal spring is present.
	Press the hub assembly on the spindle,
	Locate the inner cone of the outer bearing.
	Tighten the inner nut. and back off by 90 degrees .The hub play should be within 0.010 to 0.030 mm
	Put the locking washer.
	Tighten the outer nut.
	Press the hub cover after applying Anabond RTV 673 sealant.- Use the MST 575 to fit the hub cover, Fit the automatic hub lock.

Caution: Do not lubricate the suspension bushes/joints. For fitting & removing bush use soap solution only.

	Jack up the vehicle- locate the jack Behind the lower arm just below the first outrigger. **Care must be taken not to damage the torsion bar.**
	Remove the tyre .
	Remove the calliper assembly without

	disconnecting the brake hose . Caution: Ensure that the brake hoses are not stretched/ damaged. Put the calliper without straining the brake tube.
	Remove the Shock Absorber.
	In case only the Upper arm bushes have to be replaced- remove the arm.
	Remove the lower Ball joint using the Special tool after removing the split pin and the castle nut.
	Remove the pin fulcrum bolt on chassis & remove the upper arm.
	Remove the Lower control arms front and rear nut and remove the LCA.
	For removing the upper and lower arm bushes use the Special tool MST 564 & 565 **Note:** **While fitting new bushes use soap solution so that the bush can pressed easily.**

	**Caution: Use of any lubricant will result in degradation of the rubber bush and lower life. Pressing without soap solution will damage the bush**
	During refitting use the dolly.
	**Caution:** In the lower arm while pressing the rib in the arm has to match groove in the tool

Working principle, Dismantling, Assembly of the Front Suspension –

The front Wheel suspension in the 4 WD vehicles is wishbone type with torsion bar springs and telescopically acting hydraulic dampener. Both the lower and upper arm employ two point mounting.

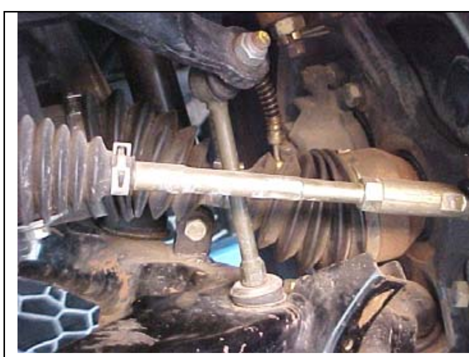
The torsion bar is connected to the Lower control Arms rear end through a Torque control Arm. The rear end of the torsion bar is connected to a ride control arm. A ride control height-adjusting nut links the control arm to chassis.

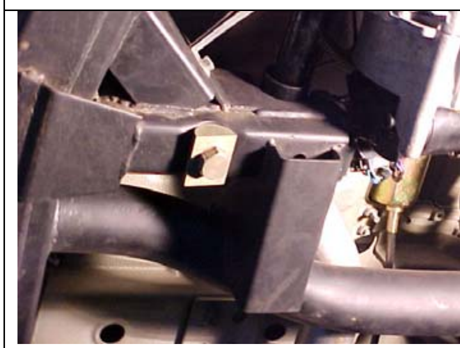
An anti roll bar is used to transfer the loads to the outer wheel during turns. The telescopic shock absorbers are used to dampen the wheel oscillations and ensure proper wheel contact irrespective of the road condition.

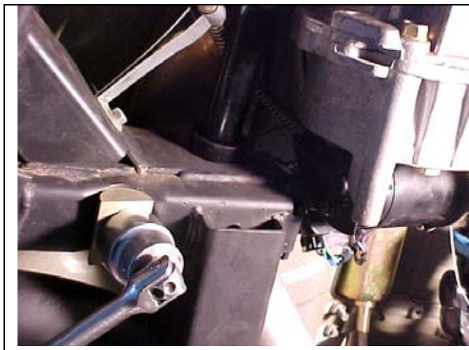
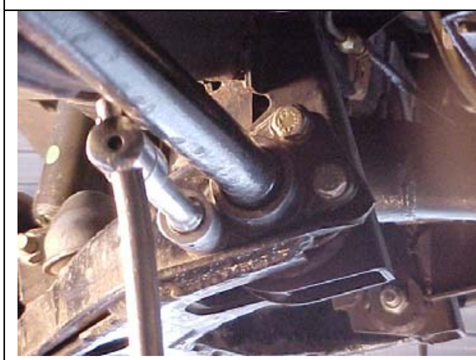
Caution:
The Torsion bars are pretwisted. LH marking identifies the Left Hand side and RH marking identifies the Right Hand torsion bar.
The arrow should be facing front.

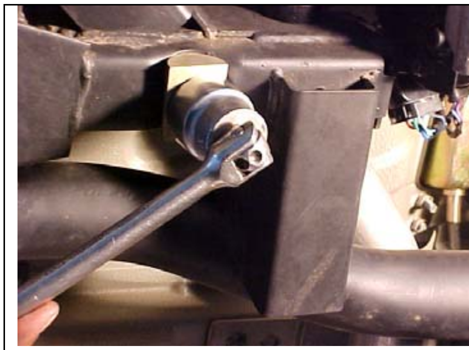
While jacking up the vehicle (for doing ride height adjustment) ensure that the jack or the two post lift points are not touching the torsion bar.

The dismantling sequence is reverse of the assembly procedure explained below –

	Jack the wheels, ensure that the anti roll bar link has been disconnected.

	Insert Lower Control Arm on frame
	Insert The torsion bar rear end in Height Control Arm serration
	Put the height control arm assembly on chassis bracket.
	It is advisable to keep all the bolts of the LCA & UCA loose while doing assembly, as it will ease the assembly operations. Also if the bolts are tightened in this position then the bushes will get preloaded. Further while trying to adjust the ride height the effort required to turn the ride height bolt will be high and cause damage to the face.

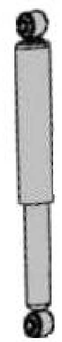
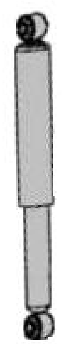
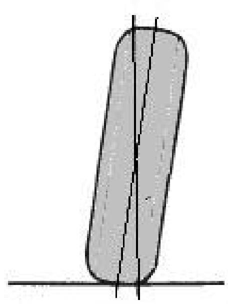
	Insert the bolt of height control Arm and flush the thread end to Height control nut. Give a slight twist to the torsion bar by hand so that the rocker maintains a horizontal position/ touching the bottom of the bracket.
	Holding the torsion bar by hand and insert/slide in the Torsion bar into the Lower Control arm's Torque Arm.
	Tighten the Torque Arms 3 bolts (2 bolts onto the weld nuts and 1 free bolt +flanged nut)
	It is essential to tighten the torque arms bolts first. In case it is not done so and the ride height is adjusted. Then the adjustment will not be achieved, and also the twist of the torsion bar by tightening will not result in proportionate lift/height of the LCA. Also the 3 bolts will not seat properly on the torque arm and may damage the threads of the 3 bolts. In other words the torque arm bolts ensure that the torsion bar becomes integral to the LCA through the Torque arm

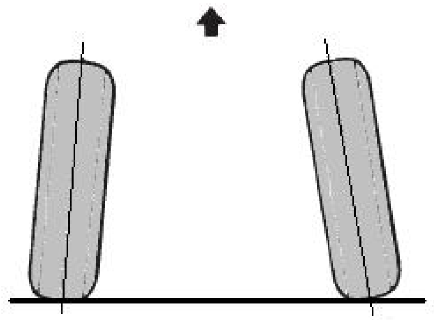
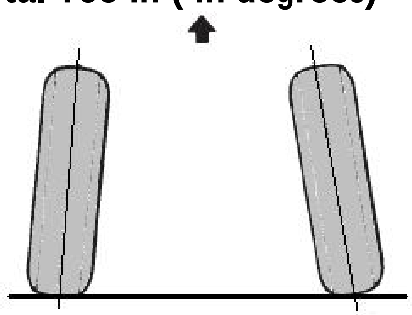
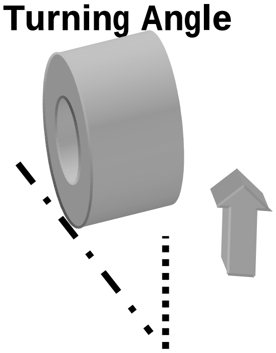
	Tighten the height control bolts by 24 to 26 Turns
	Lower the Jack so that the wheels are touching the ground
	Gently shake the Vehicle 5/6 times
	Tighten the Lower control Arms and the Upper Control Arm's both the front and rear bolts to the specified Torque.
	Measure the ride height. (Lower control Arms front bolt head center to ground.)
	**Note: Ensure that the measurement is done on level ground with specified tyre pressure on all four wheels. (Front 2.0 bar and Rear 2.2 bar).**
	If variation is more than +/- 7.0 mm then tighten or reduce the height by turning the height adjusting bolt.
	It is suggested that for turning the nut it is advisable to jack the vehicle.
	Take the measurement again after a ride.

	If the ride height varies from the specifications then readjust after loosening the UCA & LCA bolts and jacking both the wheels only 1 turn of the bolt affects the ride height by 6 to 7 mm. Hence if the ride height is less by say 3 mm then turn the ride height bolt by half a turn

The assembly procedure for fitting the bushes onto the LCA & UCA is same as mentioned in the 2WD. There is no change in setting the Wheel alignment procedure also.

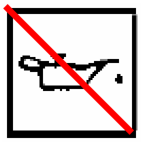
Specifications -

Description	Specification
Type	Independent, torsion bar with telescopic shock absorbers
Front Shock absorbers- 2WD 	Maximum length: 335±3. Minimum length: 222+3.
Front Shock absorbers- 4WD 	Maximum length: 378±3. Minimum length: 244+3.
Camber 	0.23 °±0.5 (0°14' ± 0°30')
Difference between LH & RH Camber	±0.5° (±30')

Castor	2.75 °± 1.0 (2°45'± 1.0°)
Difference between LH & RH castor	±0.75 ° (± 45')
Total Toe in 	1 to 3 mm.
Total Toe in (in degrees) 	0.15 to 0.45 ° (9' to 27')
Individual Toe in	0 to 20 minute
King pin Inclination	10.75° ± 1° (10°45'± 1°)
Wheel Turning Angle 	36°- 2WD 4WD 35°-Inner Wheel angle 32°-Outer Wheel angle
Ride hight to be set on vehicle	282 mm

Ride height Variation Between LH & RH. (Up to LCA front pivot bolt)	15 mm

Lubricants -



No lubricants are used in the suspension bush. Only soap to be used during assembly

Tightening Torque's –

Location	Torque
Upper Arm side bushes	110-130 Nm (81-96 Lbft)
Upper Arm Ball joint mounting nut	23-29 Nm (17- 21 Lbft)
Upper Arm pin fulcrum mounting nut	120-140 Nm (88.5 –103 Lbft)
Lower Control Arm Front Mounting	150-180 Nm (111-133 Lbft)
Lower control Arm Rear mounting	110-130 Nm (81-96 Lbft)
Torque Arm M12x1.25 with spring washer & weld nut	60-80 Nm (44-59 Lbft)
Torque Arm M10x1.25	40-60 Nm (29.5-44 Lbft)
LCA ball joint mounting nut	60-80 Nm (44-59 Lbft)
LCA bump stop mounting	40-60 Nm (29.5-44 Lbft)
Stabilizer bar on Frame	30-45 Nm (22- 33 Lbft)
Stabilizer bar +Link	60-80 Nm (44-59 Lbft)
Link on Lower Arm	16-22 Nm (12- 16 Lbft)
Shock absorber Top- on frame	16- 22 Nm (12- 16 Lbft)
Shock absorber Bottom on LCA	16-22 Nm (12- 16 Lbft)
Shock absorber Bottom on LCA (4WD)	60-80 Nm (44-59 Lbft)
Steering stopper on knuckle	50-75 Nm (37-55 Lbft)
Castle Nut UCA	120-160 Nm (88.5-118 Lbft)
Castle Nut LCA	120-160 Nm (88.5-118 Lbft)

Frame- Rebound stopper	40-60 Nm (29.5-44 Lbft)

List of the MST's -

MST Number	Description
MST-561	Upper Arm Ball Joint Puller
MST-562	Lower Arm Ball Joint Puller
MST–563	Fulcrum Mounting Bolt Spanner
MST-564	Fixture Upper/ Lower Arm Bush
MST-565	Extractor / Installer Arm Suspension Bush
MST-566	Extractor/ Installer Chassis Suspension Bush
MST-571	Special Socket for hub nut.
MST-572	Installer Front Wheel Bearing Cone-Outer
MST-573	Installer Front Wheel Bearing Cone-Inner
MST-574	Installer Front wheel Hub oil seal
MST-575	Installer Front Hub Grease Cup

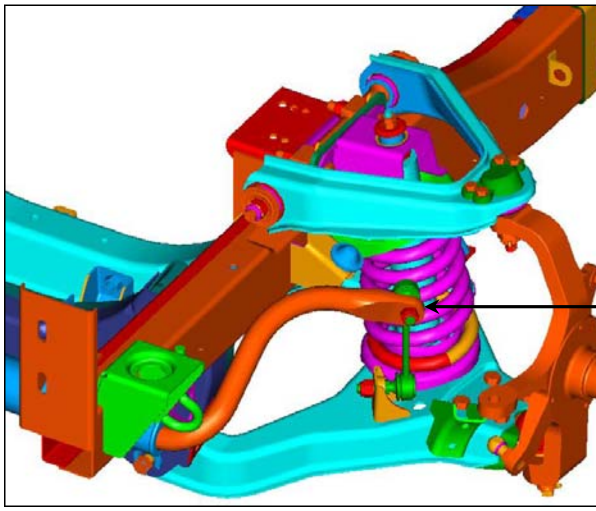
Automotive Sector

Front Suspension - 2WD

Contents

Description

The front suspension is independent while rear is multilink type. The front suspension in the 2WD vehicle is wishbone type with helical spring and telescopically acting hydraulic dampener. In the 4WD vehicles, the suspension is torsion bar type with hydraulic dampener.



Anti roll bar

The front also employs anti roll bar with ball joints on the connecting links as shown in the sketch to transfer the loads to the outer wheel during turns.

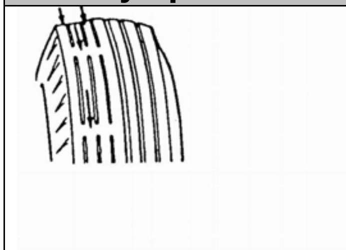
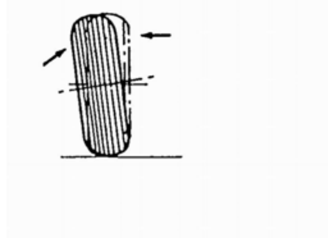
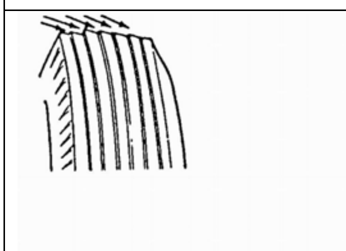
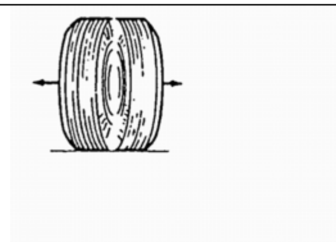
Trouble Shooting

A squeak noise from the shock absorber can be produced if movement between the rubber bushing and metal occurs. Tightening the attaching parts can usually stop this noise. If the squeak noise persist then inspect for worn or damaged bushings and attaching components. Repair as necessary if any thing found amiss.

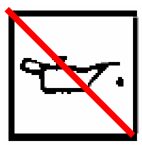
Squeak also happen due to relative movement from suspension arm's bush inner sleeve (serration end) and chassis bracket. This situation happens, if torque is not as per specs. Torque tightening the LCA & UCA bolts normally resolves the issue.

The shock absorber bushings do not require any kind of lubrication. Do not lubricate the bushings to reduce bushing noise. Grease or mineral oil base lubricants will deteriorate the bushing.

The shock absorbers are not refillable or adjustable. If a malfunction occurs, the shock absorber must be replaced. To test a shock absorber hold it upright in fully extended position for 10 minutes. Then force the piston in and out of the cylinder four or five times. The action throughout each stroke should be smooth and even.

Symptom	Causes	Remedial action
 **One Edge Wear**	 *Excessive camber*	✓ Check and adjust: ✓ Hub end play ✓ Camber to be checked and adjusted.
 **Feathered Edge Wear**	 *Incorrect Toe In*	✓ Check & correct Toe In ✓ Check the chassis bend ✓ If tyre rotation not carried out as per schedule. Do the tyre rotation.
Excessive Vehicle rolling	1. *Body Mounts loose.* 2. *Suspension mounting loose.* 3. *Broken or deteriorated stabilizer* 4. *Worn stabilizer bush* 5. *Malfunctioning shock absorber* 6. *Stabiliser link*	✓ Tighten the body mounts. ✓ Tighten the suspension mounts. ✓ If broken stabilizer bar-replace ✓ Replace the bushes & tighten to the specified torque, ✓ Replace the shock absorber. ✓ Tighten the link bolts

	bolt loose	
Vehicle inclined	*Broken or deteriorated coil spring*	✓ Replace the coil spring
Noise	*1. Parts worn or loose* *2. Broken coil spring* *3. Malfunctioning shock absorber*	✓ Tighten the parts or replace ✓ Replace the coil spring ✓ Replace the shock absorber



Caution: Do not lubricate the suspension bushes/joints.

Care of the system

- ✓ The first wheel alignment should be carried out at 5000 kms then at 10,000 Kms. Subsequently every 10,000 kilometres.
- ✓ Torque tighten the LCA & UCA bolts to the required torque. (Upper arm 110-130 Nm , LCA front 150-180 Nm; LCA rear 110-130 Nm)
- ✓ First at 5000 Kms then subsequently every 10,000 Kms.
- ✓ Check the shock absorber for leaks every 10,000 Kms.
- ✓ Check the rubber bushes for the mounting of the shock absorber, stabilizer bar and links every 20,000 Kms or once in a year

In Car repairs

a) *Wheel* alignment
b) Wheel hub *greasing*

a) Wheel alignment

The sequence of the wheel alignment, which should be followed, is:
Carry out the runout compensation when using the computerized equipment

1. Steering Wheel Centralize- cross check & adjust.

2. Castor checking & adjustment (Computerized / Manual)
3. Camber checking & adjustment(Computerized / Manual)
4. Toe in checking & adjustment. (Computerized / Manual)
5. *Wheel* Turning *Angle,* checking and adjustment. (Computerized / Manual)
6. Check the centralization of the Steering wheel as the final operation

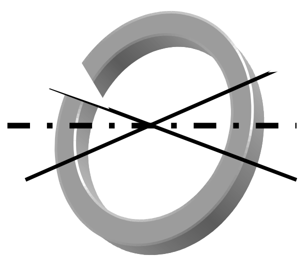
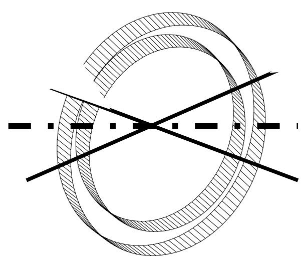
Caution: In order to obtain the correct values and avoid complaints. Please note that that the following parameters have to be adhered to without fail:

- **The tyre pressures in all the four wheels are as per the specifications.**
- **Vehicle should be unladen and parked on level surface**
- **Ensure that the wheel hub play is correct.**
- **Check that the chassis and the under body are not coated with mud. If in doubt get the vehicle cleaned before doing the checking.**
- **Check the ride height variation as per the specification.**
- **Replace the parts of suspension if found badly damaged**
- **Before starting the measurement, ensure that the parking brakes are applied and the rear wheels are blocked**
- **Before doing the wheel alignment – ensure that the linkages i.e. the ball joint are not worn or loose. Check the free play in the steering.**
- **All the tyres and the wheel disc should be of the same type.**

Caution: This procedure for centralizing the Steering wheel is valid only if the misalignment of the spokes is less than 10 degrees. In other words this procedure is only for fine-tuning the steering wheel position not for glaring error. If it is more 10 degrees then remove the steering wheel and initially realign to less than 10 degrees.

Steering Wheel Centralization

	To check for the centralization of the steering wheel. Drive the vehicle on a level road surface; note the angular position (misalignment of the steering wheel spokes.
	Raise the vehicle. Keep the wheels in Straight Ahead Position.

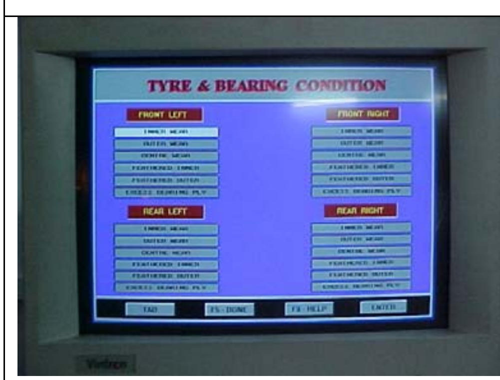
	Mark the position of the track rods and the track rod ends
	Slacken the track rod end lock nuts and also remove the gaiter outer retaining clips.
	Rotate both track rods in the same direction approximately 30 degrees for every 1-degree of steering misalignment error.
	If the steering wheel has an anti clockwise angular error then both track rods must be rotated clockwise- when viewed from the left – hand side of the vehicle.
	If the steering wheel has an clockwise angular error then both track rods must be rotated anticlockwise- when viewed from the left – hand side of the vehicle

With the computerized wheel alignment gauges the checking procedure may vary slightly. However the sequence of checking and the adjustment procedure remains the same. The most common error made while doing the wheel alignment using the computerized equipment is that the wheel run out compensation procedure is not carried. That is one of the reasons of poor repeatability

The computerized wheel alignment machines, which have been approved by M&M, are of Precision or Manatec make. It is mandatory

that the wheel alignment machine be calibrated at regular interval specified by the individual Manufacturer.

Wheel alignment using computerised gauge (Photos are with Manatec)

	Start the computerised alignment machine. Move the cursor to the alignment name and press enter.
	Enter the details of the details as displayed on the screen, the vehicle code can be selected from the list by pressing the F3 button on the key board. For moving to the other details press “enter” or “tab”. Press “F5” when all the details are entered.
	State the tyre and the bearing condition. The condition can be selected by moving the up or down arrow keys. For selecting particular condition press enter. For going to the next tyre condition press “tab” key. When the conditions are selected press “F5” key

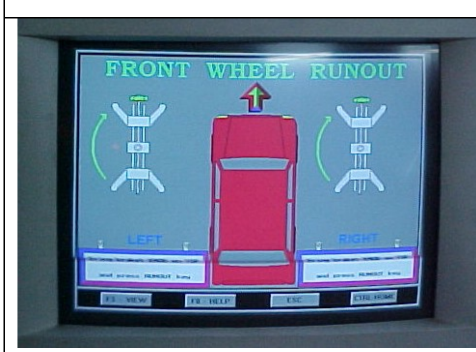
From the alignment menu select two wheel Alignment, since our vehicle have fixed alignment at the rear.

Fix the sensors on the rear as well as front wheels.
Caution:
While fitting the sensors ensure that the clamps are properly tightened.
The right sensors are in place, sensors are marked with right and left side.

Ensure that the bubble in the spirit level of the rear sensor is set in the center of the marking made on it.

Jack up the front wheels.

Loosen the knob on the sensor.

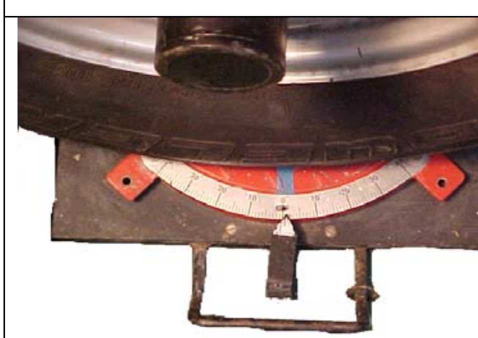


For the runout press the runout key on the sensor as shown in the figure.

Move the tyre in the direction as shown on the screen by holding the sensor, after completing half rotation press the run out key on the sensor complete the remaining rotation.

Caution : Move the tyre slowly and smoothly.

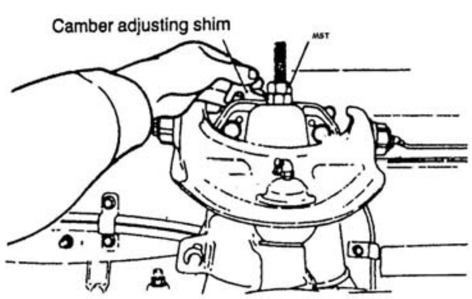
The front wheel run out will be displayed, press “enter” key to continue.



Remove the lock-pins of the turning table

	For achieving the straight ahead position move the steering wheel slowly to the directions as displayed on the screen first to the right and the to the left. Hold for some time at the end, for the computer to acquire data. Hold for some time at the centre position. Fix the steering lock at that position. Press “enter” key to continue.
	Press “enter” key to continue. The values of Castor, camber, and toe will appear.
	The castor & the camber are adjusted by addition or removal of The Toe is changing the track rod end distance. When done press “enter” key.
	The sequence of adjustment which have to be carried is Castor Camber Toe in adjustment
For adjusting the Castor	
	The values should be within 2.75 °±1.00 (2°45’± 1.0°)
	The difference between the two wheels should be within ±45'
	The adjusting shims are available in 1.6, 0.4-mm thickness.

	Addition of shims in front between the fulcrum lever and the chassis bracket will reduce the castor *Addition of shims in rear between the fulcrum lever and the chassis bracket will increase the castor* *0.4 mm = 9'(0.15°)* *1.6 mm = 37'(0.62°)*
	Loosen the lower arm mounting bolts ,and the upper arm side nuts so that the lower arm movement is free
	Remove the front apron cover.
	Compress the spring by moving the lower arm, using a jack
	Loosen the fulcrum mounting bolts
	Add or remove shims as required
	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Also refer to the Torque chart.
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. As per the Torque chart **Before tightening shake the vehicle by compressing the front and rear of the vehicle alternatively by hand.**
For adjusting the Camber	
	The value for any given wheel should be 0°14' ± 0°30' and the maximum difference between the two wheels should be ± 30'

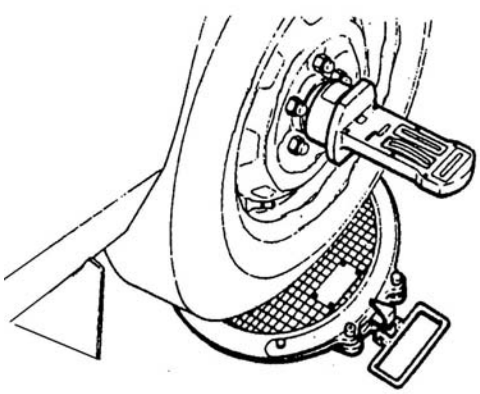
	The shims are available in thickness of 3.2, 1.6, 0.8 mm *Addition of shim between the fulcrum and the chassis bracket will decrease the camber.* *0.8mm =0.15* °(9’) *1.6 mm = 0.32* °(19’) *3.2 mm = 0.62°*(37’) To increase the camber – remove the shims
	Loosen the lower arm mounting bolts, and the upper arm side nuts. so that the lower arm movement is free
	Take out the apron cover behind the wheel by carefully removing the plastic fasteners
	Compress the spring by moving the lower arm, using a jack.
	Loosen the fulcrum mounting bolts
	Add or remove shims as required
	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Refer to the torque chart
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. **Before tightening shake the vehicle by compressing the front**

	and rear of the vehicle alternatively by hand.
	Cross-confirm the camber value.
For adjusting the Toe In	
	Adjust by moving the tie rod. The tie rods should be adjusted equally on both sides. The variation between left and right side of the tie rods should be maximum one turn. (If it is more than the centralization of the steering wheel will also be affected.)
Adjusting the Wheel tuning angle	
	Bring the Wheels in Straight Ahead Position (SAP). At this position confirm that the turntables Zero are also showing Zero
	Turn the steering wheel to Right Hand Side so that the wheel turns through 36±0.5° **(Please refer the specifications)**
	Check the condition of the stopper bolt of LH side It should touch the bracket on the lower arm assy.
	If it is not touching or the wheel is not able to turn through 36±0.5° then loosen the lock nut adjust the bolt and then lock the bolt with locknut.
	Turn the steering now towards the Left-hand side and then adjust the stopper on the right hand side.

	For print out press “F10” key to save press “ctrl” and the “home” key together.
	Take print out of the final sheet as displayed in the figure in which all details will be available.
	To exit press ctrl and home.
	The data will be stored in the computer and can be retrieved as and when required.

Even if the manual gauge is used please ensure that it is having high accuracy and also repeatability.

Castor checking (With the bubble type gauge)

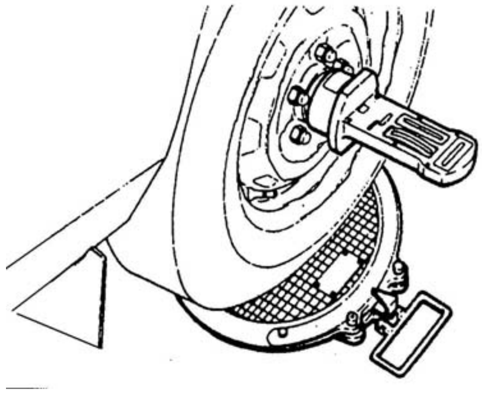
	Confirm that the bubble is set at Zero and also that the turntable is also set to zero.

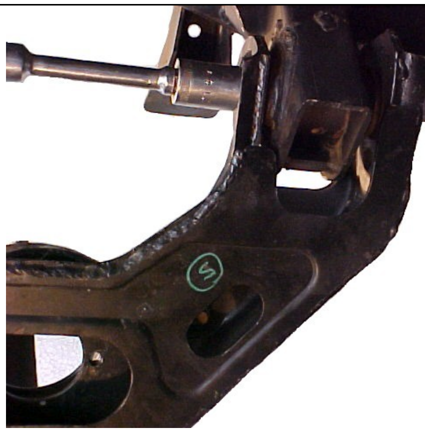
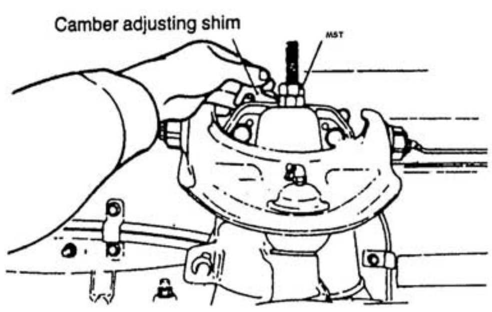
	Remove the turn tables locking pin
	Rotate the steering so that the wheel turns inwards by 20 degrees.
	Set the castor scale to zero
	Turn the steering wheel in opposite direction so that it turns outwards by 20 degrees
	The value in the castor scale gives the castor value.
	The values should be within 2.75 °±1.00 (2°45'± 1.0°)
	Repeat on the other side
	The difference between the two wheels should be within ±45'
	The adjusting shims are available in 1.6, 0.4-mm thickness. *Addition of shims in front between the fulcrum lever and the chassis bracket will reduce the castor* *Addition of shims in rear between the fulcrum lever and the chassis bracket will increase the castor* *0.4 mm = 9'(0.15°)* *1.6 mm = 37'(0.62°)*
	Loosen the lower arm mounting bolts ,and the upper arm side nuts so that the lower arm movement is free
	Remove the front apron cover.
	Compress the spring by moving the lower arm, using a jack
	Loosen the fulcrum mounting bolts.

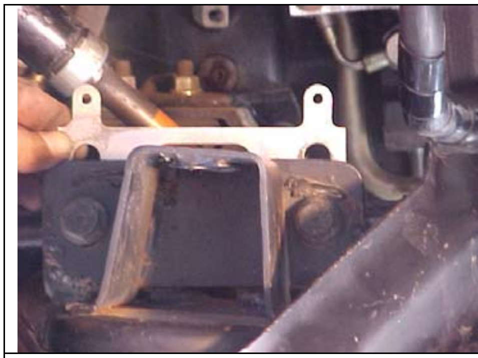
	Add or remove shims as required.
	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Also refer to the Torque chart.
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. As per the Torque chart **Before tightening shake the vehicle by compressing the front and rear of the vehicle alternatively by hand.**
	Cross-confirm the castor value.

Camber checking (With the bubble type gauge)

	Keep the front wheel in straight-ahead condition. (SAP) Clean the hub assembly for any dirt or mud. Remove the front wheel hubcap.

	Install the magnetic base of the gauge in such a way that the centre pin of the gauge aligns with stub axle centre drill and gauge is sitting squarely on the hub. By turning the gauge bring the spirit level to read " ZERO ". The value in the camber scale at this point is the Camber reading. Note the reading
	Repeat the same procedure on the other wheel.
	The value for any given wheel should be 0°14' ± 0°30' and the maximum difference between the two wheels should be ± 30'
	The shims are available in thickness of 3.2, 1.6, 0.8 mm *Addition of shim between the fulcrum and the chassis bracket will decrease the camber.* *0.8mm =0.15* °(9’) *1.6 mm = 0.32* °(19’) *3.2 mm = 0.62°*(37’) *To increase the camber – remove the shims*

	Loosen the lower arm mounting bolts and the upper arm side nuts. so that the lower arm movement is free
	Take out the apron cover behind the wheel by carefully removing the plastic fasteners
	Compress the spring by moving the lower arm, using a jack
	Loosen the fulcrum mounting bolts
	Add or remove shims as required

	Tighten the fulcrum mounting bolts to 12.0 to 14.0 Mkg (87 lb. ft- 101 lb. ft). Refer to the torque chart
	After that decompress the spring.
	Tighten the lower arm mounting bolts. And the upper arm side nuts. **Before tightening shake the vehicle by compressing the front and rear of the vehicle alternatively by hand.**
	Cross-confirm the camber value.
	Replace the apron and the hub cover.

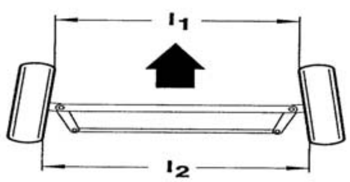
Caution: Ensure that while the hubcap is being fitted back the Anabond RTV sealant 673 has been applied. The sealant should be applied in the mounting face as well as the inner dia.

Do not fill grease in cavity.

Failure to do so will result in premature wheel bearing failure and tyre wear.

Toe in checking. (With manual gauge)

	Mark the center of the tyre treads. Do it for both the tyres
	Adjust the height of the pointer so that it touches the marked line in line with the centre of the axle spindle/ hubcap.
	Place the gauge in front of the

	vehicle so that the pins touch the centre of either the treads/ or the inner edge of the wheel disc at the flat-machined area.
	Note the value in the scale
	Take the gauge to the back of the wheel and take measurement at 180 degrees backward
	Note the value in the scale
	The difference in the value gives the toe in.
	The total difference should be between 1 to 3 mm. (0.15° to 0.45°).
	Adjust by moving the tie rod. The tie rods should be adjusted equally on both sides. with only max. The variation between left and right side of the tie rods should be maximum one turn. (If it is more than the centralization of the steering wheel will also be affected.)

Wheel Turning Angle (With manual gauge)

	Bring the Wheels in Straight Ahead Position (SAP). At this position confirm that the turntables Zero are also showing Zero

	Turn the steering wheel to Right Hand Side so that the wheel turns through -(Please refer the specifications
	Check the condition of the stopper bolt of LH side It should touch the bracket on the lower arm assy.
	If it is not touching or the wheel is not able to turn through 36±0.5° then loosen the lock nut adjust the bolt and then lock the bolt with locknut.
	Turn the steering now towards the Left-hand side and then adjust the stopper on the right hand side.

Check the Steering Wheel Centralization

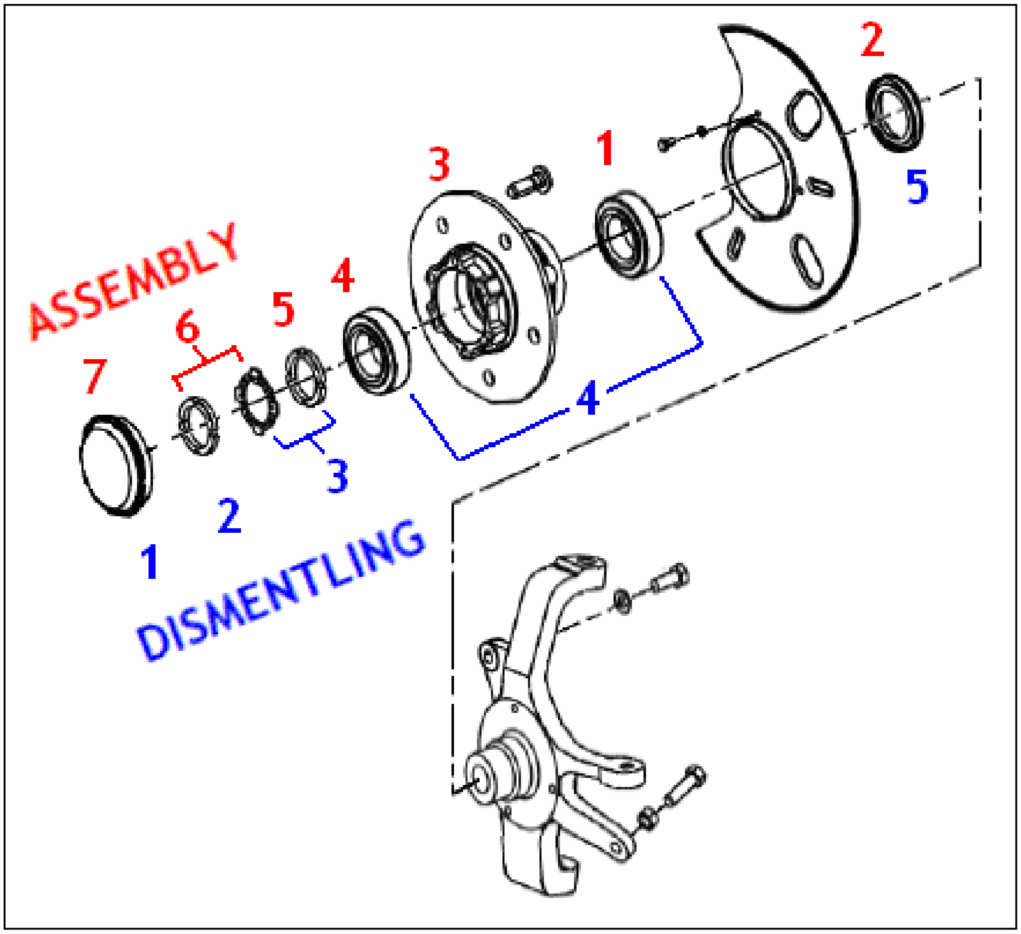
One of the most common complaints / perceptions is that after the Wheel Alignment the Steering wheel is not centralized. Though strictly speaking it does not constitute wheel alignment but if the steering wheel is centralized then a lot of customer dissatisfaction will be avoided.

Caution: This procedure for centralizing the Steering wheel is valid only if the misalignment of the spokes is less than 10 degrees. In other words this procedure is only for fine-tuning the steering wheel position not for glaring error. If it is more 10 degrees then remove the steering wheel and initially realign to less than 10 degrees.

Adjust the **Steering wheel centralization**

	Cross check the Wheel **Toe** In after this operation, before releasing the vehicle.

b) Wheel hub greasing –



Dismantling –

- Jack up the vehicle & remove the wheel.
- Remove the caliper assembly without disconnecting the brake hose. *Caution*: Ensure that the brake hoses are not stretched/ damaged. Put the caliper without straining the brake hose.

1. Remove the hub cover using a screwdriver.
2. Using the MST 571, remove the outer locknut.
3. Take out the lock washer and the inner nut.
4. Pull out the hub along with the bearings.
5. Remove the Oil Seal.

Inspection –

- Inspect the rollers and the inner races of the bearings for Scoring, pitting/ brinelling or spalling.
- If any damage is noticed – inspect the outer races also.
- To remove & refit the outer races, use MST.
- If the outer race / cup is found to be loose in the housing then it is advisable to replace the hub. Trying to recondition the hub bore is not recommended.
- If the bearing seating area or the oil seal seating area in the spindle is worn then replace the spindle.

Assembly –

- Apply the *MAXIMILE LCG3* grease on the bearings.

1. Locate the inner bearing cone in the hub.
2. Press the new oil seal using the MST 574.
   Note: The lip of the oil seal should be coated with grease. Also fill grease in the cavity where the oil seal spring is present.
3. Press the hub assembly on the spindle & fill the grease.
4. Locate the inner cone of the outer bearing.
5. Tighten the inner nut. and back off by 90 degrees .The hub play should be within 0.010 to 0.030 mm.
   Ensure that the hub assembly is being rotated while the inner nut is being tightened. This is essential to ensure that the roller centralize themselves and also so that they abut properly.
6. Put the locking washer & tighten the outer nut.
7. Apply Anabond RTV 673 sealant & Press the hub cover using the MST 575.

Automotive Sector

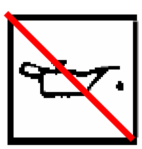
Working principle, Dismantling & Assembly of the Front Suspension 2WD

The front Wheel suspension in the 2 WD vehicles is wishbone type with helical spring and telescopically acting hydraulic dampener. Both the lower and upper arm employ two point mounting.

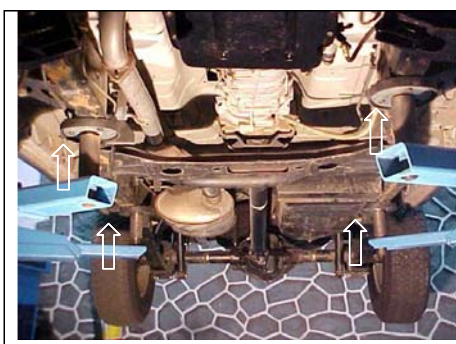
An anti roll bar is used to transfer the loads to the outer wheel during turns. The telescopic shock absorbers are used to dampen the wheel oscillations and ensure proper wheel contact irrespective of the road condition.

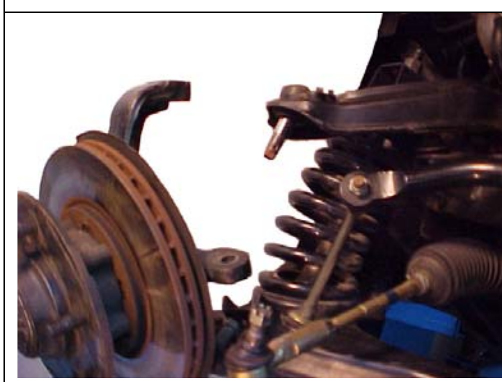
Points to be ensured while fitting any new bushes in the suspension –

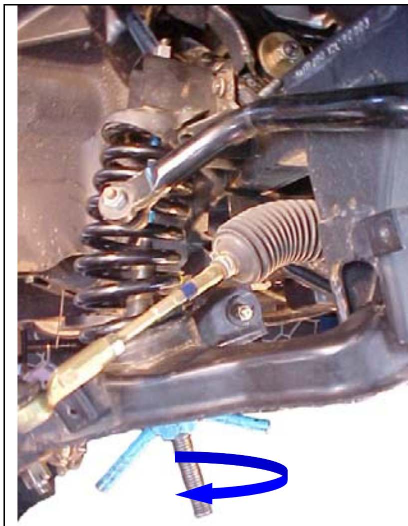
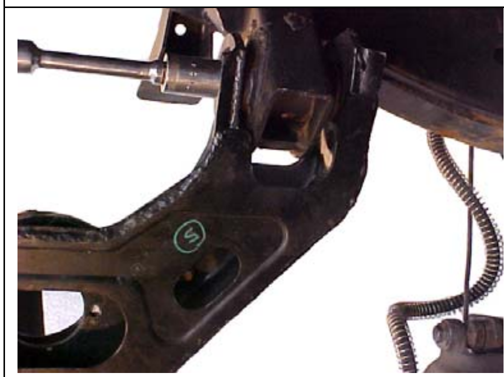
The bolts should be fully tightened only when the wheels are in ground. When the bolts are tightened with any particular wheel jacked up then it causes preloading of the rubber bush in the normal operating zone and thus reducing its life.

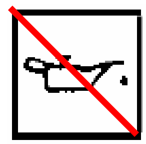


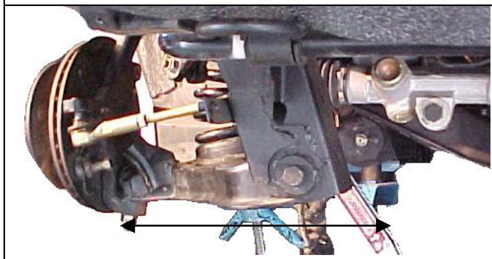
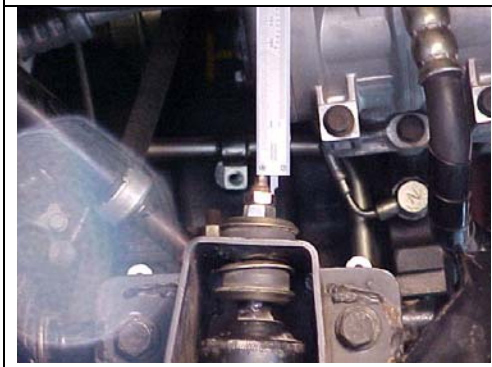
Caution: Do not lubricate the suspension bushes/joints. For fitting & removing bush use soap solution only.

	Jack the vehicle- locate the jack Behind the lower arm just below the first outrigger
	Remove the tyre .

	Remove the calliper assembly without disconnecting the brake tube. Caution: Ensure that the brake tubes are not stretched/ damaged. Put the calliper without straining the brake tube.
	Remove the Shock Absorber.
	In case only the Upper arm bushes have to be replaced- remove the arm.

	Loosen the special tools so that the spring is slowly decompressed.
	Remove the coil spring and the tool gradually
	Remove the lower Ball joint using the Special tool after removing the split pin and the castle nut.
	Remove the pin fulcrum bolt on chassis & remove the upper arm.
	Remove the Lower control arms front and rear nut and remove the LCA.
	**Note** While assembling back ensure that 1. The smaller dia of the coil spring is on top i.e. the taper of the spring is upwards. 2. Both the spring should have same spring rating (1 dot or 2 dot) 3. The rubber pad at the top has to be replaced if found cracked or ruptured.

	For removing the upper and lower arm bushes use the Special tool MST 564 & 565 **Note:** **While fitting new bushes use soap solution so that the bush can pressed easily.**  **Caution: Use of any lubricant will result in degradation of the rubber bush and lower life. Pressing without soap solution will damage the bush**
	During refitting use the dolly.
	**Caution:** In the lower arm while pressing the rib in the arm has to match groove in the tool

	Fit the shim in between the chassis and the Upper Control Arm. Tighten fully the fulcrum bolts. Note: Do not fully tighten the nuts in the end of fulcrum pin at the bush end.
	While aligning the lower arm ensure that both the pivot are inserted at the same time. If it is inserted one at a time then inserting may damage the bushes besides making the assembly difficult.
	While tightening the lower arm bolts either the wheels should be on ground or roughly the lower arm should be parallel to the ground & cross member If it is tightened on any other position then the rubber bushes will get preloaded.
	While fitting the shock absorber ensure that after torque tightening the standout is approximately 7 mm. (If the standout is more then it indicates over tightening or bad rubber washers). Refer to the torque check list
	Fully tighten the upper arm bolts after the wheel is in ground.

Working principle, Dismantling, Assembly of the Front Suspension 4WD

The front Wheel suspension in the 4 WD vehicles is wishbone type with torsion bar springs and telescopically acting hydraulic dampener. Both the lower and upper arm employs two point mounting.

The torsion bar is connected to the Lower control Arms rear end through a Torque control Arm. The rear end of the torsion bar is connected to a ride control arm. A ride control height-adjusting nut links the control arm to chassis.

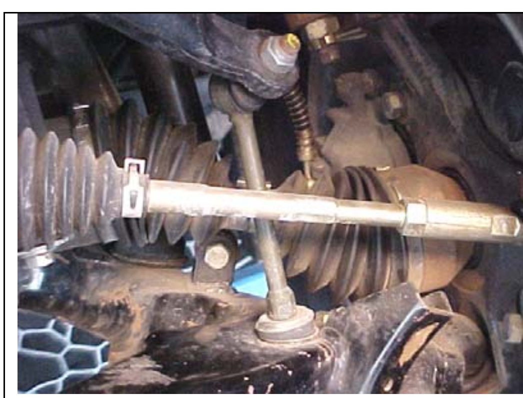
An anti roll bar is used to transfer the loads to the outer wheel during turns. The telescopic shock absorbers are used to dampen the wheel oscillations and ensure proper wheel contact irrespective of the road condition.

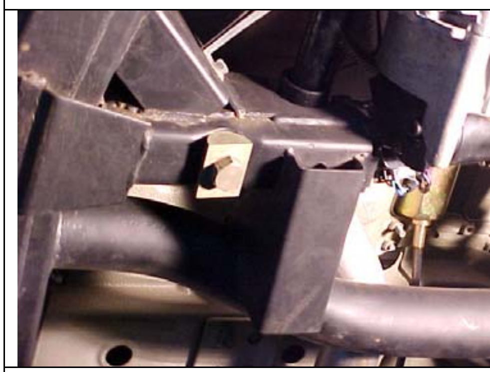
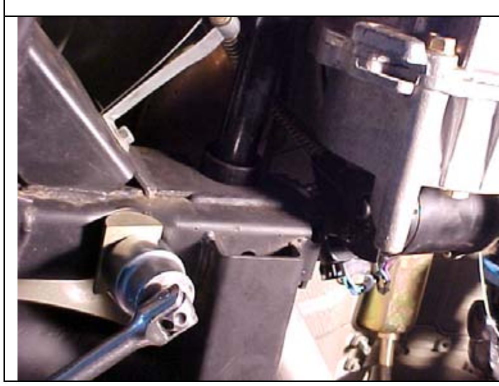
Caution:

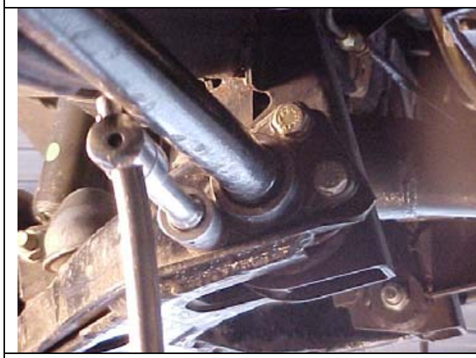
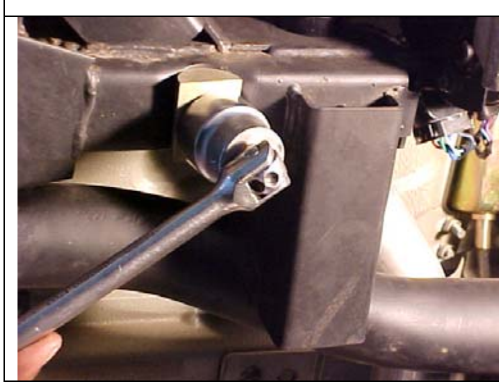
The Torsion bars are pre-twisted. LH marking identifies the Left Hand side and RH marking identifies the Right Hand torsion bar. The arrow should be facing front.

While jacking up the vehicle (for doing ride height adjustment) ensure that the jack or the two post lift points are not touching the torsion bar.

The dismantling sequence is reverse of the assembly procedure explained below –

	Jack the wheels, ensure that the anti roll bar link has been disconnected.

	Insert Lower Control Arm on frame
	Insert The torsion bar rear end in Height Control Arm serration
	Put the height control arm assembly on chassis bracket.
	It is advisable to keep all the bolts of the LCA & UCA loose while doing assembly, as it will ease the assembly operations. Also if the bolts are tightened in this position then the bushes will get preloaded. Further while trying to adjust the ride height the effort required to turn the ride height bolt will be high and cause damage to the face.
	Insert the bolt of height control Arm and flush the thread end to Height control nut. Give a slight twist to the torsion bar by hand so that the rocker maintains a horizontal position/ touching the bottom of the bracket.

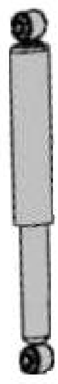
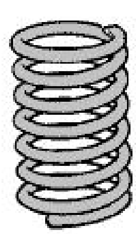
	Holding the torsion bar by hand and insert/slide in the Torsion bar into the Lower Control arm's Torque Arm.
	Tighten the Torque Arms 3 bolts (2 bolts onto the weld nuts and 1 free bolt +flanged nut)
	It is essential to tighten the torque arms bolts first. In case it is not done so and the ride height is adjusted. Then the adjustment will not be achieved, and also the twist of the torsion bar by tightening will not result in proportionate lift/height of the LCA. Also the 3 bolts will not seat properly on the torque arm and may damage the threads of the 3 bolts. In other words the torque arm bolts ensure that the torsion bar becomes integral to the LCA through the Torque arm
	Tighten the height control bolts by 24 to 26 Turns

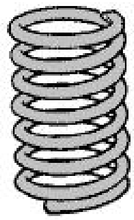
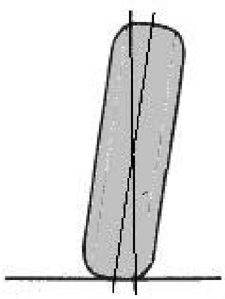
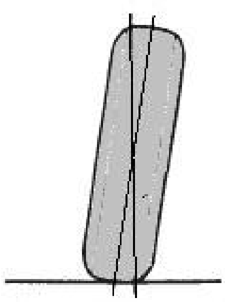
	Lower the Jack so that the wheels are touching the ground
	Gently shake the Vehicle 5/6 times
	Tighten the Lower control Arms and the Upper Control Arm's both the front and rear bolts to the specified Torque.
	Measure the ride height. (Lower control Arms front bolt head centre to ground.)
	**Note: Ensure that the measurement is done on level ground with specified tyre pressure on all four wheels. (Front 2.0 bar and Rear 2.2 bar).**
	If variation is more than +/-7.0 mm then tighten or reduce the height by turning the height adjusting nut.
	It is suggested that for turning the nut it is advisable to jack the vehicle
	Take the measurement again after a ride.
	If the ride height varies from the specifications then readjust after loosening the UCA & LCA bolts and jacking both the wheels only 1 turn of the bolt affects the ride height by 6 to 7 mm. Hence if the ride height is less by say 3 mm then turn the ride height bolt by half a turn

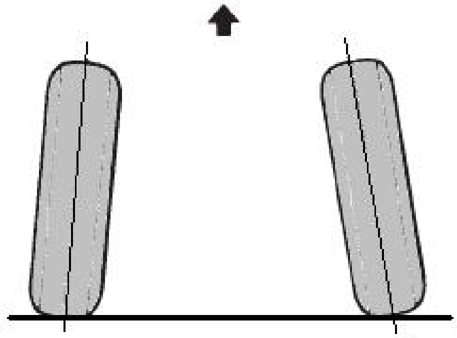
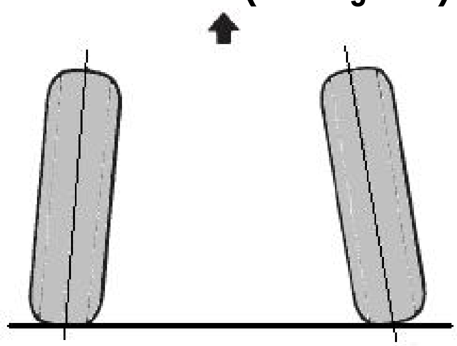
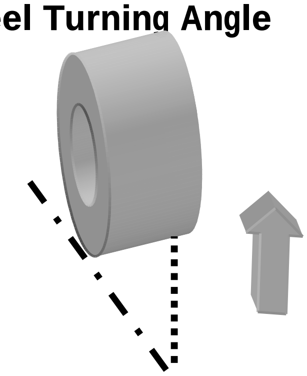
The assembly procedure for fitting the bushes onto the LCA & UCA is the same as mentioned in the 2WD. There is no change in setting the Wheel alignment procedure also.

Mahindra
Automotive Sector

Specifications -

Description	Specification
Type	Independent, double wish bone with telescopic shock absorbers
Front Shock absorbers- 2WD 	Maximum length: 335±3. Minimum length: 222+3.
Front Shock absorbers- 4WD 	Maximum length: 378±3. Minimum length: 244+3.
Coil Spring 	Approx. Free ht: 309mm Solid ht. : 152.6. Total coils: 8.34 Approx.

Description	Specification
Coil spring Load Identification 	1 yellow Dot 2 yellow Dots
Camber 	0.23 °±0.5 (0°14' ± 0°30')
Difference between LH & RH Camber 	±0.5° (±30')
Castor	2.75 °± 1.0 (2°45'± 1.0°)
Difference between LH & RH castor	±0.75 ° (± 45')

<table>
<tr><th>Description</th><th>Specification</th></tr>
<tr><td>Total Toe in
</td><td>1 to 3 mm.</td></tr>
<tr><td>Total Toe in (in degrees)
</td><td>0.15 to 0.45 ° (9’ to 27’)</td></tr>
<tr><td>Individual Toe in</td><td>0 to 20 minute</td></tr>
<tr><td>King pin Inclination</td><td>10.75° ± 1° (10°45’± 1°)</td></tr>
<tr><td>Wheel Turning Angle
</td><td>36°- 2WD

4WD

35°-Inner Wheel angle
32°-Outer Wheel angle</td></tr>
<tr><td>Ride height Variation Between LH & RH. (Up to LCA front pivot bolt)</td><td>15 mm</td></tr>
</table>

Lubricants -

No lubricants / grease to be used in the suspension bushes. Only soap solution to be used during assembly

Anabond RTV 673 is used for the hubcap.

Tightening Torque's -

Location	Torque Nm (lbf-ft)
Upper Arm side bushes	120 ± 10 Nm (88 ± 8 lbf-ft)
Upper Arm Ball joint mounting nut	26 ± 3 Nm (19 ± 2 lbf-ft)
Upper Arm pin fulcrum mounting nut	130 ± 10Nm (96 ± 8 Lbft)
Lower Control Arm Front Mounting	165 ± 15 Nm (122 ± 11 Lbft)
Lower control Arm Rear mounting	120 ± 10 Nm (88 ± 8 Lbft)
Torque Arm M12x1.25 with spring washer & weld nut	70 ±10 Nm (51± 8 Lbft)
Torque Arm M10x1.25	50 ±10 Nm (37 ± 7 Lbft)
LCA ball joint mounting nut	70 ±10 Nm (52 ± 8 Lbft)
LCA bump stop mounting	50 ±10 Nm (37 ± 7 Lbft)
Stabilizer bar on Frame	37.5 ±7.5 Nm (28 ± 6 Lbft)
Stabilizer bar + Link	45 ± 5 Nm (52 ± 8 Lbft)
Link on Lower Arm	19 ±3 Nm (14 ± 2 Lbft)
Shock absorber Top- on frame	19 ±3 Nm (14 ± 2 Lbft)
Shock absorber Bottom on LCA	19 ±3 Nm (14 ± 2 Lbft)
Shock absorber Bottom on LCA (4WD)	70 ±10 Nm (52 ± 8 Lbft)
Steering stopper on knuckle	57 ± 7.5 Nm (46 ± 9 Lbft)
Castle Nut UCA	140 ± 20 Nm (103 ± 15 Lbft)
Castle Nut LCA	140 ± 20 Nm (103 ± 15 Lbft)
Frame- Rebound stopper	50 ± 10Nm (37 ± 7Lbft)

List of the MST's -

Description / Part No. / Sketch	Usage View
MST-561 **Upper Arm Ball Joint Puller** 	
MST-562 **Lower Arm Ball Joint Puller** 	
MST-563 **Fulcrum Mounting Bolt Spanner** 	

Description / Part No. / Sketch	Usage View
MST-564 **Fixture Upper/ Lower Arm Bush** 	
MST-565 **Extractor/Installer Arm Suspension Bush** 	
MST-571 **Special Socket for hub nut** 	

Description / Part No. / Sketch	Usage View
MST-572 **Installer Front Wheel Bearing Cone-Outer** 	
MST-573 **Installer Front Wheel Bearing Cone-Inner** 	
MST-574 **Installer Front wheel Hub oil seal** 	
MST-575 **Installer Front Hub Grease Cup** 	

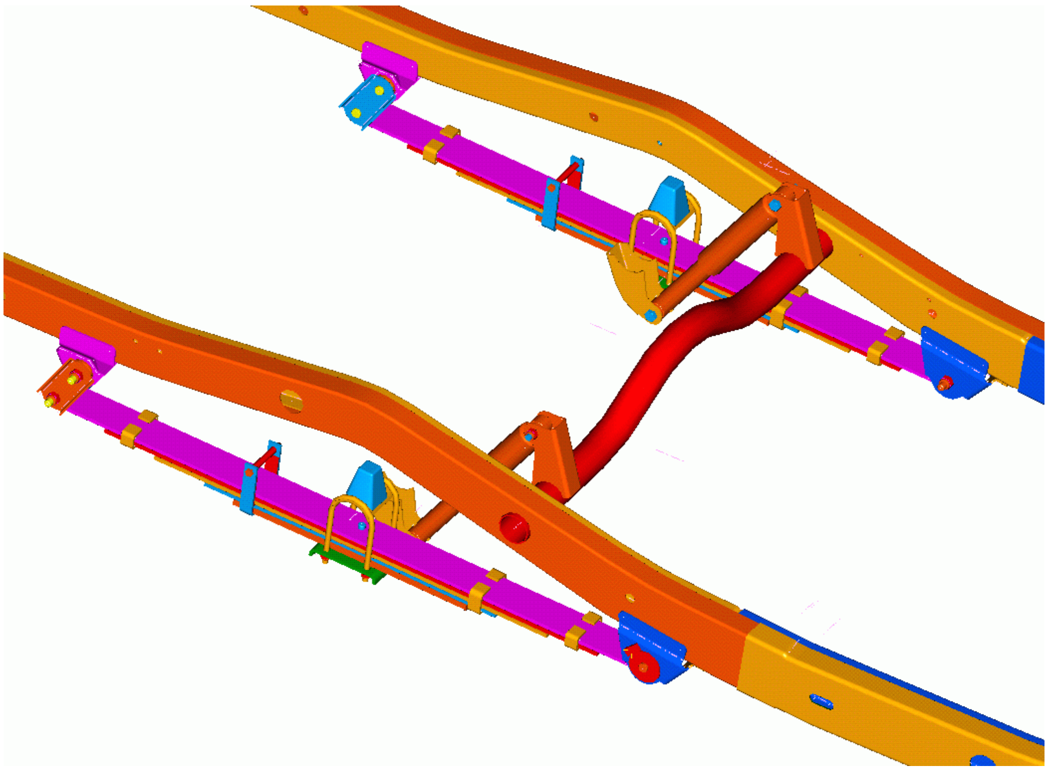
Automotive Sector

Rear Suspension

Contents

Description

The rear suspension is a progressively rated multi leaf spring with double acting shock absorber. The front end of the springs is mounted at the pivot end through rubber bushings. The bushings isolate the road noise and road harshness as the springs move. The rear end of the spring is connected to the springs through shackle



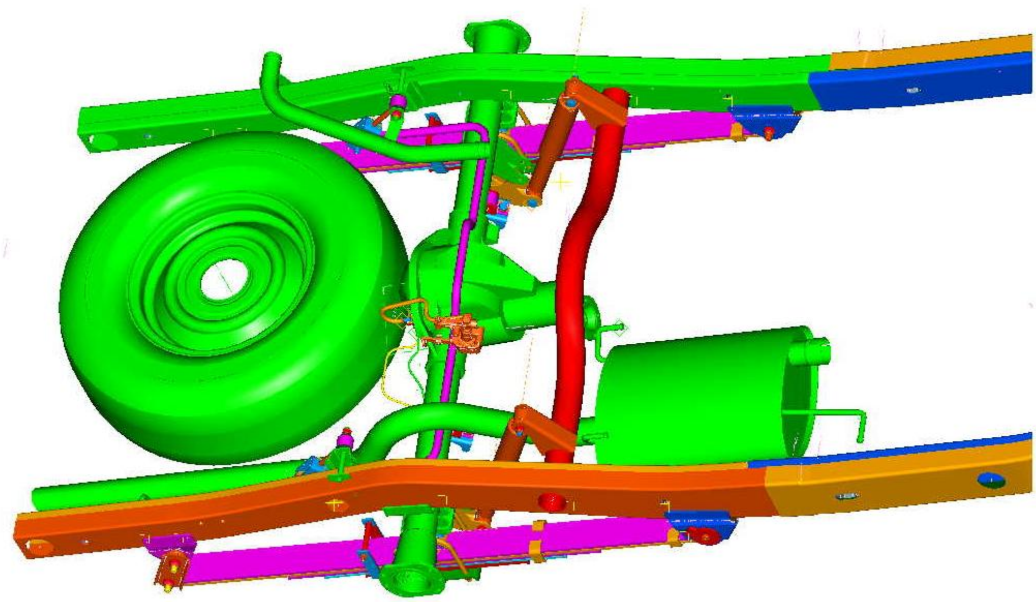
Again the spring and shackles use the rubber bushes to isolate the noise and road harshness. The shackles allow the variation of the spring length when the vehicle moves over the different terrain causing the wheel to move up and down.

The travel of the spring is controlled by bumper, which is mounted on the axle. The springs are connected to the axle with U-bolts and spring plate. All suspension components that use rubber bushings should be tightened with the vehicle at normal height. If the springs were not at normal ride height condition the ride quality would be affected and also the life of rubber will also be affected. Rubber bushings must never be lubricated.

The ride control is achieved by the use of double acting shock absorbers and leaf springs. The shock absorbers dampen the jolt and the rebound as the vehicle travels over the various road conditions. The top end of the shock absorber is connected to the chassis while the bottom end is connected to axle.

The anti roll bars are used to transfer the loads to the outer wheel during turns. They have been introduced effective Serial number 32A98547.

A sketch of the antiroll bars in rear with spring, shock absorber & axle is shown below.



Trouble Shooting

A squeak noise from the shock absorber can be produced if movement between the rubber bushing and metal occurs. Tightening the attaching parts can usually stop this noise. If the squeak noise persist then inspect for worn or damaged bushings and attaching components. Repair as necessary if any thing found amiss.

The shock absorber bushings do not require any kind of lubrication. Do not lubricate the bushings to reduce bushing noise. Grease or mineral oil base lubricants will deteriorate the bushing.

The shock absorbers are not refillable or adjustable. If a malfunction occurs, the shock absorber must be replaced. To test a shock absorber hold it upright in fully extended position for 10 minutes. Then force the piston in and out of the cylinder four or five times. Also check for any hydraulic oil leakage. The action throughout each stroke should be smooth and even.

Symptom	Causes	Remedial action
Suspension Noise	1. Check if mud is between the leaf springs. 2. Check tip insert if broken/ worn out. 3. Check bushes. 4. Check shock absorber bush-worn out/ loose. 5. Check leaf breakage.	✓ Clean with pressurized water. ✓ Replace the tip between the leaves. ✓ Replace the bushes. ✓ Tighten the shock absorber mounting bolt or replace the bushes. ✓ Replace the spring assembly.
Vehicle ride Jumpy/ Jerky	1. Improper tyre pressure. 2. Shock absorber bushes worn out. 3. Spring leaf bushes worn out. 4. Shock absorbers leaking/ weak. 5. Leaf spring sagging / broken.	✓ Keep tyre pressure as recommended. ✓ Replace the shock absorber. ✓ Replace the bushes. ✓ Check the shock absorber and replace if required. ✓ Check the bump clearance as per the specified procedure. Replace springs.

Shock Absorber -

Remove the upper attaching nut and washer.
Remove the lower attaching nuts, washer and bolts from the axle.
Remove the shock absorber.

While fitting ensure that they are tightened to a torque of 45 to 55 Nm (33 to 40 Lb ft)

Leaf Spring

Bush Replacement

Leaf replacement

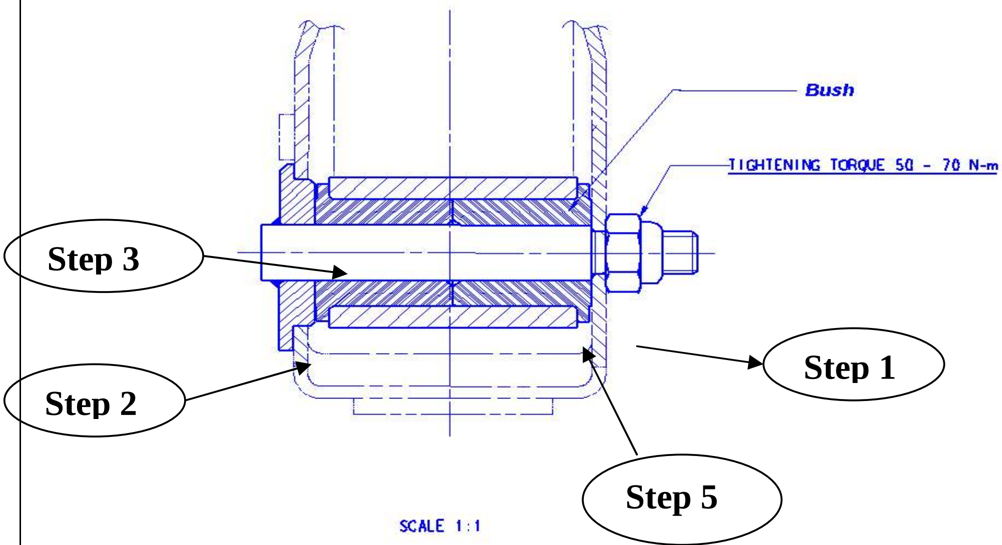
Bush replacement

Pivot end bush replacement.

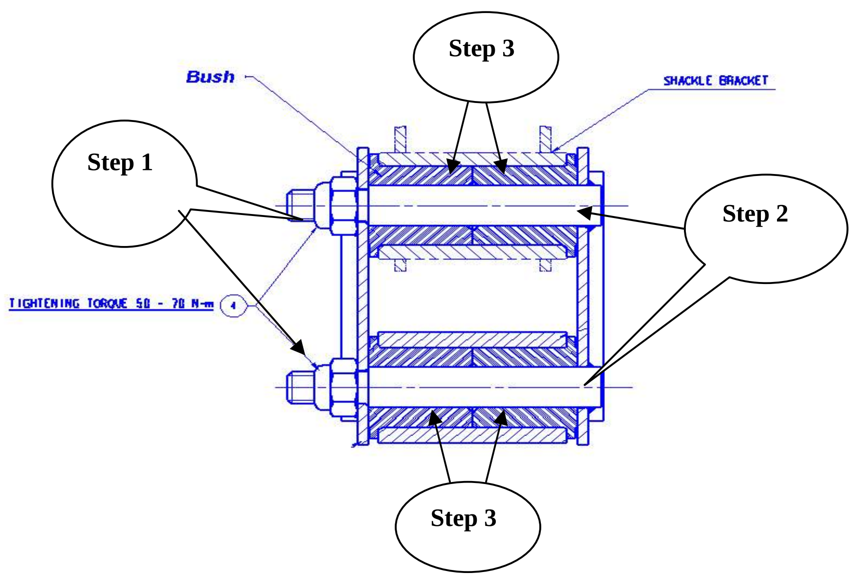
Shackle end bush replacement.

Pivot end bush replacement.

Support the vehicle in chassis
1. Loosen the shackle mounting bolts.
2. Remove the pivot mounting bolts by rotating and pulling.
3. Pull out inner bush by pulling it out
4. Lower the axle and bring the spring out of pivot.
5. Remove the bush by pulling it out.



1. Loosen the shackle mounting bolts.
2. Remove the shackle / pivot mounting bolts.
3. Pull out the one bush at a time. Each eye is having two collared bushes. They can be pulled out



While assembling ensure that:

- **The rubber bushes are liberally coated with soap water.**
- **The hole in the center of the pivot and the hanger bracket are clean and not blocked by mud. (The hole is provided so that while assembling the air should not get trapped between the two bushes- preventing proper assembly.)**
- **The eyes in spring and pivot/ shackle are properly aligned before the bushes are inserted.**

After the bushes are inserted, remove the support from the chassis & axle (if used) and then tighten the pivot and shackle bolts to 50 to 70 Nm (37 to 52 Lb ft).

Leaf Replacement –

The leaf springs need to be replaced only if the springs are broken or are sagging.

To check for the spring sagging it is recommended that bump clearance in unladen conditions is measured.

The bump clearance has to measured after ensuring that

- **The vehicle is in level ground.**
- **It is unladen.**
- **The tyre pressure is as per the recommendations and also no variation between left and right tyres.**
- **The bump stop is not in deteriorated or damaged condition.**

The bump clearance is 85± 10 mm and the variation between Left and right is allowed to be 7 mm

Recambering of the spring is not recommended. (Please note that the spring is of progressive type – any recambering will result in the ride becoming linear as well as stiff.

Tightening Torques -

Description	Torque
Bolt – Leaf spring pivot	60 ± 10 Nm (45 ± 7 Lb ft)
Shackle at chassis	60 ± 10 Nm (45 ± 7 Lb ft)
Shackle at Spring	60 ± 10 Nm (45 ± 7 Lb ft)
U Bolt	90 ± 10 Nm (67 ± 7 Lb ft)
Shock absorber top	50 ± 5 Nm (37 ± 3 Lb ft)
Shock absorber bottom	50 ± 5 Nm (37 ± 3 Lb ft)

Automotive Sector

Steering

Contents

Description

The power steering system is a rack and pinion system. The engine driven hydraulic –pump supplies oil to a control valve situated in housing that supports the pinion shaft. Movement, imparted to the control valve from the shaft in the steering column is via a torsion bar. This sensing bar moves the control valve, which in turn directs the oil to one side or the other side of the ram piston inside the steering rack.

The control valve is a rotary type spool valve controlled by the torsion bar interposed between the steering shaft and pinion of the steering box. The spool valve is a shaft with six flutes and a sleeve, which has six internal axial grooves, encases this. Radial ports in the sleeve and shaft pass the oil from the supply to the lines connected to the ram chamber.

A series of the splines between the shaft and the sleeve limit the twist of the torsion bar to about 7 degrees in each direction; below this angle the torque applied by the driver to the steering box is transmitted by the torsion bar. This fail-safe feature provides a mechanical drive from the steering shaft to the pinion in the event of any power system failure.

The amount of the twist of the torsion bar and the movement of the spool valve is proportional to the effort applied by the driver. Initial power steering assistance is obtained at about 0.5 degrees deflection of the bar and this power rises progressively as the bar moves to about 4 degrees; the point o maximum assistance.

When the wheel is in straight-ahead position, all the ports are open so oil is allowed to flow through the valve and return to the reservoir.

As soon as the wheel is turned, the torsion bar is deflected; this allows the spool valve to rotate relative to the sleeve, cutting off the oil flow both to the reservoir and one side of the ram. At the same time the other side of the ram is subjected to oil pressure, which builds up sufficiently to move the road wheel and return the torsion bar to no – torque position. During this stage the oil displaced from the uncompressed side of the ram is returned to the reservoir.

On occasion when the resistance to road wheel movement is excessive, the oil pressures build up to its maximum. At this pressure a relief valve fitted inside the pump opens and allows the oil to return to pump inlet.

Trouble Shooting –

The rack and pinion design is a simple design. However it is still susceptible to various problems in particular to leaks. If the bellows are ripped or are unable to keep the contaminant's away then it can cause damage to oil seal and subsequent leaks.

One complaint, which can be present, is that the steering may be stiff and jerky when the unit is cold and as the vehicle is driven/ warmed the power assist gradually comes back. It normally indicates that grooves worn into the bore of the pinion aluminum housing by hard control valve seals.

Wear in the centre housing causes the fluid to leak around the rack piston. Causing either steering wander or lack of straight-ahead stability. Another cause of steering wander and erratic control often accompanied by clumping, thunking noise is the deterioration of rack mounting bushings.

Fluid levels can be hard to locate. Sometimes you will see a low level in the pump reservoir but no evidence of escaping liquid. Squeeze the bellows and you will probably find that they are full of liquid. To confirm if that side of the rack is the culprit, then remove the both the bellows, clean the rack housing and then operate the system to observe the seepage directly.

It should be mentioned that a rusty input shaft U joint or deteriorated flexible textile/rubber coupling could imitate rack problems.

Caution: After attending to the repairs it critical that the system be completely flushed completely. Disconnect the return line from the pump and put in a container, then disable the injection (remove the wire from the shut off solenoid) and crank the engine. Add fresh fluid until you get a clear flow from the line. Take care that the reservoir does not run dry during the flushing. Failure to do so will result in premature failure of the repaired unit.)

The possible causes for the power steering complaints are tabulated below:

PROBLEM	POSSIBLE CAUSES	CORRECTION
Objectionable Hiss	Noisy relief valve in hydraulic pump. Steering gear noise valve noise is transmitted trough the steering column or open-air passages in the area where the column or controls pass through the floor into the engine compartment.	There is some noise in all the power steering system. One of the most common is a hissing sound most evident at stand still parking. Hiss is a high frequency noise that is present in every valve and results from high velocity fluid passing valve orifice edges. There is no relationship between this noise and the steering gear performance. DO not replace the intermediate shaft or the steering gear unless the noise is too objectionable. Check the dashboard seals between the drivers area and under hood to eliminate

		open space/ gaps
Rattle or chuckle noise in Steering Gear	1. Gear loose on frame. 2. Steering linkage looseness. 3. Pressure hose touching other parts of the vehicle. 4. Loose IBJ or OBJ 5. Improper over centre-clearance. A slight rattle may occur on turns because of increased clearance off the high point. This is normal and clearance must not be reduced below specified limits to eliminate this slight rattle.	1. Check the gear mounting bolts. Torque the bolts to specifications. 2. Check the IBJ and OBH for wear. 3. Adjust the hose position. Do not bend the tubing by hand. 4. Replace. 5. Adjust to specification
Excessive wheel Kick Back or Loose Steering	1. Air in the steering. 2. Steering Gear Mounting loose. 3. Front wheel Bearings Incorrectly adjusted or worn. 4. Steering Gear Improperly adjusted. 5. Damaged or worn steering	1. Add oil to the pump reservoir and bleed. 2. Tighten attaching bolts to the specified torque. Replace loose parts. 3. Adjust the wheel bearings or replace as required. 4. Adjust to specifications 5. Dismantle and assemble the steering

	Gear. 6. Worn or damaged rubber bushing for mounting steering gear	gear as specified. 6. Replace the rubber bushings
Vehicle leads to one side or the Other (keep in mind the road condition and wind conditions.) Test the vehicle , Going in Both directions , On a Flat road	1. Front end misaligned. 2. Unbalanced steering gear valve. If this is the cause steering effort will vary light in direction of lead and heavy in opposite direction. 3. Steering shaft rubbing with the ID of the shaft tube 4. Steering linkage not level.	1. Adjust to specifications. 2. Replace the gear Valve. 3. Align the column. 4. Adjust as required.
Momentary Increase in steering Effort When Turning the Wheel Quickly To the Right or Left	1. Low oil level in Reservoir. 2. Pump Belt slipping. 3. High Internal leakage's (Steering Gear or Pump)	1. Add steering fluid as required. 2. Tighten or replace belt. 3. Refer to pump test.
Poor return of Steering	1. Tyres under inflated. 2. Lower coupling flange against the steering gear adjuster 3. Steering wheel rubbing against directional signal housing. 4. Tight or seized steering shaft bushing/bearings 5. Steering joint or linkage binding.	1. Inflate to specified pressure. 2. Loosen the pinch bolt and assemble. 3. Adjust the steering column. 4. Replace the bearings. 5. Relubricate/ replace the joints.

	6. Steering column misaligned. 7. Lack of lubrication in the suspension ball. 8. Improper front end alignment. 9. Steering gear adjusted too tight. 10. Kink in return hose.	6. Align the steering column. 7. Relubricate/ replace the ball joints. 8. Check & adjust to specifications. 9. Adjust the preload. 10. Replace the hose.
Steering wheel Surges or Jerks when Turning with engine running, especially during Parking.	1. Low oil level in Pump. 2. Loose pump belt. 3. Sticky flow control valve. 4. Insufficient pump pressure/	1. Add fluid as required. 2. Adjust tension as per specification. 3. Clean the control valve or replace the pump. 4. Refer to the power steering System Test.
Hard steering effort in both the directions	1. Low tyre pressures 2. Lack of lubrication is suspension or ball joint. 3. Steering gear to column misalignment. 4. Pump belt slipping. 5. High internal leakage. 6. Sticky flow control valve. 7. Lower coupling flange rubbing against steering gear. 8. Steering gear preload	1. Adjust the tyre pressure. 2. Lubricate & relubricate at proper intervals. 3. Align the steering column. 4. Tighten or replace belt. 5. Fill to proper level and inspect for leaks. Refer to pump Pressure test. 6. Replace or clean the valve. 7. Loosen the pinch bolt and assemble correctly. 8. Adjust the preload in

	high. 9. Improper front end alignment	Straight-ahead position. 9. Check & adjust to specifications.
Foaming Milky Looking Power Steering Fluid. Low Level and Possible low pressure	Air in the fluid and loss of fluid due to internal pump leakage causing overflow	Check for leak & correct. Bleed the system. Extremely cold temperature will cause aeration problems if the oil level is low. If oil level is correct and the pump still foams then check for the air leakage caused by loose joint
Low oil Pressure due to Restriction in the Hose	1. Check for kinks in the hose. 2. Foreign objects stuck in the hose.	1. Remove the kinks or replace the hoses. 2. Remove the foreign objet or replace the hose.
Chirp Noise in Steering Gear	Pump belt slipping	Tighten or replace Belt
Belt squeal (Particularly noticeable at Full wheel Travel & Standstill Parking)	Pump belt slipping	Tighten or replace Belt
Growl noise in Steering Pump	1. Scored pressure plate, thrust plate or rotor 2. Extreme Wear of cam ring	1. Replace Pump. 2. Replace Pump.
Growl noise in Steering Pump	1. Low oil level 2. Air in the oil. Poor pressure hose connection.	1. Add the power steering fluid. 2. Bleed the system.
Rattle or knock noise in	Pump Vanes sticking in rotor slot	Replace pump, flush system.

steering Pump	Pressure hose touching other parts of the Vehicle.	Adjust hose position.
Swish Noise in steering Pump	Faulty flow control valve	Replace pump.
Whine Noise In Steering Pump	Pump shaft bearing scored	Replace pump.
Low oil Pressure Due to Steering pump	1. Flow control valve stuck or inoperative 2. Pressure plate not flat against the cam ring. 3. Extreme wear of the cam ring. 4. Air in oil. 5. Low oil level 6. Pump belt slipping 7. Damaged hoses or steering gear	1. Replace pump. 2. Replace pump. 3. Replace pump, flush system. 4. Locate source of leak & correct. Bleed the system. 5. Add power steering fluid as required. 6. Tighten or replace belt as required 7. Replace as necessary.

Care of the system -

The lubricant level should be checked every 10000 Kms with the vehicle unladen and in a level ground. The lubricant level should be between the maximum and minimum mark. The fluid level should be checked with the engine in off condition. If the oil level is excess it will tend to come out from the filler cap in use lubricant meeting oils specification of ATF (Automatic Transmission Fluid. The brand names have been specified in the Operators Manual and also in the **end of the Section**.

In Car repairs -

The following repairs can be carried out without removing the assemblies.

a) **Removal** and refitment of out board Joints (OBJ)
b) **Greasing** of the OBJ (In case the rubber gaiter is torn.)
c) Removal & Refitment of the Steering **Wheel.**
d) Checking for Steering **Play.**
e) Steering Wheel - **Centralize**
f) Bleeding the **system.**

a) Removal and refitment of Track rod ends/ Outer Ball Joint

	Loosen the wheel nuts. Lift up the vehicle and remove the front wheels.
	Slacken the track rod end lock nut.
	Remove the castel nut split pin and remove the castel nut.
	Remove the track rod end using the special tool.
	Remove the track rod end. While removing the track rod end, make a note of the number of tuns required to remove the end.
	While fitting back the end or fitting a new end turn it back the same number of threads

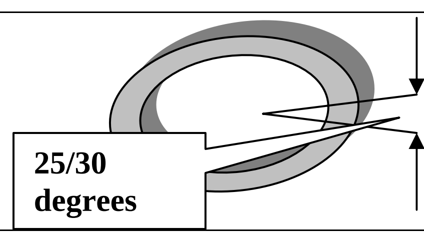
b) Greasing of the track rod end/Outer Ball Joint (Only if the rubber gaiter is torn.)

	After removal of the track rod end
	Remove the circlip
	Fill the joint with about 10 grams of grease
	Fit a new gaiter and put the lock

c) Removal & Refitment of the Steering Wheel

	Remove the horn cover, using the screw driver
	Remove the lock nut, using the 22 mm socket

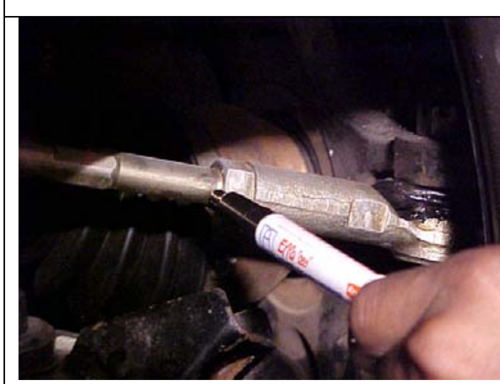
d) Checking and adjusting the Steering Play

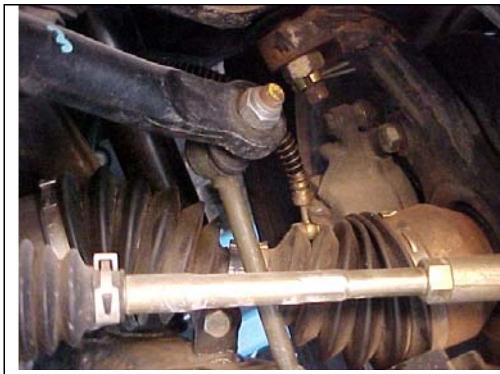
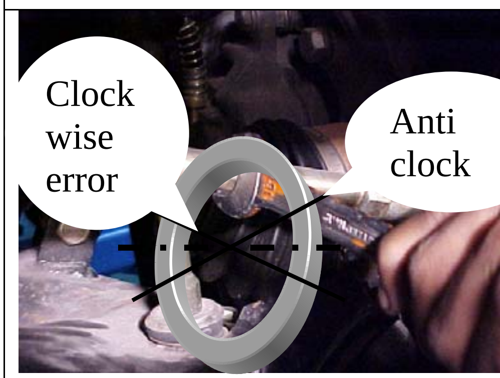
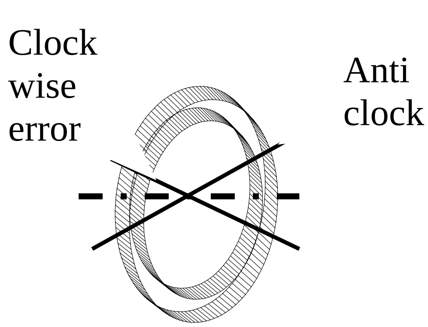
	After driving the vehicle in a straight road, check the wheel spokes for angular play. If more than 25 to 30 degrees then

	check -Tie-rod end ball joint or steering gear inner ball joint or Lower arm ball joint or universal joint
	Replace the defective part/parts
CAUTION	**Caution- While checking ensure that the engine is in off condition and wheels are in Straight Ahead Position (SAP position)**

e) Steering Wheel – Centralize

Caution: This procedure for centralizing the Steering wheel is valid only if the misalignment of the spokes is less than 30 degrees. In other words this procedure is only for fine-tuning the steering wheel position not for gross error. If it is more 30 degrees then remove the steering wheel and initially realign to less than 30 degrees.

	To check for the centralization of the steering wheel. Drive the vehicle on a level road surface; note the angular position (misalignment of the steering wheel spokes.
	Lift up the vehicle
	Mark the position of the track rods and the track rod ends

	Slacken the track rod end lock nuts and also remove the gaiter outer retaining clips.
	Rotate both track rods in the same direction approximately 30 degrees for every 1-degree of steering misalignment error. If the steering wheel has an anticlockwise angular error then both track rods must be rotated clockwise- when viewed from the left – hand side of the vehicle
	If the steering wheel has an clockwise angular error then both track rods must be rotated anticlockwise- when viewed from the left – hand side of the vehicle

	Check the front wheel alignment (Toe In) after the steering wheel has been centralized

f) Bleeding the system

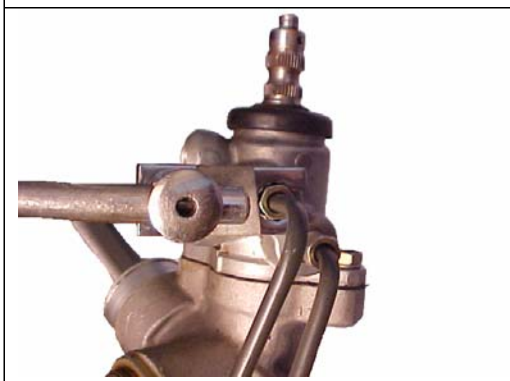
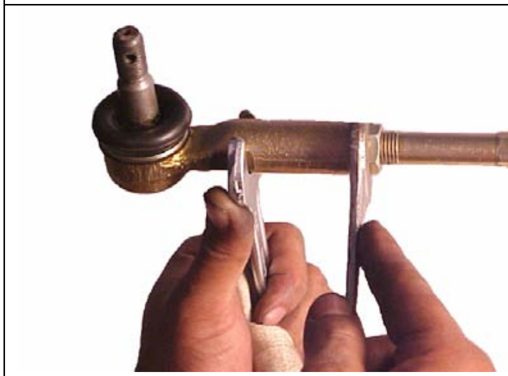
Before starting the Bleeding operation, ensure that the Vehicle is in level ground, and the reservoir is filled to the maximum specified.

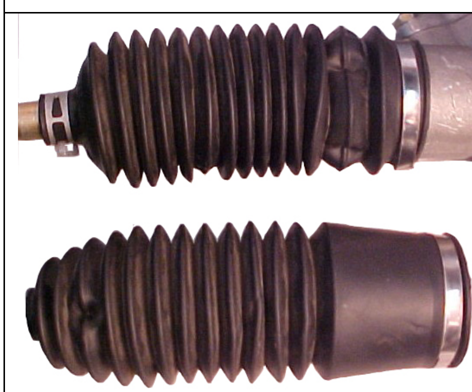
As with any hydraulic system ensure that the recommended fluids only are used. Ensure that no dirt enters the system while topping up. Before opening the reservoir cap, wipe the area with a cloth.

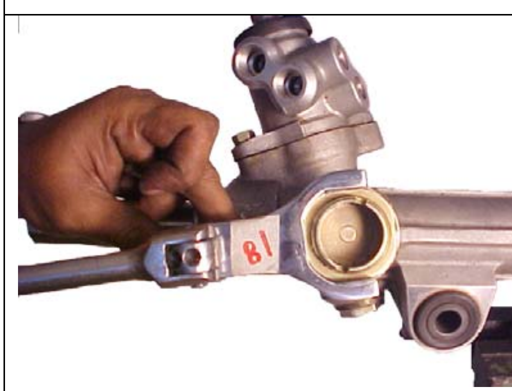
CAUTION	**Caution: Ensure that the front wheels are jacked up and wheels are lightly touching the ground.** **If this is not done then the steering linkage and components will be under undue stress.** **Even with the wheels partly jacked up, do not hold the steering in fully locked position for more than 10 second. Failure to do so may damage the pump beyond repairs.**
	Start the engine.
	Rotate the steering wheel from lock to lock 3 to 4 times.

	Check if the oil in the reservoir has dropped down drastically- if so check for any leaks.
	Check if any foaming/ frothing is taking place.
	Repeat the rotation from lock to lock till the foaming subsides
	If the foaming is not subsiding after ¾ of the above cycle, check for the tightness of the hoses in particular the reservoir to the steering pump and later the steering gear to reservoir. The loose connection in these pipes will allow air to sucked into the system.
	After completing the bleeding operation, ensure that with the engine running the oil level is between the maximum and minimum mark
	Close the cap

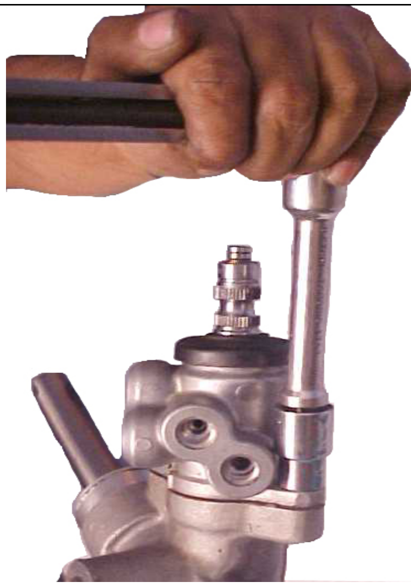
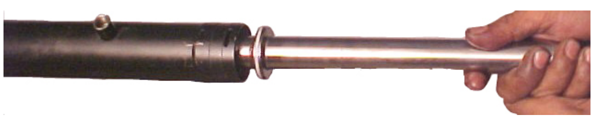
Dismantling & Assembly of the Steering Gear -

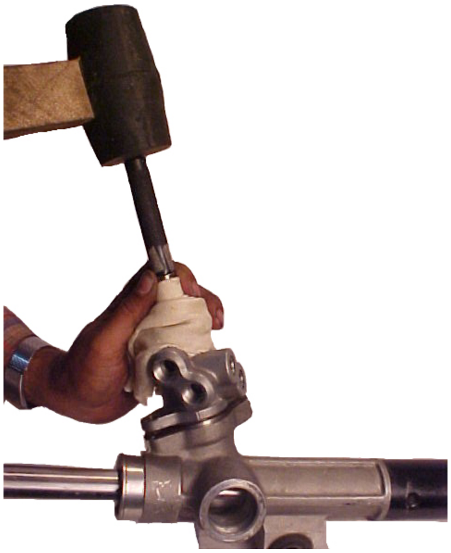
	Using the Special Tool, hold the steering gear in the vice.
	Using the special tool remove the steering gears pipes connecting the control valve to the gear.
	Remove the outer Ball Joint.

	Loosen and dislodge the outer clips holding the bellows with the help of screw driver and pliers
	Remove the bellows along with the clips.
	*If the bellow is having any crack, or swelling then discard them. It is also advisable to use new clips along with the bellows*. Note that the RHS and LHS bellows are not equal.
	Before removing the Inner Ball Joint (IBJ). Cover the threads with tape so that during handling and reassembly they do not get damaged.

	Remove the claw washer after opening it using screwdriver.
	Remove the inner Ball joint
	Remove the IBJ on the other side.
	*Caution: During assembly check that the steering rack hole is not clogged with grease. If the hole is clogged, the pressure inside the boot will change after it is assembled and the steering is turned.*
	Remove the bottom end cover, used for controlling the preload using the special tool.

	Remove the endplay-controlling plug. Note the condition of plastic wear area. Remove the spring
	Remove the end cap on the tube side.
	Remove the end bush (tube end)
	Before removal of the control housing the rack should be pressed to the either end.(At the extremes of the rack the clearance with the pinion teeth is more hence assembly and removal is easy)

	Remove the control housing
	Remove the rack..
	The Teflon piston seal should be removed and refitted by fingers only. Smear power steering oil on seal before assembly.
	To remove and refit the inner seal use the special tool.
	Caution: While refitting the rack ensure that rack teeth do not damage the inner seal in the tube and the housing

	To remove the pinion bearing use the special tool. For assembly also use the same tool but the other end.
	For removal and refitting the pinion outer bearing use the special tool.
	Tap out the pinion from the control housing using the special tool.
	Remove the bearing & the sleeve.

	Push the pinion along with the control housing.
	While assembly fit the control sleeve using the special tool.
	Press the oil seal using the special tool.
	After the rotating torque has been adjusted by using the end plug. It has to be locked.
	Press the oil seal at the tube end using the special tool.
	Fit the end plug (tube end) using the special tool.

	Fit the bottom plug using the 18-mm socket.
	Fit the inner ball joint
CAUTION	Fit the bellows. Caution: ensure that the outer clips are fitted on top of the groove. (The rubber boot also has a beading, which sits on the groove.)
CAUTION	Caution: The tube side boot is smaller than the control housing side.

Working principle of the Steering Pump -

The steering pump is non-serviceable. Hence it cannot be repaired.

The pump is a constant flow, vane type incorporating a flow control valve (with an integrated relief valve) and it is gear driven by engine. The power steering pump consists of housing, drive shaft, cartridge assembly & bearing(s) apart from the valve.

As the pump rotates a vacuum is created at the inlet, which causes atmospheric pressure to force the fluid in to pump from the reservoir. As the rotor rotates, the inlet port closes and the fluid is trapped between the vans. Further movement forces the fluid to be pressurized as the profile of the cam ring constantly reduces the available volume. At the minimum point of the profile the chamber opens into the outlet port.

The rotor is having 10 vanes, thus each rotation is equal to 5 pumping action. The discharge rate of the power steering pump increases in proportion to the pump speed increases.. The flow control valve is provided to maintain the optimum flow of the supplied oil for power steering operation, at all engine speeds. The relief pressure will open when the system pressure exceeds the set value. This normally happens when the steering wheel is turned and held in the lock position.

Specifications –

Description	Value
Steering Gear Type	Rack & Pinion, End Take Off, Integral Power Assisted
Steering Gear Make	Sona Koyo
Rack Travel (Steering Gear)	LH – 75 mm & RH – 75 mm, maximum
Overall Steering Ratio	20 : 1
Total Turns Available on Input Shaft of the Steering Gear	3.75
No. Of Steering Wheel Rotations (Lock to Lock)	3.6
Torque required on input shaft to move the Rack (preload)	1.5 Nm
Normal Operating Pressure	85 bar
Steering Wheel Diameter	395 mm / 365 mm
Power Steering Pump	Sliding Vane Type – Positive displacement
Pump Make	Koyo
Pump Make	Delphi
Direction of pump rotation	Clockwise when viewed from shaft end
Pump Flow	8.5 LPM @ 1000 rpm
Pump – Pressure Relief	75 kg/cm2 0r 75 bar
Pump – Drive	Gear driven
Wide Operating Speed – Pump	600 rpm - 6500 rpm
Wide Operating Temp. Pump & Gear	- 40 ° C to + 120 ° C

Automotive Sector

Flow Control cum Pressure Relief Valve in Pump	In-built System 7.5 +0.5 / - 0 Mpa. 8.5 ± 0.7 lit / min @ 1500 RPM
Oil capacity – System	0.8 lts. aprox.

Tightening Torque's –

Description	Torque Value Nm (lbf-ft)
Steering Gear Centre Bolt	120 ±10 Nm (88 ± 7 lbf-ft)
Steering Gear Mounting Clamp Bolts	85 Nm (63 lbf-ft)

Mahindra
Automotive Sector

List of the MST's -

Description / Part No. / Sketch	Usage View
MST – 547 **Steering wheel puller** 	
MST – 548 **Steering stand** 	
MST – 549 **Tie rod end remover** 	
MST – 550 **Socket steering pump Nut** 	

Mahindra
Automotive Sector

MST - 551 **Unit wrench -12 mm** 	
Description / Part No. / Sketch	**Usage View**
MST - 552 **Spanner power Steering Lock nut** 	
MST - 553 **Drift pinion assembly** 	
MST - 554 **Rack stopper wrench** 	
MST - 555 **Installer power Steering Oil End Cap** 	
MST - 556 **Driver needle bearing**	

	
MST - 557 **Driver bearing rack Housing** 	
Description / Part No. / Sketch	**Usage View**
MST - 558 **Installer oil seal-Steering** 	
MST - 559 **Installer pinion Housing Upper Pinion Oil seal**	
MST - 560 **Installer oil seal Power steering.** 	

<u>Recommended Lubricants</u> -

The recommended brand names are

DEXTRON TEXMATIC 1278 / 1888 from CALTEX ATF

Capacity is 0.8 lts.

Brakes

Contents

Description

The brake system is vacuum assisted 'H'split type. The front brakes are twin pot calipers with ventilated rotor. The rear brakes are drum types with self-adjusting mechanism. The parking brakes are actuated in the rear through cable. Both the front disc pads and the rear brake liners are non-asbestos.

The braking system includes a Load sensing Proportioning Valve. It controls the brake fluid pressure going to the rear depending on the load on the vehicle. Normally when the vehicle is loaded and brakes applied; due to the weight transfer the load on the rear wheels become very less. In vehicles without the LSPV the full pressure of brake fluid going to the rear wheels tend to lock them. In vehicles with the LSPV, the LSPV reduces the brake fluid going to the rear depending on the load hence avoids the rear wheel locking. Since the rear wheel locking is avoided it results in reducing the braking distance (distance covered before the vehicle comes to a stand still)

The brake circuit is having an inbuilt bypass valve in the LSPV. In an unlikely situation of the front brake circuit failure; the LSPV valve is bypassed and the full pressure of brake fluid goes to the rear. This ensures that braking is achieved. The complete details about the LSPV valve & its functioning and setting are mentioned later.

Trouble Shooting -

Preliminary checks involve inspecting fluid level, parking brake action, wheel and tyre conditions. Checking for obvious or external leaks or component damage and pedal response. A road test will confirm or deny the existence of the problem.

While road testing if the complaint involved low brake pedal, make several low speed stops and note if pedal comes back to normal height. Check the pedal response with gear in neutral and engine running. The pedal should remain firm under steady pressure. During road test make normal and firm brake stops in speeds of 40 to 60 Km/h. Note faulty brake operation such as pull, grab, drag, noise, low pedal, hard pedal, fade, pedal pulsation, etc.

Diagnosis –

Pedal falls away

A brake pedal that falls away under steady foot pressure is generally the result of system leak. The leak point could be at a brake line, fitting hose, wheel cylinder or Master Cylinder Internal leakage's caused by worn or damaged piston, seals may also be the problem cause.
If leakage is severe fluid will be evident at or around the leaking component.

Low pedal

If a low pedal is experienced, pump the pedal several times. If the pedal comes back up, worn lining and worn rotors or drums are the most likely cause. However, if the pedal remains low and / or the warning light illuminates then the problem is in the master cylinder, wheel cylinder, or calipers.
A decrease in master cylinder fluid may only be the result of normal lining wear. Fluid level will decrease in proportion to the lining wear. It is a result of the outward movement of caliper and wheel cylinder pistons to compensate for normal wear. Top up reservoir fluid and check brake operation to verify the complaint.

Spongy pedal

A spongy pedal is most often caused by air in the system. However thin drums or substandard brake lining and hoses will also cause a condition similar to spongy pedal. The proper course of action is bleed the system or replace thin drums and suspect quality brake lining and hoses. In case the system has not been maintained as per recommendations and the brake hoses have not been replaced then due to swelling of the hoses during braking – it also causes spongy braking. In such a condition it is advisable to replace the hoses and replace all the seals and change the brake fluid.

Hard pedal or High pedal effort

A hard pedal or high pedal effort may be due to lining that is water soaked, contaminated, glazed or badly worn. Defective vacuum assistance will also cause hard operation. The vacuum booster or check valve (NRV) could also be faulty. Test the booster function. As detailed below –

1. Start engine & check booster hose connections as well as the EGR valve connections. Correct any vacuum leak before proceeding further.
2. Stop the engine and put in neutral.
3. Pump the brake pedal until all the vacuum in the reservoir is exhausted (normally after 6 to 8 pedal applications the brake pedal will become hard)
4. Press and hold brake pedal under light foot pressure

a) If the pedal hold firm then proceed to step 5.
b) If the pedal does not hold firm then and falls away then the master cylinder is defective.

5. Start the engine and note pedal action.

a) If the pedal falls away slightly under light pedal action and then hold firm then proceed to step 6
b) If no pedal action is discernable then vacuum pump or vacuum check valve is defective.

6. Rebuild the vacuum reserve as follows. Release brake pedal. Increase engine speed to 1500 rpm and then bring it to idle and shut off engine.
7. Wait for about 90 seconds and try brake action again. Booster should provide two or more vacuum assisted pedal applications. If vacuum assist is not performed then perform check for the check valve and booster.

Find the enclosed flow chart for reference –

TROUBLE SHOOTING OF VACUUM BOOSTER ASSEMBLY
BASIC TEST

ENGINE OFF. Depress & release brake pedal several times to remove vacuum from Booster Assembly. After this the pedal application will feel hard to press.

Depress the brake pedal & hold with light pressure of @ 10kgs. & start the ENGINE

If the booster is functioning satisfactory, the pedal will fall slightly & then hold. Here less pressure will be needed to hold the pedal dawn.

.

IF THE BOOSTER IS NOT OPERATING
Disconnect the vacuum hose from the NRV .
Then with ENGINE RUNNING ,
check vacuum supply with a vacuum gauge.
There should be at least 600 mm of Hg vacuum for Diesel & 500 mm of Hg for petrol vehicle.

If the BOOSTER is OPERATING pl. turn over & do the VACUUM LEAK TEST.

If VACUUM SUPPLY IS BELOW 600 mm of Hg for diesel & 500 mm of Hg for petrol veh. replace or repair vacuum hose & vacuum source.

If VACUUM SUPPLY IS 600 mm of Hg for or more for diesel or 500 mm of Hg or more for petrol vehicle, then the booster is faulty & should be replaced.

When adequate vacuum supply is obtained, repeat basic test.

VACUUM LEAK TEST

Run engine to medium speed. Release accelerator & turn Engine OFF. This builds up vacuum.

Wait for 90 sec.& apply brakes. Two or more applications should be vacuum assisted.

IF APPLICATIONS ARE NOT VACUUM ASSISTED disconnect vacuum hose from vacuum source or NRV whichever is easier. If disconnected from NRV , attach short length of hose to valve.

IF APPLICATIONS ARE VACUUM ASSISTED there is no vacuum leak.
DO THE HYDRAULIC LEAK TEST.

Blow into hose attached to NRV. If air passes through , valve is defective.

IF NRV or CHECK VALVE IS DEFECTIVE install new NRV & repeat VACUUM LEAK TEST.

IF NRV OR CHECK VALVE IS OK , vacuum booster is leaking & should be replaced.

HYDRAULIC LEAK TEST

Depress & release brake pedal several times . Then hold pedal depressed with medium pressure.

IF PEDAL FALLS AWAY hydraulic system is leaking. Check for external leakage at wheel cylinders, calipers , brake pipes , hoses & joints.
If there is no external leak, there may be an internal leak (master cylinder seals) . Repair or replace parts needed to correct leak.

IF PEDAL DOES NOT FALL AWAY hydraulic system is not leaking.

CHECK VALVE OR NRV -- NON RETURN VALVE (MOUNTED ON VACUUM BOOSTER FT. FACE

Brake drag

Brake drag occurs when the lining is in constant contact with the rotor or drum. Drag can occur at one wheel, all wheels, front only or rear only. It is caused by incomplete shoe release. Drag can be minor or severe enough to overheat the lining, rotor and drum.

Brake drag has a direct effect on fuel economy. Undetected minor drag can be misdiagnosed as an engine complaint. In case of severe drag it can also cause clutch slip.

Minor drag will usually cause slight surface charring of the lining. It can also generate hard spots in the rotor or the brake drum from the overheating/ cooling process. In most cases the rotors, drums, wheels, and tyres are quite warm to touch after the vehicle is stopped.

Severe drag can char the brake lining all the way through. It can also cause distort and score rotors and drums to the point of replacement. The wheels, tyre and brake components will be extremely hot. In severe cases the lining may generate smoke as it chars from overheating.

Some common causes of brake drag are:

- Loose or damaged wheel bearing
- Seized or sticky caliper or wheel cylinder piston.
- Loose caliper-mounting bracket.
- Loose mounting bolts of the rotor.
- Distorted brake drum or shoes.
- Rear brake shoes binding on worn/ damaged support plates
- Misassembled components
- Incomplete release of parking brake
- No free play
- Clogged master cylinder return port
- Broken master cylinder return spring
- Early lock of rear wheel due to change in setting distance of LSPV (Any change in rear spring camber can affect or also wrong setting.)

If the brake drag occurs at all the wheels, the problem may be related to a blocked master cylinder compensation port or faulty vacuum booster (binds does not release).
An improperly mounted brake light switch can also be a cause of drag. An improper mounting may prevent the brake pedal to return completely. This will cause the master cylinder feed port port to be blocked. The brakes would be partially applied causing the drag.

Brake Fade

Brake fade is a product of overheating caused by brake drag. However overheating and subsequent brake fade can also be caused by riding the brake pedal, making repeated high deaccelration stops in a short time span, Constant braking on steep roads also cause brake fade. If the brake lining is contaminated with oil or glazed then also the brake fading will take place.

Pedal Pulsation

Pedal pulsation is caused by components those are loose or beyond tolerance limits.
Disc brake rotors with excessive lateral runout or disc thickness variation, or out of round drums are the primary cause of pulsation. Other causes are loose wheel bearings or calipers and worn, damaged tyre

Pull

A front pull condition would be the result of:

- Contaminated lining in one caliper.
- Seized caliper piston
- Binding caliper.
- Loose caliper.
- Loose or corroded slide pin.
- Improper brake shoes
- Inadequate contact of pad.
- Damaged rotor
- Incorrect wheel bearing adjustment (at one wheel)

- Incorrect tyre inflation(High variations between two wheel)
- Shoe return spring weak or broken

A worn, damaged wheel bearing or suspension components are further cause. A damaged front tyre (bruised, ply separation) can also cause pull.

A common and frequently misdiagnosed pull condition is where the direction of pull changes after a few stops. The cause is a combination of brake drag followed by brake fade at the dragging brake unit.

As the dragging brake overheats, efficiency is so reduced as the fade occurs. If the opposite braking unit is still functioning then its braking effect is magnified. These causes pull to switch direction in favor of the brake unit that is functioning normally.

While diagnosing a pull in change in pull condition, remember that pull will return to the original direction if the dragging brake unit is allowed to cool down (and is not seriously damaged)

Rear Brake Grab

Contaminated lining, bent, or binding shoes and support plate usually causes rear grab (or pull). This is particularly true when one wheel is involved. However when both rear wheels are affected the master cylinder or the proptionating valve could be at fault.

Brakes Do not Hold After Driving Through Deep Water Puddle

This condition is generally caused by water soaked lining. If the lining is only wet it can be dried by driving with the brakes lightly applied for 2 to 4 kms. However if the lining is both wet and dirty then it will be necessary to dismantle, clean and reassemble.

Brake Fluid Contamination

There are two causes of brake fluid contamination. The first involves allowing dirt, debris, or other liquid material to enter cylinder

reservoir when the cover is off. The second involves adding to, or filling the cylinder with a non- – recommended fluid.
Brake fluid contaminated with only dirt, or debris usually retains a normal appearance. In some cases the foreign material will remain suspended in the fluid and be visible. The fluid and foreign material can be removed from the reservoir with a suction gun but only if the brakes have not been applied. If the brakes are applied after contamination, system flushing will be required. The master cylinder may have to be disassembled, cleaned and the piston seals replaced. Foreign material lodged in the reservoir compensator/ports can cause brake drag by restricting the fluid return after application.
Brake fluid contaminated by a non recommended fluid will usually be discolored, milky, oily looking or foamy. In some cases it may even appear as if the fluid contains sludge. *However remember that the brake fluid will darken in time and occasionally are cloudy in appearance. These are normal conditions and should not be mistaken for contamination.*

If some type of oil has been added to the system then the fluid can separate into distinct layers. This can be verified by draining off a sample with a clean suction gun. Then pour the sample into a glass container and observe fluid action. If the fluid separates into distinct layers, it is definitely contaminated.

The only real correction for contamination by non-recommended fluids is to flush the entire hydraulic system and replace all the seals and the brake hose.

Brake Noise –

Squeak/Squeal

Brake squeak or squeal may be due to linings those are wet or contaminated with brake fluid, grease or oil. Glazed linings and rotor/drums with hard spots can also cause squealing. Dirt and foreign material embedded in the system will also cause squeak/squeal. Worn retaining pins can also cause disc pad to squeak/ rattle.
A very loud squeak or squeal is frequently a sign of severely worn brake lining (or the drum or the rotor). If the lining has worn to the rivets then metal to metal contact takes place. If the condition is

allowed to persist then rotors/drums can become so scored that replacement is necessary.

Thump/clunk

Thumping or clunking noise during braking are not caused by the brake components. In many cases such noises are caused by loose or damaged steering, suspension or engine components. However caliper that bind on the slide surface can generate thump or clunk noise. In addition, worn out improperly adjusted, or improperly assembled rear brake shoes can also produce a thumping noise.

Chatter –

Loose or worn components or glazed/burnt lining usually causes brake chatter. Rotors with hard spots can also contribute to chatter. Additional causes of chatter are out of tolerance rotors, brake ling not secured properly to shoes, loose wheel bearings and contaminated brake lining.

Brake lining contamination –

Brake lining contamination is usually a product of leaking calipers or wheel cylinders, driving through deep puddles, or lining that has become covered with grease and gravel during repair.

Wheel & Tyre Problems –

Some conditions attributed to brake components may actually be caused by a wheel or tyre problem

A damage wheel can cause shudder, vibration and pull. A worn or damaged tyre can also cause pull.

Severely worn tyres with very little tread depth can produce a condition similar to grab as the tyre loses and recover traction.

Flat spotted tyres can cause vibration and wheel tramp and generate wheel shudder during brake operation.
A tyre with internal damage such as bruise or ply separation can cause pull and vibration

Defective Parking Brake -

Can be caused by excessive brake lever play. Sticky parking cable, grease or oil on shoe, excess shoe clearance (normally caused by malfunction of automatic adjusting mechanism)

Care of the system -

The brake fluid should conform to DOT 3 specifications.

The brake fluid should be replaced once a year or every 40,000 Kms – which ever is earlier. This is because brake fluid is hygroscopic in nature hence it absorbs moisture. The normal braking operation also results in brake fluid getting heated. The process of heating and cooling also results in moisture. The brake fluid boiling point keeps coming down due to the presence of moisture hence if not changed it can cause higher corrosion of the wheel cylinders/ master cylinders/ brake tubes as well as spongy or poor braking.

Caution – Do not mix brake fluid of different brands. Do not use any brake fluid, which is kept in an open container. Always use brake fluid from a sealed container.

The brake fluid should not be contaminated with any mineral oil. Do not use reuse brake fluid that has just been bled.

The list of the recommended lubricants is enclosed at the end of the chapter.

In Car repairs -

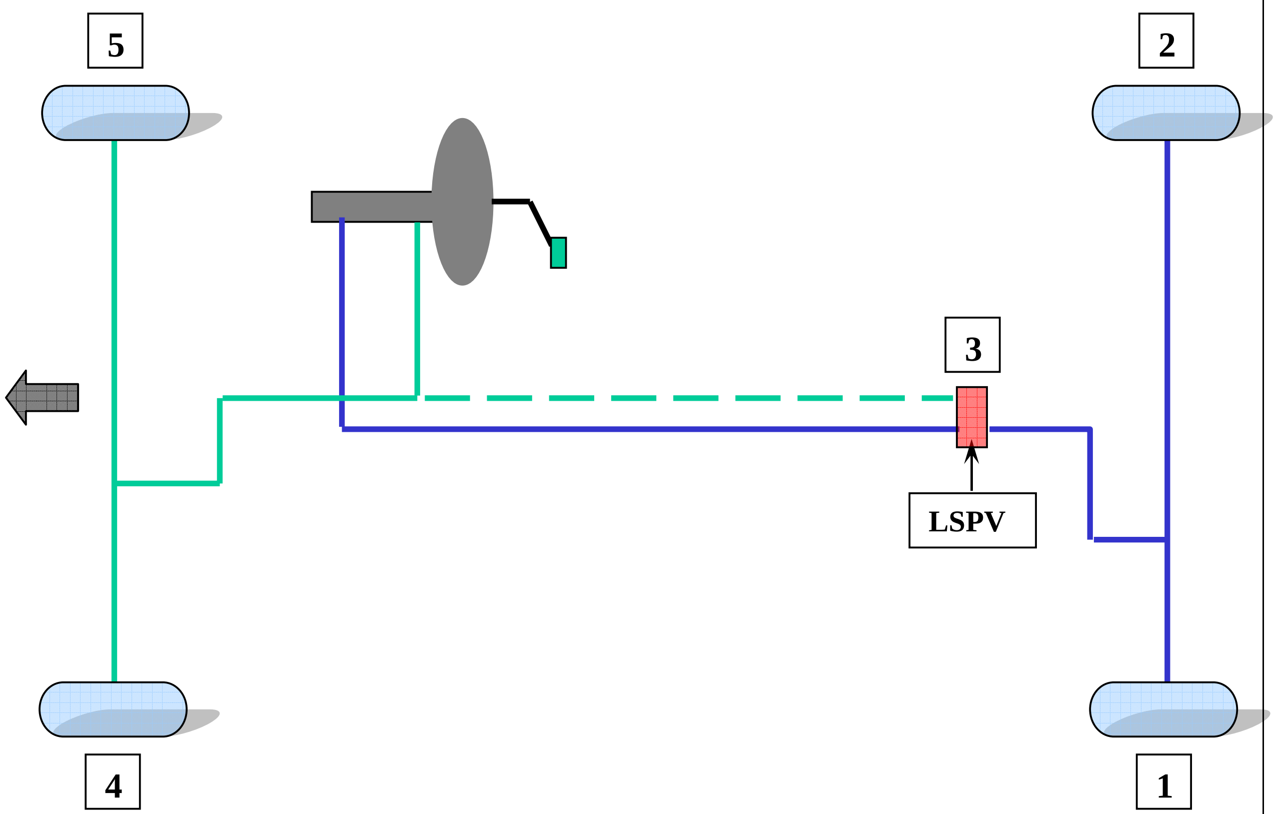
a) **Free** Play Adjustment.
b) Brake **Bleeding.**
c) **Front** Pad replacement
d) **Rear** brake shoe replacement.

a) Free Play adjustment

Adjusting the pedal to booster push rod sets the free play adjustment.

b) **Brake bleeding**

The sequence of the bleeding which has to be ensured is –



1. Rear left
2.Rear right
3.LSPV
4. Front left
5. Front right

The procedure at each of the bleed point is to pump 2 to 3 times; open the bleed screw1/4th turn. Then close the bleed screw. Again pump 2/3 times then open the bleed screw keeping the pedal pressed down. Close the bleed screw and release the pedal. Repeat the operation until no bubbles are coming. The Bypass valve is inbuilt in the LSPV & it shold be bled at the time of bleeding.

It is also advisable to keep the engine running at idling so that the pedal travel is complete.

Caution

Before opening the reservoir cap- clean the area of all dust and muck.

Before starting the bleeding – ensure that the parking brake is in released condition.

After bleeding each point put back the rubber cap.

Always use the brake fluid from an unopened container.

A pipe should be connected from the bleed screw to a clean container where the pipe other end is fully immersed in brake fluid. Doing the bleeding without the pipe can lead to improper bleeding as the presence of small bubbles can not be seen without the tube.

DO not reuse the bled fluid immediately. (It will have air bubbles entrapped.)

During the bleeding operation ensure that the master cylinder fluid level does not become below lower level. (It can draw air thus defeating the purpose of bleeding)

If the brake fluid has to be reused then it should be poured into a can using clean plastic pipe. The removed fluid should be kept without disturbing for at least 72 hours, so as to allow the air bubbles to get out. Later it is suggested to use chamois leather to strain the brake fluid.

c) Front Pad replacement

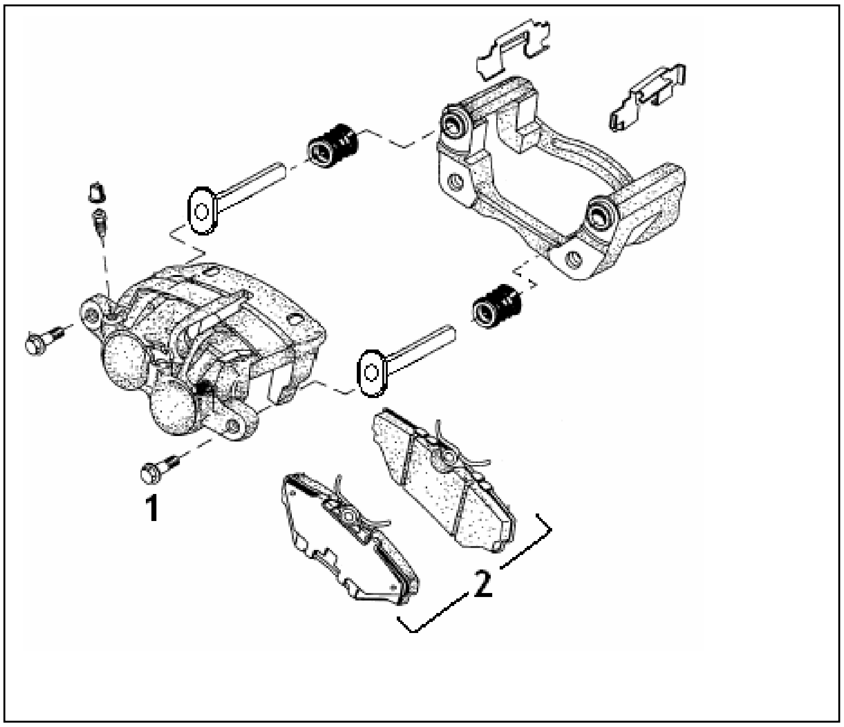
Put the vehicle under hand brake in order to prevent from rolling.

In Car Repairs –

Removal & Refitment of Brake pads --

Note : The Assembly sequence is the reverse of the dismantling sequence.Any special precautions to be taken while disssembling or assembly are indicated & shown later.

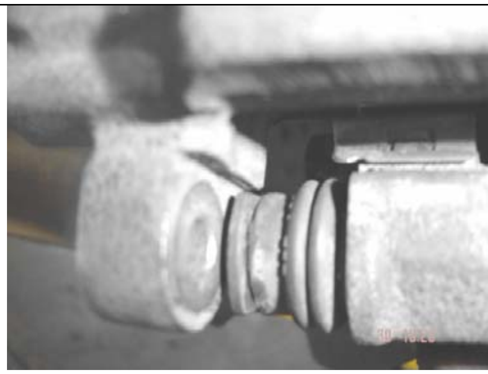
Replacement of the brake pads –



1. Loosen and remove the bolt - Pin of the guide pin & swing up the caliper. (Check Point A)

2. Remove the old pads one by one.

Check Points –

	**A)** While swinging down the caliper take care and see that the antisqueal shims are not damaged. While fitting the guide pin ensure that the straight portion of the pin matches the with ear of the caliper body. It is recommended to change the antirattle clips at the time of pad change. After tightening the bolt to torque . **Rotate the disc and ensure that the disc is free to rotate.**
	**B)** **Connect a transparent plastic pipe to the bleed screw on the caliper.Dip the other end of the pipe into a container filled with brake fluid.** Ensure the tip of the plastic pipe always remains dipped in the brake fluid. Loosen the bleed screw & push both the pistons one by one into the caliper bore. Ensure the pistons are pushed back fully into the caliper bore.

Caution :

Because the bleed screw is loosened to push the pistons of the caliper back, it is required to bleed the vehicle to retain the original brake performance of the vehicle.

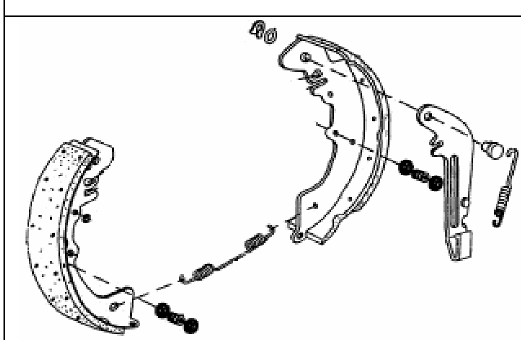
CAUTION

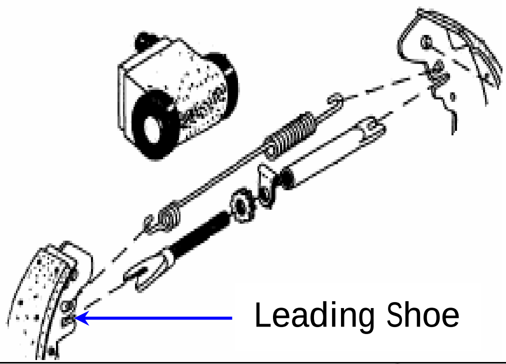
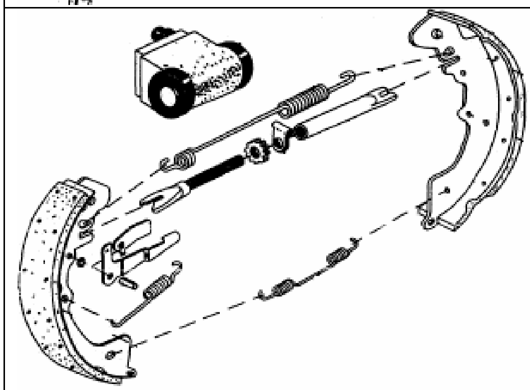
If the pads are to be reused make sure they are assembled back in the same position as they were when removed i.e., inboard pad on to the piston side and outboard pad to the wheel side. This is possible only when at the time of removal these pads are marked for their positions and kept aside.
Never lubricate the pad seating areas as it may lead to jamming.
After fitting the pads, apply brake pedal 5 to 6 times in static condition in order to make the pads align properly.
The brake pads require nearly 200 Kms of running for bedding in. Hence it is advisable that during the brake testing after fitting the new pads and also during the initial run, severe braking and / or continuous operation be avoided.

Rear Brake liner replacement --

	Remove the wheel. The jacking point for rear axle is below the axle . Care must be taken to avoid any damage to the suspension links.
	Remove the brake drum after removing the drum mounting screw.

	Remove the parking brake cable lock.
	If there is any difficuly in removing the drum ; using a screw driver push the hand brake lever. A click sound will denote that the shoe setting is dropped. Now the drum can be removed using two puller bolts.
	Detach the hand brake cable from the lever on the trailing shoe by moving the lever towards the centre of the brake. & remove the cable end from its location in the end of the lever
	Remove the return spring (near the wheel cylinder) from trailing shoe.
	Reduce the adjuster assembly to its minimum length by lifting the end of the pawl lever and rotating the serrated adjuster nut.
	Remove shoe hold down springs and cup washers from the back plate by compressing the spring.
	Slide both shoes off the wheel

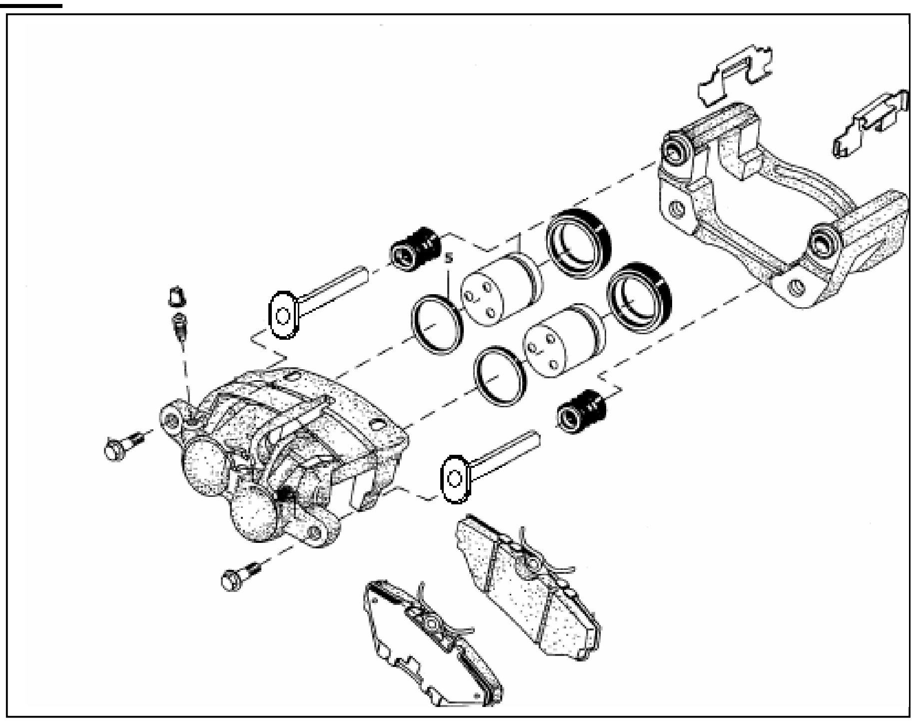
	cylinder pistons. Care must be taken not to damage the rubber boots on the wheel cylinder. Detach the adjuster assembly and shoe return spring from the shoes.
	While riveting the new liners on to the shoe following care should be taken – - the hole in the shoe rim has not become oblong/oval. - While fitting the rivet the holes in the liner and the shoe rim are in same line. - The rivet head at the back is formed properly & the rivetting should be done inside out. - Inspect the shoe hold down springs, cups & shoe hold down pins for any damage / deformation. Replace if required. - It is advisable to use new shoe return springs. - It is advisable to fit the parking brake cable on the slot in the trailing shoe before assembling it on the back plate. Clean the shoe resting pads on the back plate & both the shoe tips.
	Place one shoe on backplate & assemble pin shoe hold down cup. Fit one end of the shoe return spring – lower (abutment spring) in the slot provided on brake shoe. Assemble the other end of the shoe return spring – lower (abutment spring)in the second shoe.

	Hook the shoe return spring (short length coil) to the leading shoe with the adjuster assembly in its minimum length condition,assemble it in between the shoe webs. Attach the other end of the shoe return spring to the opposite end of the trailing shoe.
	Fit the pawl lever to the spring dowel inserting one leg of the pawl between male push rod end & shoe web of the leading shoe & the other end of the pawl leg resting on the adjuster nut. Hook the short end of the spring into the hole in the pawl lever & use plier to attach the opposite end of the spring on to the shoe web.
	Note - Ensure proper resting of auto adjuster inside web & hand brake lever slot.
	Ensure that the the auto adjuster pawl lever edge is properly located on tooth of auto adjuster wheel.
	Connect the Parking brake cable in reverse order of dismantling.
	Centre the shoes relatively by tapping & moving upwards or downwards.
	Before refitting the brake drum check that the drum thickness has

	not gone below 8.20 mm. **A thin brake drum will flex during braking reducing the braking efficiency and also it will cause improper functioning of the parking brakes**.
	Refit drum & wheels. Apply brakes few times to adjust the brake shoes.

Working principle, Assembly & Dismantling of Twin Pot Caliper Assembly –

Description –



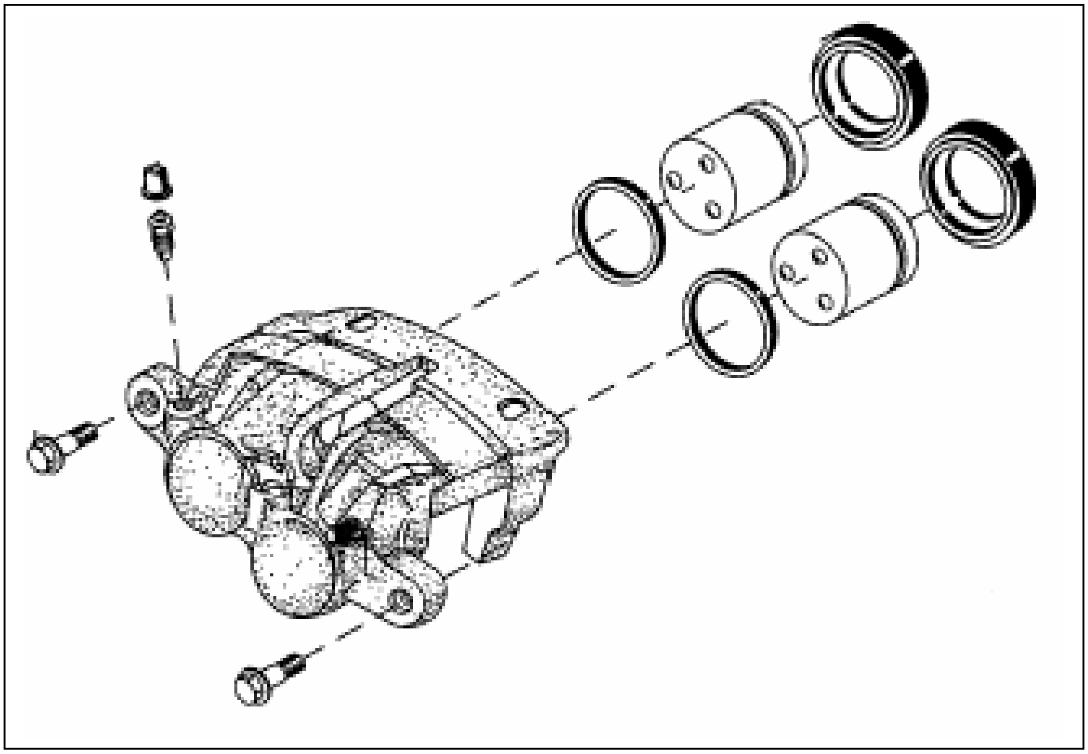
When the brake pedal is pressed then the hydraulic pressure pushes the two pistons to act simultaneously on the brake disc. The combined thrust provided by two pistons is much higher than the single piston caliper.

The sliding rail type carrier on which the twin caliper body slide easily to ensure that equal thrust is applied on both pads. A higher friction pad area improves the durability (life) of the friction material.

Disc brakes by their very nature & design are self adjusting to the wear and hence do not require brake adjustment to compensate the pad wear.

Servicing of Caliper –

- Apply hand brakes. Place wheel chocks on rear wheel
- Jack up the front of the vehicle and remove the front wheels by loosening / removing the wheel nuts.
- Disconnect the hose from the caliper by removing the banjo bolt



1. Loosen and remove the mounting bolts of the caliper.
2. Remove the caliper assembly after removing the banjo bolt at caliper inlet port.

3. Loosen & remove the sliding pin bolts. Remove the pads. Separate the caliper sub assembly from the carrier sub assembly.
   Clean the caliper & carrier assembly externally with alcohol or fresh brake fluid.

4. Remove the caliper pistons from the bore by blowing dry compressed air through the inlet port of the caliper. Care must be taken to remove both the pistons at a time. Also to avoid the damage to the pistons, place a wooden block in front of the pistons.

4. Remove the boot.

5. Remove the seal- Pistons from the groove by using a blunt edged connector or feeler gauge. Take care druing seal removal the bore is not damaged.

6. Remove the bleed screw from the caliper body.

Cleaning & Inspection –

All the removed parts should be cleaned properly using fresh brake fluid or alcohol and kept in a clean tray.

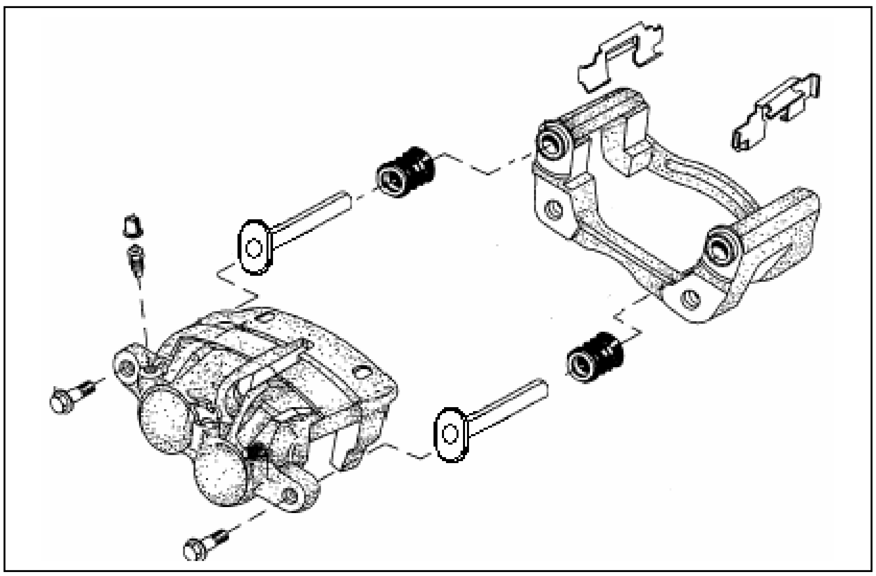
NEVER USE ANY MINERAL OIL BASE FLUIDS LIKE KEROSENE ,DIESEL , PETROL etc,. FOR CLEANING OF REMOVED PARTS.
DO NOT CLEAN THE BORE OF THE CALIPER WITH WATER OR STEAM.

Tips –

	The Piston seals are to be lubricated with fresh brake fluid and assembled in to the seal grooves in the caliper bores. Make sure the seating of this is properly done. Then lubricate the outer surface of the pistons with fresh brake fluid.
	The piston boots are to be lubricated internally with the

	grease supplied in Caliper Repair Kits before it is assembled on the pistons.
	Fit the boot into the groove in the caliper body. Locking of the rubber boot in the groove to be ensured. Expand the rubber boots & insert the pistons one by one into the caliper bore. The piston should be inserted into the bore in a straight position only. If it gets tilted while pushing , there is a chance that the piston will get jam half way & also can damage the seal.

Servicing / Replacement of Sliding pin –



1. Separate the sliding pins from the carrier assembly .

2. Separate the rubber boots from the sliding pins.

4. Clean the sliding pins & sliding pin bores.

5. Check the sliding pins for bent / damage / rust. If found should be replaced with new ones.

Discard all rubber parts.

Smear the pins and the pin bores with the special grease supplied in Kit.

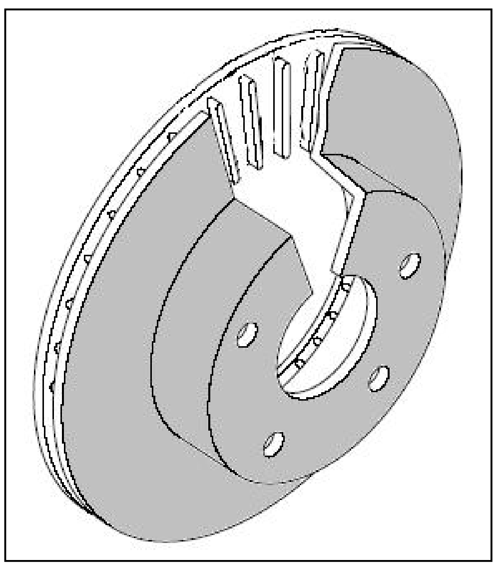
Fit the pin boots on to the pins and assemble it on to the carrier bore.

Ensure proper location of the boot lip on to the carrier. Move the pins in and out 3 to 5 times in order to allow for the trapped air inside the bore to escape.

Repeat the above procedure for the other side caliper assembly.

Inspection of the rotor –

1. Check the runout of the wheel disc in four places. Excessive lateral



runout will cause brake pedal pulsation and rapid unven wear of the brake pads.

The maximum runout permissible is 0.12 mm

2. **Disc Brake Rotor thickness variations:** Variations in the rotor thickness will cause pedal pulsation, noise and shudder. It should be kept in mind that the disc rotor thickness variation is one of the primary causes for brake pedal pulsation.

The maximum variation permissible is ± 0.012 mm

The rotor thickness should be measured in at least 6 different points around the rotor face. Position the micrometer approximately 15 mm from the outer edge.

Recondition on out of specification rotor -

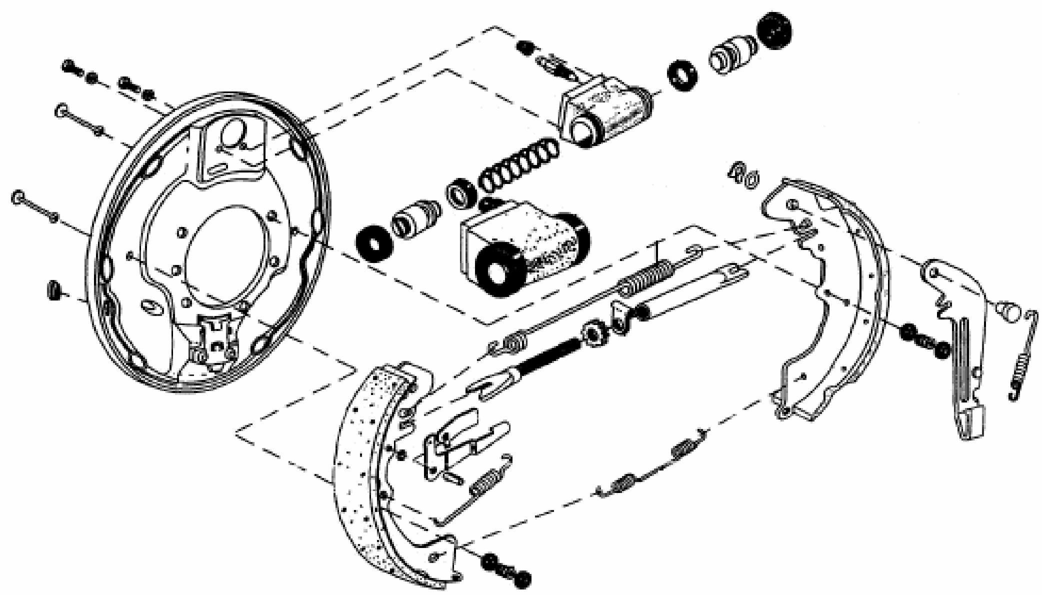
The rotor/disc should be mounted in such that the lathe can take cut in both the face at the same time. *It is important to remember and note that a lathe which take cut only on a face will produce a tapered rotor.*

If the rotor requires only minor cleanup of rust, scale or minor scoring then use abrasive disc to clean up the rotor face. However when a rotor is scored or worn, machining with cutting tools will be required.

Caution:
Do not go below the minimum specified thickness of 21 mm.

Please ensure that whenever the disc is removed from the hub, then while fitting it back. Use the sealant METALOCK 343 or ANR124 from FEVICOL on the disc mounting bolts thread. Use new spring washers. Failure to do so may cause the mounting bolt to work loose.

Working principle, Assembly & dismantling of the Rear Brake -



This brake is designed for use on rear wheels and is equally efficient in both forward and reverse direction of movement. A mechanical lever mechanism is incorporated for normal hand brake operation. The feature of this brake is that the brake shoe adjustment takes place automatically when the service brake is applied.

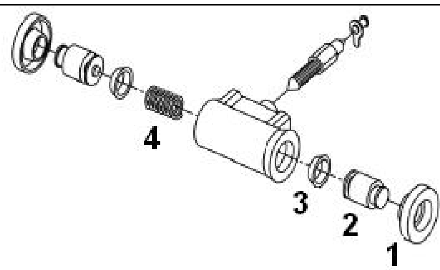
The leading and trailing shoes are connected at one end by a two-piston wheel cylinder and an adjuster assembly. The adjuster assembly consists of a male and female push rod with an adjuster nut operated by a pawl.
Coupled on the trailing shoe is a hand brake lever, which pivots on a pin at the wheel cylinder end of the shoe.

A spring dowel fitted at the leading shoe provides a pivot for the pawl lever , which is retained in position by a spring hooked on to the web. The hand brake cable passes through a hole in the back plate, and the slotted cable end fits in the end of the hand brake lever. When the hand brake is applied, the cable pulls the lever and this movement is transferred via the adjuster assembly to the shoes, which move outwards onto the drum.
When the foot brake is operated, both the shoes are pushed on to the drum by the wheel cylinder pistons. As the shoe linings wear, the

outward movement of the shoes exceeds a predetermined amount and the pawl pivots on the spring dowel to rotate the adjuster nut. This action lengthens the adjuster assembly sufficiently to reduce the clearance between the brake shoes and drum to the desired minimum. The adjustment is repeated, whenever necessary, according to the rate of lining wear.

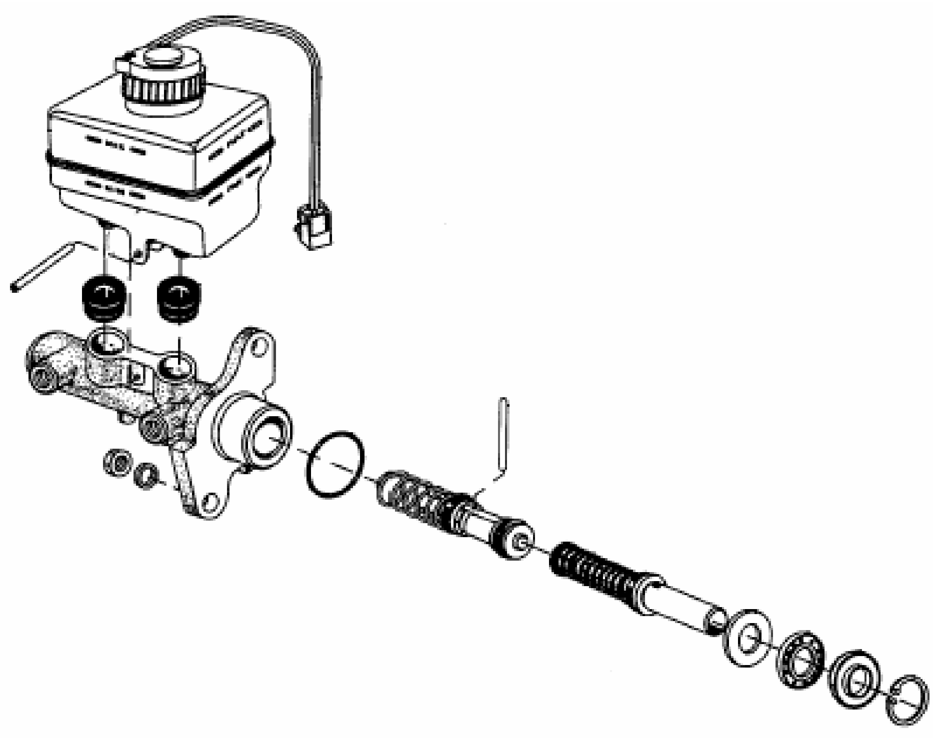
Dismantling & assembly consist of:

Shoe removal & Wheel cylinder overhaul -

	For removal and refitting the brake liner. Refer to **Rear** Brake Liner replacement section.
	Disconnect the brake Bundy tubes.
	Remove the rubber boots at the ends of the wheel cylinder. Remove the pistons along with the spring.
	Check the bore of the cylinder for any pitting or scuffing- if so then the wheel cylinder will need to be replaced.
	Check the piston for any deep scoring or scuffing.
	Before assembly clean the wheel cylinder and piston with alcohol or clean brake fluid. **Do not attempt to clean with any mineral oil. Any trace of it left will contaminate the brake fluid**

	and reduce the life of the all the rubber components of the hydraulic system.
	It is advisable to fit the parking brake cable on the slot in the trailing shoe before assembling it on the back plate
	Before refitting the brake drum check that the drum thickness has not come below 8.20 mm. **A thin brake drum will flex during braking reducing the braking efficiency and also it will cause improper functioning of the parking brakes**.

Working principle , Assembly & Dismantling of the Master Cylinder -



The center Flow master cylinder, Suitable for ABS system is made of aluminum body with the brake fluid reservoir coupled on to the Master cylinder.

The Tandem Master Cylinder is designed to operate dual line hydraulic systems .It consists of two independent hydraulic chambers working in series and should one chamber or circuit develop a fault, the other remains operative.

In the normal-"Brakes-off" position, the brake fluid can flow unrestricted between the dual line systems and separate chambers in the integral fluid reservoir. Fluid movement to the Independent cylinders is controlled by two valves-(center valves). Hence CF/ CF Master cylinder. When the brake is applied the push rod pushes Master Cylinder primary plunger of the bore.

This master cylinder is divided in to two chambers .The primary train is composite assembly and is resting on stop washer through a connecting pin. Connecting pin is rectangular in section and has a hole at center .One end of the valve stem passes through this hole. The connecting pin is assembled in to the circular hole on primary plunger.

The poppet valve train consists of poppet valve assembled on the valve stem. This composite assembly is ahead upon by a valve spring. The end of the valve spring is resting on the distance sleeve. The distance sleeve is held rigidly with the plunger by 6 or 8 crimps on the plunger.

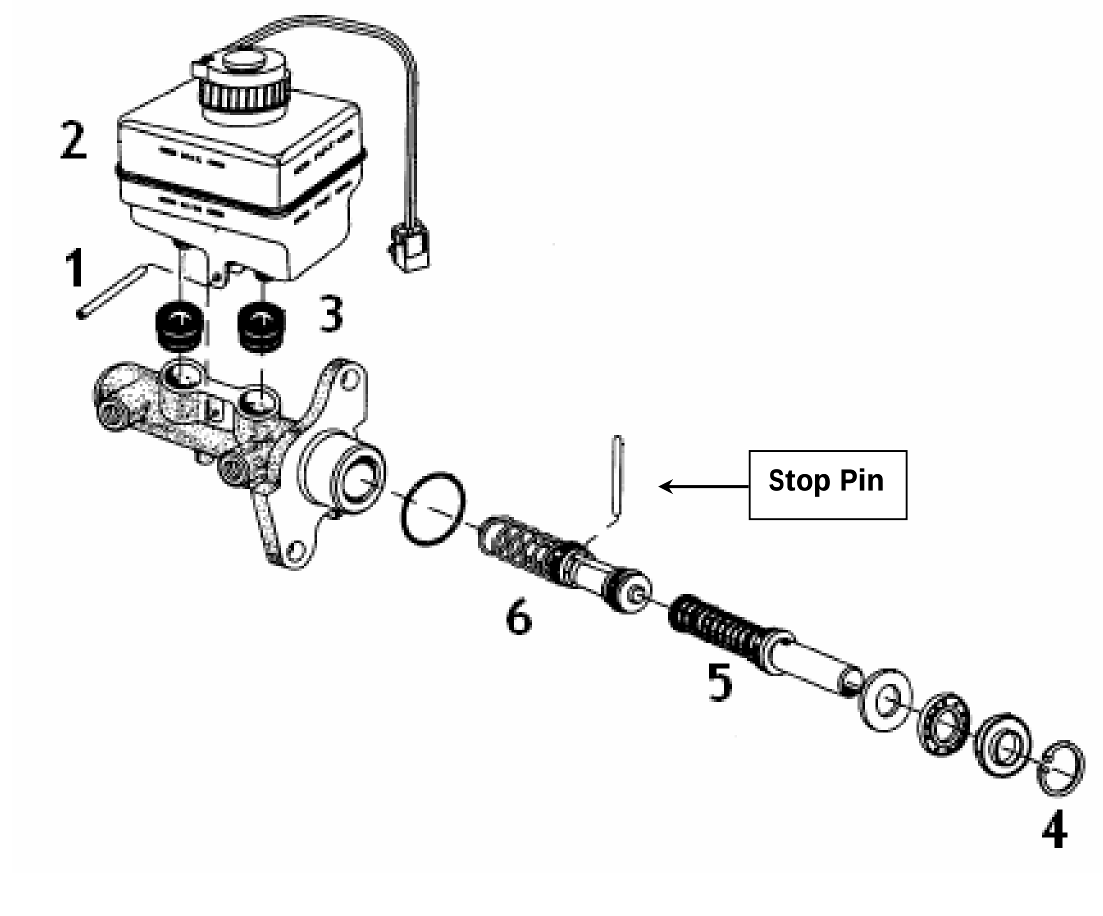
A similar arrangement is provided for secondary train also. The secondary plunger has a center slot into which the stop pin reciprocates. A cover plate is assemble in-between the secondary grommet and connecting pin to prevent falling off of connecting pin from cylinder body. This plate also acts as a baffle and reduces the velocity of fluid jet that will emerge form secondary feed ports on return.
Secondary and primary plunger train moves as a composite assembly. At this juncture the poppet valve (centre valves) of both primary and secondary close the respective sealing faces of the plunger and pressure is developed.

During further stroke of the primary plunger, the primary spring is compressed and pressure is developed. The pressurised fluid is forced though pipelines to the calipers and wheel cylinders.

When the brake is released, the master cylinder plungers move back creating partial vacuum in front of poppet valves (center vlaves) deseating by deflecting poppet spring and the port are opened and the brake fluid can again move unrestricted between separate systems and the fluid reservoir.

Servicing of Master Cylinder –

As the TMC is of CV/CV (Center Valve type) design ; the TMC can be serviced using only Major Repair Kit. The assembly procedure is in the reverse order of disassembly.



1. Remove the Reservoir Fixing Pin by tapping it carefully.
2. Remove the Reservoir Assembly from grommets.
3. Using a blunt edge screw driver; remove the reservoir grommets.
4. Press the Primary Piston in the bore using a hylem rod & remove the circlip.
5. Gently remove the Primary Piston assembly.
6. Hold the TMC in upside down condition & by pressing Secondary Piston gently; remove the stop pin from secondary feed port of TMC assembly. (If any problem is observed while removing the stop pin ; push the Secondary Piston gently using a hylem rod & gently tap the TMC from the Secondary Feed port side on a wooden block.)
7. Remove the Secondary Piston assembly.

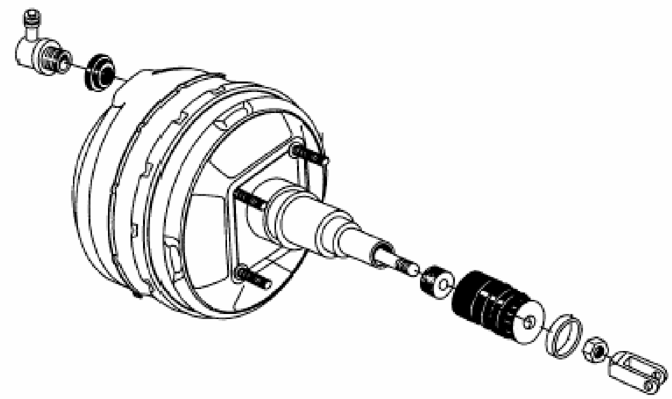
Caution -
Use only fresh brake fluid for cleaning.
If contamination is observed in the seals (seals would have swollen and the size would have enlarged compared to the new seals) ensure all rubber parts in the system including rear wheel cylinder seals, front caliper seals and the front and rear rubber hoses must be discarded and the entire system to be flushed with new brake fluid.

ENSURE THAT THE TMC FLANGE SURFAE IS FREE FROM DIRT,DENT & BURR BEFORE MOUNTING IT ON TO THE BOOSTER.

NOTE -

1. It is essential that reservoir cap must be removed and cleaned. While assembling the reservoir cap ensure the presence of filter in the reservoir.
2. After fitting TMC on to the vehicle / vacuum booster , the outlet pipes are to be connected and torque tightened.

Working principle of the brake booster –



Note -- The Booster is a non- serviceable Unit & it should never be tampered with.

Ensure booster out put rod is correctly aligned to the primary piston bore during the coupling of TMC to the booster.

The Scorpio vehicle is equipped with a Tandem type vacuum booster to assist driver's effort. This is achieved by using vacuum from the vacuum pump provided on alternator in case of diesel engines & from inlet manifold in case of petrol engines.

A pair of diaphragms is provided between the two shells of the booster & difference of pressure on two sides of diaphragms (one side vacuum & other side atmospheric pressure) gives mechanical advantage. This amplifies the driver's pedal effort while braking.

The booster assembly & TMC assembly are coupled with the help of two nuts & washer. The meting dimensions of booster & TMC are factory set. Hence –

Do not alter the height of the output rod of the Vacuum Booster unit at any stage and ensure Booster out put rod is correctly aligned to the primary piston bore during the coupling of TMC to the booster.

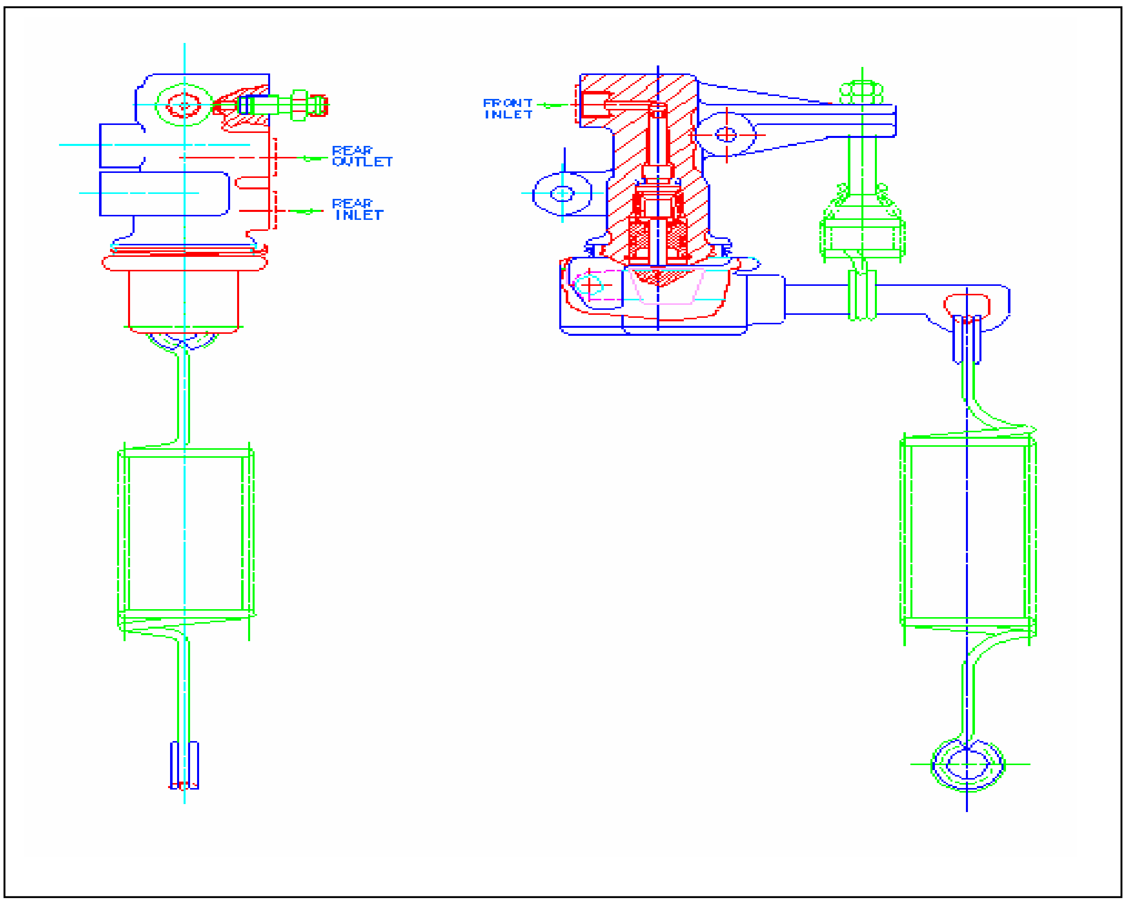
Working principle of LSPV Valve -

Description -

The load on a vehicle governs the amount of braking which can be applied to the rear wheels, before locking-up and sliding occurs. As the load can vary between unladen to fully laden, it is sensible to assume the braking pressure which can be applied, should also be varied.

The LSPV senses the weight on the rear wheels and adjusts the braking pressures accordingly, even if by weight transfer, the alteration occurs during braking. The valve is fitted in the rear line and has no effect on the front brakes. At front circuit failed condition, rear circuit receives 100% of inlet pressure.

Working of Valve - Please refer the attached figure.



Working of Valve -

At front circuit healthy condition, fluid pressure from the master cylinder passes through the open valve to the rear brakes. As pressure in the rear brakes increases, it loads the valve piston until the pressure is sufficient to overcome the combined load from internal spring and sensing (control) spring. The plunger then moves down allowing valve seal to close, thus preventing further pressure going to the rear brakes. The pressure increases to the rear brakes is a proportioning of the increase to the front brakes and these rapid controlling movements are repeated as long as the pressure from the master cylinder continues to rise.

At front failed condition, valve is always open. 100% fluid pressure from the master cylinder passes through the open valve to rear brakes completely.

Maintenance Precautions -

LSPV is a non-serviceable unit & should be replaced if any problem arises.

During vehicle servicing control spring setting should be checked & corrected if required with the help of an ‘ Installation gauge ‘ provided for the purpose. The stretched length of the control spring should be set at 92.5 mm with the help of Installation gauge.

The correct setting of Control Spring ensures adequate oil pressure to rear circuit & thereby ensures no skidding of rear wheels.

Do’s & Don’ts –

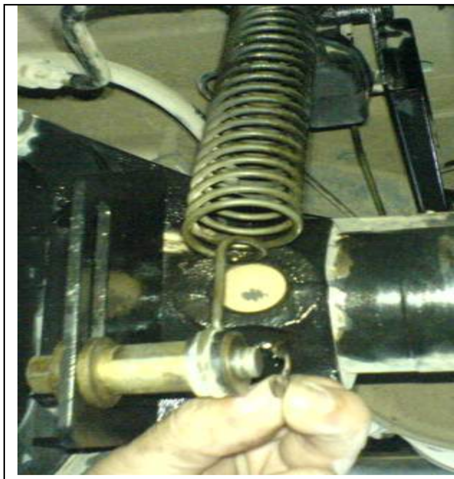
Do’s	Don’ts
Check LSPV setting whenever the vehicle is reported to the Workshop for servicing. Spring setting to correct length should be done by stretching the control spring to the manufacturer's	No other spring setting except the control spring is to be disturbed in field. Main spring setting should not be disturbed as it is set in factory & any change in the setting of this

specification by loosening the nut provided on rear axle bracket & retightening after correct setting.	spring can lead to malfunctioning of LSPV & result in brake locking on rear.
While doing any suspension job (when the chassis of the vehicle is lifted) or whenever the vehicle is lifted on a two post lift, remove LSPV Control spring from the hooking on rear axle. LSPV is a non-serviceable unit & should not be opened in field. If any problem arises this unit is to be replaced.	If the leaf springs are removed from vehicle putting Axle stands below the chassis the whole rear axle will float downwards & result into overstretching of LSPV control spring. This also can lead to malfunctioning of LSPV.

The LSPV setting needs to be carried out if:
-The axle has been removed.
-LSPV Valve replaced.
-Any change in rear suspension carried.

Procedure for fitting and setting the LSPV Valve –
Mount the LSPV valve on the bracket in the chassis.
Fit all the hydraulic connections

Caution: Before fitting / setting the LSPV valve ensure that the
- *Vehicle unladen condition. Fuel tank is assumed to be ¾ full.*
- *Before doing the fitment/setting run the vehicle through rough road / normal road for 5 to 10 kms. This is essential for the spring/ bushes to settle.*

	Remove the 'e' clip.
	Remove the Washer.
	Slide the control spring out from the bolt.
	Put the projecting pin of the tool in the eye of the spring & allow the tool to hang freely..

	Loosen the nut & move the bolt in such away that the bolt is alligned & enters in the slot on the tool.
	Retighten the nut in such a way that the bolt is in the correct position as indicated by the tool.
	Remove the tool .
	Pull down the spring and locate the eye in the bolt. **Ensure that the spring is sitting properly in its position.** Fit the washer & the 'e' clip.

<u>Parking Brake -- Description, Setting</u> –

The parking brake is cable actuated and acts on the rear brakes.
On applying the parking brake the parking cables are pulled and they act on the trailing shoes at the lower end. Since the shoe is pivoted on top it result in actuation of the trailing shoe. Due to the scroll plate the force also gets transmitted to the leading shoe.

Based on the slackness in the system the parking brake is manually adjusted by readjusting the adjusting stud and lock nut.

Specifications & Wear data -

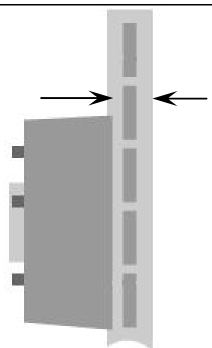
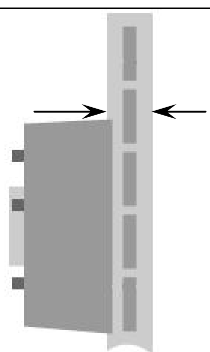
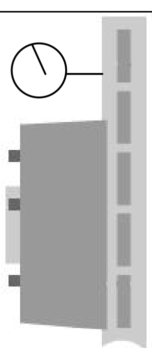
Figure	Description	Value
	Disc pad Usable thickness	8.5 max
	Replace disc pad if worn out thickness less than	9 mm
	Disc pad Material	Rane R808 asbestos free
	Rotor thickness	24 mm
	Minimum disc thickness	21 mm
	Runout of rotor face- permissible limit	0.12 mm

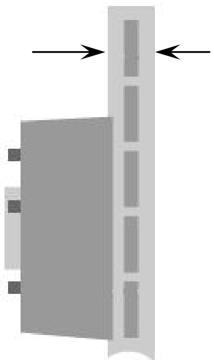
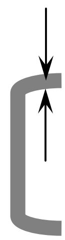
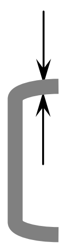
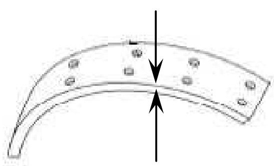
Figure	Description	Value
	**Disc thickness variation allowed**	**± 0.012 mm**
	**Rear Drum thickness**	**8.20 to 8.35 mm**
	**Minimum thickness of brake drum**	**8.20 mm**
	Maximum taper/ bell mouthing of brake drum	**0.05 mm**
	**Rear brake lining Usable thickness**	**3.5 mm to 4.3 mm**

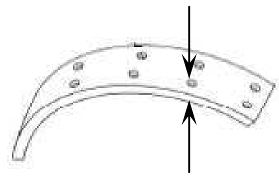
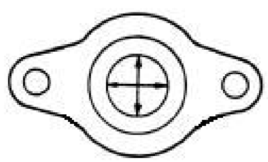
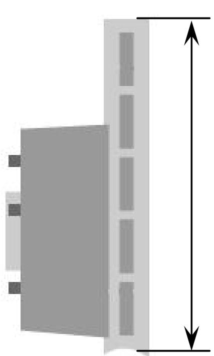
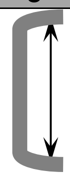
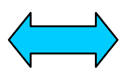
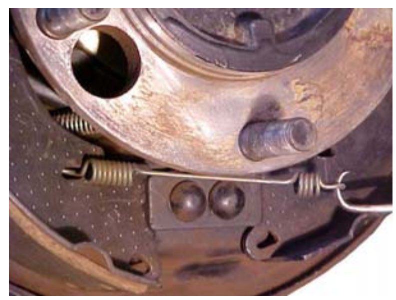
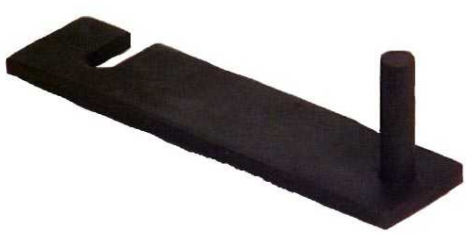
Figure	Description	Value
	**Replace when lining thickness falls below Minimum Usable thickness of**	**0.2 mm.**
	Brake shoe Lining Material	**Sundaram Asbestos free 3691**
	Setting length (By setting gauge)	**92.5 mm**
	**Master cylinder I.D**	**26.99 mm**
	**Wheel Cylinder I.D** **Wheel Cylinder I.D**	**25.4 mm**
	**Brake disc O.D**	**298 mm**

Figure	Description	Value
	Rear Drum I.D	282.2 mm
	Boost ratio-tandem booster	7.5
	Booster size Tandem	8 + 9 inch
	Clearance Adjustment- Front Rear	Automatic Automatic
	Free Play of the Brake Pedal	3 mm

Tightening Torques -

Description	Torque Value
Front Brake Caliper Mounting Bolts	24 Nm (18 lbf-ft)
Sliding Pin Bolts	27 ± 5 Nm (20 ± 4 lbf-ft)
Banjo Bolt - Caliper	24 Nm (18 lbf-ft)
Brake pipe connectors – Master Cylinder	18 ± 4 Nm (13 ± 3 lbf-ft)
Vacuum Booster – Mounting Nuts	21 ± 7 Nm (15 ± 5 lbf-ft)
Brake Pipe connectors – Wheel Cylinder	21 ± 7 Nm (15 ± 5 lbf-ft)
LSPV Banjo Bolt	24 ± 2 Nm (18 ± 1 lbf-ft)
LSPV Brake Pipe Connectors	18 ± 4 Nm (13 ± 3 lbf-ft)

Special Tools --

Description/ Part No./ Sketch	Usage View
Tool for removal of Brake shoe hold down spring **MST – 570** 	
Tool for removal of return spring. **MST – 569** 	
Tool for LSPV setting **MST – 568** 	

Recommended Lubricants -

Specification:

Castrol: DOT 3

TVS Girling: DOT 3

Sealant:
METALOCK 343 or ANR124 from FEVICOL

Automotive Sector

HVAC

Contents

Description --

The Heater, Ventilation and Air conditioning combines air conditioning, heating and ventilating functions.

The system comprises of:

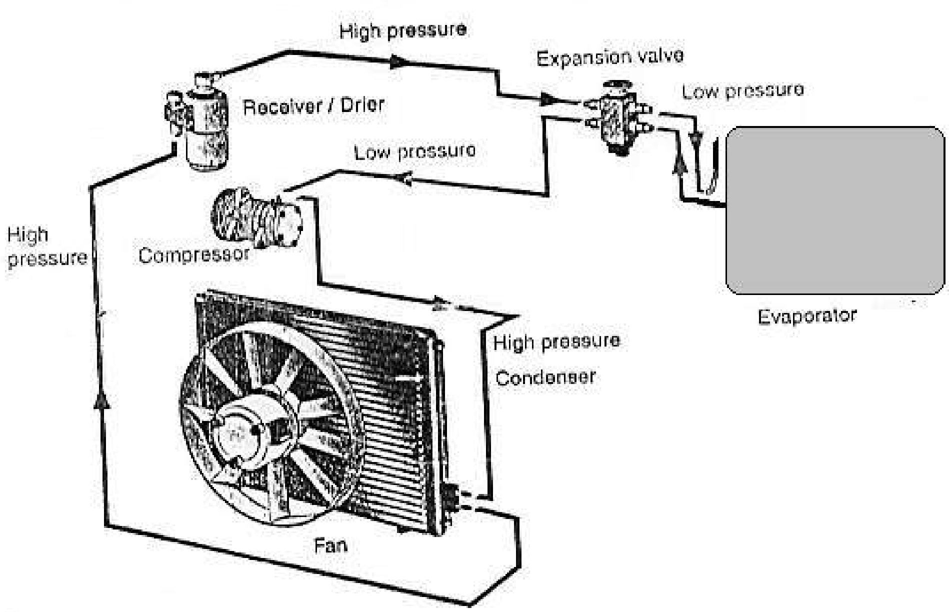
- ✓ Blower & Air Inlet system
- ✓ Heater core, and Air distribution assembly.
- ✓ Air Conditioning system.

Heater system

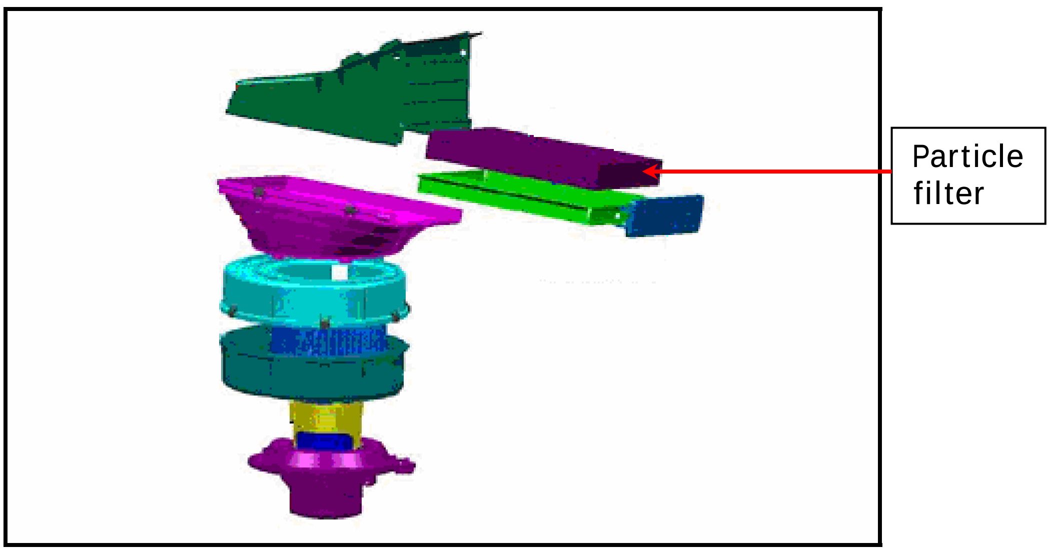
The heater system is controlled water flow system. A water valve controls the quantity of water entering the heater core.

Air conditioning System

The system uses non-CFC refrigerant R134A.



The refrigerant at low pressure and temperature enters the compressor where it is compressed and its pressure and temperature increase. The refrigerant after leaving compressor enters condenser and here it is condensed into high-pressure liquid and is collected in receiver drier. From the receiver drier it passes through expansion valve where it is throttled down to a low temperature and pressure. After finding its way through expansion valve it finally passes into evaporator coil where it extracts heat from surrounding. The refrigerant, which was in low-pressure liquid state, converts to low-pressure vapour. The low-pressure vapour then again enters the compressor.



The incoming air (in fresh mode or recycle mode) passes through a particle filter & then gets cooled and dehumidified by the evaporator. The evaporator is in operation all the times unless the AC switch is kept in off condition. To maintain minimum evaporator temperature a fixed thermostat-setting switch controls the compressor clutch. This switch which is called Anti freeze switch has a probe so that it touches the coldest part of the evaporator is used to avoid formation of ice. (If ice formation is allowed then the ice formed prevents exchange of heat thus reducing the cooling and forcing the compressor to work continuously/ longer period leading to low cooling as well as system failure.)

The evaporator always cools the incoming air (recirculated or fresh) to an amount set by the fixed thermostat value. The cooled air later goes through the heater coil. Thus the final air temperature is dependent on the amount of hot water passing through the heater.

For example when the control panel thermostat is set to the coldest value then no quantity of hot water goes through the heater and the final outcome is only the cold air. As the control panel's knob is moved towards the hotter the mixing start i.e. the quantity of hot water going through the heater starts increasing proportionately.

It should be borne in mind that when the engine is cold the temperature of incoming water is low, hence to get a desired temperature the knob will have to be set any given position. However as the engine warms up the water coming to the heater also gets warmer, thus the final outcoming air temperature will raise. As a result after the engine warms up the knob in the panel will have to be readjusted to get the same outcoming air temperature.

Trinary Pressure switch: It is mounted on Receiver drier.

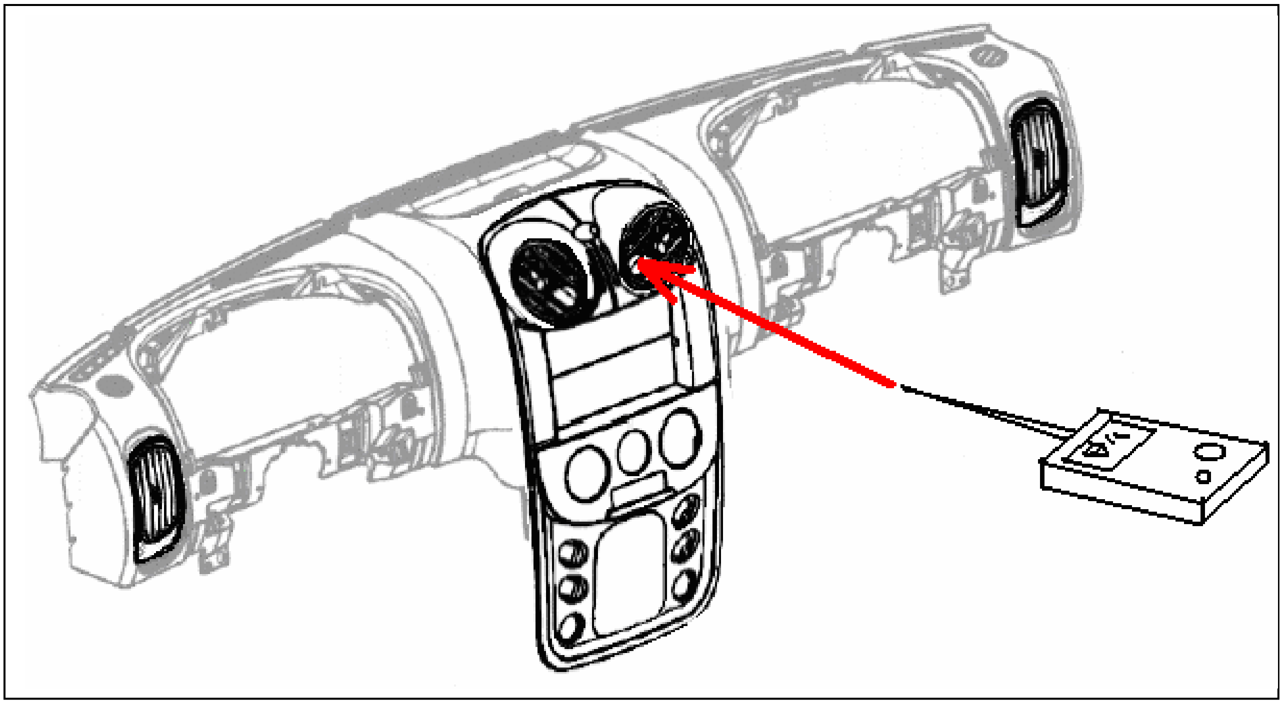
High-Low Pressure operation:. If the system pressure becomes low then it switches off the compressor. Thus in the case of refrigerant loss due to any system leak the compressor failure is avoided. Once the pressure increases above 32 bar then the compressor is shut off to avoid any system failure. If the system pressure falls due to any leaks then the compressor is switched off.

Medium pressure operation: When the pressure in the system goes above 17 bars then it switches on the condenser fan. As the pressure reduces below 14 bar the condenser fan is switched off.

Trouble Shooting –

AC Performance Test --

This test has to done in shade and at an ambient temperature of 30 to 40 degrees maximum. If the ambient temperature is more than that, then please take the vehicle to the coolest area available in shade and then carry out the test.



A. Start the engine, switch on the AC and keep the Engine RPM at 1500.

B. Set the Blower to 3rd speed, the ventilation mode to be set to chest and recirculation mode. The temperature control should be set to the coolest.

1. These tests have to be performed at ambient temperature ranging from $30^0 - 40^0$ C.

2. Vehicle must be in shed with bonnet closed and engine speed should be set at 1500 RPM with AC on.
3. Blower to be set in 3rd speed, ventilation to be set recirculation mode and temperature control to be set to the maximum cool.
4. In 10 minutes close door test the average grill temperature should be less than 12^0 C. *(Open Door Test - in 10 minutes open door test the drop in average grill temperature with respect to ambient temperature should be 15^0 C)*.

Note:
In normal conditions:
The low side pressure should be 1.5 to 2.5 bars.
High-pressure side the pressure should be 15 to 17 bar.

This is with reference ambient temperature of 30 to 35 ° C
If the ambient temperature is different from the range refer to the chart for getting the range of suction and discharge pressures.

Symptom	Causes	Remedial action
Low pressure side pressure high **Ps>2.5to 2.9** **And** **High pressure side pressure gauge high.** **Pd>19.5 to 25 bar** **Discharge air warm**	Evaporator flooding due to Block valve stuck open. 1. Dirt in Block valve. 2. Moisture in the refrigerant circuit	✓ Remove refrigerant ✓ Evacuate/dehydrate ✓ Change expansion valve ✓ Change filter/drier. ✓ Charge correct amount of oil & refrigerant. ✓ Check performance.
Low side -High **High Side- High** **Ps>2.5-3.0 bar**	Non condensable (excessive air)	✓ Remove refrigerant ✓ Evacuate/dehydrate

Pd> 19.5-25 bar **Suction side piping is hot to touch.**	1. Large amount of air caused by insufficient evacuation after repair or servicing of system 2. Leak in system allowing air and moisture to enter.	✓ Change filter/drier. ✓ Charge correct amount of oil & refrigerant. ✓ Check performance
Low side -High **High Side- High** **Ps>2.5-3.0 bar** **Pd> 19.5-25 bar** **Frosting on suction side piping**	1. Expansion valve stuck open.	✓ Change the expansion valve.
Low side -High **High Side- High** **Ps>2.5-3.0 bar** **Pd> 19.5-25 bar** **Discharge air- Warm** **High side tubes-Very hot** **Compressor clutch- Could continuously cycle on the high pressure switch** **Pressure does not come to normal when condenser cooled by water**	1. Excessive refrigerant 2. Poor condenser cooling 3. Engine or condenser fan not working 4. Fan direction reverse. 5. Condenser fan clogged with debris/ sand. 6. Radiator overheating.	✓ Check refrigerant condition ✓ Check & repair condenser fan. ✓ Check condenser. ✓ Check pressure cap, clearance between fan and radiator. Check coolant and any other radiator problem.
Low side- Low or vacuum **High side- High**	1. Expansion valve- Stuck closed and or insufficient refrigerant	✓ Remove refrigerant ✓ Evacuate/dehydrat e

Ps> 1.5 bar to vacuum **Pd> 19 to 22 bar** **Discharge air- slightly cool**	flow to suction side of the compressor. 2. Foreign material or moisture entry causing rust formation.	✓ Change filter/drier. ✓ Charge correct amount of oil & refrigerant. ✓ Check performance.
Low side _ low or vacuum **High side- High** **Ps> 1.5 bar to vacuum** **Pd> 5 to 7 bar** **Discharge air-slightly cool** **High side tubes- Cool and showing signs of sweating or moisture build up at the position after the point of restriction.** **Temperature difference found on both the sides of the clogged component.**	Clogging on high side: 1. Clogging between compressor outlet and evaporator inlet (High side) 2. Very little or no refrigerant flow to suction (low) side of the compressor	✓ Remove refrigerant. ✓ Clean & flush system. ✓ Change filter drier. ✓ Charge correct amount of oil & refrigerant. ✓ Check performance
Low side Gauge- Normal to Vacuum (Gradual reduction) **High side- Normal** **Ps> 1.5 to vacuum** **Pd> 14 to 16 bar** **Discharge air becomes warmer as low side cycles to vacuum.**	1. Excessive moisture in system 2. Moisture can freeze within the expansion valve and cause blockage through rust formation.	✓ Remove refrigerant ✓ Evacuate/dehydrate ✓ Change expansion valve 9 check) ✓ Change filter/drier. ✓ Charge correct amount of oil and refrigerant. ✓ Check performance.

Low side- High **High side- Low** **Ps> 4 to 6 bar** **Pd> 7 to 10 bar** **Compressor –Noisy.** **Discharge air- Warm** **Discharge hose- Cool.**	1. Compressor malfunction. 2. Compressor faulty, internal blockage in suction Hose after low side filing port.	✓ Replace compressor. ✓ Remove refrigerant ✓ Evacuate/Dehydrate. ✓ Change filter drier. ✓ Charge correct amount of oil & refrigerant ✓ Check performance.
Abnormal noise	1. Belt slippage/damage. 2. Idler pulley misalignments 3. Compressor clutch pulley faulty. 4. Loose compressor mounting bolts 5. Loose A/C plumbing touching firewall/ front panel/ fenders. 6. Compressor internal damage.	✓ Correct belt tension/ replace belt. ✓ Replace bearing in the pulley. ✓ Check the compressor mounting ✓ Check for loose parts and correct. Fit rubber packing where clearances low. ✓ Replace compressor.
High /Low pressure equalize soon after compressor stops. **Compressor is not hot to touch.**	1. Faulty compressor discharge or inlet valve. 2. Faulty compressor seal.	✓ Replace compressor.

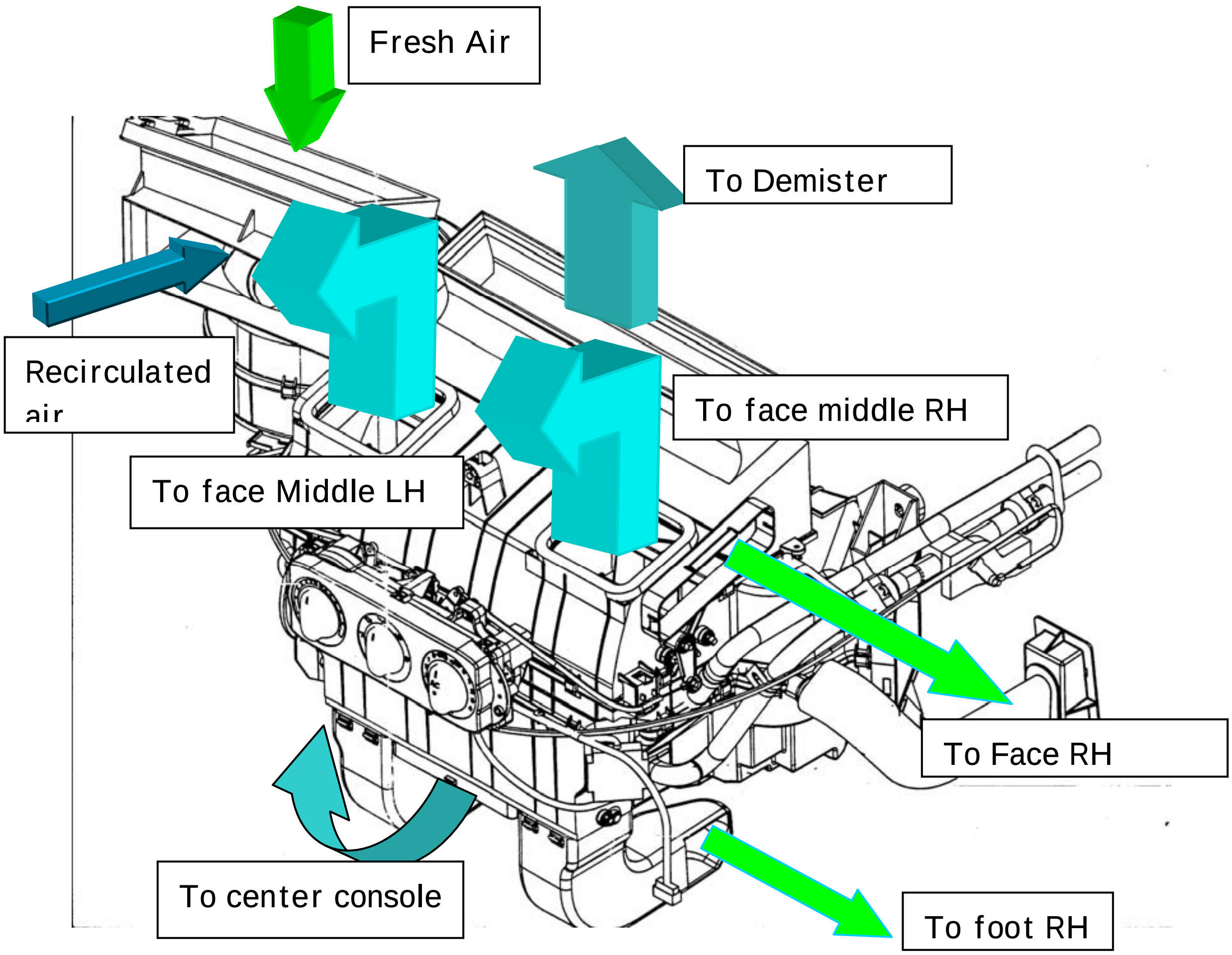
Compressor pressure drops rapidly after switching off and does not stabilize to saturation pressure as per ambient temperature.	1. Non condensable in system	✓ Recover refrigerant/ check for leaks and repair
Line to condenser is excessively hot.	Restricted flow of refrigerant in system	✓ Remove restriction Evacuate ✓ Replace receiver drier. Charge through the charging unit.
Insufficient/ no air flow	1. Blower rotation direction wrong. 2. Sealing disconnected. Insulation piece blocking air passage. 3. Mode cable not adjusted properly. 4. Voltage insufficient < 12 Volts 5. Improper earthing. 6. Open circuit, wiring harness. 7. Fuse blown 8. Filter clogged	✓ Correct the blower fitment. ✓ Renew sealing. Remove blockage. ✓ Adjust cable. ✓ Recharge battery. Check the charging system. ✓ Correct earthing. ✓ Correct wiring. ✓ Replace fuse. ✓ Clean filter element by tapping. ✓ Replace filter element if airflow is still insufficient after cleaning. ✓ Replace filter element after 15,000 km OR one year.

Compressor clutch engagement not satisfactory	1. Open circuit/ Fuse blown. 2. Weak battery. 3. Faulty clutch relay. 4. No refrigerant. 5. Shorted clutch coil. 6. Oil/ dirt on clutch plate.	✓ Replace fuse. ✓ Charge battery. ✓ Change relay. ✓ Check for leaks, charge refrigerant & oil & check. ✓ Replace coil. ✓ Change clutch plates
Check condenser/ radiator Fan- direction of rotation	1. Condenser fan pusher type Radiator fan puller. If fan not operating: • Loose connection • Loose wiring harness. • Motor burnout.	

Mahindra
Automotive Sector

MAHINDRA TECHNICAL INFORMATION SYSTEM

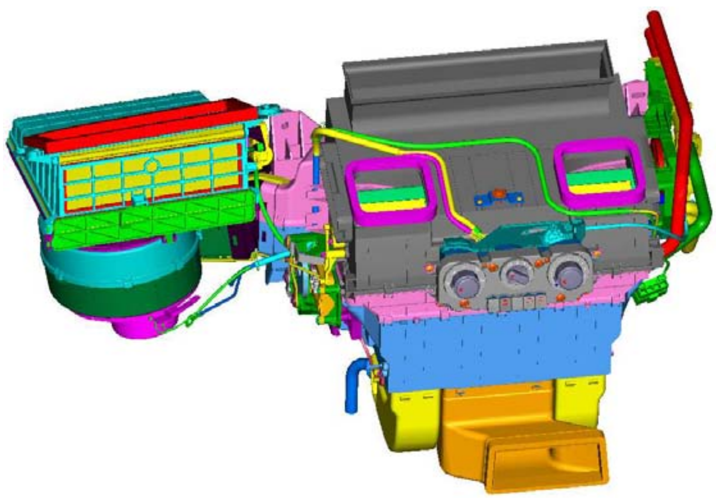
Air circulation in the climate box -



	Knob Position				
Flaps↓	Face	Face-foot	Foot	Foot-defrost	Defrost
Face LH	Open	Open			
Face RH	Open	Open			
Face Middle RH	Open	Open			
Face Middle LH	Open	Open			
Center Console	Open	Open	Open	Open	
Foot LH		Open	Open	Open	

Foot RH		Open	Open	Open	
Defrost				Open	Open

The Airflow can be either fresh air or recirculation mode.
The air box with the electrically controlled flaps & recirculation mode is slightly different. Sketch given below –



Care of the system --

The system should be flushed and charged every 50,000 or 1 year of operation. The quantity of the gas which has to be filled is 800 ± 20 grams.

The refrigerant used is R134A.

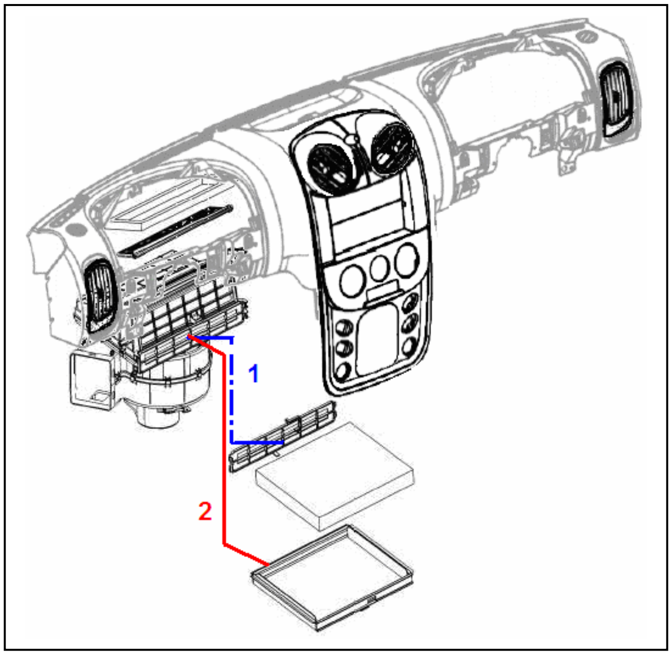
Do not use / mix R12 & R134 A. the oils used for compressor is unique for R134. DO NOT MIX. IT WILL CAUSE DAMAGE TO ‘O’ RINGS as well as the R/D.

Though R134A is non-CFC, it is recommended that it should not be discharged to atmosphere.

We recommend the use of **ROBINAIR** equipment for evacuation, charging of the system.

The particle filter should be cleaned at every 5000 kms & changed at every 15,000 Kms. Also it is recommended that the vehicle should not be driven with AC or Blower on without the particle filter as it will seriously damage the AC system components.

The procedure for cleaning the particle filter is as follows –

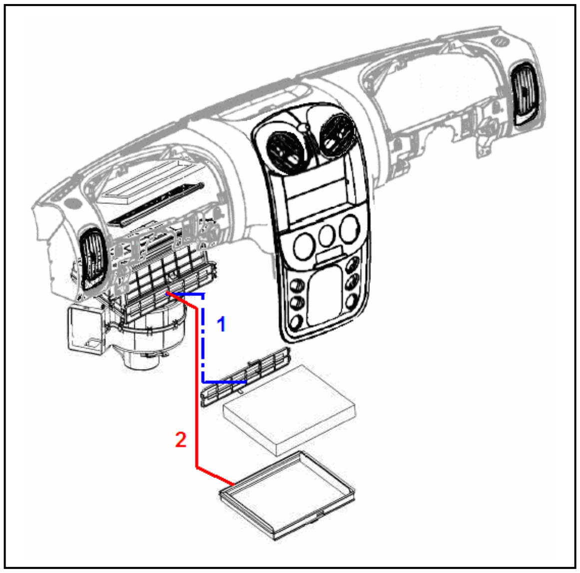


Remove the Glove Box.

1. Remove the HVAC Filter Cover by opening the snap clips on both sides.
2. Take out HVAC Filter Element.
3. Clean the Filter Element with air blow (!! – If compressed air is used, please ensure the pressure should be low).

Fit the cleaned HVAC Filter & Cover; lock the snap clips on both sides.

The procedure for the replacement of particle filter is as follows -



Remove the Glove Box.

1. Remove the HVAC Filter Cover by opening the snap clips on both sides.

2. Take out HVAC Filter Element.

3. Put the new Filter Element.

4. Fit the HVAC Filter Cover & lock the snap clips on both sides.

It is recommended that the evaporator fins be cleaned of dirt/ fungus every 40,000 Kilometer or once in 9 months for normal operation. If the vehicle is not clocking long mileage then also it should be cleaned every 9 months (normal areas) and 4 months in dusty conditions.

This will ensure that the heat transfer is effective hence better cooling and also increase the airflow. The recommended cleaning agent is mentioned in the recommended lubricant section.

In Car repairs --

Caution

- ✓ **Extreme care has to be taken to prevent any liquid refrigerant in coming in contact with skin. Always wear safety goggles.**
- ✓ **Do not allow liquid refrigerant to touch bright metal. Refrigerant will tarnish bright metal and chrome surface. Refrigerant in combination with moisture is very corrosive and can damage to all metal surfaces.**
- ✓ **When charging, always keep the tank in upright position. If the tank is on its side or upside down, liquid refrigerant will enter and affect the compressor.**
- ✓ **Always double check that the gas being used is a R134A.The refrigerant cylinder is color-coded to avoid confusion. R134A is Blue.**
- ✓ **The compressor oil for R134A gas is different from R12A compressor oil. Do not mix. If the R12A compatible compressor oil is used then it will damage the O rings as well as the receiver Drier.**
- ✓ **The Robinair equipment AC 350 should be used with R134A gas only.**
- ✓ **Never discharge a system or do brazing/welding operation when the engine is ON.**
- ✓ **PAG oil is highly hygroscope. Open containers only when ready to use. Cap containers immediately after use.**
- ✓ **Use only the specified oil for the AC system**
- ✓ **Do not allow PAG oil to contact bare skin.**
- ✓ **Do not allow PAG oil to contact paint work- wash immediately**

The charging procedure comprises of the following distinct steps -

Discharging the system --
The following procedure is recommended for evacuation.

1. Connect the hose of Recovery unit to the vehicle circuit
   Red hose to the high pressure charging port
   Blue hose the low pressure charging port

2. Open the quick coupler valves on the hose after they are connected to the system

3. Check the manifold gauges the units control pane. They should register above zero. If it is indicating zero then either the hose is not connected properly/or/quick coupler valves are not opened or the system is empty.

4. Make sure that the drain valve at the bottom is closed.

5. Open both the manifold valves on the control panel

6. Open the Gas (vapor valve and liquid valve on the tank).

7. Switch on the power

8. Choose Recover option from the panel

9. To assure that the complete recovery of the refrigerant. Wait for 5 minutes and watch the manifold gauges for a rise above zero.
10. If a rise occurs, press HOLD/CONT. repeat until the system pressure hold for at least 2 minutes

11. The system displays the weight of the refrigerant recovered.

12. Confirm that the oil catch bottle is empty. Then slowly open the drain valve and allow the oil to be drained into the bottle. When all the oil has been recovered, close the valve immediately. New clean oil must be added to system before recharging with the refrigerant

13. The automatic recovery unit will operate until the air conditioning system has been emptied of refrigerant down to atmospheric pressure. The cylinder can now be closed.

Evacuation of the system –

The evacuation and leak test ensues that the system does not leak under low-pressure conditions.

Ensure that the hoses are connected to the charging ports and valves on the hoses. Tank & manifold are open.

Choose vacuuming program (Shift/Reset option) from the control panel.

Set up the vacuuming time in minutes. Approximately 15 minutes of vacuuming time is recommended.

The unit displays the complete message after the vacuuming is over.

Check the moisture indicator. If it is green, it means that the system is ready for recharging. If it is not green then manual recycling has to be done for one hour. In case the moisture indicator still does not turn green, the reason could be saturated receiver drier. It should be replaced.

The charging station is equipped with recycling facility. During evacuation the refrigerant is automatically recycled to assure recharging with the cleanest possible refrigerant. Recycling begins automatically after 5 second of the vacuum pump starting. Non condensable gases (mostly air) are automatically vented from the tank.

The system must hold the vacuum of –100 Kpa for a minimum of 15 minutes. If vacuum is held then the system has no ands and should be evacuated for further 15 minutes

This completes the evacuation process.

Purging – if required --

Where the system has been ruptured, contaminated, or a compressor has to be removed, reinstalled or replaced, the system should be checked for contamination, and if so then the entire system must be flushed.

The system can be flushed with Nitrogen.

Preliminary charging & High Pressure leak test --

This ensures that the system does not leak under high pressure conditions.

Confirm that the hoses are connected to the charging ports and valves on the hose, Tank & manifold are open

Enter the refrigerant quantity by weight and press ENTER. (At least 200 grams of charge is required to do the high-pressure leakage test)

Press CHG to start charging. The unit displays the completed message after the charging is completed.

Use the electronic leak detector to probe the leakages. Leakage checking to be done at the following points –

- Expansion valve joints
- All pipe joints.
- Suction & discharge ports.
- Both the charging ports

Note: Inspect for leaks by slowly moving the probe of the detector around all the hose connections and points of possible leakages. The R134A is heavier than air; hence, any leakage will be more apparent at the bottom of fitting.

Charging the system –

If no leaks are found then do an additional charging of 600 ± 20 grams. The total system requirement is 800 ± 20 grams.

However in case of leakage, the system should be discharged.
After that repeat, the steps from evacuation onwards till the above steps. Then proceed.

In case the system was checked for High pressure leaks by using Nitrogen, Evacuation should be done first and then system should be directly charge with 800 ± 20 grams.

Close both the manifold valves and then start the vehicle.

Start the vehicle's AC system and set it to maximum cooling. Check the pressure gauges and temperatures in the vehicle.

Turn off the engine.

Disconnect the high side hose and start the vehicle. Open both the manifold valves to pull the refrigerant from both the hoses into the system.

At the lowest operating pressure close the low side valve and switch off the vehicle. Disconnect the low side hose and remove adapters if used.

Close the high side manifold valve. Both the valves should now be in closed position.

- ✓ Do not start the engine when the valve on the manifold and tank are open.
- ✓ Ensure that the valves are closed before starting the engine.
- ✓ Never run the compressor without the refrigerant in the system as the lubricant relies on the refrigerant flow

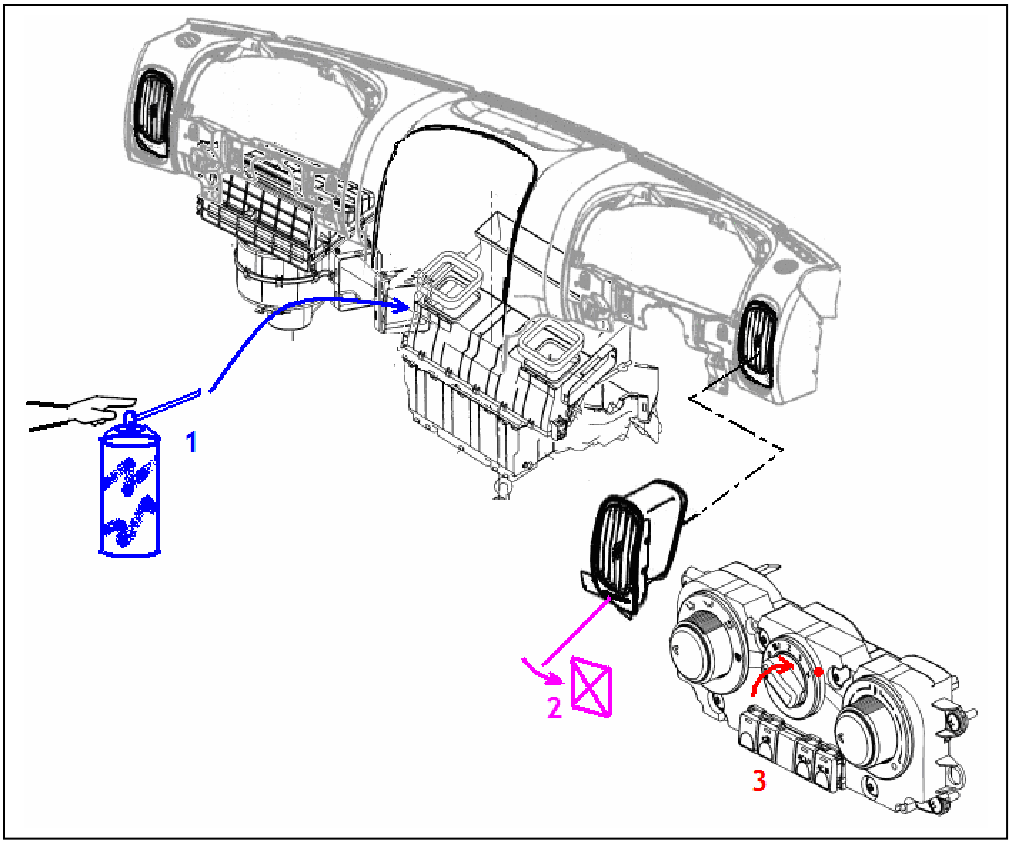
Accurate system refrigerant charge can only be determined by charging the correct amount of R134a.

If in doubt as to gas charge, e.g.
Suction pressure low
Or
Discharge pressure low
Or
Air outlet temperature at the face high.

Then: Evacuate the system and Charge with the 800 ± 20 grams of R134 A

Carry out cooling system pressure test and suction (low side) pressure reading *comparison.*

Evaporator Cleaning Procedure -



Remove the Glove Box, remove Blower Connection & remove Blower Assembly.

1. Insert "Coil Rinse Nozzle" inside the Climate Box Assembly at the blower neck.
   - Spray "Coil Rinse" at least 2 times.
   - After Spraying, the Liquid becomes Foam & enters in the Evaporator coil.
   - Assemble the removed Blower Assembly again.
   - Wait for 10 minutes.
2. Close all the Vents / louvers.

3. Start AC with Blower on 1st speed, Run the Engine at 1500 RPM for 5 minutes.

- Put AC Off & put Blower on 4th Speed for 5 minutes, Close all the Vents.
- All the Evaporator Containments & Water (Liquid) will drain out through the Drain Hose & Evaporator becomes clean.

Special Instructions for Vehicle Users to avoid Wet Smell on the Evaporator:

Put OFF the AC & put Blower on 4th speed 5 minutes before stopping the Vehicle, this will keep Evaporator DRY & NO WET SMELL will come from Evaporator.

Performance test -

Pressure gauge readings together with the face air outlet temperatures are the only method of checking and diagnosing the cooling system.

Checking system oil charge —

The compressor is charged at the factory with 130 cc of FD46XG(PAG) refrigerant oil, which circulates within the entire AC system. Only this type of oil, which is pale yellow in color, must be used when adding or changing oil. This oil is not compatible with any other PAG oil. It is not necessary to regularly check the oil level in the system. It should be remembered that the oil gets circulated within the whole system. Therefore, whenever an AC system component is replaced a quantity of new refrigerant oil must be added to the system, where a major loss of system oil has occurred. The loss normally takes place when:
Hose failure or leak is present.

Refrigerant system component is damaged due to collision.
If oil is suspected to be in the system

The procedure to be followed is -

Recover refrigerant from the system by evacuation.
Drain out the refrigerant oil.
Flush the remaining oil using R134a refrigerant.
Add 110 cc of new refrigerant oil to the compressor.
Install the compressor after replacing the Suction and discharge “O” rings.
Note: Ensure that the ‘O” rings are not twisted and that both the seals and ‘O’ rings are clean and then oil.
Follow the steps of **charging procedure**.

Compressor Replacement -

1. Discharge the refrigerant

2. Remove the suction and discharge pipes from the compressor, ensuring no foreign items get clogged to the ports. (In order to have better accessibility it is suggested that the following parts be removed first-right wheel, right aprons; oil cooler)

3. Loosen the tensioner pulley.

4. Remove the fan belt

5. Loosen the compressor mounting bolts.

6. Remove the compressor.

7. Drain and measure the refrigerant oil from the original compressor by removing the drain plug.

8. For example, the oil quantity drained from the original compressor is 80 cc.
   The replacement compressor comes with 130 cc of compressor oil.
   The implication is that out of the total 130 cc of the original compressor; 50 cc of oil is in the system. Hence if the replacement

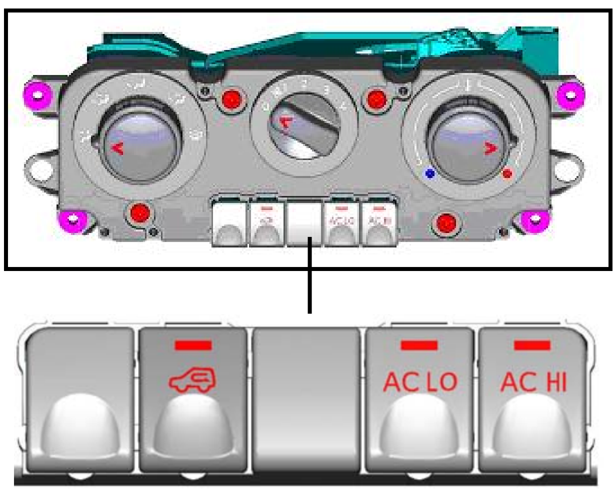
compressor is fitted as it is, it will cause this 50 cc extra to get into the whole system and affect the performance.

9. Hence it should always be –
   Oil to be drained from new compressor =Total oil capacity of compressor- Drained oil
   The refitting procedure is the reverse of assembly procedure.

10. Follow the steps of **charging procedure.**

Control Panel --

The control panel has 3 knobs- the right knob is for degree of cooling to heating- depending on the knob setting. For maximum cooling set the knob on blue color dot and for maximum heating set the knob on red color dot.

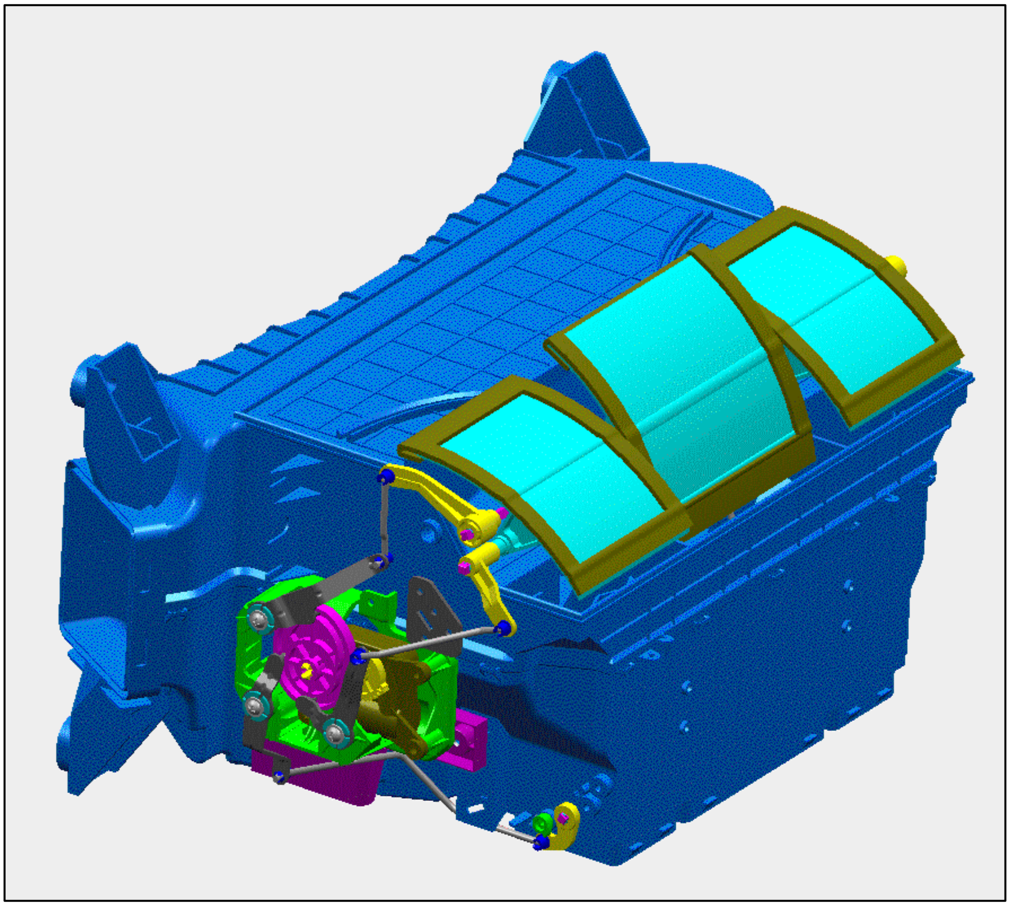


The left knob sets the flap position to direct the airflow to face only or face & feet or feet only or feet & defrosting or only defrosting.

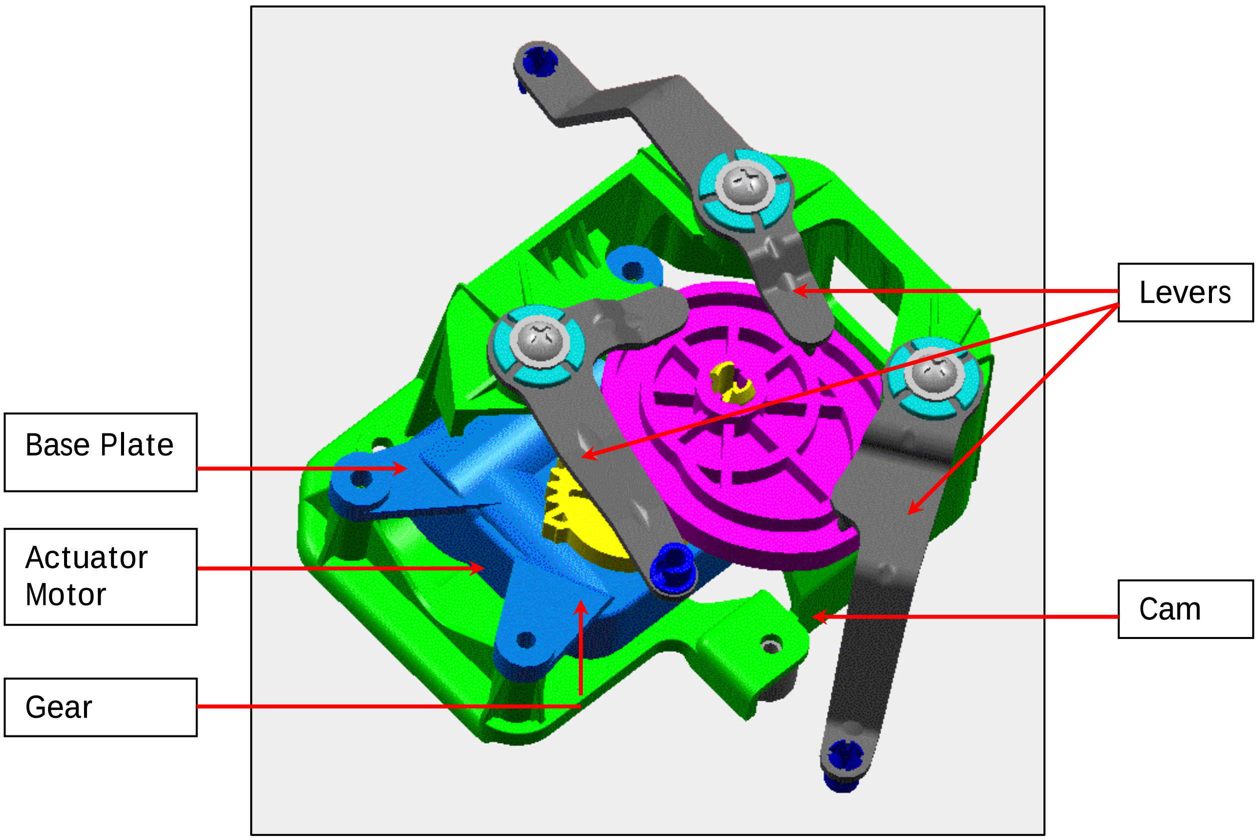
The middle knob controls the blower speed. The bottom row indicates AC low , AC high & fresh air / recirculation mode.

The control panel is PCB based & has only one cable for water valve opening operation.

View of the Base plate assembly with actuators (Electrical Operation of Flaps & circulation modes –



View of the electrical actuator base plate Assembly –



Setting of the Control Panel Cable --

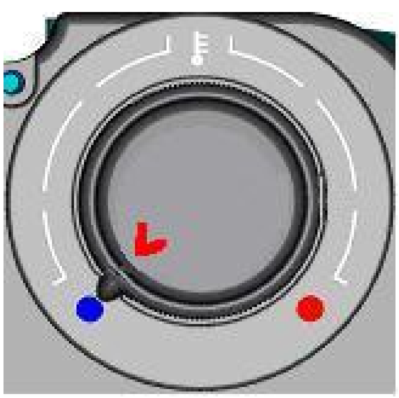
The procedure, which is, outlined below are the setting procedure for assembly. However, please note that the removal of the cables should also be done in the same positions.

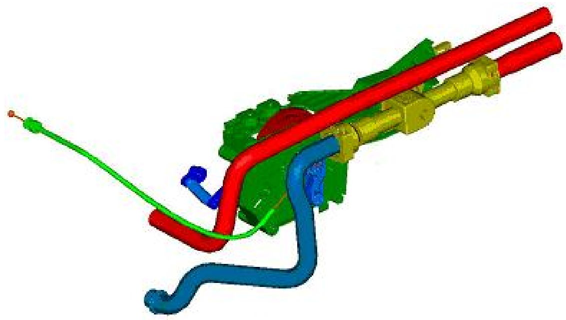
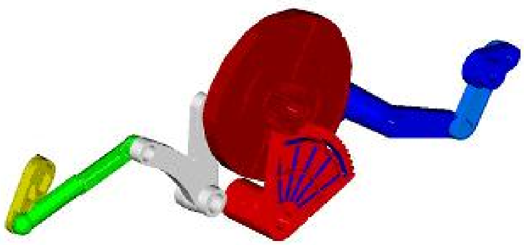
Caution: Failure to follow the procedure may cause breakages.

Note: The procedure for setting of the links with Electric actuation is given after the manual control panels

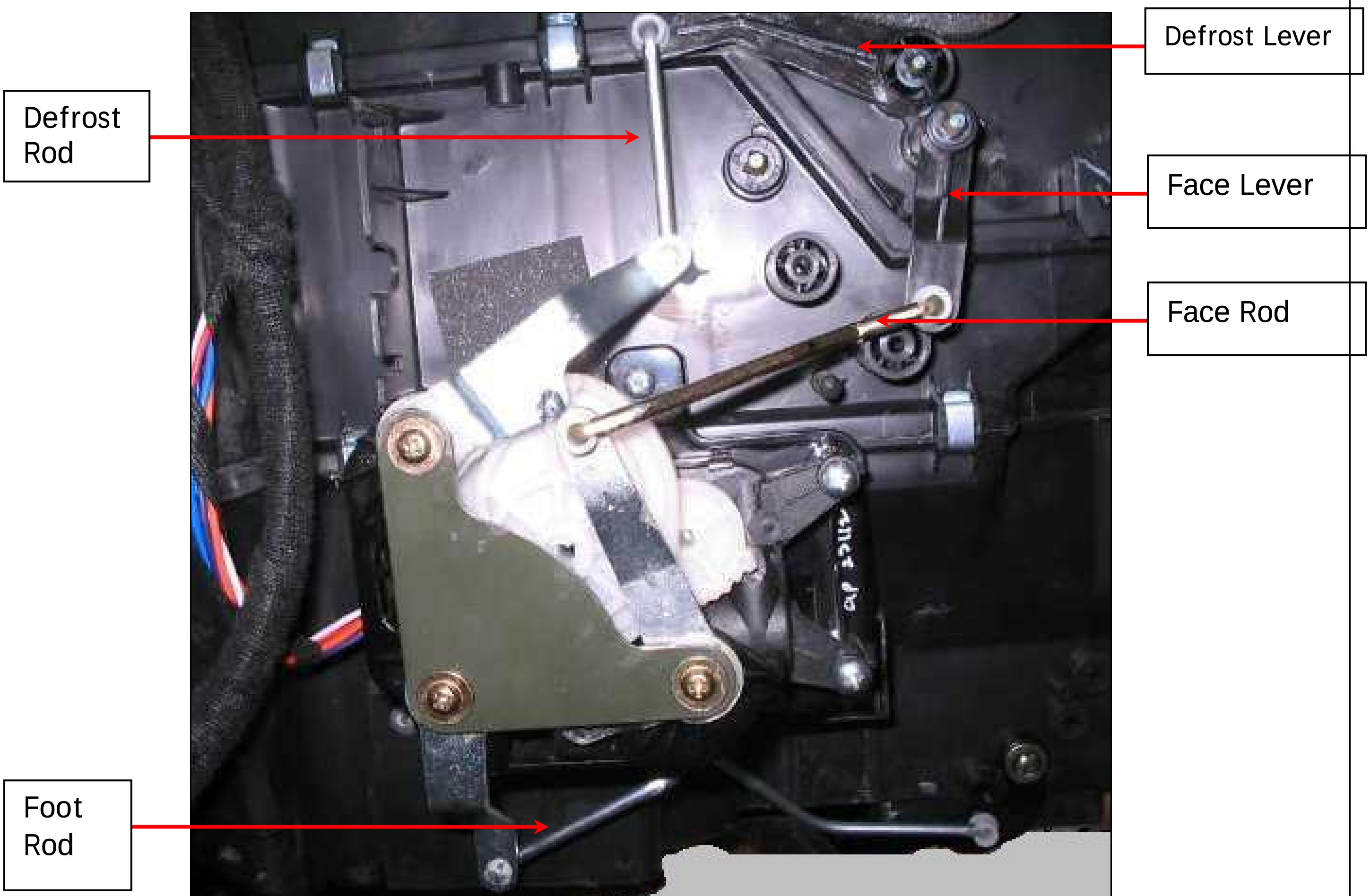
[Water valve setting Procedure]

Water valve setting Procedure –

Hold the control panel in front of the housing.	
	Keep the cooling & heating knob at the highest cooling point position.

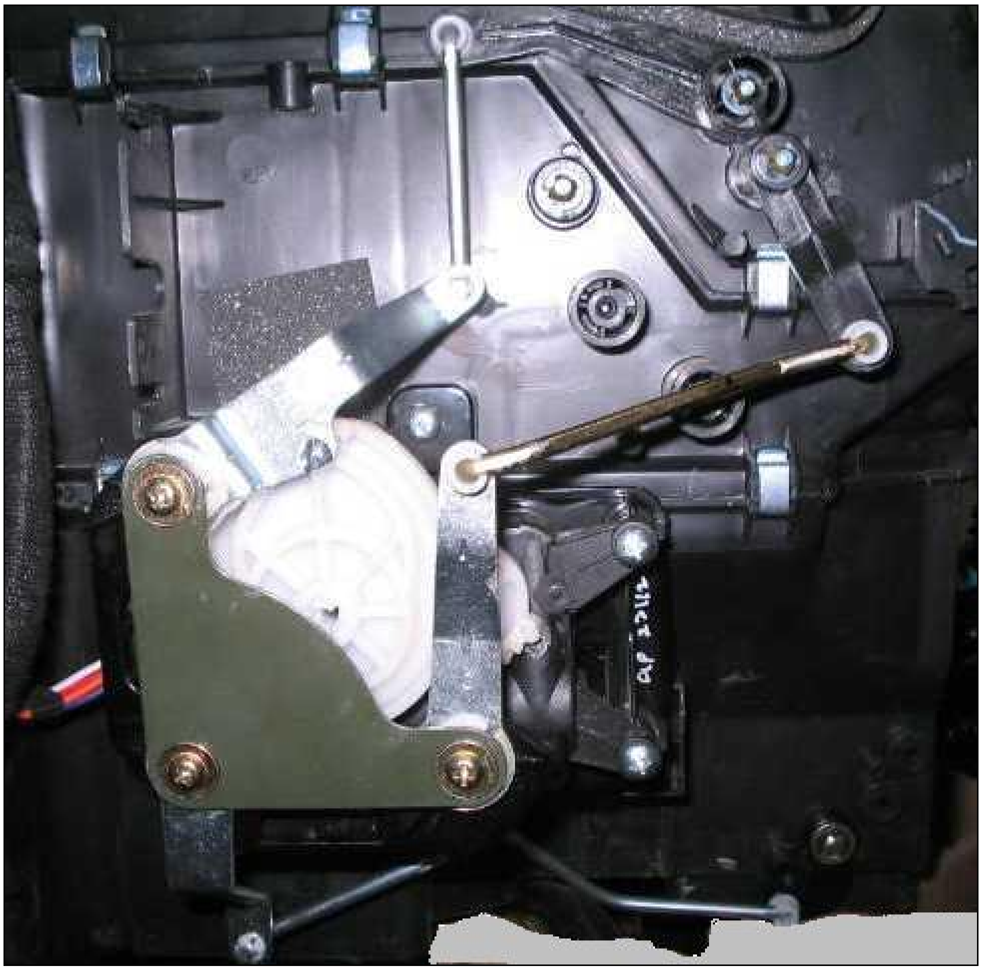
	
 **Water lever at closed position,**	Clamp the cable of the control panel water valve to closed position of water lever in the housing side.

View of the Climate control box with Electric Actuation Showing the linkages for different actuation –

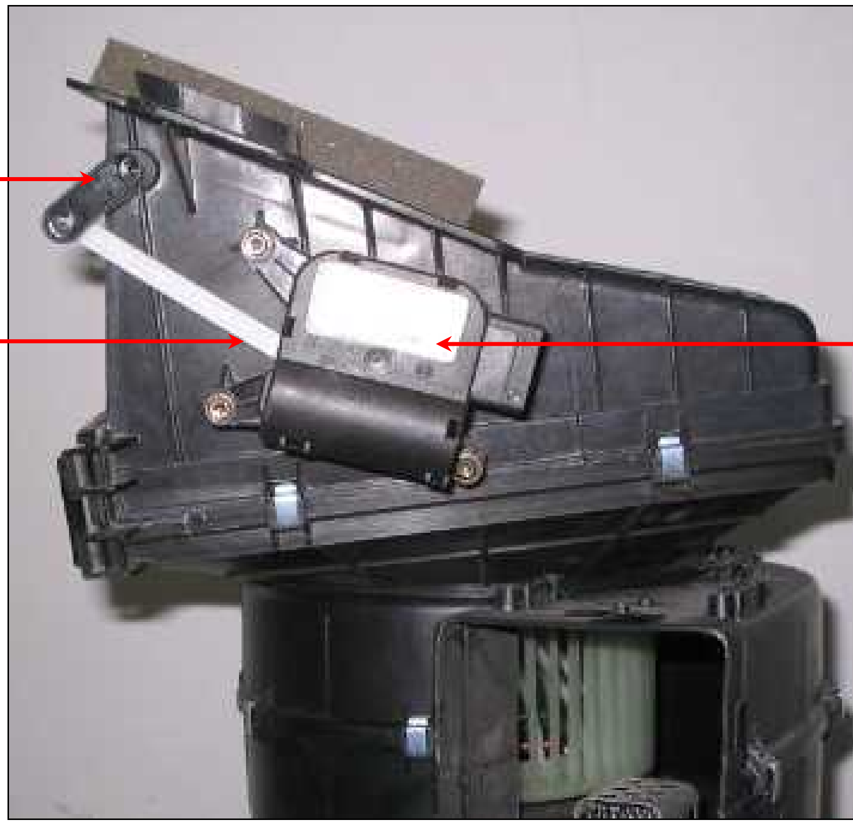


Fitting the rod by snapping it on the Hook -

Photo showing the levers in the face mode -



Fitting the Fresh /re circulating flap (with the flap in the fresh air mode)



Automotive Sector

Replacing the Antifreeze switch -

The function of the anti freeze switch is to protect the refrigerant system from damage. It switches off the compressor when the condenser water dries ices up on the evaporator fins. Otherwise, the evaporator becomes extra cool, resulting in the air passage between the fins getting blocked. Suction pipe becomes extra cool and sometimes iced up, the refrigerant remains liquid even after the expansion valve due to insufficient heat transfer across the evaporator surface and eventually the compressor will get damaged due to liquid refrigerant inflow.

Replacement procedure:

Remove the wiring harness from the connector.
Pull out the probe carefully.
While fitting back, ensure that the washer & the O ring is present.

Recommended Lubricants -

Refrigerant: R134A
Compressor oil: FD46XG. PAG stands for (Poly Alkaline Glycol oil)

Evaporator cleaning Agent --

"Coil Rinse" Packaged by Chemguard Laboratories; Kuala Lumpar.

In India Marketed by Astro Trading Company
Contact person Mr. Rakesh Bhai; Mobile no 9820141308

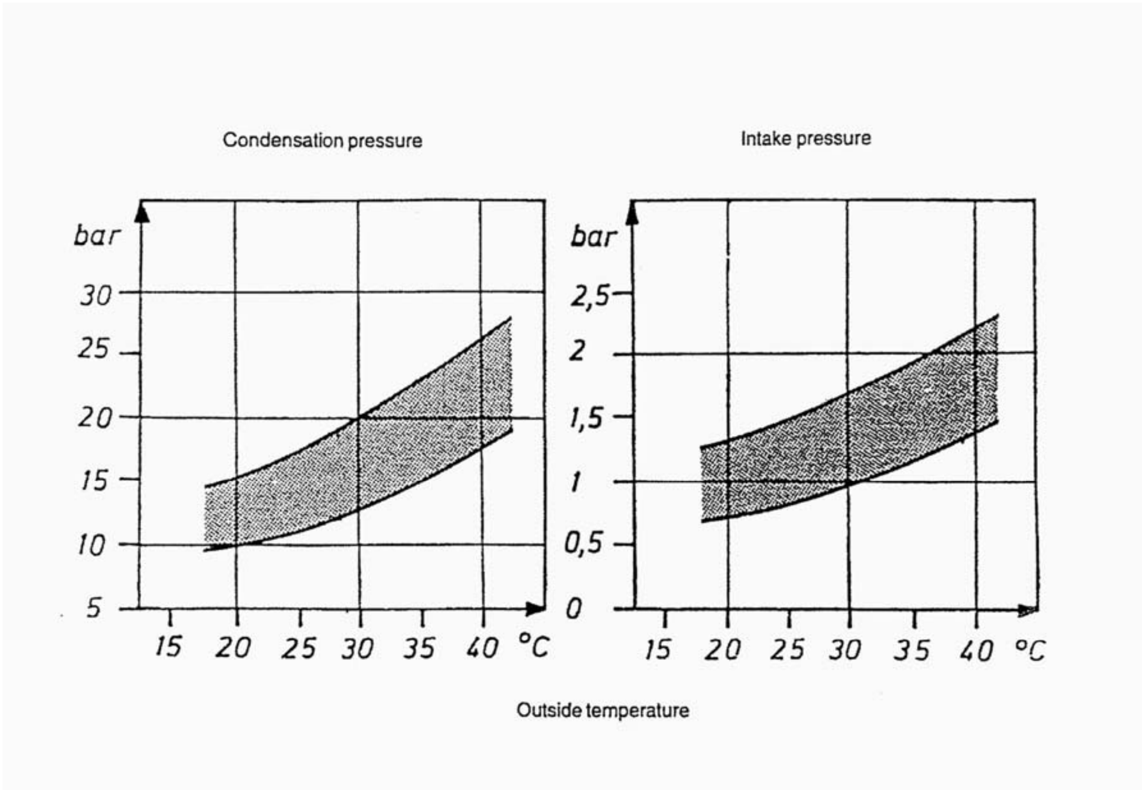


Chart showing the Effect of ambient temperature on Low Pressure side pressure & High side pressure with R134 A

Blower Motor: 3700±300 ; 12 V; 300 W
Condenser Motor : 2500± 200; 12V ; 200 W
Expansion Valve- 2T

Specifications -

Description	Specification
Compressor Capacity	110 cc
Oil Specification & quantity	FD46XG. PAG stands for (Poly Alkaline Glycol oil) – 130 ml.
AC Gas Specification	R 134 a
Gas Quantity	800 ± 20 gms.

Mahindra
Automotive Sector

MAHINDRA TECHNICAL INFORMATION SYSTEM

Wheels & Tyres

Contents

Description

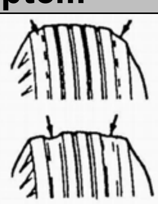
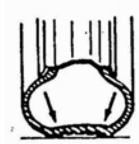
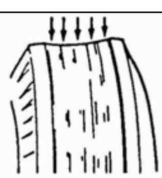
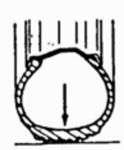
The tyres fitted in Scorpio are radial tubeless tyres and with a suitable wheel disc.

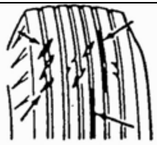
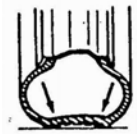
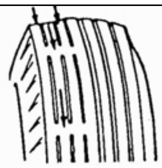
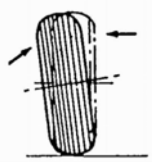
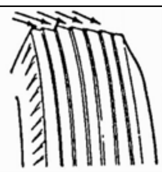
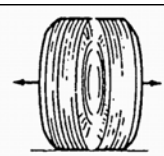
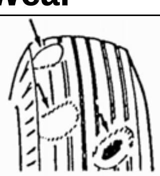
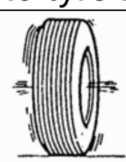
In the tyre P 245/75 R 16 - The 245 is the width of the tyre in mm at the designated air pressure and load. The / 75 is the aspect ratio of the tyre. (Ratio between the height and width here the height is 0.75 times the width

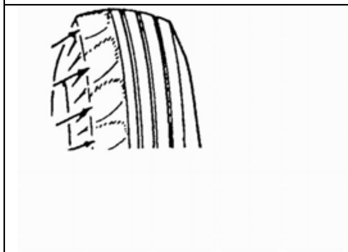
The tyres play a very important and vital role in the vehicle handling and ride characteristic. Hence it is advised that any change not as per the specification have to be done with caution.

The air pressure maintained has a direct influence on the fuel average obtained, braking and also on ride characteristic. Hence it is imperative that the tyre pressure be maintained as per specification. The tyre specified with the specified air pressure gives these tyres a safe speed of 180 Km/hr

<u>Trouble Shooting</u> -

Symptom	Causes	Remedial action
 **Rapid wear at Shoulder**	 Under Inflation Lack of rotation Excessive cornering.	✓ Maintain the correct tyre **pressure.** ✓ Do the **tyre rotation.**
		✓ Maintain the correct tyre pressure.

Rapid wear at centre	Over inflation	
 **Cracked Treads**	 Under Inflation	✓ Maintain the correct tyre pressure.
 **One Edge Wear**	 Excessive camber Excessive cornering	Check and adjust: ✓ Hub end play ✓ Camber to be checked and adjusted.
 **Feathered Edge Wear**	 Incorrect Toe In No tyre rotation.	✓ Check & correct Toe In ✓ Check the chassis bend ✓ If tyre rotation not carried out as per schedule. Do the tyre rotation.
 **Bald Spots**	 Unbalanced tyre Out of round brake drums in rear. Faulty wheel bearings.	✓ Balance the tyres. ✓ Check the brake drum roundness. ✓ Check jammed wheel cylinder/ calipers. ✓ Check the wheel bearings. ✓ Avoid driving with sudden brake locking.

	Sudden braking.	
 **Wavy / Scalloped wear**	Lack of rotation or Worn or Out of Alignment Suspension	✓ Tyre rotation. ✓ Check & replace the suspension components.
Side Wall crack-radial/ diagonal	Kerb damage Stone hit	
Side wall crack circumferential / tyre bulging	Run Flat (It is more obvious from inside)	

Care of the system -

The tyre is one of the most abused components hence maintaining the tyre is of utmost importance.

The recommended tyre pressures are given below:

	245/75 R16	
	Front	**Rear**
Laden	2.1 bar / 30 psi	2.5 bar / 36 psi
Unladen	2.0 bar / 29 psi	2.1 bar / 30 psi

The tyre pressure should be checked once in a fortnight. (Once a week during summers). The tyre pressures should always be checked & corrected in cold condition. The valve should be always covered with the valve cover. An opened valve can have the valve needle stuck in a partial position causing the tyre to bleed during operation..

The tyre pressure specified can cater to continuous high-speed performance. Hence it is not advisable to increase the tyre pressure before going on a high speed run.

The practice of keeping the tyre pressure lower in summer is actually detrimental to the tyre. To understand that let us examine what happens – if lower pressure is kept. Then the sidewall flexing is going to be more hence the heat generation will also be higher which will result in a faster increase in tyre pressure. So the wear rate is going to be higher.
Similarly the practice of bleeding the tyre pressure to reduce the pressure after a long run can cause the sidewall to crack and in a worst scenario sidewall bulging.

Before going on a long drive it is a good practice to remove the stones/pebbles trapped in the treads. The probability of a puncture due to stone trapped and digging through the crown once it gets heated up is reduced.

It should also be kept in mind that a radial tyre with higher pressure is more prone to burst under impact from stone at high speed or kerb impact. Lower air pressure results in higher sidewall flexing and drastically increases the chance of sidewall damage / cut in bad roads.

Wheel balancing should be done at least every 20,000 Kms. It is compulsory to do a balancing of the wheel after any puncture.

The tyre rotation should be carried out every 10,000 Kms.

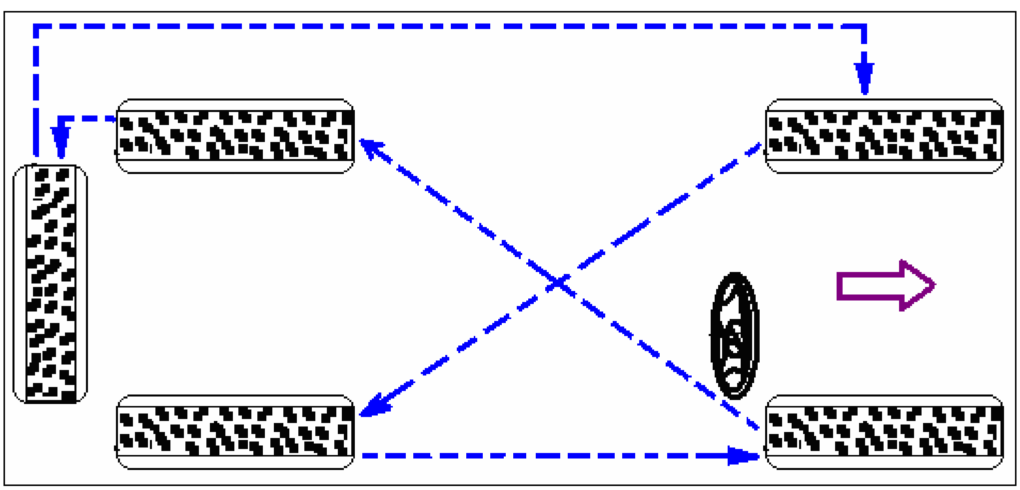
An improper wheel alignment will have an adverse affect on the life of the tyre. Hence it is suggested that the wheel alignment be checked initially at 10,000 kms then every 20,000 Kms. (In case the vehicle has traversed through extremely bad terrain at high speed then it should be done earlier. If the wheel disc is having any deformation particularly in the bead seating area then do not wait until the mileage has covered- get it balanced.) In case of abnormal tyre wear refer to the Trouble shooting section and take the corrective action suggested.

The grooves in the tyre are used to pump out the water between the road and the tyre. In case the water is not pumped out the tyre will ride on water. Since the coefficient of friction of water is very low that will result a sliding action. Obviously the amount of water which the tyre can pump out between the ground and the tyre will depend on the depth of the groove which is acting as a channel. The tyre manufacturers recommend that a minimum tread depth of 1.6 mm should be present.

Once the tread depth is less than 1.6 mm it is recommended to replace the tyres. I t is not advisable to retread the tyre.

Any kind of lubricant on the tyre is detrimental as it promotes degradation of rubber and also increases the chance of hardening. Normally this happens when a mechanics rubs the spare oil or grease on to the sidewall of the tyre.

Tyre Rotation –



1. Rotate (swap the positions) the wheels as shown in the diagram above

- Driver side rear goes to Driver side front position.
- Driver side front wheel goes to Co-Driver side rear position.
- Co-Driver side rear wheel goes to spare wheel position.
- Spare wheel goes to Co-Driver side front position.
- Co-Driver side front wheel goes to Driver side rear position.

2. Check & ensure tyre pressure as specified above in all five wheels according to their positions.

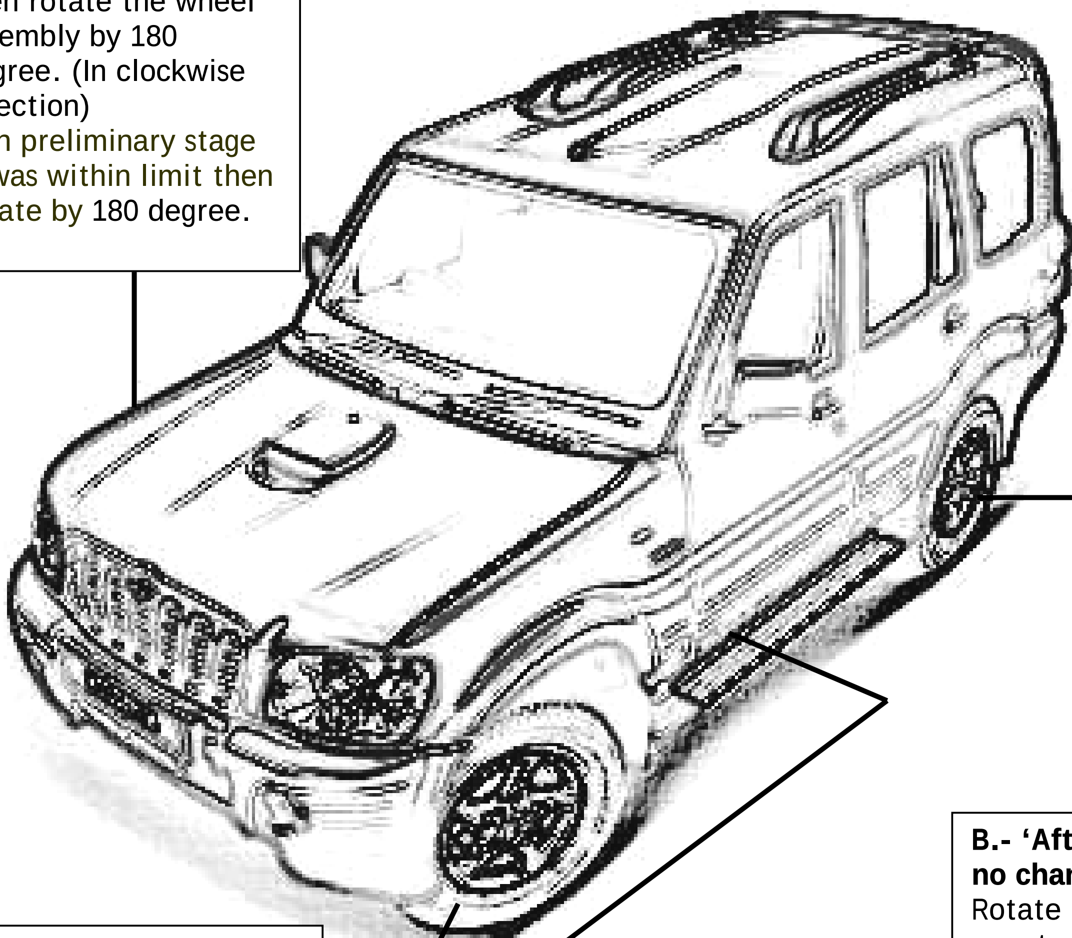
In case the vehicle reports for wheel wobbling then the sequence of balancing & rotation should be as follows:

Important: Before going ahead with the procedure; do a road test and at that time:-

Please remember that the road shocks can come to the steering wheel while going over rough or uneven patch.
The important point is that after the road shock is over then it should not continue to vibrate.

Preliminary Stage:
Mark each tyre assembly position with respect to the hub/ axle shaft.
Balance all the tyre and place it back it each wheel in the same position. (Tyre pressure for all wheel-32psi)
Now follow the sequence of Stage A, Stage B, Stage C. Road test after each stage:

A. If in preliminary stage this tyre balance was above balancing limit, then do not rotate.
If during road trial no change in wobbling, then rotate the wheel assembly by 180 degree. (In clockwise direction)
If in preliminary stage it was within limit then rotate by 180 degree.



rotate the assembly by 180 degree in clockwise direction

B.- 'After A if no change'
Rotate both the rear tyres assembly by 180 degrees.
(In clockwise direction)

Sequence of operations:

Road Test → **A** → Road test → **B** → Road test → **C** → Road test

Caution: If the stages of A, B, & C are done together then improvement may not be noticed. In worst case scenario the problem may get aggravated.

Before dismounting the wheel Mark the position of the wheel & tyre assembly with respect to the hub (uses any wheel mounting bolt as a reference and applies a paint mark to hub with respect to disc + tyre.

↓

Check the wheel balancing.

If the imbalance amount is less than 40 gm.

If the imbalance is > 40 gm

C After B - If after road test no change in wobbling; then

↓

Rotate the wheel assembly & check the imbalance

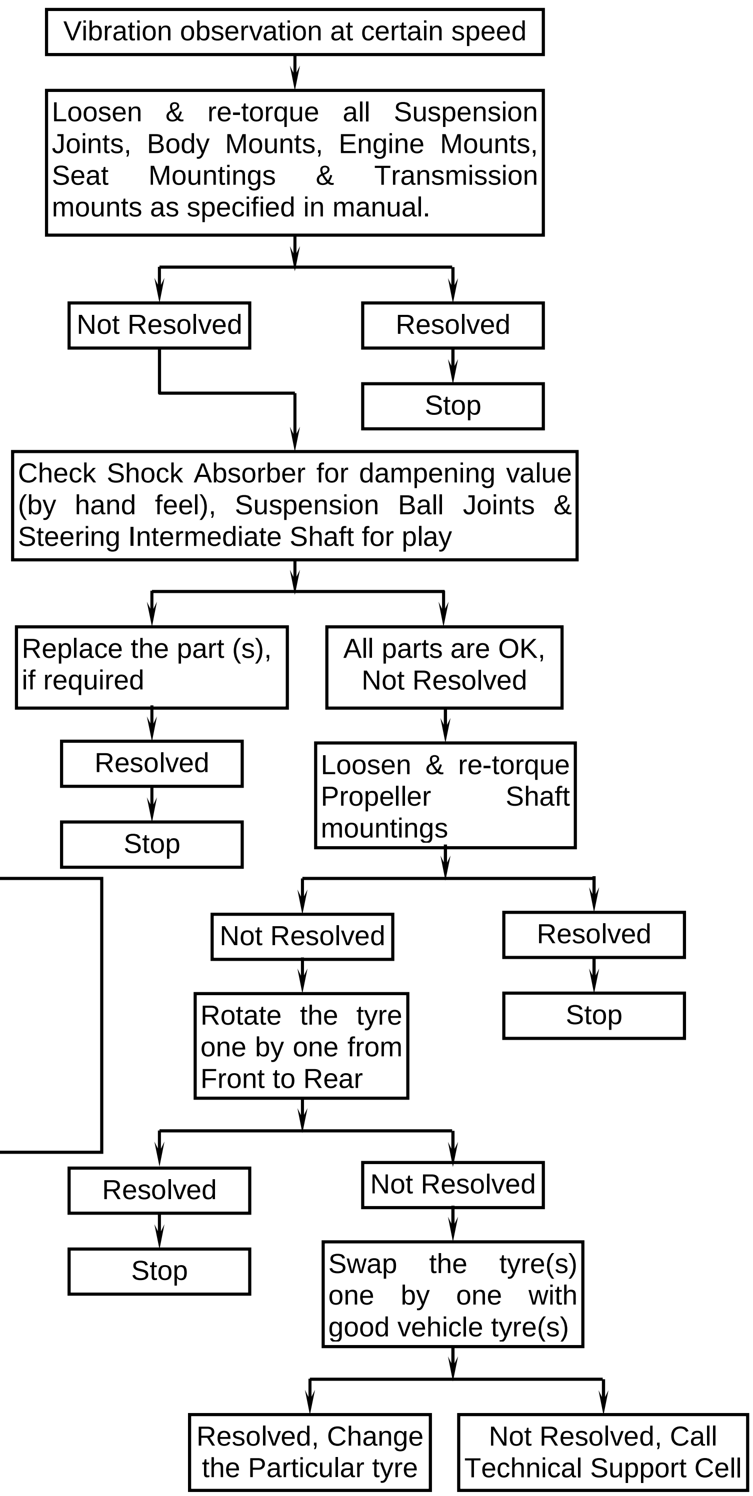
↓

Imbalance location should not change more than 80 mm in circumference.
The max imbalance can be 40 gms

↓

While mounting the wheel assembly, rotate the wheel assembly by 180 degrees.
Now the matching marks will be opposite

Flow chart to attend Vibration Concern



In Car repairs -

The tyres should be removed and then only be attended for puncture or damage.

For removal of the tyre from the vehicle the jacking points are:

For 2WD Front- to be supported on the chassis, behind the lower arm just below the first outrigger.

For 4WD Front -Behind the lower arm just below the first outrigger. While locating the jack or the locating for the 2-post lift please ensure that it does not touch the torsion bar. (It can cause the torsion bar to bend.)

For the rear wheels: below the axle.

Caution

Never go under the vehicle when it is jacked up. This jack is meant for only raising the wheel. For any under body work/inspection support the vehicle on vehicle stands.

If the vehicle is run with severely under inflated tyres – the vehicle stability may be affected. A run flat wheel can also damage the wheel disc- besides literally shredding the tyre.

Removal & Refitment of the tyre -

It is recommended that the tyre removal and re-fitment on the wheel disc be done in a tyre specialist shop where the tyre fitting machines are available. The advantage of the machine over the conventional method is that the damage to the beading area is totally avoided.

In absence of the machine; ensure that:

No sharp tools are inserted while removing the tyre.
No sharp tools/ screwdriver is used while fitting the tyre.

While refitting the tyre the use of powder between the tube & the tyre is recommended

It is recommended that the tyre be inflated to a pressure of 40 PSI. This will ensure that the bead is locked in properly and also in centralizing. Then later reduce the pressure to the recommended pressure.

Removal & Refitment of the spare wheel from the vehicle -

	Remove the covering on the rear and using the wheel spanner lower the spare wheel
	Lower the wheel on to the ground and take off the locating tang from the disc.
	The fitment of the old tyre to the spare wheel carrier is the reverse of the above procedure.
	While fitting the tyre on to the axle ensure that : - The boltholes in disc are not oblong. - The threads of the bolt are not having dirt – neither is there dirt/ mud in the nut. (Generally while removing a wheel the nuts are left in the ground collecting dirt/mud. It is a better practice to keep the removed nuts on vehicle. -

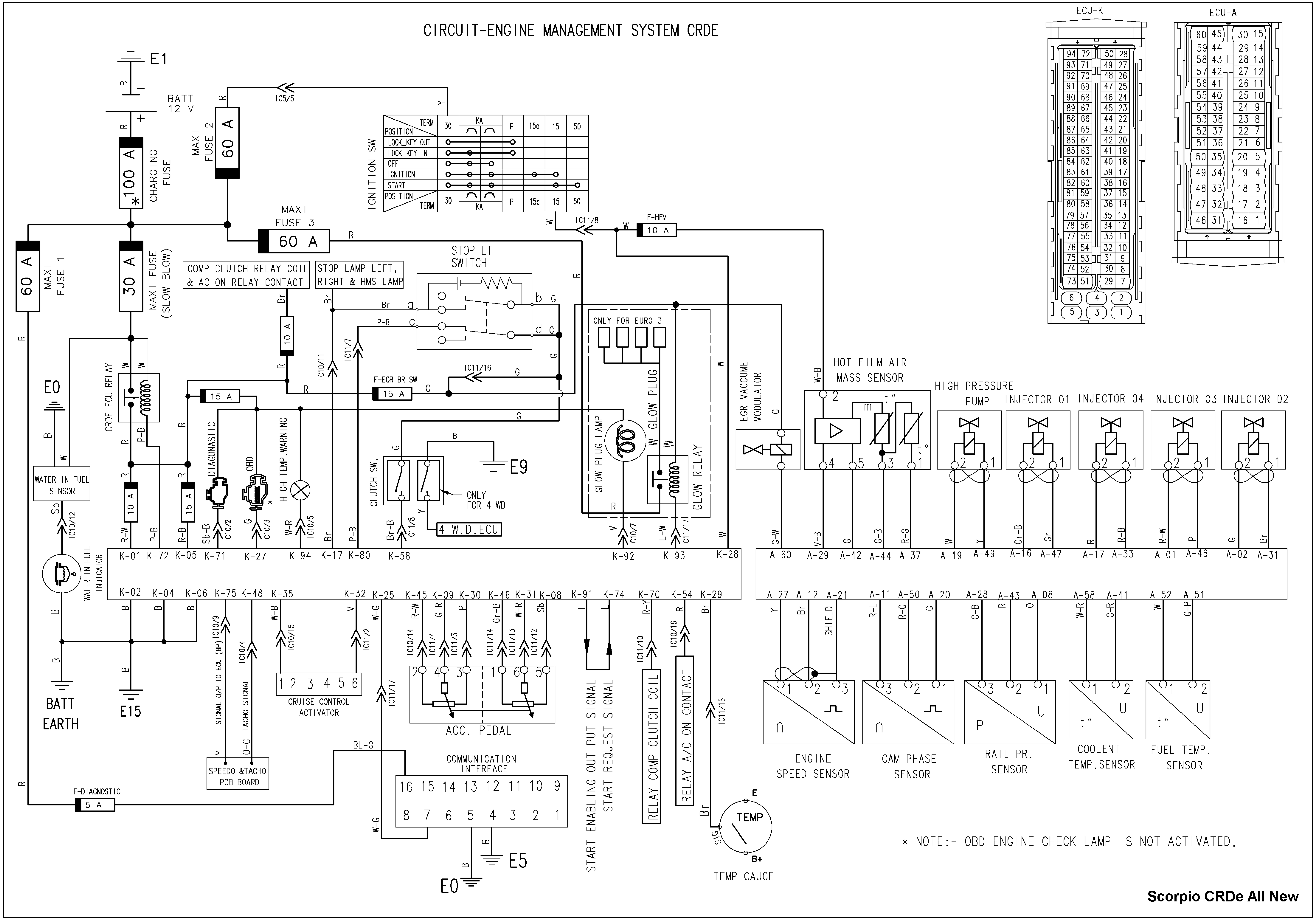
	While tightening the wheel nut tighten in diagonally opposite order to each other. **Caution : Failure to do so can cause vibration of the steering wheel at high speed.**

Tightening Torque's –

Description	Torque in Nm (lbf-ft)
Wheel Nut	97.5± 5 Nm (72 ±4 lbf-ft)
Body Mounts	45 ± 5 Nm (33 ± 4 lbf-ft)

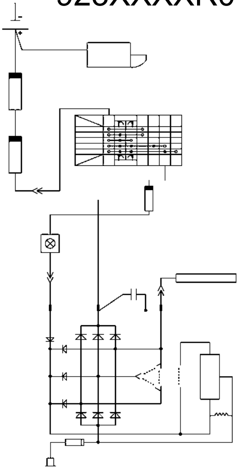
Specification & Wear Data –

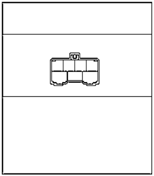
Description	Value
Run out of the tyre- radial	1.5 mm
Run out of the tyre- lateral	1.5 mm
Unbalanced allowed- tyre	Max. 1.8 Kgf
Minimum tread depth	1.6 mm


CIRCUIT-ENGINE MANAGEMENT SYSTEM CRDE
E1
BATT 12 V
CHARGING FUSE
100 A
MAXI FUSE 2
60 A
MAXI FUSE 3
60 A
MAXI FUSE 1
60 A
MAXI FUSE (SLOW BLOW)
30 A
IGNITION SW
TERM
POSITION
LOCK_KEY OUT
LOCK_KEY IN
OFF
IGNITION
START
30
KA
P
15a
15
50
COMP CLUTCH RELAY COIL & AC ON RELAY CONTACT
STOP LAMP LEFT, RIGHT & HMS LAMP
STOP LT SWITCH
F-HFM
10 A
F-EGR BR SW
15 A
ONLY FOR EURO 3
GLOW PLUG
GLOW PLUG LAMP
GLOW RELAY
EGR VACCUME MODULATOR
HOT FILM AIR MASS SENSOR
HIGH PRESSURE PUMP
INJECTOR 01
INJECTOR 04
INJECTOR 03
INJECTOR 02
ECU-K
ECU-A
E0
CRDE ECU RELAY
WATER IN FUEL SENSOR
WATER IN FUEL INDICATOR
DIAGONASTIC
OBD
HIGH TEMP.WARNING
CLUTCH SW.
ONLY FOR 4 WD
4 W.D.ECU
E9
BATT EARTH
E15
SIGNAL O/P TO ECU (8P)
TACHO SIGNAL
SPEEDO &TACHO PCB BOARD
CRUISE CONTROL ACTIVATOR
ACC. PEDAL
COMMUNICATION INTERFACE
F-DIAGNOSTIC
5 A
E5
E0
START ENABLING OUT PUT SIGNAL
START REQUEST SIGNAL
RELAY COMP CLUTCH COIL
RELAY A/C ON CONTACT
TEMP
TEMP GAUGE
ENGINE SPEED SENSOR
CAM PHASE SENSOR
RAIL PR. SENSOR
COOLENT TEMP.SENSOR
FUEL TEMP. SENSOR
* NOTE:- OBD ENGINE CHECK LAMP IS NOT ACTIVATED.

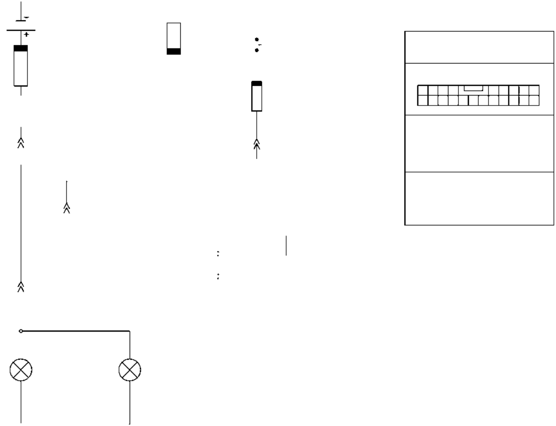
923XXXXR010607EN-RM

923XXXXR010607EN-RM





923XXXXR010607EN-RM

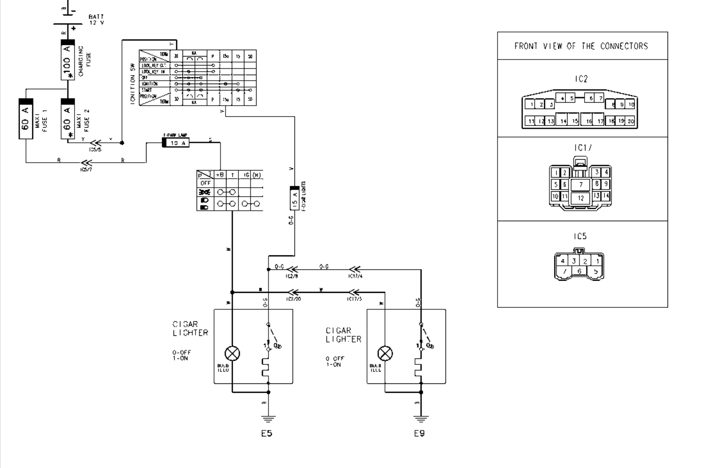


CIRCUIT TRANSFER CASE ELECT.SHIFT

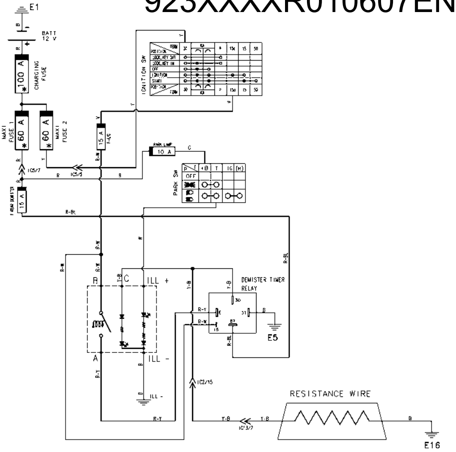
923XXXXR010607EN-RM

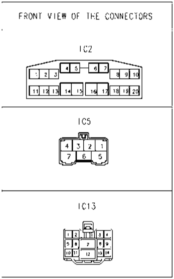
NOTE:
1. CIRCUIT FOR WARNING LAMP-DIAGNOSTIC AS SHOWN IN DOTTED LINE, IS USED ONLY FOR SERVICE PURPOSE.
2. POINT A, B & C SHOULD BE BROUGHT TO JUNCTION BOX.

923XXXXR010607EN-RM

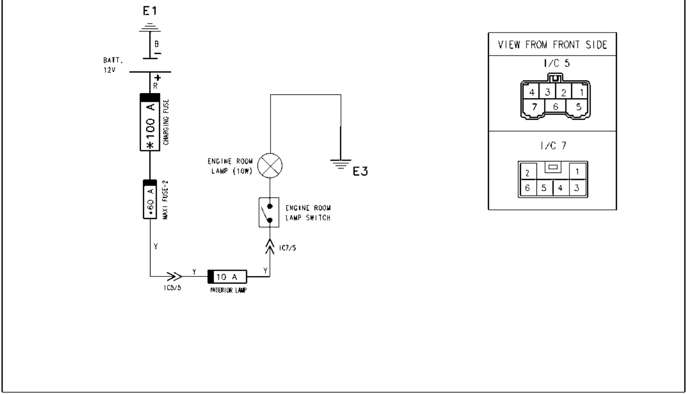


923XXXXR010607EN-RM

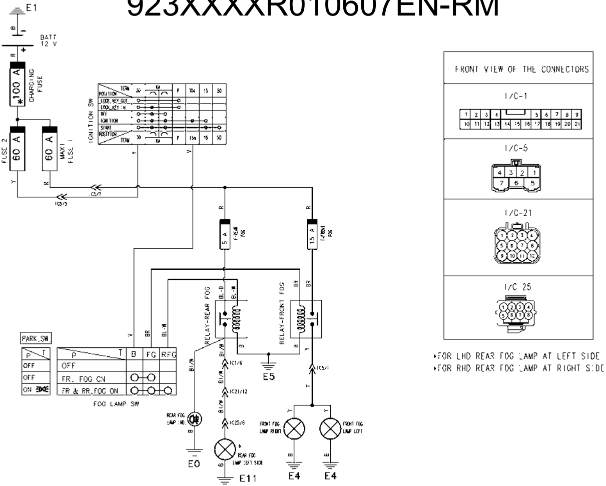




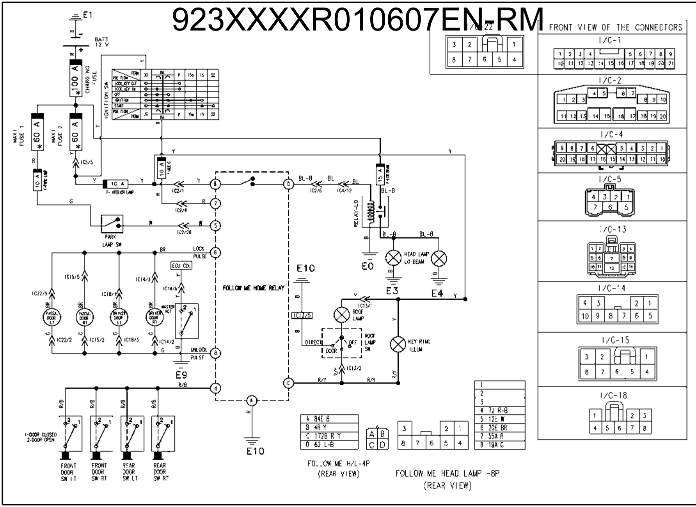
923XXXXR010607EN-RM



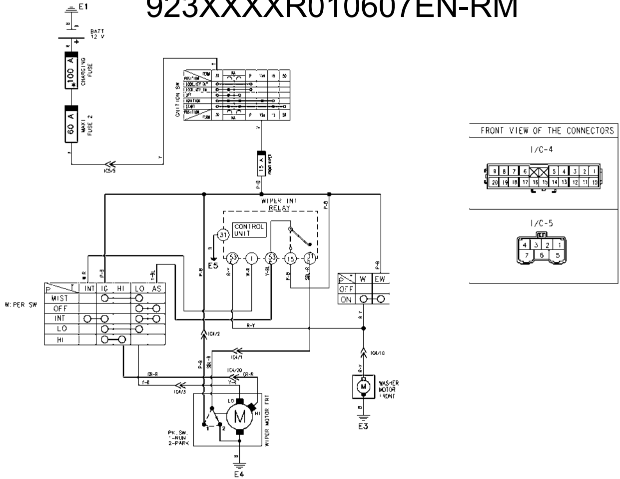
923XXXXR010607EN-RM



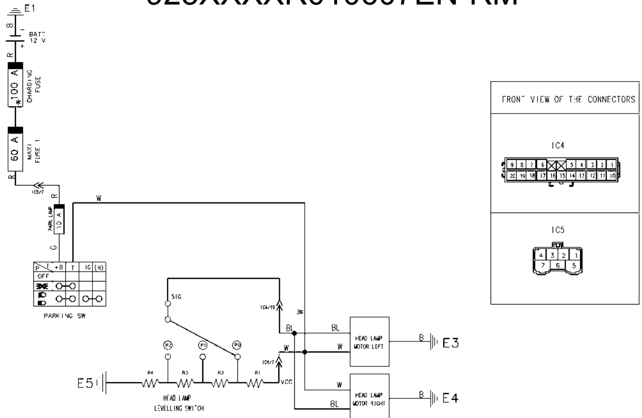
923XXXXR010607EN-RM



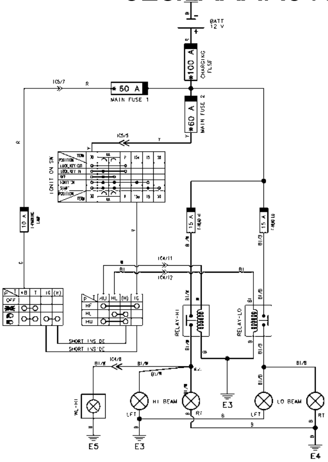
923XXXXR010607EN-RM

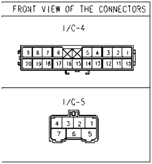


923XXXXR010607EN-RM

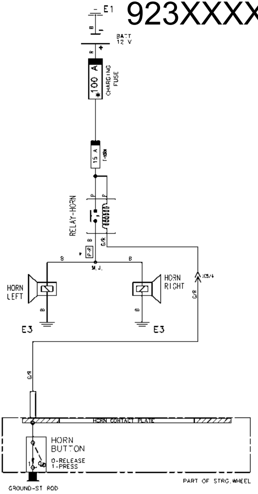


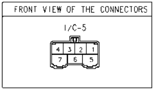
923XXXXR010607EN-RM





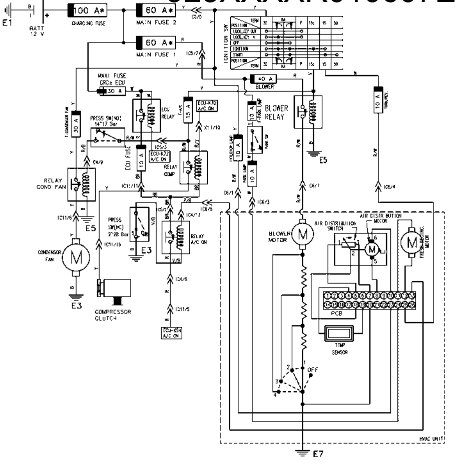
923XXXXR010607EN-RM



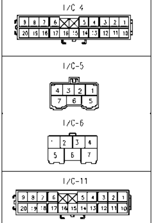


* FOR RHD RELAY O/P WIRE COLOUR P-R
* FOR LHD RELAY O/P WIRE COLOUR B

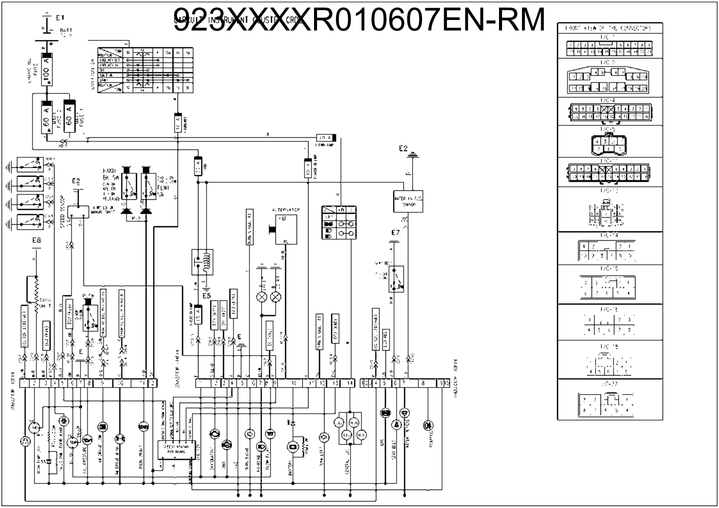
923XXXXR010607EN-RM



FRONT VIEW OF THE CONNECTORS



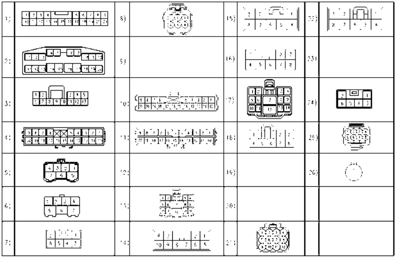
923XXXXR010607EN-RM

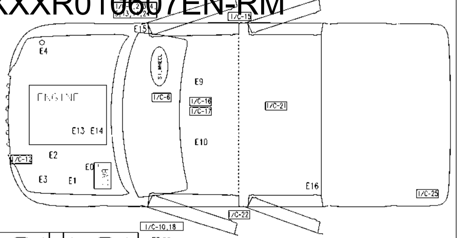


923XXXXR010607EN-RM

INTER-CONNECTOR DETAILS

SR. NO.	DESCRIPTION	TYPE	LOCATION	PIN
1	I/C IP TO FLOOR	FEMALE	A PILLAR RIGHT	[illegible]
2	I/C IP TO FLOOR	FEMALE	A PILLAR RIGHT	20
3	I/C IP TO FLOOR	FEMALE	A PILLAR RIGHT	13
4	I/C IP TO ENGINE ROOM	MALE	A PILLAR RIGHT	20
5	I/C IP TO ENGINE ROOM	MALE	A PILLAR RIGHT	5+2
6	I/C IP TO HVAC	FEMALE	BEHIND DRIVER IP COVER	5+2
7	I/C IP TO ENGINE ROOM	MALE	A PILLAR LEFT	5
8	I/C ENGINE ROOM TO ABS	FEMALE	ENGINE ROOM FUSE BOX	6
9				
10	I/C IP TO ENGINE	MALE	A PILLAR LEFT	21
11	I/C IP TO ENGINE	MALE	A PILLAR LEFT	20
12				
13	I/C FLOOR TO ROOF WRG	FEMALE	A PILLAR RIGHT	14
14	I/C FLOOR TO DRIVER DOOR	MALE	A PILLAR RIGHT	10
15	I/C FLOOR TO REAR DOOR	MALE	B PILLAR RIGHT	8
16	I/C FLOOR TO TRANSFER CASE	FEMALE	BELOW CONSOLE	8
17	I/C FLOOR TO CONSOLE	FEMALE	BELOW CONSOLE	12+2
18	I/C FLOOR TO CO DRIVER	FEMALE	A PILLAR LEFT	8
19				
21	I/C FLOOR TO CHASSIS	FEMALE	NEAR FUEL TANK	12
22	I/C FLOOR RR DOOR	MALE	B PILLAR LEFT	8
23				
24	I/C IP TO ENGINE ROOM	MALE	A PILLAR RIGHT	9
25	I/C CHASSIS TO CARGO	FEMALE	AT TAIL LAMP LEFT	8
26	I/C ENGINE TO GLOW PLUG	FEMALE	AT FIRE WALL	1



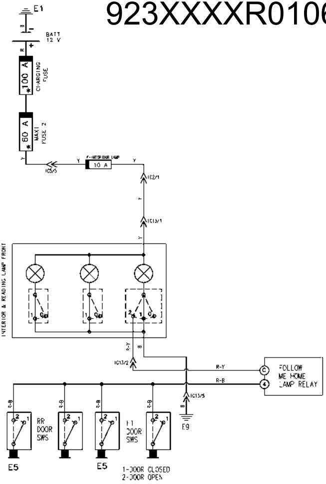


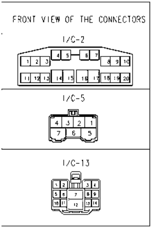
VEHICLES TOP VIEW WITH
INTER CONNECTION & EARTH POINT LOCATION

E0 - STARTER RELAY, VEH. SPEED SENSOR, ECU ..., CLUSTER GAUGE ECU EARTH
E1 - BATTERY -VE TERM TO BODY EARTH
E2 - UNUSED
E3 - PARK, TURN HEAD LT. LEFT, HORN LH, RH, WASHER TANK FRT, RR & SIREN, WIPER WASH, WIPER MOTOR FRT, ENGINE ROOM LAMP, FRT FOG LAMP RH, HLLD LH
E4 - PARK, TURN HEAD LT. RIGHT, CONDENSER FAN PRESSURE SW, HLLD RH
E5 - RELAY COILS HAZARD, FUEL ..., DEMIST HAL LEVELING & COMB. SW, ... DIAGNOSTIC & CIGAR LIGHTER, STARTER RELAY
E6 - AUDIO SYSTEM
E7 - HVAC
E8 - UNUSED
E9 - PW CONT, TANK UNIT, INTERIOR LAMPS, FOLLOW ME RELAY, ECU, ... WASHER LH, RH, ... ECU, SEAT BELT, ... SW LH, RH, HAZ. LAMP, CLUTCH ..., ECU & ROTARY SW, TAIL LAMPS, REGISTRATION PLATE LAMP
E10 - UNUSED
E11 - N.A. FOR ...
E12 - N.A. FOR ...
E13 - UNUSED
E14 - BATTERY -VE TERM TO ENG. NEG. (STARTER EARTH) FOR EARTHING THE COMPONENT BODY
E15 - N.A. FOR ...

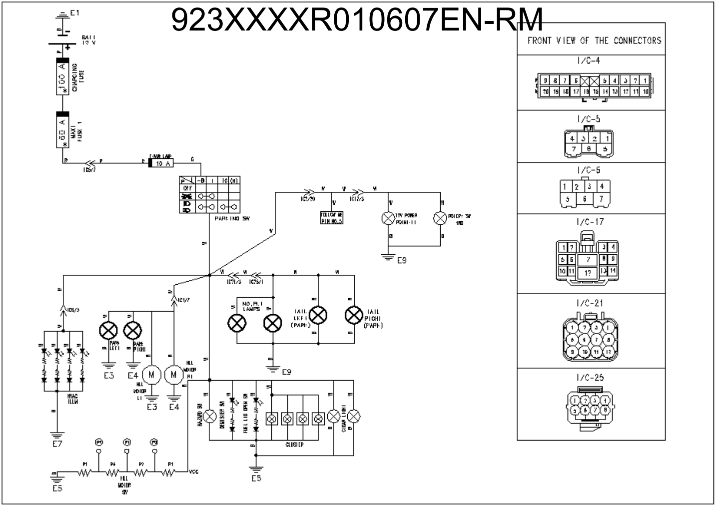
CODE	COLOUR NAME
B	BLACK
BL/L	BLUE
G	GREEN
GR	GREY
O	ORANGE
P	PINK
R	RED
S	SKY BLUE
V	VIOLATE
W	WHITE
Y	YELLOW
BR	BROWN
Lg	LIGHT GREEN

923XXXXR010607EN-RM

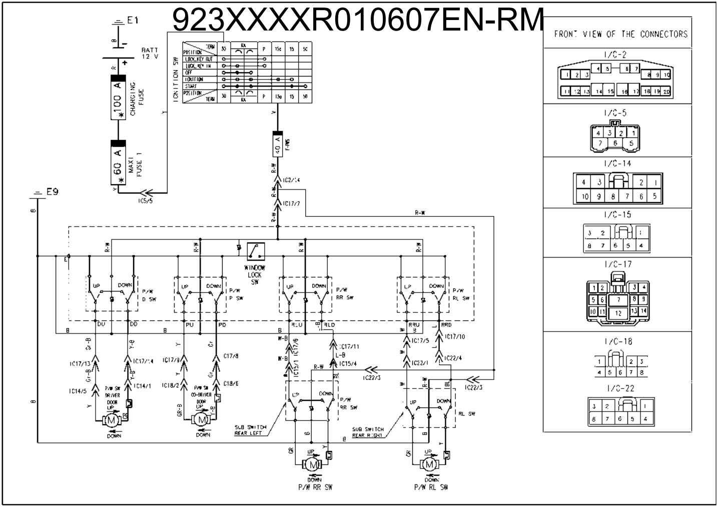




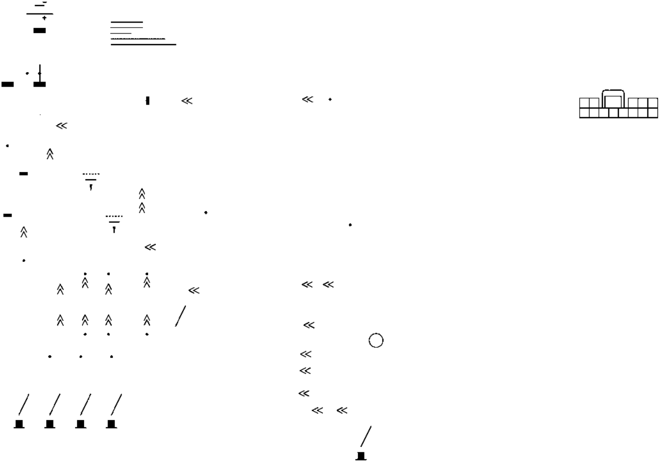
923XXXXR010607EN-RM



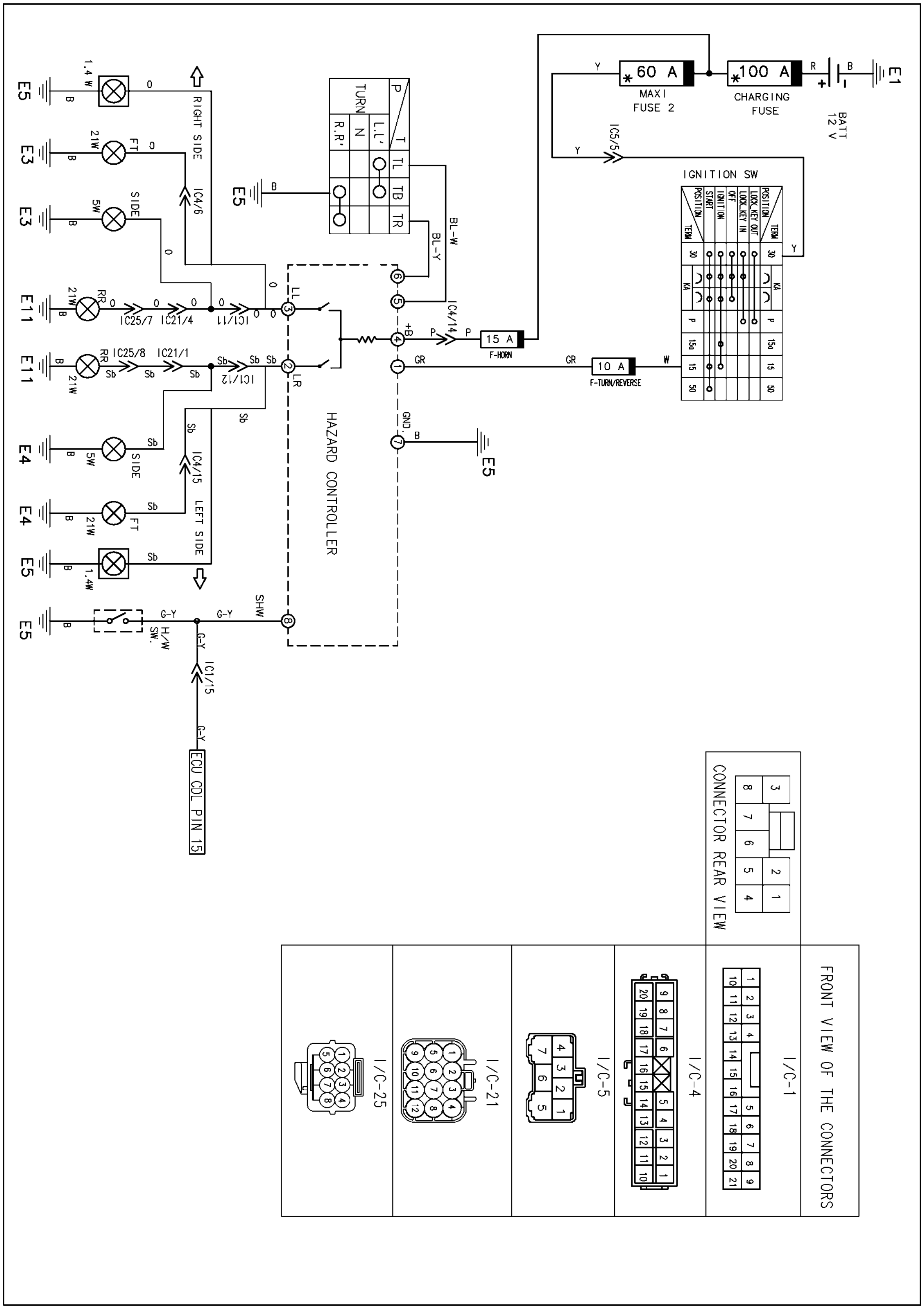
923XXXXR010607EN-RM



923XXXXR010607EN-RM



XXXR010607E


HAZARD CONTROLLER
IGNITION SW
MAXI FUSE 2
CHARGING FUSE
BATT 12 V
60 A
100 A
15 A
F-HORN
10 A
F-TURN/REVERSE
RIGHT SIDE
LEFT SIDE
H/W SW.
ECU CDL PIN 15
CONNECTOR REAR VIEW
FRONT VIEW OF THE CONNECTORS
I/C-1
I/C-4
I/C-5
I/C-21
I/C-25