TECHNICIANS TRAINING
AND REFERENCE MATERIALS

Technicians Reference Booklet

4EAT Phase II

Module 304

Technical Training

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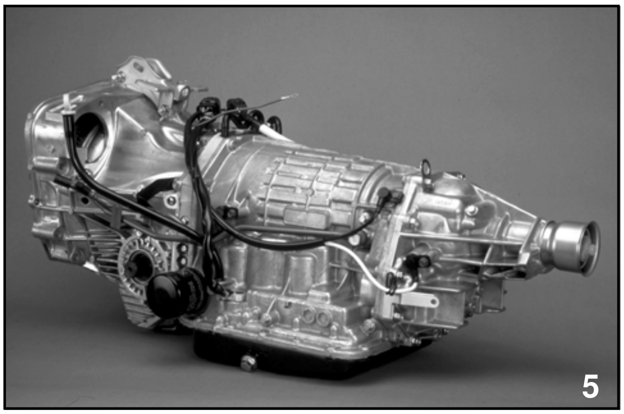
4EAT Phase 2

Introduction

The 4EAT Phase 2 (introduced on 1999 Model Year vehicles) provides the same type of electronic control used by prior model year vehicles and shares many of the same diagnostic procedures, however there have been internal and external changes that require this 4EAT to be viewed as an entirely new automatic transmission. Additionally, beginning with the 2001 model year, an enhancement to the all wheel drive transfer section was introduced. This enhancement, Variable Torque Distribution (VTD), is covered in this reference booklet starting on page 9.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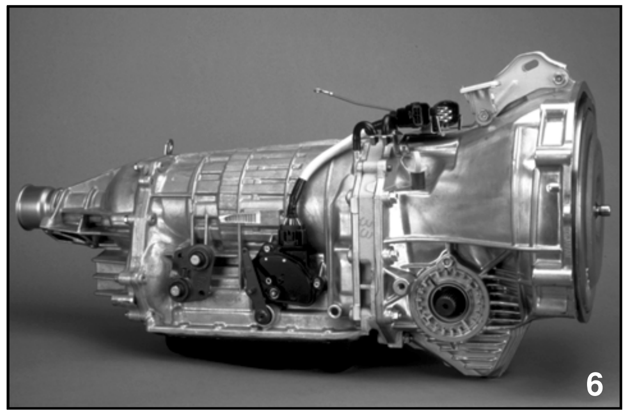
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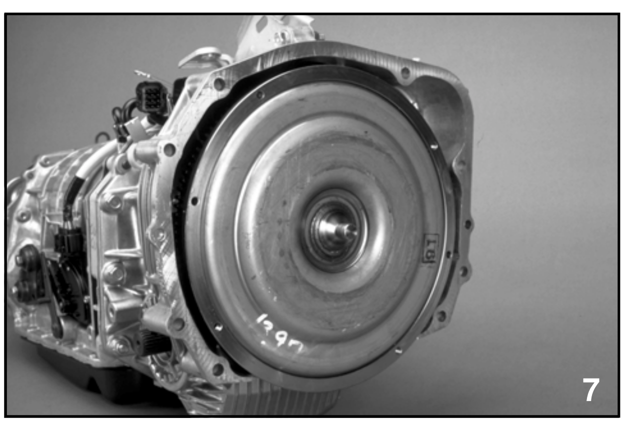
Externally, the number of bolts in the torque converter housing area have increased to match the increase in the number of bolts in the bell housing of the engine. The use of an external canister type oil filter has been adopted which requires no scheduled maintenance. Three speed sensors are now located on the outside surface of the transmission case reading rotational speeds of internal components improving transmission characteristics.

Internally the Brake Band and Servo Mechanism have been deleted and in its place an additional clutch pack is used as a holding member for second and fourth gear. Also the remaining clutch assemblies and the valve body have been redesigned requiring new disassembly and assembly procedures.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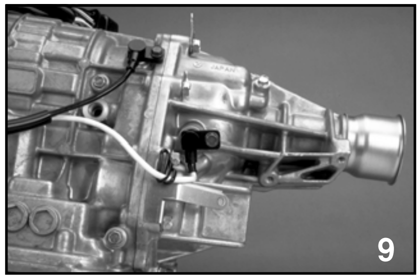
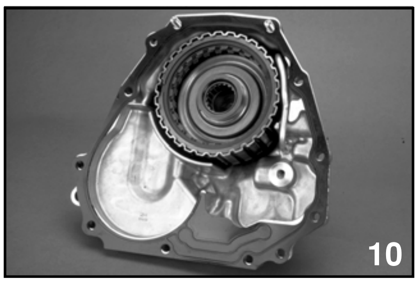
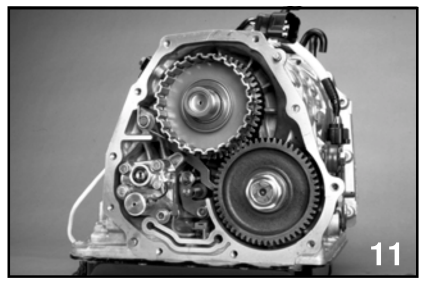
Disassembly

Before beginning the disassembly process, label the speed sensors so that they are not incorrectly installed during reassembly.

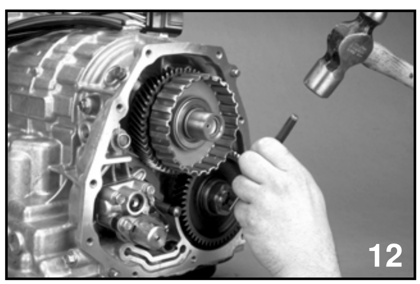


Remove vehicle Speed Sensor 1 from the extension case. Followed by the bolts that secure the extension case to the rear of the transmission.



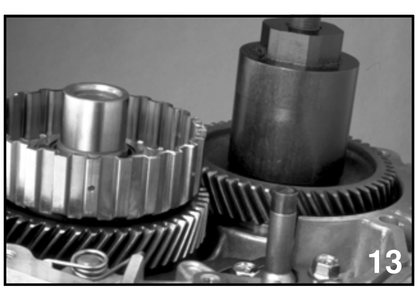


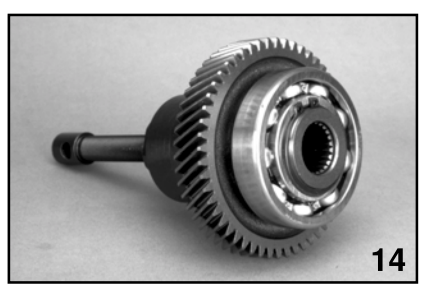
Set the select lever to the park position to engage the Parking Pawl to the front of the reduction drive gear.



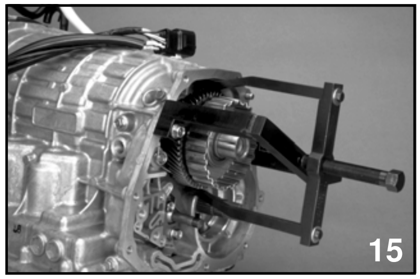
Straighten the peen mark of the locknut. (This locknut is designed to be used only once.) Remove the locknut and washer.

Clean the threaded portion of the backside of the Reduction Driven Gear and install the special tool puller. (499737000 and 899524100)

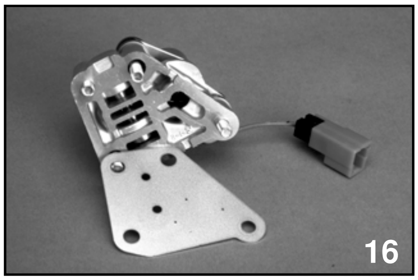


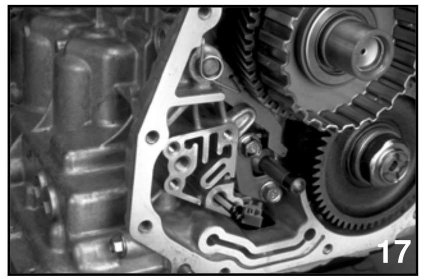


Turn the puller until the Reduction Driven Gear has cleared the Pinion shaft.

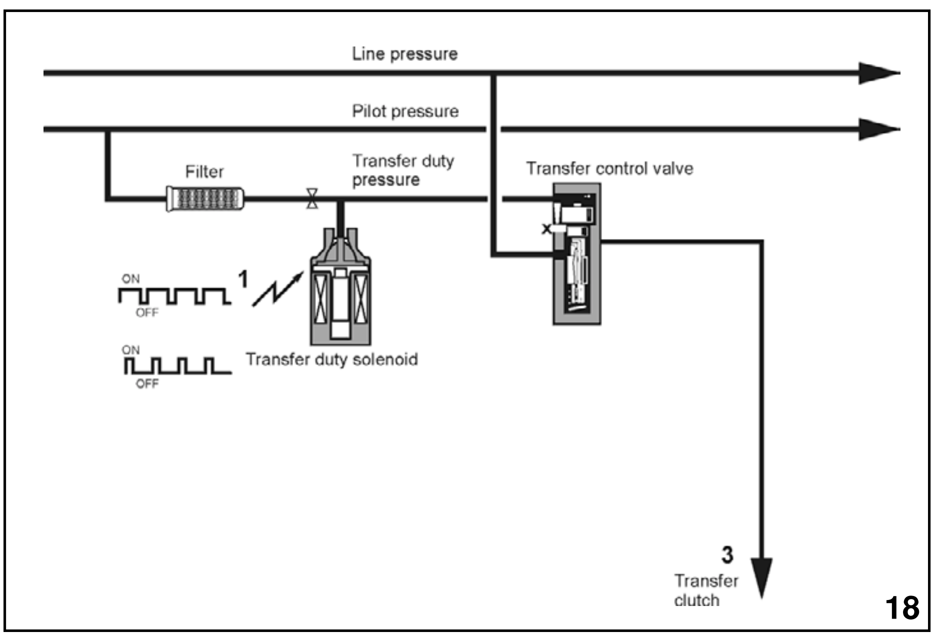


Install the reduction drive gear puller to the rear of the transmission as shown and slowly remove the drive gear assembly. (499737100 and 899524100)

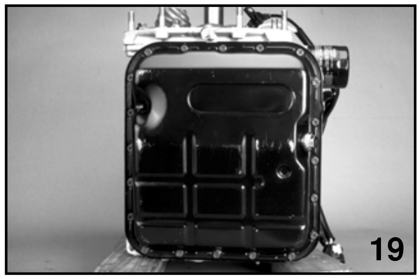




Disconnect the Transfer Duty Solenoid Connector and remove the bolts that secure the Duty Solenoid and Transfer Control Valve to the Transmission Case. Remove the small filter from the cavity in the Transmission case at this time. Remove the Parking Pawl, spring and Parking Pawl Shaft.



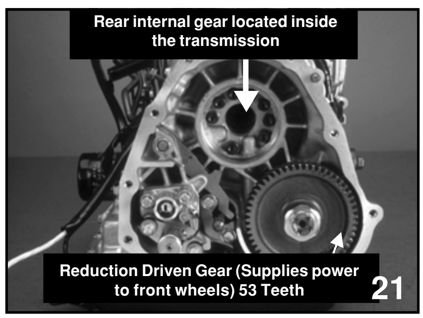
The Transfer Duty Solenoid controls the amount of pilot pressure supplied to the backside of the Transfer Control Valve Piston. If the duty ratio signal from the Transmission Control Unit (TCU) is small the Transfer Duty Solenoid stays off more than it is on and drains less of the pilot pressure. This will result in an upward movement of the control valve increasing the amount of line pressure to the Transfer Clutch. An increase in the duty ratio turns the solenoid on more than it is off and drains more of the pilot pressure. The Transfer Control Valve moves downward restricting the amount of line pressure to the Transfer Clutch.



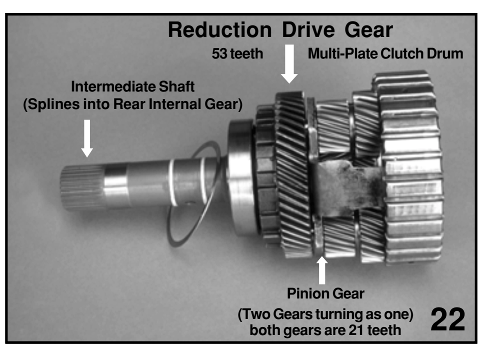
The next step in the disassembly process is to remove the Oil Pan. Position the transmission on the worktable with the Oil Pan facing upward and held in position with wooden blocks.
Remove the Oil Pan Bolts. Use a putty knife or similar tool with a hammer and carefully separate the pan from the transmission. Do not score or scratch the mating surface.

Variable Torque Distribution (VTD)

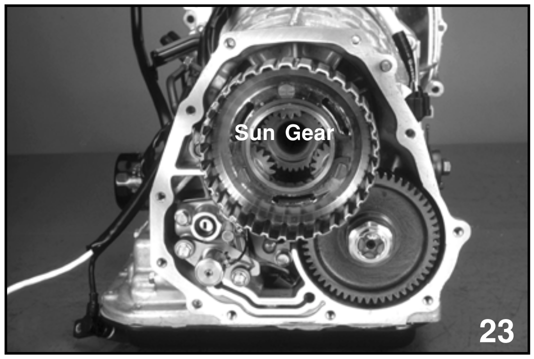
Variable Torque Distribution (VTD) is an addition to the current 4EAT transfer section. VTD is designed to smoothly transfer and divide the power from the engine to the wheels. This new system for North America is equipped on all Subaru vehicles with Vehicle Dynamic Control (VDC).



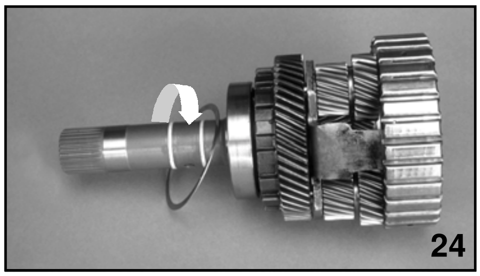
The view of the extension case area is similar to the current 4EAT Phase 2. The difference is the Reduction Drive Assembly.



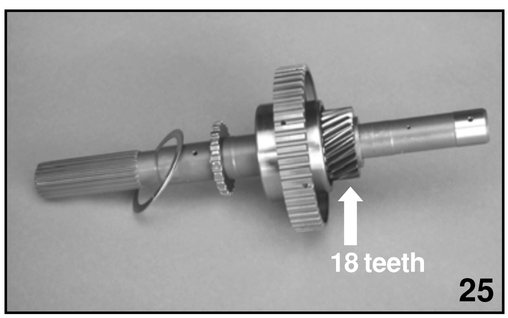
An Intermediate Shaft is splined to the Rear Internal Gear, carrying power to a Sun Gear. The Sun Gear is made onto the end of the Intermediate Shaft. The rotating Sun Gear delivers power to a set of Pinion Gears.



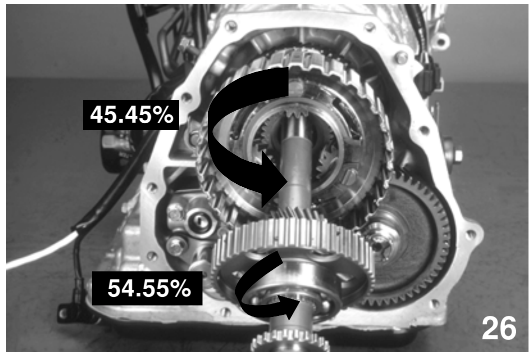
The Pinion Gears are two gears made together. The smaller gear and larger gear have the same number of teeth. The Intermediate Sun Gear drives the smaller Pinion Gear and the larger Pinion Gear.



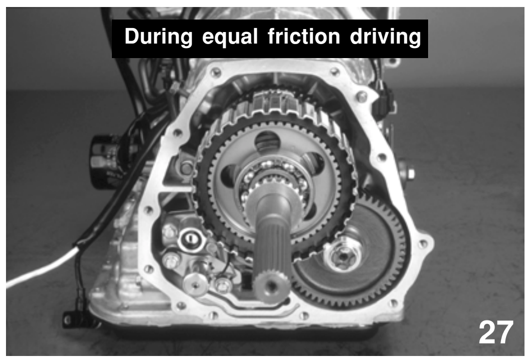
The Pinion Gear is secured to the carrier and delivers power to it. The carrier will now rotate, driving the Reduction Drive Gear. This supplies power to the front wheels. At the same time, the larger Pinion Gear is driving the Rear Drive Shaft.



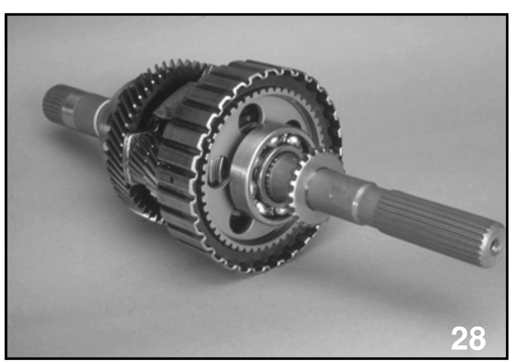
A Sun Gear made on to the end of the Rear Drive Shaft receives the power and transfers the power to the shaft.
The final drive shaft is splined to the Rear Drive Shaft. This carries power to the rear differential.



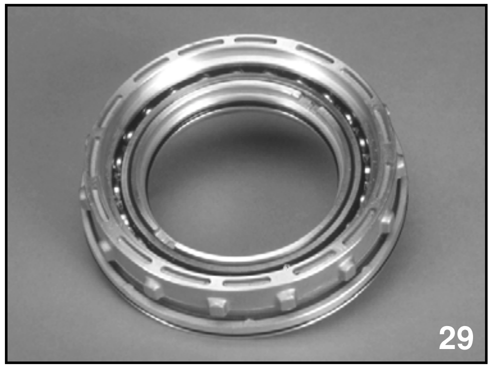
Assuming the friction of the front and rear tires is the same, the power is split 54.55% to the rear and 45.45% to the front.



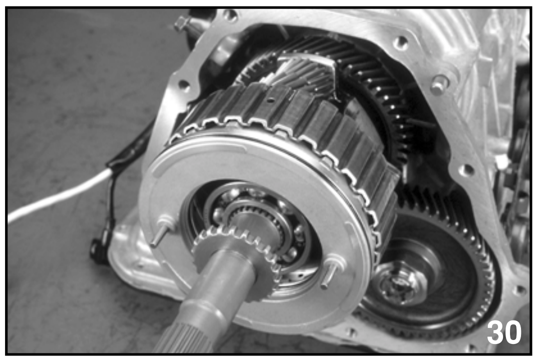
The Front Wheels load the reduction drive and driven gears.
The Rear Wheels load the Rear Drive Shaft and Pinion Gears.
Driving the vehicle results in the Pinion Gears rotating and advancing around the Intermediate Sun Gear.
The Intermediate Sun Gear has 33 teeth; the Small Pinion has 21 teeth.
The Rear Drive Shaft Sun Gear has 18 teeth; Large Pinion has 21 teeth.
You can calculate the power split by dividing 18 by 33 for the Rear Wheels. The remaining power drives the Front Wheels.



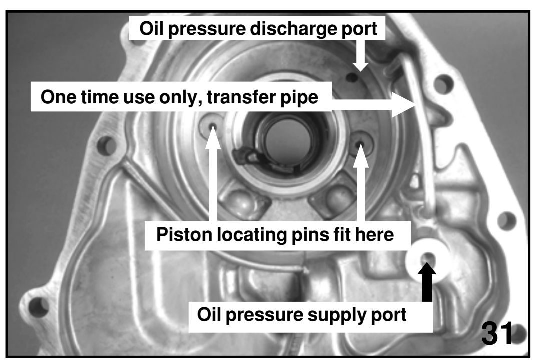
The TCM adjusts the duty ratio of the MPT clutch to maintain the optimum transfer of power.
A large speed difference in the rear to the front wheels results in the MPT clutch locking the Rear Drive Shaft to the carrier.
Power is then split 50% to the front and 50% to the rear.



The piston for the MPT Clutch is machined to spline with the MPT Drum. The piston will rotate with the drum.



The backside of the piston is made with two locating pins. This prevents the backside of the piston from rotating.

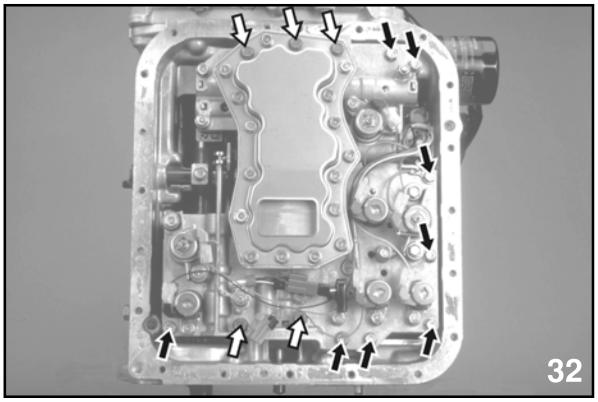


Pressure port locations.
Note: Oil Pressure Transfer Pipe is one-time use only.

4EAT Phase 2 Disassembly Continued

Carefully disconnect and remove the wiring harness.

Remove the control valve body. There are 8 short bolts marked with an (8) and 5 long bolts marked with (7B).



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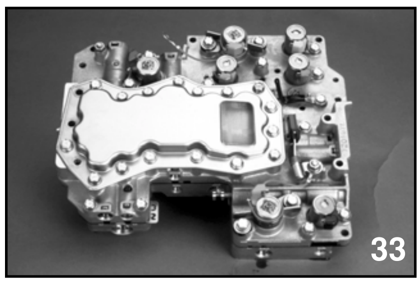

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Carefully disconnect all solenoids. Observe the color of the connectors and the color of the wire that connects to them.

Solenoid	Color	Failsafe
2-4 Brake	Red	1st and 3rd
2-4 Brake Timing	Black	1st and 3rd
Shift A	Green	3rd
Shift B	Yellow	3rd
PL	Red	1st and 3rd Line press set at maximum
Low Clutch Timing	Gray	1st and 3rd
Lock Up	Blue	no lock up

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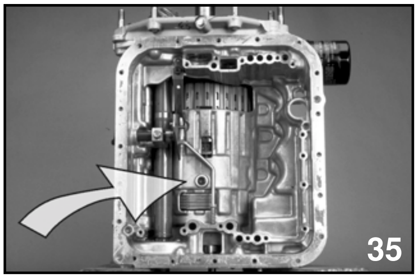
Reposition the transmission to vertical using the wooden blocks to stabilize the case. Remove the bolts and nuts that secure the pump assembly to the transmission case. Remove Seal Pipe.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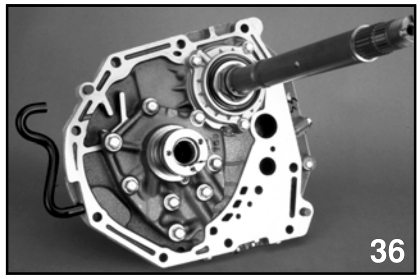
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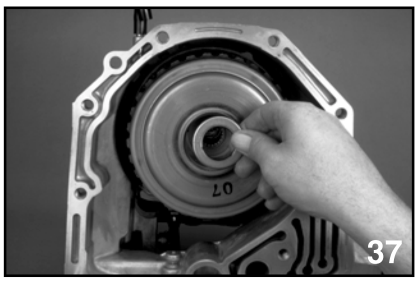
Use the stator support as a handle and remove the pump assembly and gasket.
Caution: the Thrust Needle Bearing may stick to the pump. Ensure it is set aside as it may be used during reassemble if the total end play requires the thickness of the needle bearing to be the same as the original.

Remove the High Clutch Drum, Thrust Needle Bearing and the High Clutch Hub.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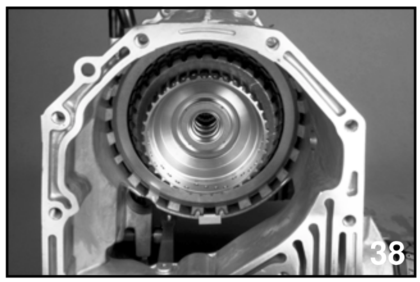
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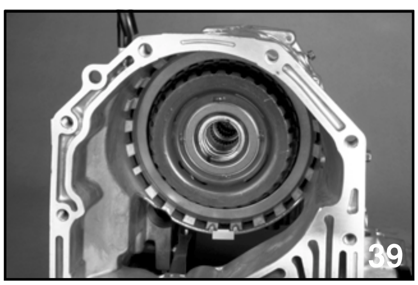
Remove the Thrust Needle Bearing and the front Sun Gear.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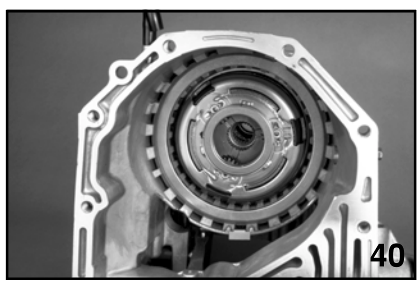
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Remove the Snap Ring and the drive and driven plates of the 2-4 brake clutch with pressure plate.


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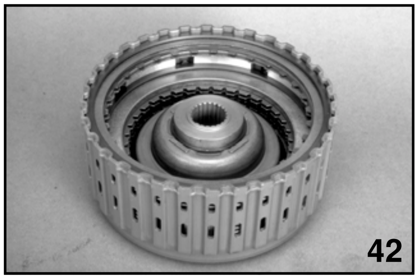
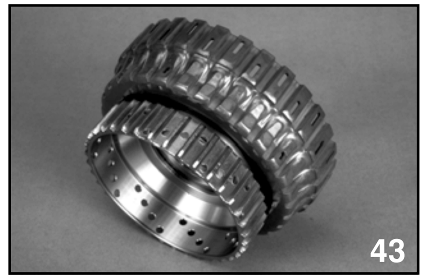
Note: When installing the 2-4 brake clutch, line up the grooves to ensure proper leaf spring positioning.



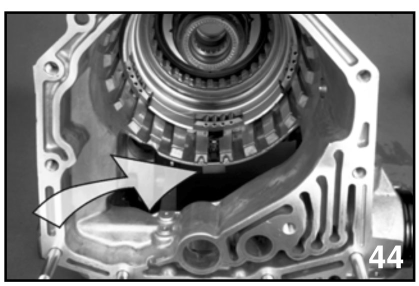


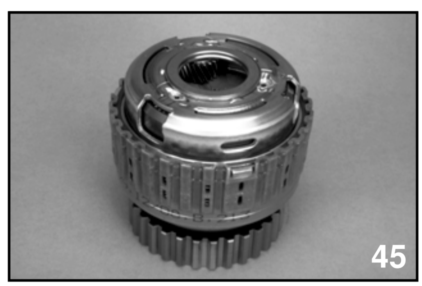
The High Clutch Drum houses the high and reverse clutch. The high clutch is applied in all 3rd and 4th gear ranges. The Reverse clutch is applied in the reverse range only. Position the high clutch with the open end facing upward. The lower positioned clutch assembly is the high clutch. The wide end of the High Clutch Hub engages with these drive and driven plates while the smaller end of the High Clutch Hub engages with the Front Planetary Carrier.

The reverse clutch plates engage with the top section of the front Sun Gear. The lower section of the front Sun Gear engages with the 2-4 brake clutch. Any time the 2-4 brake clutch is applied the front Sun Gear assembly is fixed to the case of the transmission and cannot rotate.

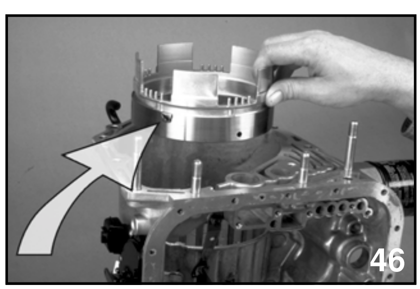
The High Clutch Drum itself is splined to the turbine shaft. When the high clutch is applied the power from the drum is transferred to the rear Sun Gear via the High Clutch Hub and turns the rear planetary carrier.

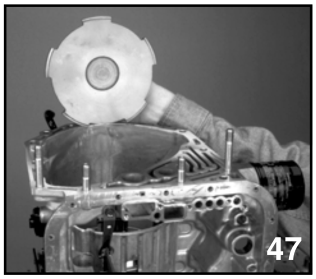
Remove the Upper Leaf Spring. This device reduces chatter and vibration. Carefully observe its location.

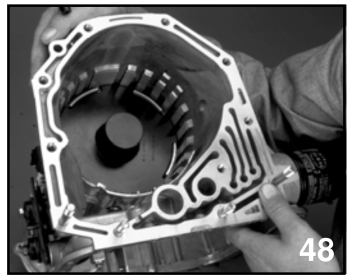




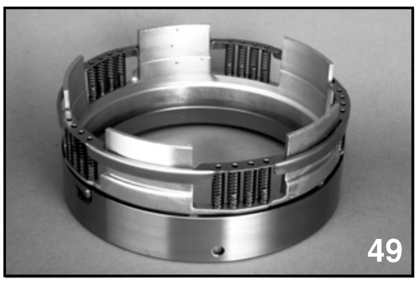
Remove the planetary assemble as a unit. Followed by the Snap Ring and Spring Retainer of the 2-4 Brake Piston. Observe the location of the 2-4 locating lug of the 2-4 Brake Piston so that it is properly positioned during reassembly.

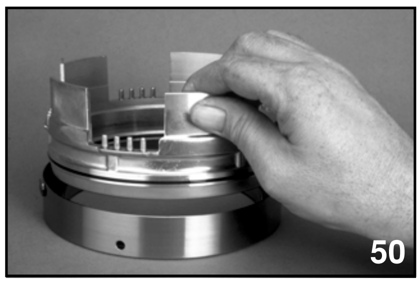


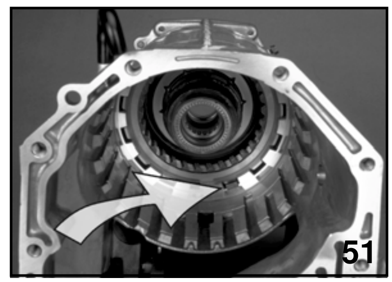




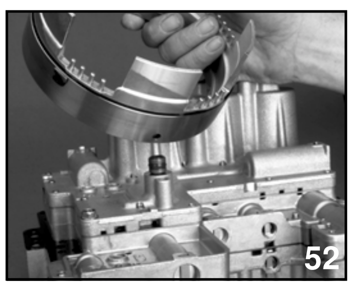
During reassembly, the installation of the Snap Ring of the 2-4 brake Spring Retainer requires the use of a special tool. Carefully position the Snap Ring over the retainer and place the special tool on top of the Snap Ring. Apply steady, firm pressure until you hear the Snap Ring fully seat. Remove the tool and check that the Snap Ring is fully seated. Using both hands, remove the 2-4 Brake Piston. It may be necessary to provide a wobbling motion to expedite its removal. The piston retainer may come out with the piston. If it does not, remove it at this time.



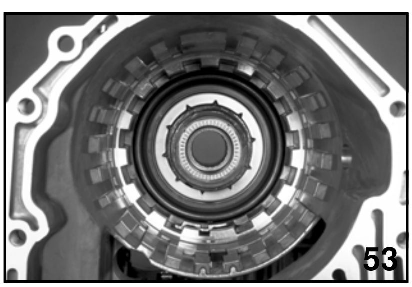




Remove the Lower Leaf Spring followed by the Snap Ring and Low and Reverse Brake Clutch. Observe the orientation of the Dish Plate so it is properly positioned during reassemble.



The Seal Pipe carries pressure from the valve body to the 2-4 Brake Clutch Piston Retainer.



Remove the Thrust Needle Bearing from the machined surface of the one way clutch inner race. Reposition the transmission case horizontally and remove the bolts that secure the one way inner race to the transmission case. Carefully remove the inner race from the transmission.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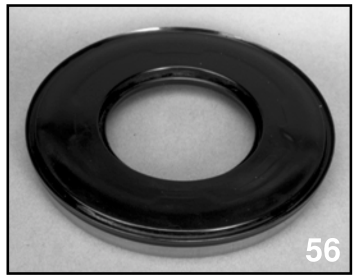
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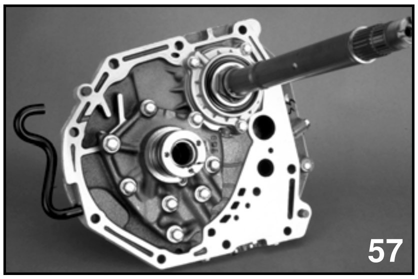
Also remove the Spring Retainer, Wave Washer and the Low and Reverse Brake Piston.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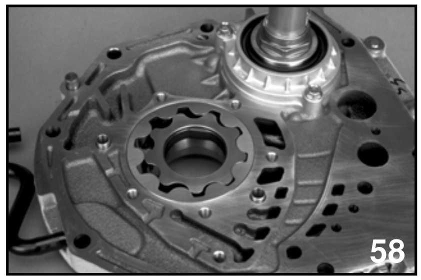
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Servicing the Oil Pump

Remove the seven bolts from the Oil Pump Cover. Lift the cover off and inspect the inner and outer rotor for damage. Check for wear, seizing, and deformation of parts and clogged or dirty oil passages.
Measure the clearance between the inner and outer rotor.
Standard value 0.02-0.15 mm

Measure the side clearance of the inner and outer rotor.
Standard value 0.02-0.04 mm

If the side clearance is beyond specifications replace the rotors as a set. Choose the thickness of the set that will place the side clearance within specifications.

Parts number	Thickness
15008AA060	11.37-11.38
15008AA070	11.38-11.39
15008AA080	11.39-11.40

Line the dowel pins of the oil pump housing with the alignment holes of oil pump cover and set the cover into place. Torque the bolts to the proper specifications.

Caution: The cover must sit flush on the pump before it is tightened. Failure to do this will result in a cracked pump and or cover.

Note: When installing new friction plates soak them in automatic transmission fluid for at least 2 hours before installation.

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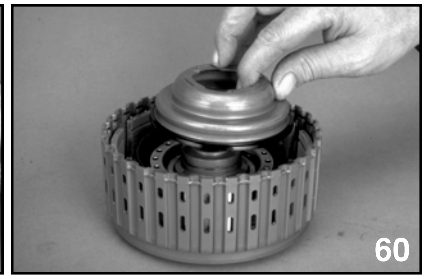

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Servicing the High and Reverse Clutch

Remove the Snap Ring from the open end of the High Clutch Drum.

Caution: the Retaining Plate of the High Clutch is directional. Observe how it is positioned so it is properly placed during reassemble.

Caution: the Dish Plate is directional. Observe how it is positioned so it is properly placed during reassemble. Remove the drive and driven plates.

Remove the Snap Ring and the Drive and Driven Plates of the Reverse Clutch.

Position the High Clutch Drum with the open-end facing upward on suitable press plates. Carefully position the compressor and seat against the High Clutch Spring Retainer. Apply slow steady pressure until there is enough room to remove the Snap Ring. Slowly release the pressure ensuring the Spring Retainer does not move to one side partially engaging with the Snap Ring groove.

Remove the Spring Retainer, spring, High Clutch Piston and Reverse Clutch Piston.

Reassemble parts in reverse order of disassembly. Check the operation of the high and reverse clutch by applying air pressure to the their pressure ports.

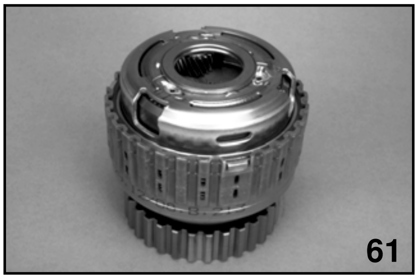
Check for proper clearance between the Snap Ring and Retaining Plate of each clutch assembly.

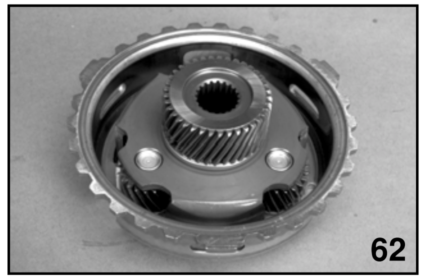
If the clearance is beyond specifications replace the Retaining Plate with one that will provide the proper clearance.

Retaining Plate High Clutch	Thickness	Retaining Plate Reverse Clutch	Thickness
31567AA710	4.7	31567AA750	3.8
31567AA720	4.8	31567AA760	4.0
31567AA740	5.0	31567AA780	4.4
31567AA730	4.9	31567AA770	4.2
31567AA670	5.1	31567AA790	4.6
31567AA680	5.2	31567AA800	4.8
31567AA690	5.3	31567AA810	5.0
31567AA700	5.4	31567AA820	5.2

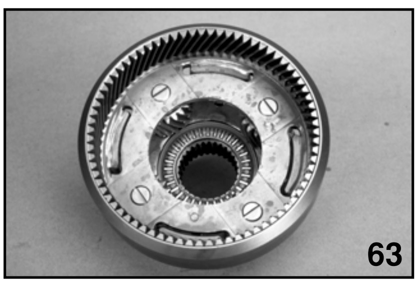
Servicing the Planetary Gear Assembly and Low Clutch

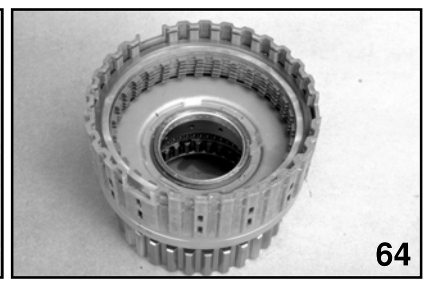
Position the planetary gear assembly with the open end upward. Remove the Snap Ring.
Caution: There are 2 Thrust Needle Bearings and Thrust Washers used in this assemble. They may stick to components when they are removed. Use extreme care when handling.
Remove the Front Planetary Carrier, Thrust Needle Bearing and rear Sun Gear.
Note: All bearings, washers, and gears are directional.





Remove the Rear Planetary Carrier, Thrust Washer, and Thrust Needle Bearing. Remove the Rear internal gear and Thrust Washer.

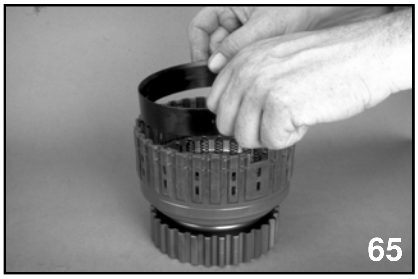


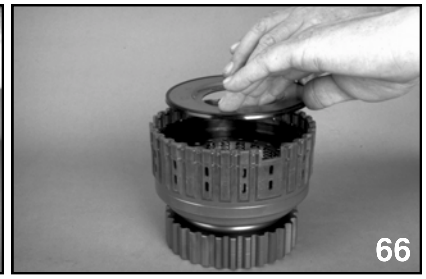


Remove the Snap Ring and Retaining Plate. Next remove Drive and Driven Plates.
Caution: The Retaining Plate of the Low Clutch is directional. Observe how it is positioned so it is properly placed during reassemble.

Position the Low Clutch Drum with the open-end facing upward on suitable press plates. Carefully position the compressor and seat against the Low Clutch Spring Retainer. Apply slow steady pressure until there is enough room to remove the Snap Ring. Slowly release the pressure ensuring the Spring Retainer does not move to one side partially engaging with the Snap Ring groove.

Remove the Spring Retainer, Spring, and Low Clutch piston.





Reassemble parts in reverse order of disassembly. Use the Low Clutch Spring Retainer guide to help center and maintain the position of the retainer. This prevents the guide from catching on the Snap Ring groove. Check for proper clearance between the Snap Ring and Retaining Plate.

If the clearance is beyond specifications replace the Retaining Plate with one that will provide the proper clearance.

Available Retaining Plates Part Number	Thickness
31567AA830	3.8
31567AA840	4.0
31567AA850	4.2
31567AA860	4.4
31567AA870	4.6

Check the operation of the Low Clutch by placing the one way clutch inner race into the bottom of the Low Clutch Drum and applying air pressure to the pressure port.

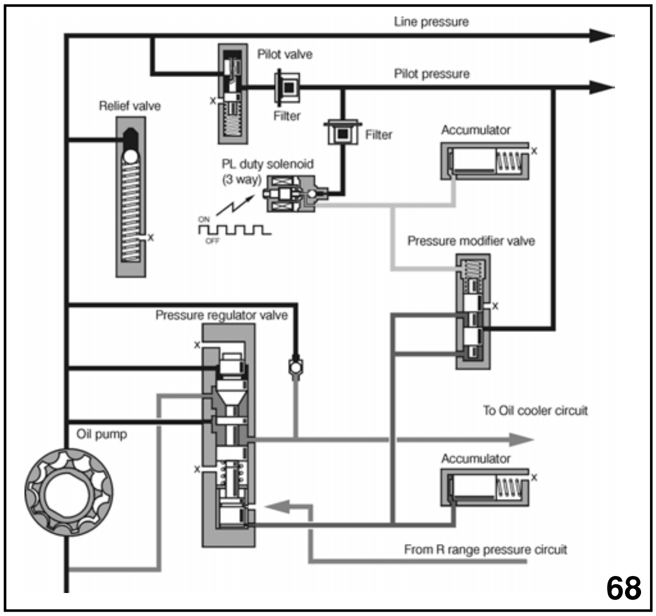
Caution: Do not place hands inside drum when air checking.

Check the operation of the One Way Clutch at this time. It should **not** allow the Low Clutch Drum to rotate counter clockwise. The Low Clutch is applied in all forward gears except 4th. When applied the Low Clutch locks the rear internal gear to the Low Clutch Drum.

In 1st gear this action initially turns the Low Clutch Drum counterclockwise. However, the One Way Clutch catches the drum and prevents it from turning. The rear internal gear locked to Low Clutch Drum via the Low Clutch now makes the planetary pinions revolve around the rear Sun Gear. This turns the rear planetary carrier, which is connected, to the reduction drive gear assembly.

Hydraulic Control

Line Pressure



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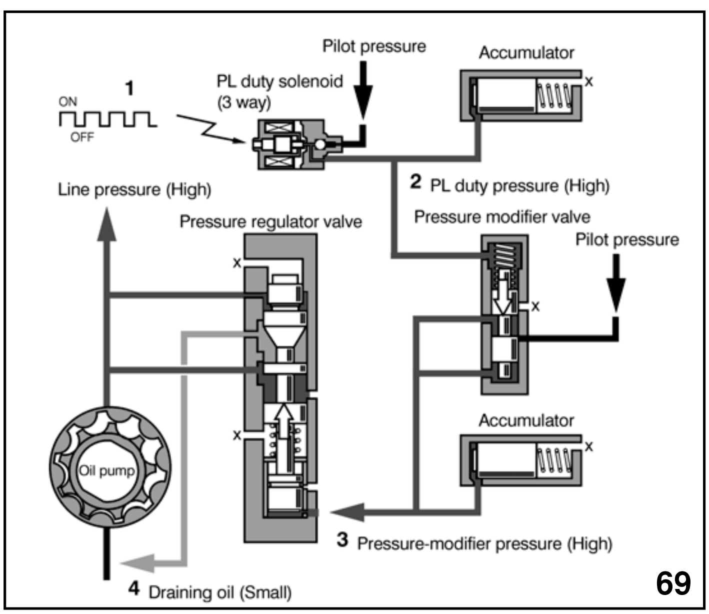
Line pressure provides the force necessary to engage driving and holding members as well as lubricate and cool the transmission. Adjusting the line pressure to various levels reduces the amount of load placed on the engine and minimizes wear on the transmission.

Line pressure is adjusted using data that indicates throttle opening, vehicle speed, and other input signals. Control of the pressure during low load conditions results in a duty ratio, or on verses off time that is large. This duty ratio results in the PL Duty Solenoid staying on more than it is off. Pilot pressure is drained away from the Pressure Modifier Valve. Resulting circuit action lowers the pressure in the lower side of the Pressure Regulator Valve allowing line pressure in the upper side of the valve to push the valve down increasing the amount of pressure drained from the line pressure circuit.



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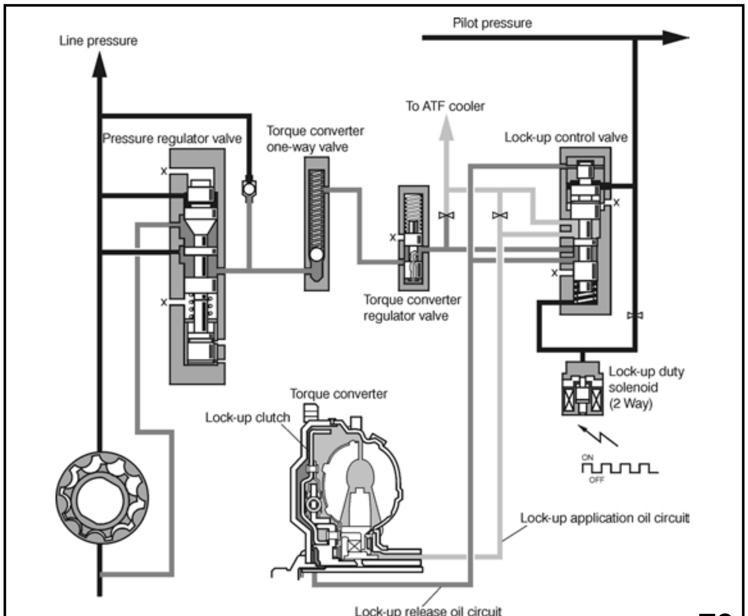
Control during high load conditions results in a low duty ratio increasing the pressure to the pressure modifier valve. This will result in an increase in pressure to the bottom of the pressure regulator valve creating an upward movement of the pressure regulator valve. Reducing the amount of line pressure drained. The amount of line pressure throughout the transmission will then increase.



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Lock up control engages the Lock Up Clutch inside the Torque Converter when traveling in 4th gear under uniform conditions, transmitting engine power directly to the Input Shaft.

Lock up Engagement

1. The TCM increases the duty ratio and the oil drainage rate increases in proportion to the duty ratio.
2. The lock up control valve is pushed down, connecting the torque converter regulator valve port and the lock up application port.
3. Oil pressure from the Torque Converter Regulator Valve is conducted through the application port to the torque converter and the Torque Converter Clutch. The lock up release port ATF is drained through the lockup control valve at this time.
4. The lock up clutch is engaged by the oil pressure from the lock up application port. After the clutch is engaged, the TCM lock up duty solenoid ratio is fixed in the on position.

Lock up Release

1. The Duty Ratio of the Lock up solenoid is adjusted to 5%. Drainage of the duty solenoid oil is stopped and the lock up duty pressure rises.
2. The lock up control valve spool is pushed up, connecting the torque converter regulator valve port and the torque converter release port.

3. Oil pressure from the Torque Converter Regulator Valve is conducted through the release port to the Torque Converter Clutch and the Torque Converter Application Circuit.

4. The Clutch Plate moves away from the Torque Converter Case and the Lock up Clutch is released.

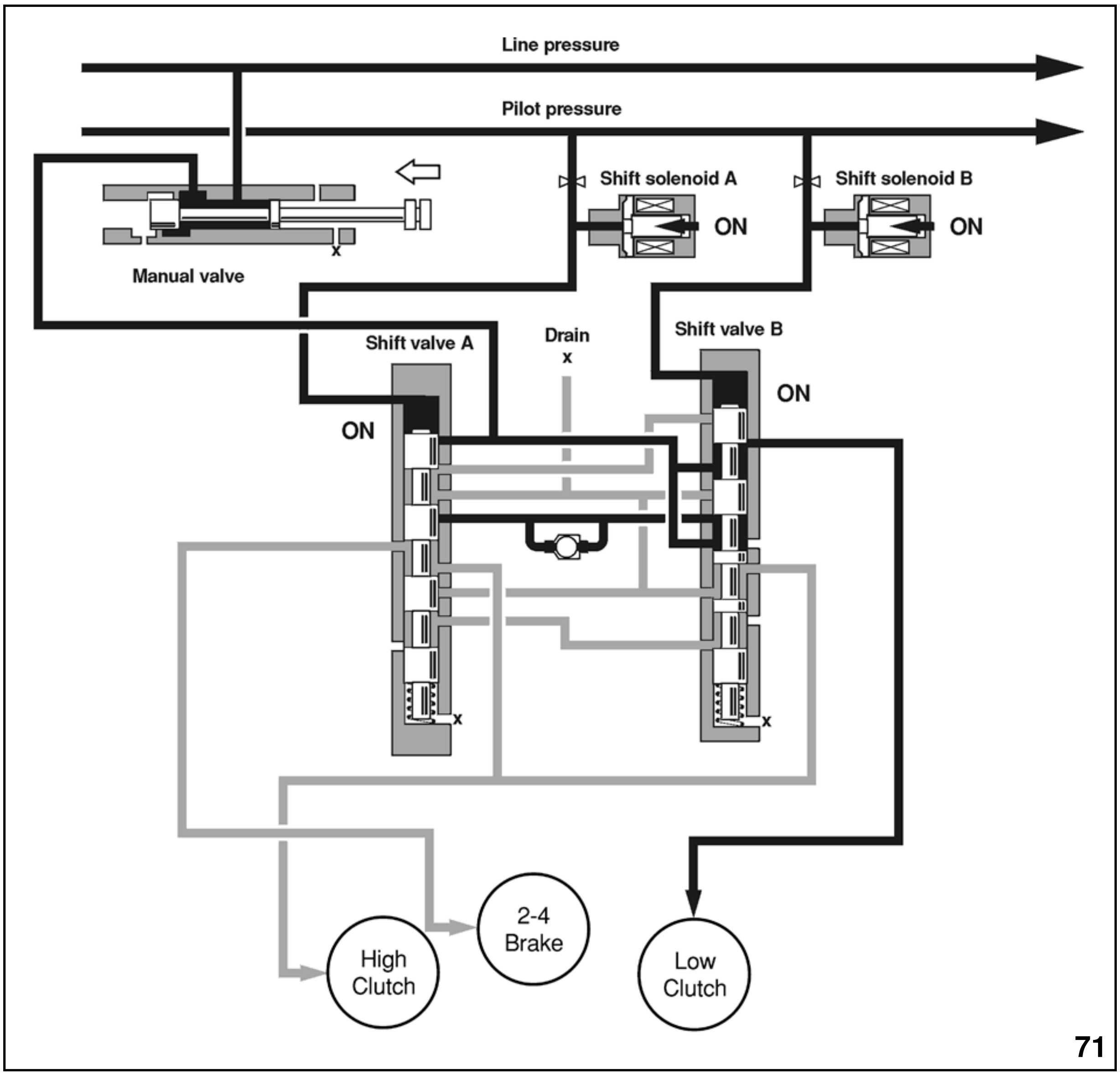
Gear Shift Control

The shift control operates the engagement and release of the Low Clutch, 2-4 Brake, and the High Clutch. TCM output signals control Shift Solenoid A and Shift Solenoid B based on input from vehicle speed and throttle opening.

The solenoids in turn supply or remove pilot pressure from Shift Valve A and Shift Valve B. The positioning of the shift valves route line pressure to the correct clutch and or brake assemblies.

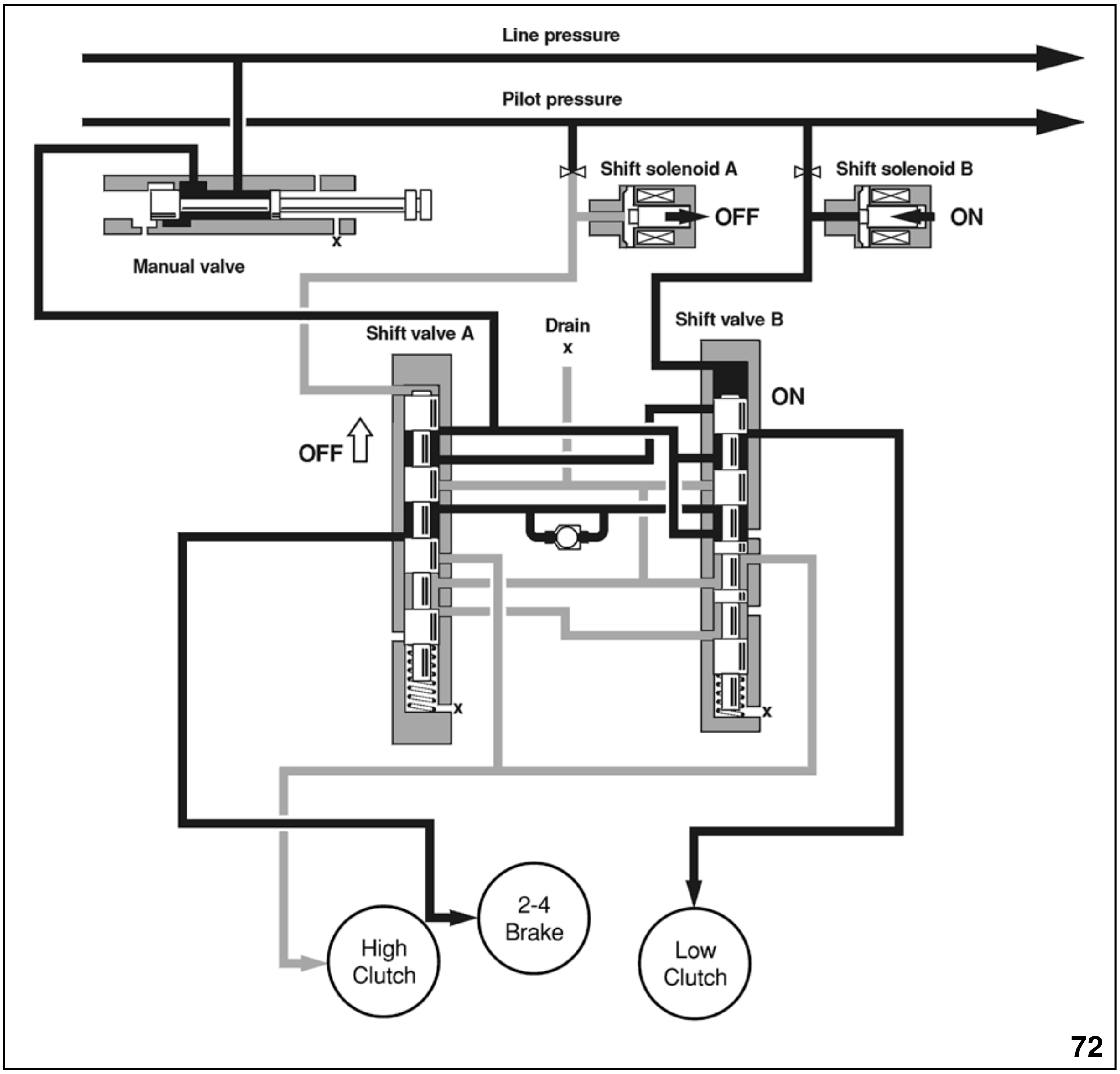
1st gear

When the selector lever is placed in the D range the manual valve opens the port to the shift valves A and B supplying Line pressure. Shift solenoids A and B are turned on by the TCM and pilot pressure is applied to the top of both Shift Valves. The Shift valves move to the bottom of their bores providing a route for line pressure to the Low Clutch.



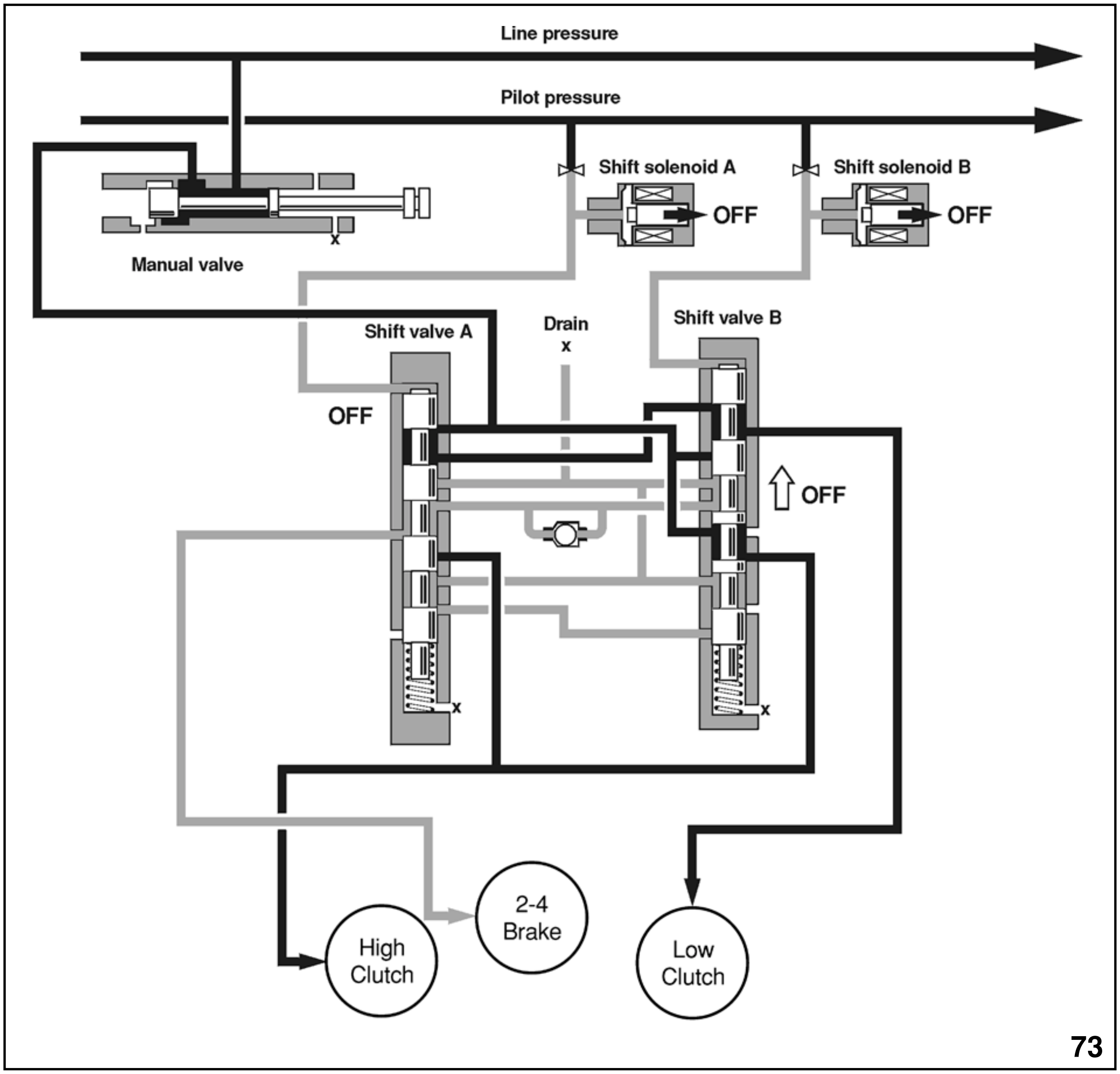
2nd Gear

TCM output turns shift solenoid A off and shift solenoid B on. Shift valve A moves upward and opens the 2-4-Brake port. The Low Clutch and 2-4 brake are now applied.



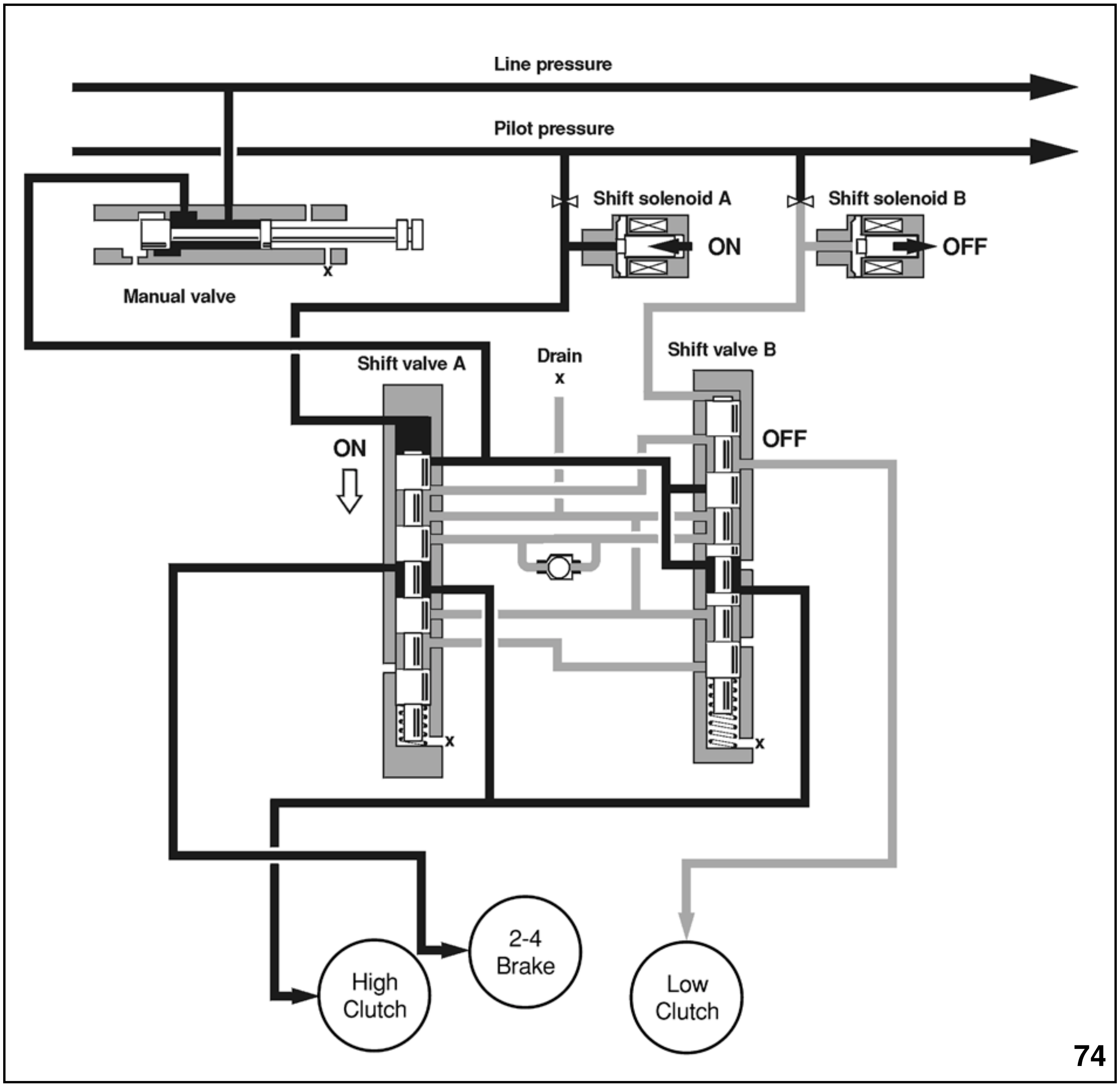
3rd Gear

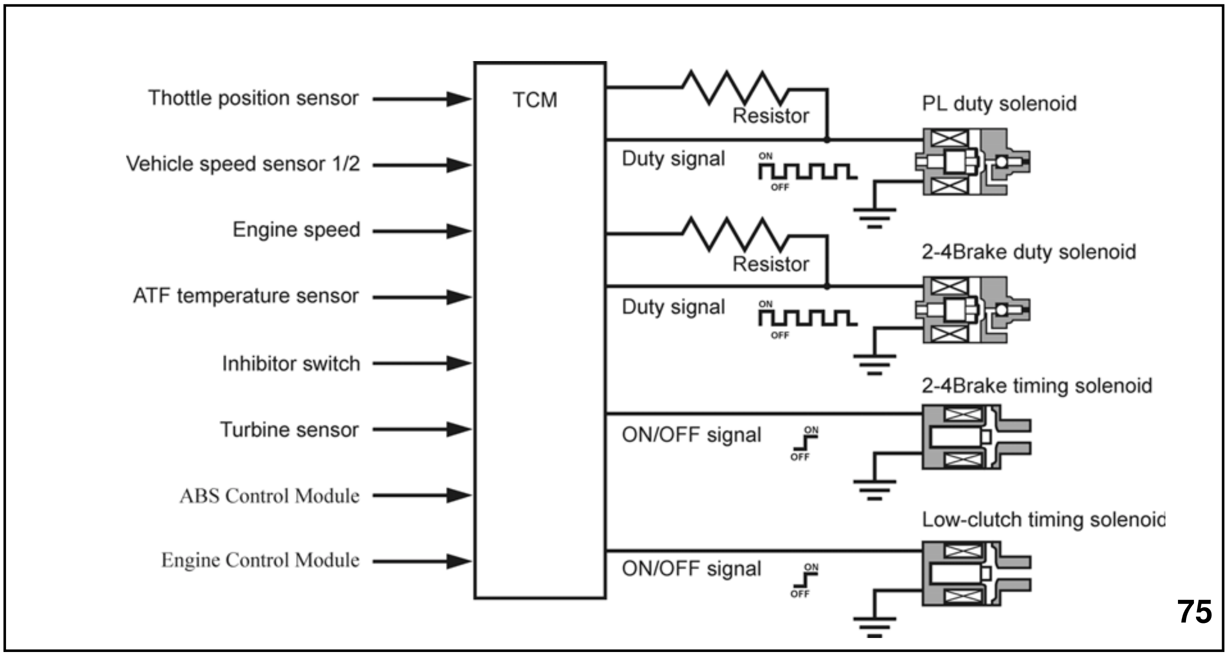
Both solenoids are turned off allowing the pilot pressure supplied to the shift valve to drain. The shift valves move upward allowing line pressure to the Low Clutch and the High Clutch.

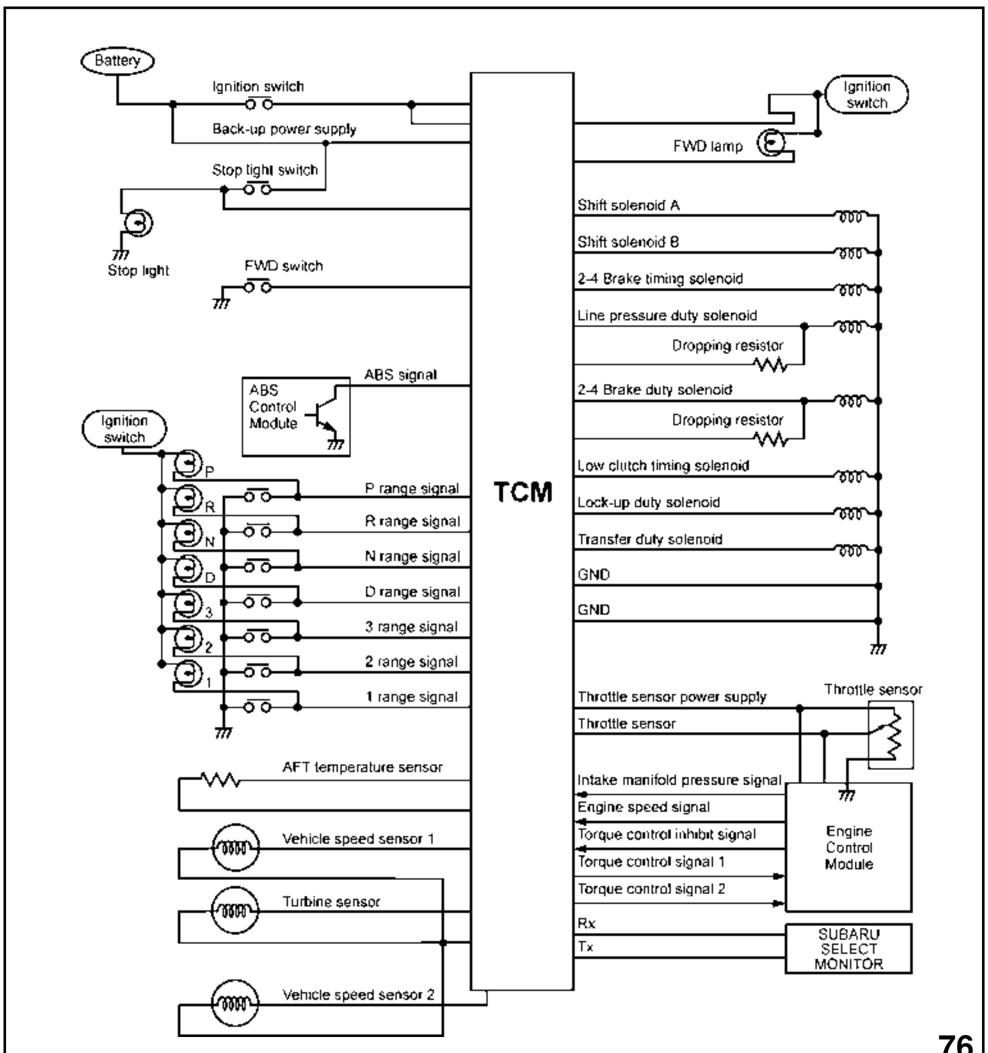


4th Gear

The TCM turns shift solenoid A on and B off. Pilot pressure is supplied to the top of shift valve A which results in the valve moving downward closing the passage for the Low Clutch and opening the passage for the 2-4 brake. The High Clutch and 2-4 brake is now applied.




Thottle position sensor
Vehicle speed sensor 1/2
Engine speed
ATF temperature sensor
Inhibitor switch
Turbine sensor
ABS Control Module
Engine Control Module
TCM
Resistor
Duty signal
ON
OFF
PL duty solenoid
Resistor
Duty signal
2-4Brake duty solenoid
ON/OFF signal
2-4Brake timing solenoid
ON/OFF signal
Low-clutch timing solenoid
75


Battery
Ignition switch
Back-up power supply
Stop light switch
Stop light
FWD switch
ABS signal
ABS Control Module
Ignition switch
P range signal
R range signal
N range signal
D range signal
3 range signal
2 range signal
1 range signal
AFT temperature sensor
Vehicle speed sensor 1
Turbine sensor
Vehicle speed sensor 2
TCM
Ignition switch
FWD lamp
Shift solenoid A
Shift solenoid B
2-4 Brake timing solenoid
Line pressure duty solenoid
Dropping resistor
2-4 Brake duty solenoid
Dropping resistor
Low clutch timing solenoid
Lock-up duty solenoid
Transfer duty solenoid
GND
GND
Throttle sensor power supply
Throttle sensor
Throttle sensor
Intake manifold pressure signal
Engine speed signal
Torque control inhibit signal
Torque control signal 1
Torque control signal 2
Engine Control Module
Rx
Tx
SUBARU SELECT MONITOR
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TCM Control

Normal Shifting

The logic for all gear ranges is stored in the TCM memory and is mainly influenced by the throttle opening and vehicle speed. Monitoring of these signals enables the TCM to turn on or off the shift solenoids enabling up and down shifting.

Slope Control

This control regulates shifting up from 3rd to 4th gear when traveling uphill and forcefully downshifts from the 4th to 3rd gear when traveling downhill.

The TCM determines the driving force of the traveling vehicle from input of the speed sensor signals, throttle signal, turbine sensor signal, etc.. and forcefully maintains 3rd gear.

Control at Low Temperature

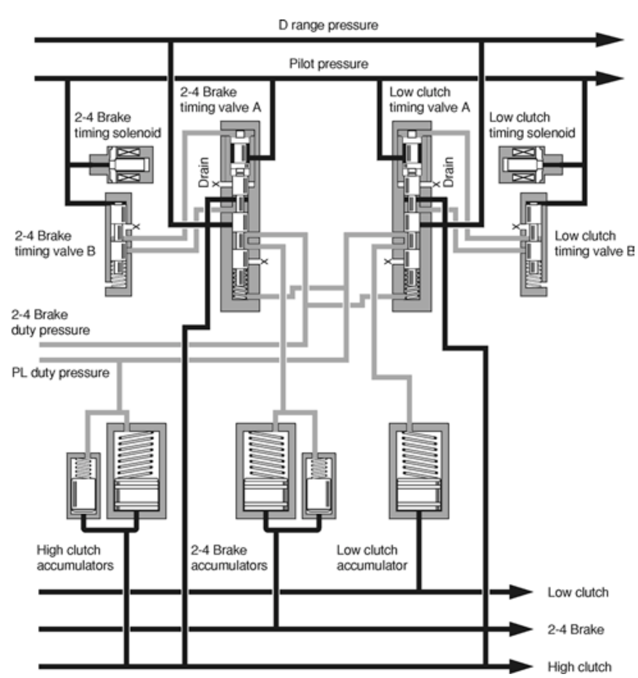
To prevent shift shock, shifting up to D range 4th gear is not performed when the ATF temperature is below approximately 12 degrees C.

Control During ABS Operation

During ABS operation the TCM forces the transmission to 3rd gear. This allows the ABS control to exhibit its maximum effect.

Engine Over Speed Prevention Control

Engine over speed is controlled by a fuel cut.



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Timing Control

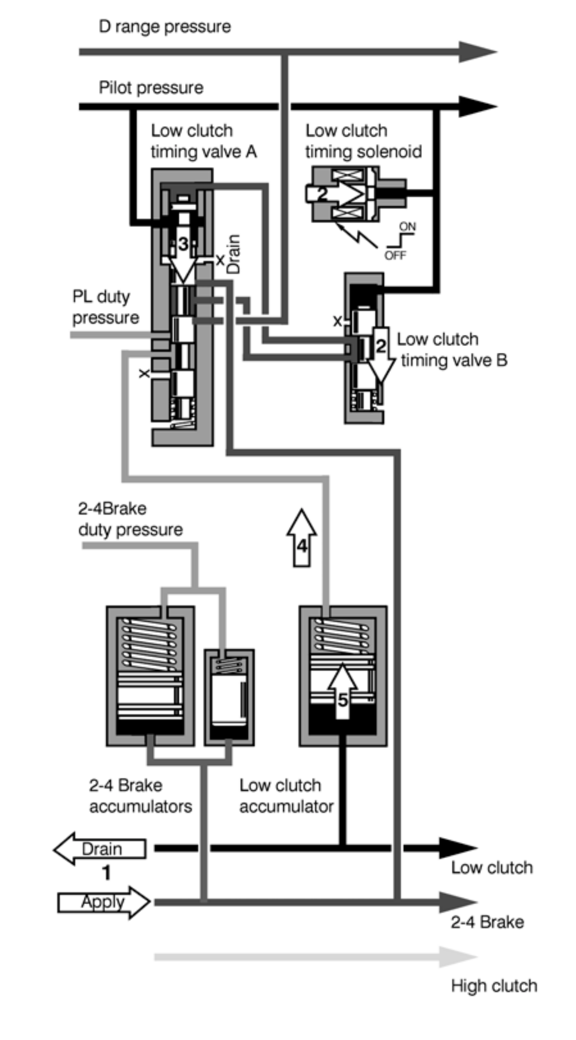
Timing control is designed to prevent shift shock and engine racing. Two types of timing control are used with the new eat. 2-4 brake timing and Low Clutch Timing.

2-4 brake timing is utilized during the upshift from 2nd to 3rd gear. This control temporarily engages both the 2-4 brake and the high clutch, preventing shift shock and engine racing when upshifting from 3rd to 4th gear.

When the TCM turns the 2-4 brake timing solenoid on the 2-4 brake-timing valve A is acted upon by the high clutch pressure.

The 2-4-Brake Timing Valve Spool is pushed down as the high clutch pressure overcomes the set pressure.

The movement of the spool valve changes the draining characteristics of the 2-4 brake accumulators. The faster the back pressure of the accumulators drain the faster the release of the 2-4-Brake Clutch.



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Low Clutch Timing Control

Low Clutch Timing Control is designed to prevent shift shock and engine racing when the transmission is upshifting from 3rd to 4th gear.

During the upshift to 4th gear the 2-4-Brake clutch and the Low Clutch are temporarily engaged together. At the same time the Low Clutch Timing Solenoid is activated controlling the pilot pressure applied to top side of the Low Clutch Timing valve B.

The movement of the Low Clutch Timing valve B spool regulates the 2-4 brake apply pressure to the top of Low Clutch Timing valve A. When this pressure overcomes the set pressure the spool valve moves down, changing the draining characteristics of the Low Clutch accumulator back pressure. The faster the back pressure of the accumulator drains the faster the low clutch fully disengages.

Control performed by the PL Duty Solenoid and the 2-4 Brake Duty Solenoid

The line pressure duty solenoid and the 2-4 brake duty solenoid are adjusted to set values determined from preexisting conditions of the vehicle just before an up shift or down shift occurs. This set value is lower than the applied value and is designed to prevent shift shock and improve shifting characteristics.

The drop in both duty pressures cause the accumulator control valve A and B spool valves to move up, and the low clutch and 2-4 brake accumulator back pressures to be reduced.

This allows the accumulators to absorb a larger shock when the clutches are applied.

The turbine sensor detection signal inputted to the TCM influences the rate in which the duty ratios are increased.

Down shifting from 4th to 3rd

The line pressure and 2-4 brake duty solenoid are adjusted to a lower set value just before the actual downshift.

This drops the back pressure in the high and 2-4 brake accumulators. The lowered back pressure allows the applied pressures to be lower, creating a slipping condition of the high and 2-4 brake. Higher engine speeds will then be obtained, generating a higher driving force to the rear internal gear.

The TCM gradually increases the duty ratios eliminating the slip.

Engine Torque Control

Engine torque control is performed by the engine control module which lowers the engine torque by retarding the engine ignition timing and cutting the fuel supply, reducing shift shock.

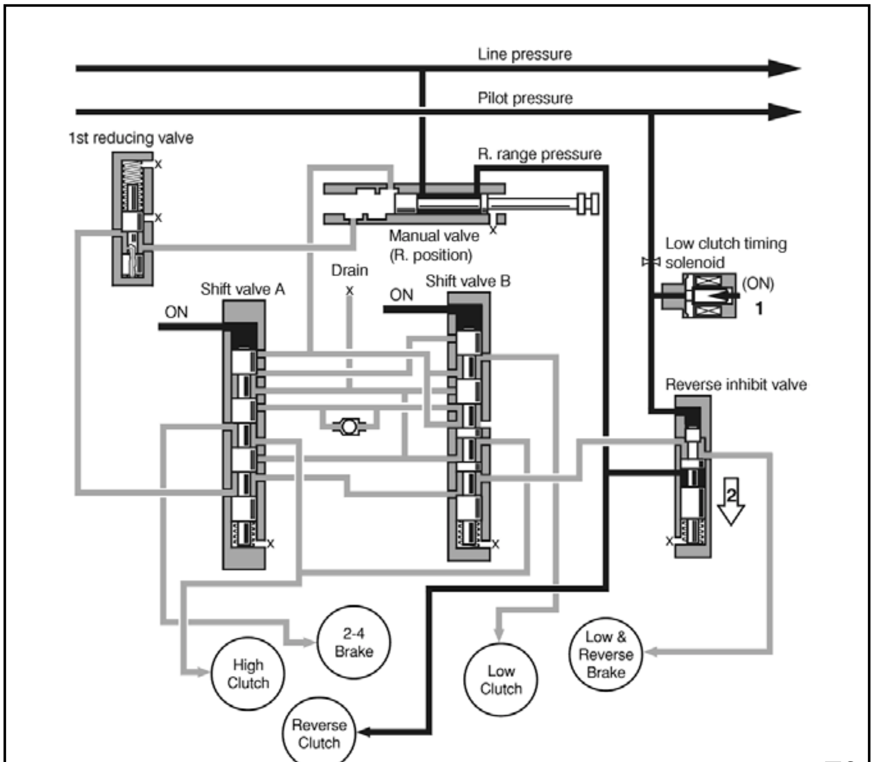
While shifting is in progress, the TCM detects the brake and clutch engagement \ release conditions by comparing the turbine sensor signal and the speed sensor signals. The TCM outputs a signal to the ECM to reduce the torque when set conditions are reached.

Learning Control

Learning control is utilized to prevent shift shock that is created because of clutch and brake wear.

The TCM always detects the turbine sensor signal after starting shift control. It measures the time from when this signal changes until the clutch or brake starts to engage and the time from that point until the clutch or brake fully engages.

The TCM compares these times and their respective target values and determines the clutch or brake status. Based on the results, it decides the operating characteristics of the line pressure control solenoid and the 2-4 brake duty solenoid. By controlling the line pressure control solenoid and the 2-4-Brake solenoid based on these operating characteristics, increased shift shock due to change with passage of time can be prevented.



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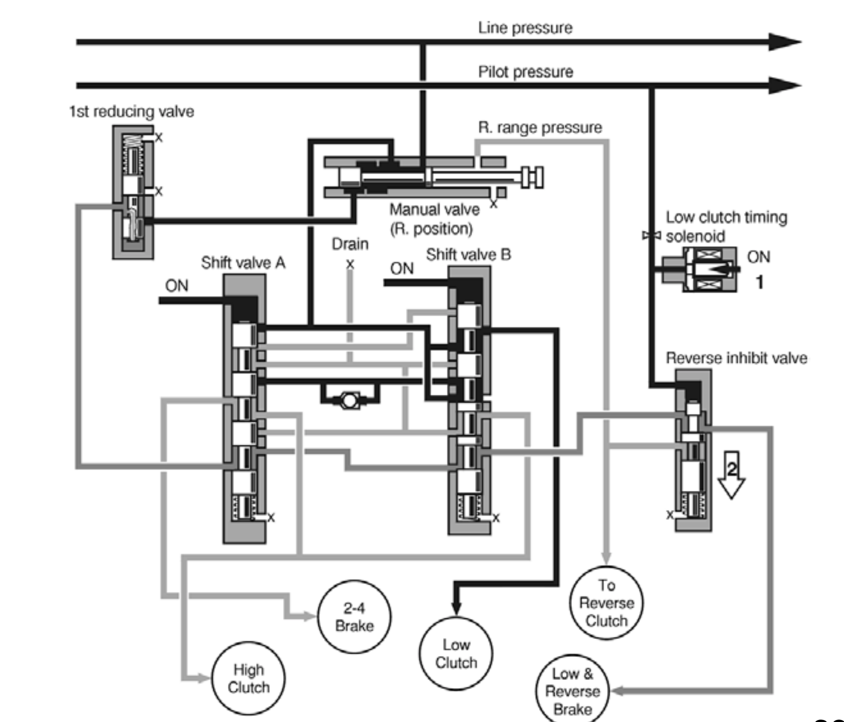
Reverse Inhibit Control

Designed to prevent the accidental shift into reverse gear . This feature is only active above 10km/h (6 m.p.h.). The Low Clutch Timing solenoid is turned on allowing pilot pressure to build up on the top side of the Reverse Inhibit valve. The valve spool is then pushed down blocking the passageway to the low and reverse brake.



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Engine Brake Control

Engine brake operation will occur in the 1 range 1st gear. The TCM turns the Low Clutch Timing Solenoid on and supplies pilot pressure to the reverse inhibit valve. The pilot pressure causes the reverse inhibit valve spool to move downward, opening the port to the low and reverse brake. Pressure from the 1st reducing valve engages the low and reverse brake. The Low Clutch Drum is then fixed to the transmission case and the rotation of the wheels is transmitted to the engine side, operating the engine brake effect.

Self Diagnosis

Slides 82, 83, and 84

The TCM detects trouble in the detection signals from the sensors and the signals output to the actuators. This function is referred to as the self-diagnosis function.

When either signal is faulty, the TCM indicates system trouble by flashing the ATF lamp in the combination meter.

By counting the flashes of the lamp a trouble code can be specified.

CODE	ITEM	DIAGNOSIS	TROUBLE
11	Line pressure duty solenoid	Short or Disconnection in solenoid driving circuit	More severe shifting shock and faulty shifting
12	Lockup duty solenoid	Short or disconnection in solenoid driving circuit	Fails to lock up (after warm-up)
13	2-4 brake timing solenoid	Short or disconnection in solenoid driving circuit	Faulty shifting
14	Shift solenoid B	Short or disconnection in solenoid driving circuit	Fails to shift
15	Shift solenoid A	Short or disconnection in solenoid driving circuit	Fails to shift
16	2-4 brake duty solenoid	Short or disconnection in solenoid driving circuit	Faulty shifting
21	ATF temperature sensor	Short or disconnection in input circuit	Faulty shifting when cold
22	Pressure sensor	Short or disconnection in input circuit	More severe shifting shock
23	Engine speed signal	No signal input above 10km/h	Fails to lock up (after warm-up)
24	Transfer (AWD duty solenoid	Short or disconnection in solenoid driving circuit	Excessive tight corner braking phenomena
25	Engine torque control signal	Short or disconnection in engine torque control signal circuit	More severe shifting shock
31	Throttle sensor	Short or disconnection in input circuit	Faulty shifting and excessive shifting shock
32	Vehicle speed sensor 1	No signal input to speed sensor 1 above 20km/h	Speed sensor 1 malfunctions: more severe shifting shock One or the other malfunctions: excessive tight corner braking phenomena Both malfunction: fails to shift
33	Vehicle speed sensor 2	No signal input to speed Sensor 2 above 20km/h	
34	Turbine sensor	No signal input in ranges other than N range (vehicle speed sensors 1 and 2 are operating normally) while vehicle is traveling	More severe shifting shock
36	Low clutch timing solenoid	Short or disconnection in solenoid driving circuit	Faulty shifting

Failsafe Function

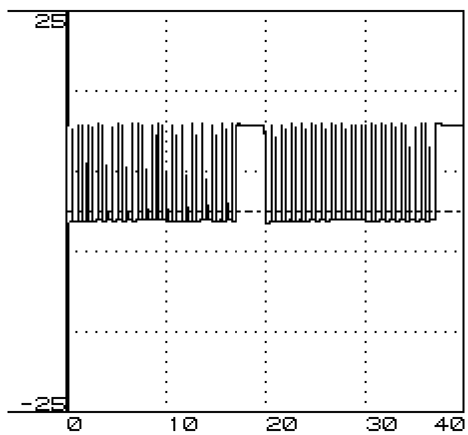
Failsafe function is a TCM controlled function that enables the vehicle to be driven in the event of malfunction of the vehicle speed sensors, throttle sensor, inhibitor switch, or the various solenoids.

In the event of trouble the TCM executes the following control.

Item	Failsafe Function
Line pressure duty solenoid	TCM turns the solenoid off and sets the transmission so only 1st and 3rd are available . The line pressure is also set to maximum.
Lockup duty solenoid	TCM turns the solenoid off and torque converter lock up does not occur.
2-4 brake timing solenoid	TCM turns the solenoid off and sets the transmission so only 1st and 3rd are available.
Shift solenoid B	When either solenoid malfunctions the TCM turns both solenoids off and sets the transmission to 3rd gear.
Shift solenoid A	When either solenoid malfunctions the TCM turns both solenoids off and sets the transmission to 3rd gear.
2-4 brake duty solenoid	TCM turns the solenoid off and sets the transmission so only 1st and 3rd are available
Transfer (AWD duty solenoid	TCM turns the solenoid off and adjusts the transfer clutch pressure to maximum.
Throttle sensor	TCM assumes the throttle opening of 3/8 open and continues at that level.
Vehicle speed sensor 1	Vehicle speed sensor 2
Vehicle speed sensor 2	Vehicle speed sensor 1 (If both sensors malfunction then the TCM sets the transmission to 3rd gear.)
Low Clutch Timing Solenoid	TCM turns the solenoid off and sets the transmission so only 1st and 3rd are available

86 and 87

2002 Impreza 4EAT Phase 2 Enhancements "Chopper Voltage Signal"



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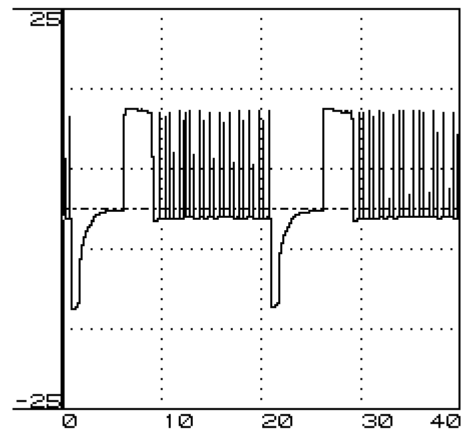
Ignition On Engine Off (line pressure)



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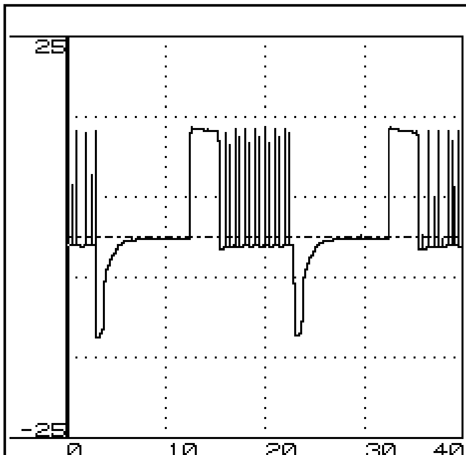
Idle (line pressure)

The external dropping resistors for the 4EAT have been eliminated. The TCM now incorporates circuitry that produces a “chopper voltage signal” during the time the resistors previously operated.

The “chopper voltage signal” is a series of voltage pulses up to 12 volts that average out to approximately 3 volts. This will function to hold the line pressure control and 2-4 brake solenoid in the open position until the signal is removed.



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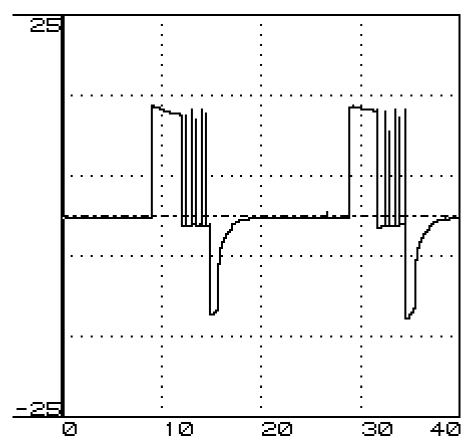
Part Throttle (line pressure)



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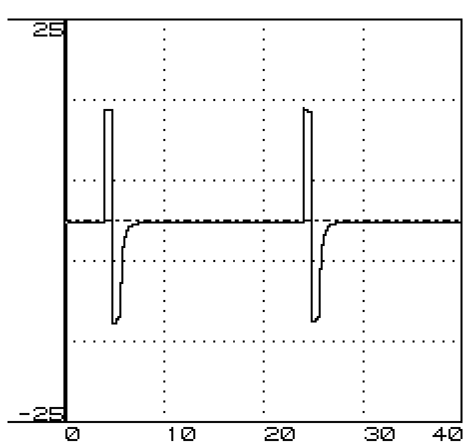
Half Throttle (line pressure)



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Stall Speed (line pressure)

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CERTIFIED SUBARU TECHNICIAN

Technicians Reference Booklet

5 Speed Automatic Transmission

Module 305

AUTOMOTIVE Youth Educational Systems

September 2005

MSA5P0474C

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of September 2005.

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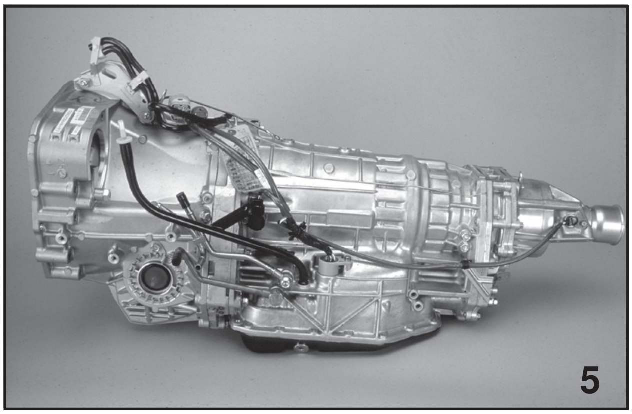
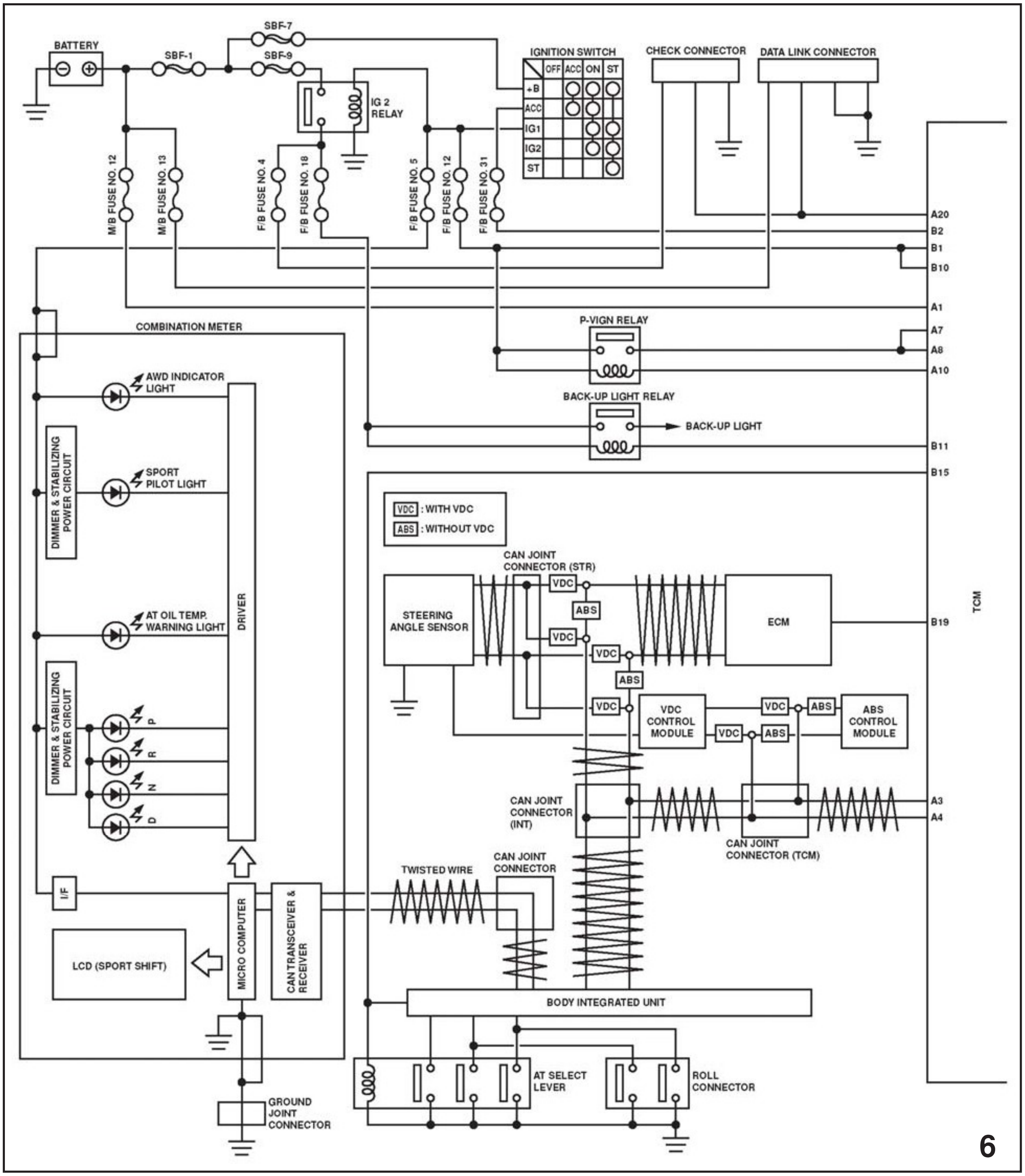
Introduction and Operation



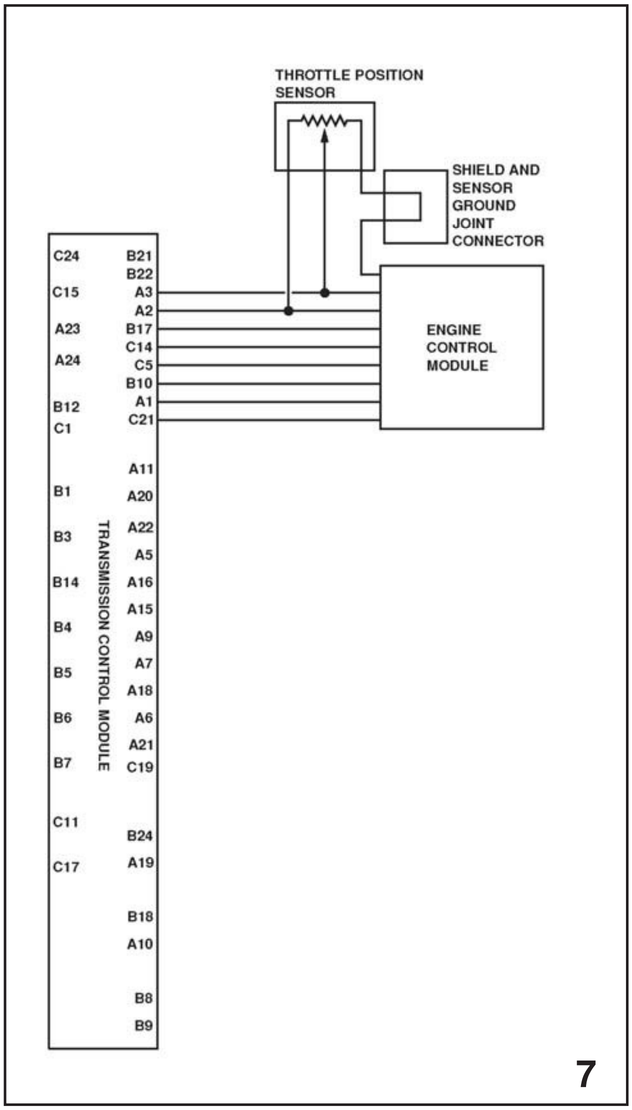
5 Speed Transmission

The 5 speed automatic transmission equipped on select 2005 Legacy vehicles is designed to electrically function with the Local Area Network (LAN). The LAN is a network of computers and components that share information over a single pair or wires. The name for this shared information is Controller Area Network (CAN) data. CAN data is transmitted, received and translated by creating or reading a series of binary codes from one computer to the others.

-All of the computers on the LAN have this ability; however, components on the drive train side operate at a faster rate than those on the body side. When drive train components and body components need to share information a translator must be used. This translator is called the Body Integrated Unit (BIU). The faster signals from the drive train and the slower signals of the body components are adjusted so that they can be read and understood by each other. This is also referred to as a gateway function. The BIU performs many other functions but the gateway functions are all we are concerned with in regards to the 5 AT.

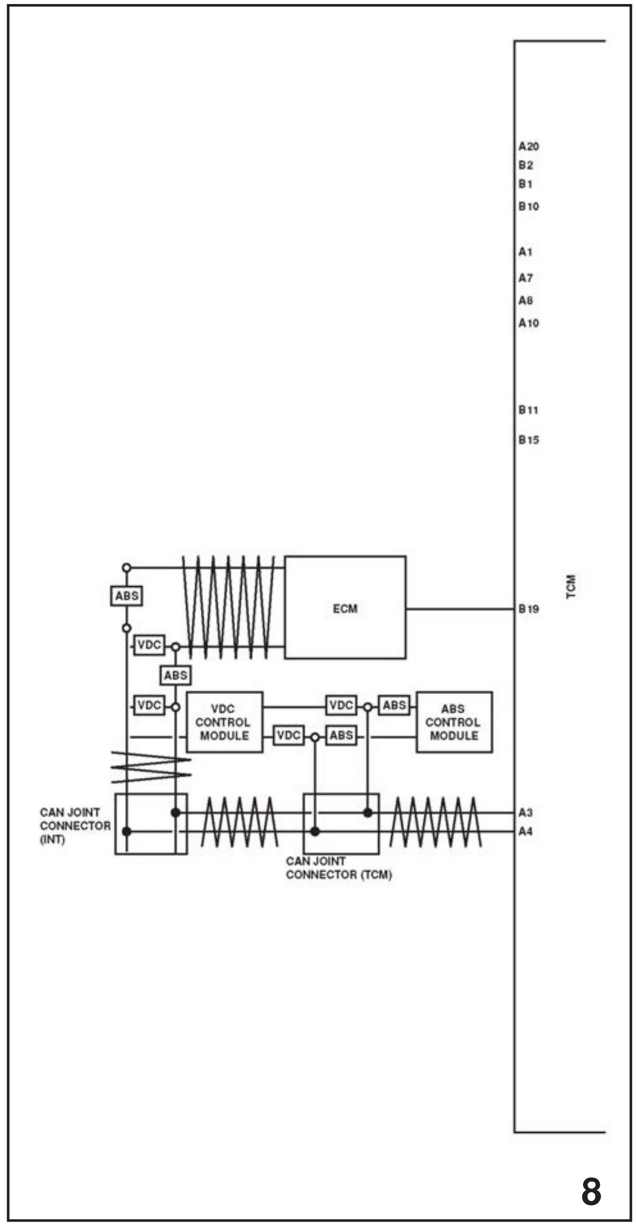


2005 Wiring Schematic



2004 4AT

The LAN also reduces the number of wires connecting to the TCM. For example the throttle position sensor normally hard wired to the TCM is now delivered to the TCM through the LAN. This improves performance and reliability by reducing the number of physical connections and conductors that can short or open. Additionally the diagnostics become more simplified as the number of DTCs and circuits to trouble shoot are reduced.



2005 5AT

The chart below lists all the signals that the TCM receives through the LAN.

T = Transmits the signal
R = Receives the signal
G = Gateway function

Signal	ECM	TCM	ABS	SAS	BIU	Com. Meter	AC
Current engine torque	T	R	R				
Accelerator pedal open angle	T	R	R				
Engine speed	T	R	R		R		
Torque down prohibit	T	R					
Idle switch	T	R					
Power steering switch	T	R					
AC compressor output	T	R					
Cruise control main switch	T	R	R				
Throttle position switch	T	R					
Torque control signal	R	T					
Idle up request	R	T					
Gear position	R	T			GR	R	
Lock up information	R	T					
AT turbine speed	R	T					
Road surface gradient est.	R	T			G	R	
ATF temperature	R	T			G	R	
Sport lamp output		T			G	R	
AWD lamp output		T			G	R	

Major Signal Name	ECM	TCM	VDC ABS	SAS	BIU	Com. Meter	AC
ECO lamp output		T			G	R	
Sports shift buzzer output		T			G	R	
Shift range information	R	T			G	R	
AT trouble info 1,2	R	T			G	R	
Yaw rate	R	T					
Brake pressure	R	T					
Lateral acceleration	R	T					
ABS operation	R	R	T		R		
TCS operation	R	R	T		G	R	
VDC/ABS sensor failure	R	R	T		R		
Vehicle speed	R	R	T		GR	R	R
ABS/VDC judgment flag	R	R	T		R		
Brake lamp switch	R	R			T		
Sport Shift mode switch		R			T		
Sport Shift, shift up		R			T		
Sports shift, shift down		R			T		
ECO mode switch	R	R			T		
BIU failure info	R	R			T	R	
Ambient temperature Cel.	R	R			T	R	R
Engine coolant temp	T	R			G	R	R

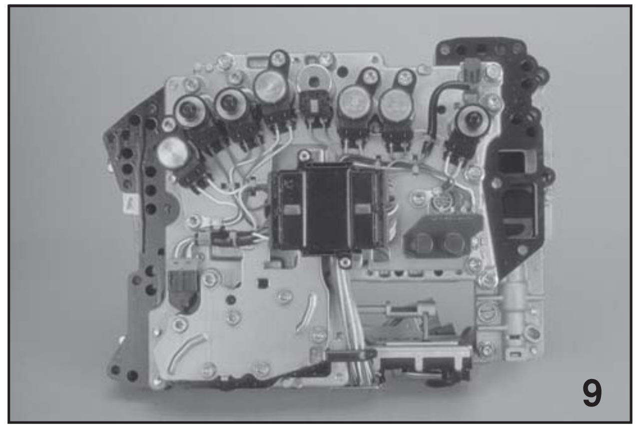
It is important to remember that analog signals remain an integral part of the operation of the transmission.

- Power
- Ground
- ATF temperature sensor 1
- ATF temperature sensor 2
- High & Low Reverse Clutch oil pressure switch
- Front Vehicle speed sensor
- Lateral G sensor
- Inhibitor switch
- Rear vehicle speed sensor
- Front brake oil pressure switch
- Turbine speed sensor 1
- Direct Clutch oil pressure switch
- Low Coast brake oil pressure switch
- Input clutch oil pressure switch

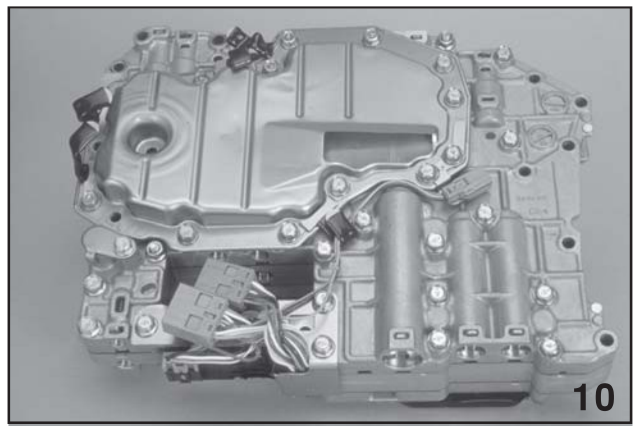
These input signals are all located inside the transmission except for :

- Power
- Ground
- Speed sensor 1
- Turbine speed sensor 1 and the lateral G sensor

These signals control the activation and timing of the solenoids located on the valve body.

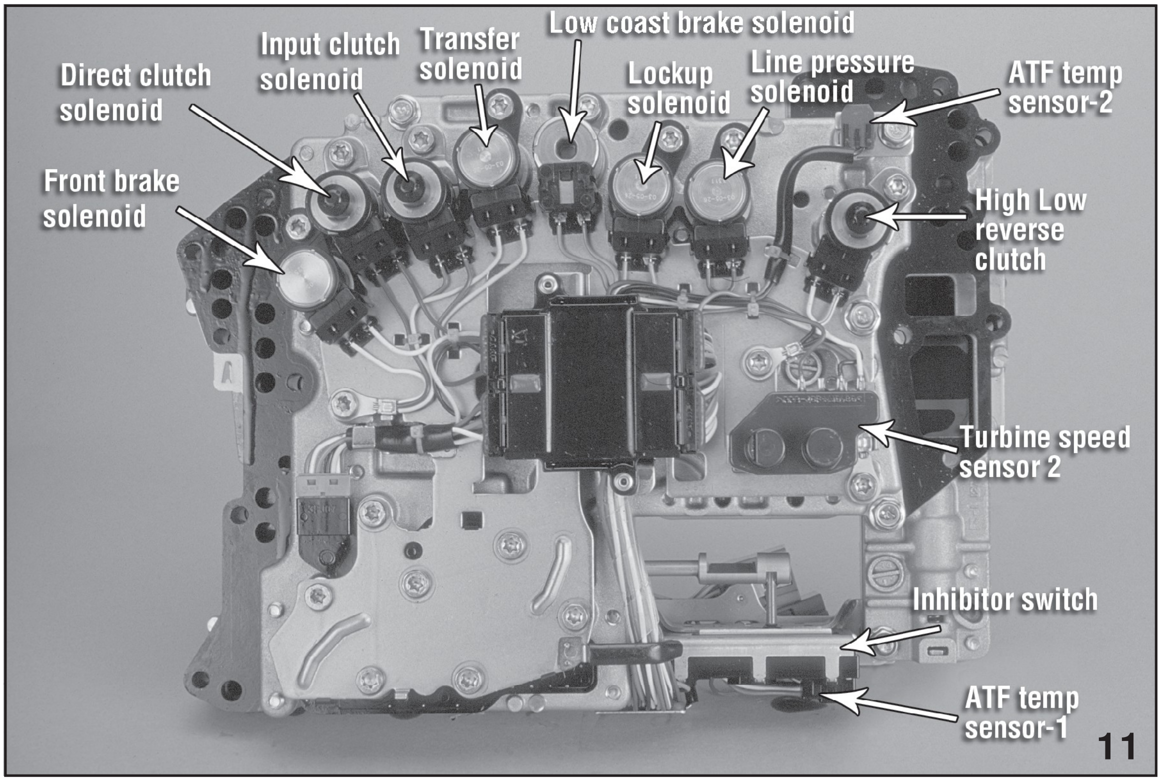


Transmission Side View of Control Valve Body

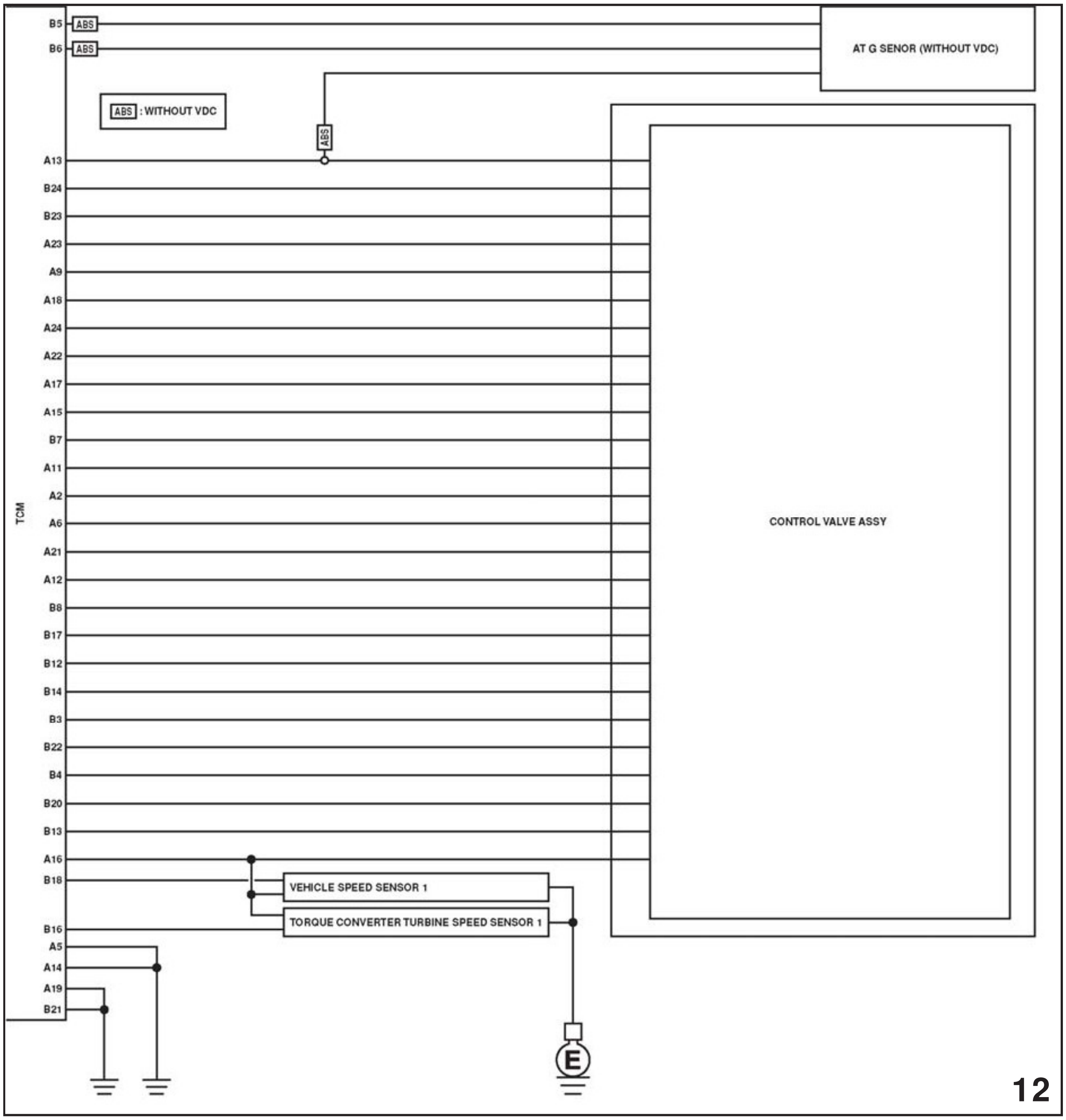


Oil Pan View of Control Valve Body

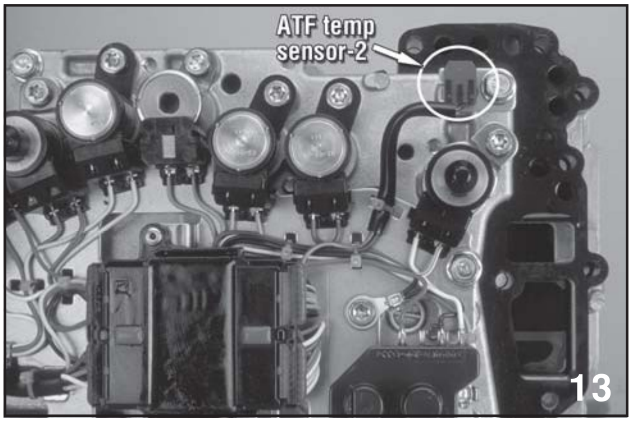
The valve body cannot be serviced. The factory calibrates and adjusts each solenoid and monitors the reaction and timing of the valves and stores the information on the built in memory box which is located on the valve body itself.



Valve Body Component Location



Analog Signals



Memory Box

The TCM uses the data on the memory box for initial control of the valves until adjustments are made to fine tune their control.

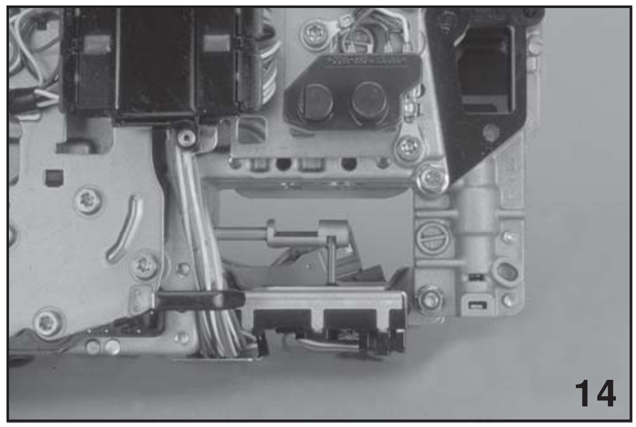
Contents of shift learning control

1. The current and oil pressure characteristics of the linear solenoid are measured by the control valve unit, and calibration values are stored in the memory box at the factory.
2. The transmission is test-driven with the hydraulic control valve, and the input and output torque variation characteristics that the transmission undergoes during shifting are stored in the memory box as initial learning values.
3. The calibration values and initial learning values stored in the memory box at the factory are read by the TCM. Based on this data, the TCM executes learning control, which ensures smooth shifting right from day one.

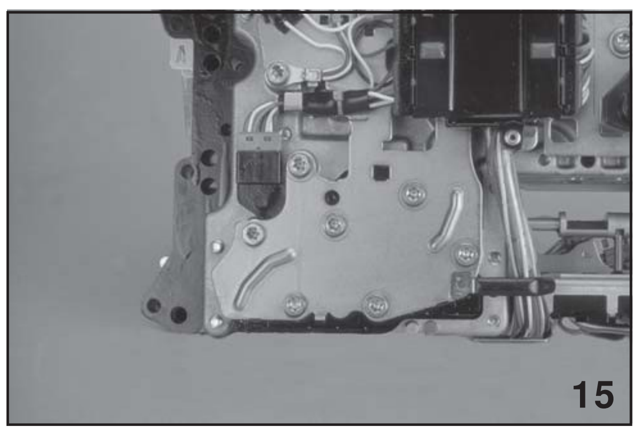
ATF Temperature sensors

ATF temperature sensor 1, which is mounted on the inhibitor switch, measures the temperature of the ATF in the oil pan.

ATF temperature sensor 2, which is mounted in the hydraulic control valve oil passage, measures the temperature of the ATF returning from the torque converter. The value measured by ATF temperature sensor 2 is used for lock-up clutch control.



Turbine Speed Sensor 1



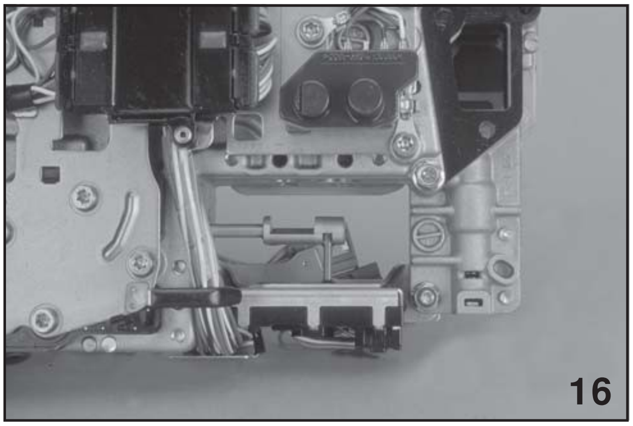
Oil Pressure Switches

Turbine Sensor

Turbine sensor 1 detects the rotation of the front sun gear, while turbine sensor 2 detects the rotation of the front carrier. Using the values detected by these sensors, the TCM calculates the turbine speed and uses it for shift control.

Oil Pressure Switches

Five oil pressure switches detect the shift circuit oil pressure, and this data is used to diagnose solenoid valve trouble.



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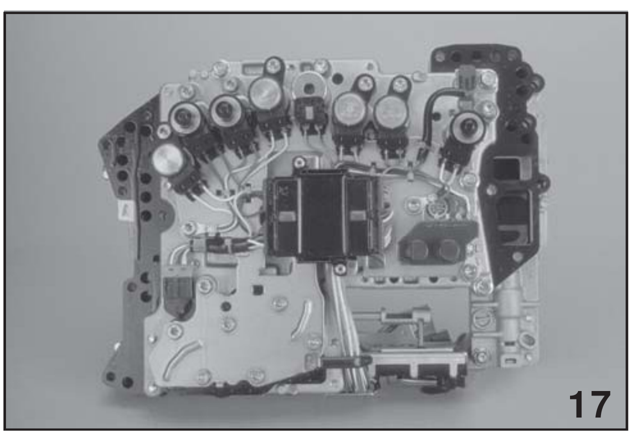
Inhibitor Switch

Inhibitor Switch

A slide-switch type inhibitor switch is provided inside the transmission to detect the manual valve position (P, R, N, D).

Based on the values detected by this switch, the TCM outputs a P signal or N signal to the ECM, allowing the starter motor to operate only in P position or N position. In R position, it turns on the back-up lamp relay and illuminates the back-up lamp.



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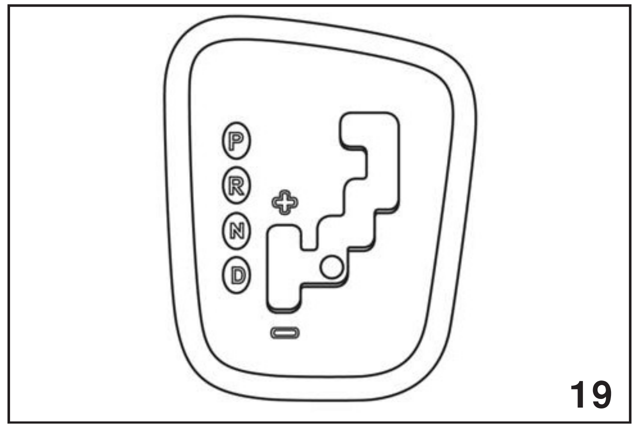
Solenoids

Hydraulic Control Valve has 8 solenoid valves, which are used for line pressure control, shift control, and various other controls.

Selector Lever Function

There are three modes on the selector lever. Normal mode, Sport mode and Manual shift mode. These operation modes are changed over with the position of the selector lever.

Normal Mode



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Selector Normal

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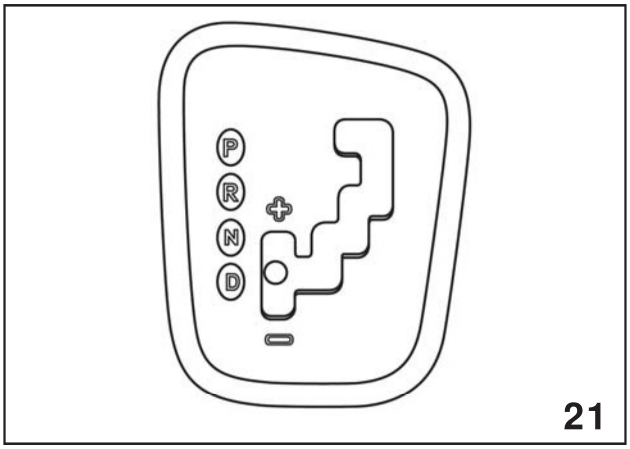
Drive Light

The TCM performs gear shifting control according to driving conditions by using the normal shifting map stored in the memory of the TCM.

Sport Mode



Selector Sport

Sport Light

When the selector lever is moved to the sport mode position the TCM changes over shifting control map data from the normal map to the sport mode map. The shifting up and the shifting down point are varied more high ranges. (sports mode only).

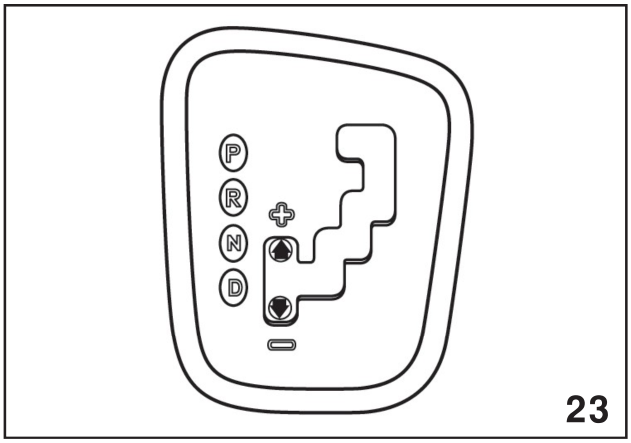
Control during cornering

When the system interprets that the vehicle is turning a corner by the lateral acceleration and the change rate in vehicle speed, it prevents unwanted upshifts to maintain a stable drive force and cornering performance (operates in sports shift mode only).

Sports Mode Control

When the shift lever is moved toward the manual gate side in D range, the SPORT light in the combination meter illuminates and the system enters the Sports mode. Gearshift timings are set at higher vehicle and engine speeds to make more use of low speed gears. The full lockup vehicle speed in 5th is also set higher than in the normal mode.

Manual Shift Mode Control



Selector Manual

Manual Lights +-

Manual shift mode is activated by moving the select lever to the manual gate and activating the up shift or downshift switch. .In this mode, operating the “+” switch causes up shifting while operating the “–” switch causes downshifting; manual shifting is enabled and the selected gear position is held while driving.

However, at certain vehicle speeds or ATF temperatures, the following inhibiting control is performed.

Up shift inhibiting and auto down shift control

The gear up shifts from 1st to 5th each time the “+” switch is operated, however, when the vehicle speed is too low for the selected gear speed, the TCM inhibits further up shifting. If the vehicle speed becomes too slow for the current gear speed, a downshift will be made automatically to prevent engine stall. When the vehicle comes to a stop, the transmission will always be controlled to shift to 1st speed unless the vehicle was in sports shift 2nd hold control.

Downshift inhibiting control

The gear downshifts from 5th to 1st each time the “–” switch is operated, however, when the vehicle speed is too high for the selected gear speed, the TCM inhibits further shifting. A sports shifting inhibiting buzzer will sound to warn the driver.

Engine over speed prevention control

If the engine speed exceeds the preset value during accelerating, the fuel supply is cut to prevent over-revving of the engine.

Semi sports mode

The up and downshift buttons on the steering wheel can be used in normal drive mode to temporarily shift the vehicle into manual mode. The vehicle must be moving greater than 6 m.p.h. and under low engine load conditions for activation. Pushing the up or downshift button will activate the semi sports mode and will stay engaged until the engine load is reduced or the up or downshift buttons are left untouched for a time while the vehicle is operating.

The buttons can also be used when the shifter is placed into manual mode and the buttons are used for up or downshift control instead of the shifter lever.

2nd Hold Control

When the "+" switch is operated when the vehicle is in manual shift mode and not moving, the transmission shifts to 2nd speed enabling start in 2nd. This status is held unless the manual shift mode is canceled, the vehicle speed exceeds a certain value, or 1st speed is selected with the "–" switch.

Downshifting is limited to 2nd even when the stopping the vehicle.

2nd Light

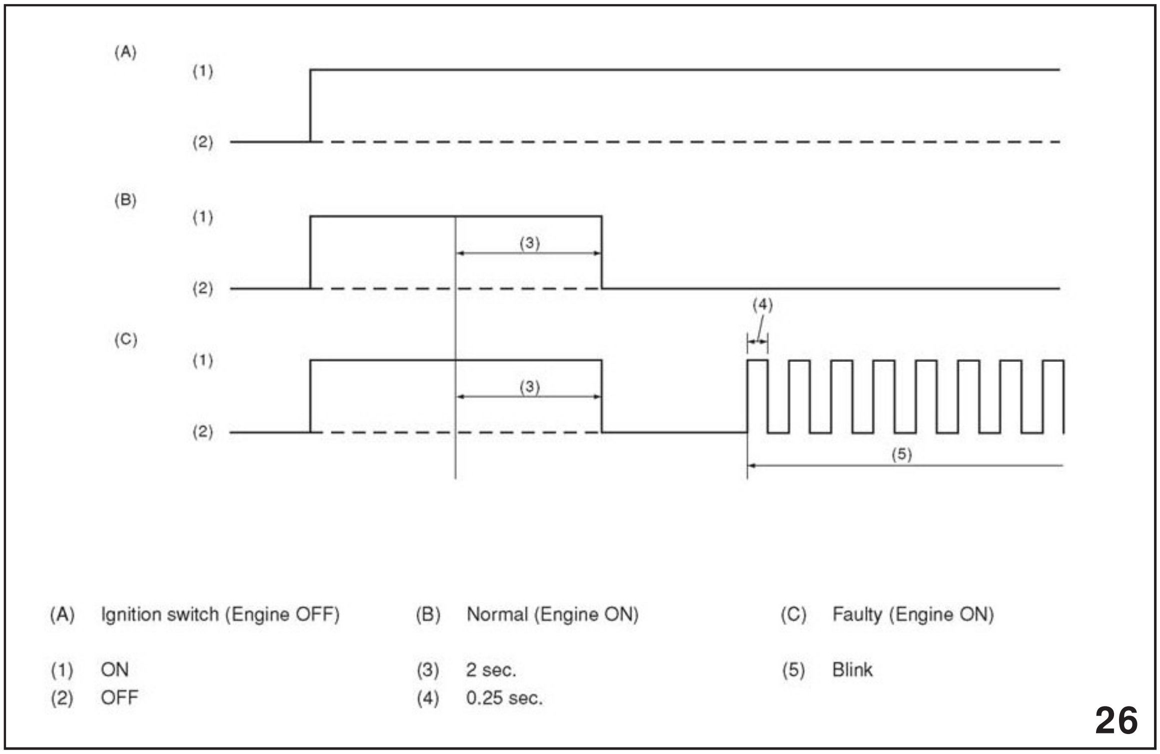
Diagnostics

Sport Indicator Light Display

Diagnostics for the 5AT are necessary when the function of the sports light illuminates as described below or the vehicle operator physically detects unwanted operation. As previously described the proper operation of the 5AT is dependent on the complete operation of the LAN. The transmission itself is checked by the TCM for electrical and mechanical performance. The TCM no longer outputs specific trouble codes for the transmission itself rather it communicates Diagnostic Trouble Codes generated by the TCM or the LAN. Hydraulic ports for checking pressures of individual clutches has been deleted and replaced by a single port for checking line pressure and transfer clutch pressure. The use of the select monitor when checking hydraulic pressure becomes necessary as the target pressure for gear ranges is provided.

When any on-board diagnostics item is malfunctioning, the SPORT indicator light blinks from the time the malfunction is detected after starting the engine until the ignition switch is turned OFF. The malfunctioning part or unit can be determined by a DTC during the on-board diagnostics operation.

Problems which occurred previously can also be identified through the memory function. If the SPORT indicator light does not show a problem (although a problem is occurring), the problem can be determined by checking the performance characteristics of each sensor using the Subaru Select Monitor.



Sports Light Operation

	In/C	H & LR	Di/C	Rev/B	Fr/B	LC/B	FW D/B	OWC 1st	OWC fwd	OWC 3rd
P		0			0					
R		0		0	0			0		0
N		0			0					
1st					0	Sp	0	0	0	0
2nd			0		0	Sp	0		0	0
3rd		0	0		0		0			0
4th	0	0	0				0			
5th	0	0			0		0			
Sp: Sport mode										

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Application Chart

Fail Safe Function

Front or rear speed sensor

The vehicle speed information received from the ABS unit VIA CAN communication is substituted for control. This enables normal quality shifting.

Inhibitor switch

If an input other than the specified pattern is entered into the TCM, the select position indicator lights in the combination meter are turned off, the starter is disabled, the reverse light is disabled, the transmission is fixed in D range and sports shift mode is inhibited.

PN signal abnormal

The output is inhibited (starter inhibited) if an abnormality is detected in the PN signal output. However if the ECM is receiving range signals through the backup of CAN communications, the starter can be used in P and N ranges.

AT interlock

If an AT interlock is detected, the vehicles minimum mobility is maintained by fixing the transmission in 2nd, 4th or 5th speeds in accordance with the engaging pattern detected by the hydraulic switch. The relationship between the hydraulic switch detection pattern and fixed gear speeds are shown in the following table.

- **ENGINE BRAKING IN 1ST ABNORMAL**

If engine braking in 1st is judged as abnormal the low coast brake solenoid is deactivated to cancel the engine braking effect.

- **LINE PRESSURE SOLENOID ABNORMAL**

The solenoid is deactivated and the line pressure is set to maximum, 5th speed is inhibited. Except for this, the system is controlled normally.

- **LOCKUP SOLENOID ABNORMAL**

The solenoid is deactivated and lockup is inhibited.

- **LOW COAST BRAKE SOLENOID ABNORMAL**

If the solenoid is failed and is stuck on (electrically or mechanically) the transmission is fixed to the 2nd speed, and when the solenoid is failed and is stuck off the solenoid is turned off. (Engine braking is made available in 1st and 2nd speeds.

- **INPUT CLUTCH SOLENOID ABNORMAL**

The transmission is fixed to 4th gear.

- **DIRECT CLUTCH SOLENOID ABNORMAL**

The transmission is fixed to 4th gear.

- **FRONT BRAKE SOLENOID ABNORMAL**

If the solenoid is stuck on the transmission is fixed to 5th gear. If the solenoid is stuck off the transmission is fixed to 4th gear.

- **HIGH AND LOW REVERSE CLUTCH SOLENOID ABNORMAL**

The transmission is fixed to the 4th gear.

- **TRANSFER CLUTCH SOLENOID**

The transfer clutch solenoid is turned off.

- **TURBINE SENSOR 1,2 ABNORMAL**

Shifting control is performed without using turbine sensor values to maintain minimum mobility. 5th speed and sports shift mode are inhibited.

- **TCM DATA COMMUNICATION IS ABNORMAL**

If communication with the memory box on the control valve assembly fails, back up values stored in the TCM are used for controlling the solenoids.

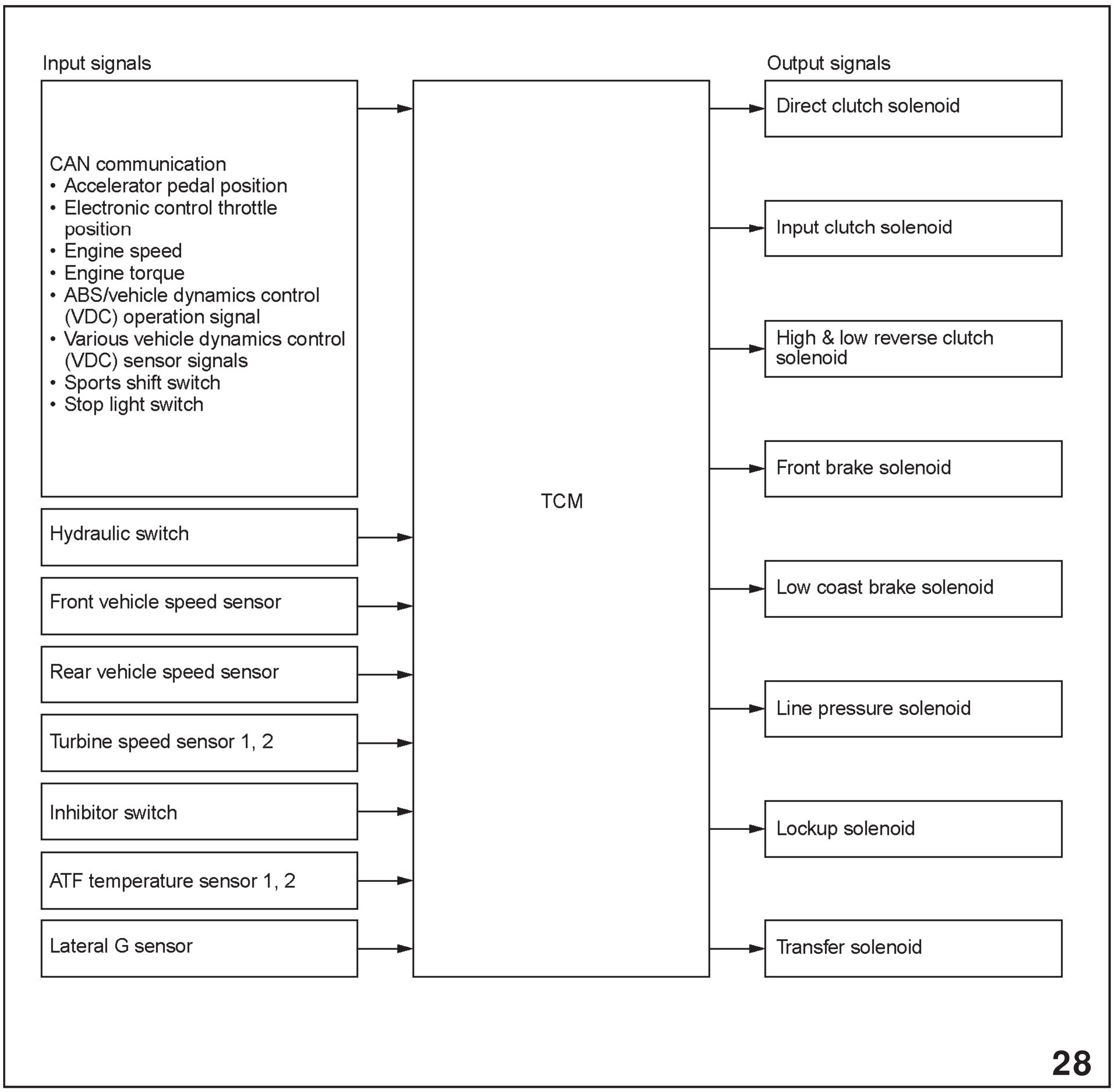
- **CAN COMMUNICATIONS ABNORMAL**

If an abnormality occurs in CAN communications, data received via CAN communications are fixed to preset values to perform shift control and maintain minimum mobility. Lockup and sports shift mode are inhibited.

Electronic-Hydraulic Control System

Description

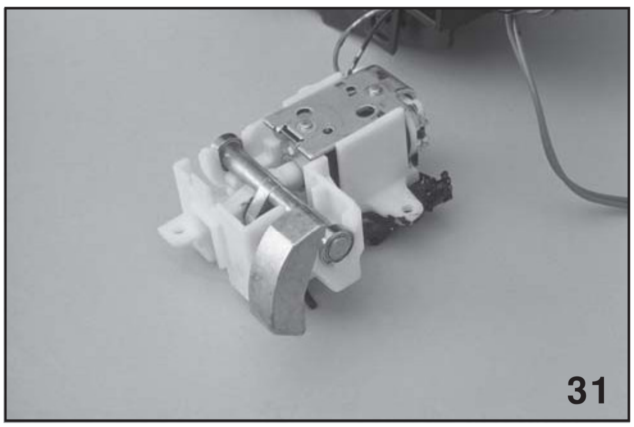
The electronic-hydraulic control system for the transmission and transfer consists of various sensors and switches, TCM, and the control valves including solenoid valves. The system controls the automatic transmission operation, including gear shifting, lockup clutch operation, line pressure, pilot pressure, and gear-shift timing. It also controls the operation of the transfer clutch. The TCM determines vehicle operating conditions from various input signals and controls a total of eight solenoids (front brake solenoid, low coast brake solenoid, input clutch solenoid, high and low reverse clutch solenoid, direct clutch solenoid, lockup solenoid, line pressure solenoid, and transfer solenoid) by sending appropriate signals to them.



Electronic-Hydraulic Control

Shift Lock

Shifter



Shift Lock Solenoid

The shift lock solenoid located in the shifter assembly performs two functions.

When in "Park" position the shift lock solenoid is off, allowing the shifter lever to be blocked from moving until the brake pedal is depressed with the ignition on.

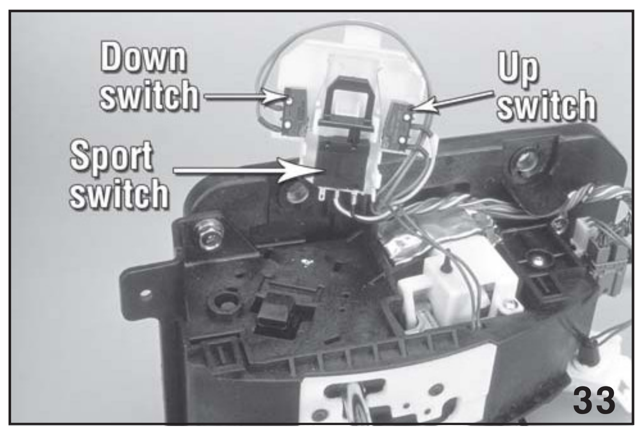
When in a gear range other than "Park" at a speed greater than 6 MPH, the shift lock solenoid will be off, preventing the shifter lever from accidentally being placed into "Park" or "Reverse".

When the shift lock solenoid is on the BIU activates the solenoid, allowing the shift lever to be placed into any gear range.

With the ignition off, and the shifter in a gear range other than "Park", the shift lock solenoid will be turned off after 30 seconds. This will prevent the shifter from being placed into "Park".

CAUTION: SET THE PARKING BRAKE TO ON WHEN PERFORMING SERVICE TO THE VEHICLE WITH THE TRANSMISSION PLACED IN A GEAR OTHER THAN "PARK".

Shift Lock Solenoid Bench

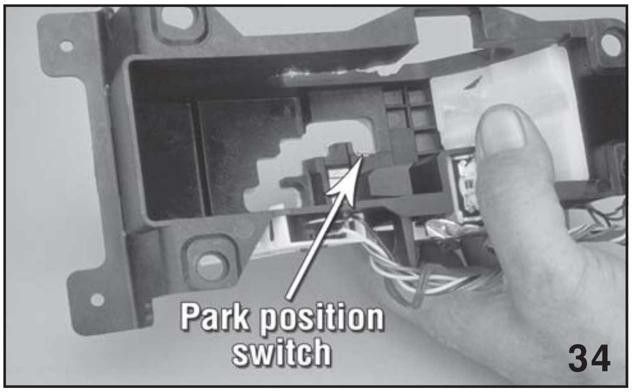


Sports Switch

The "Sport" mode or "Tiptronic" switch assembly is attached to the shifter near the sport gate.

When the shifter is placed in to the sport gate the shift lever pushes on the "Sport" or "Tiptronic" switch and the switch sends a signal to the BIU. The BIU will then illuminate the "Sport" mode light in the combination meter.

The "Up" and "Down" switches are located next to the "Sport" or "Tiptronic" switch. These switches send signals to the BIU that control the up and down shifting of the transmission in manual mode. The BIU will also use these signals for controlling the illumination of the manual gear lights in the combination meter.

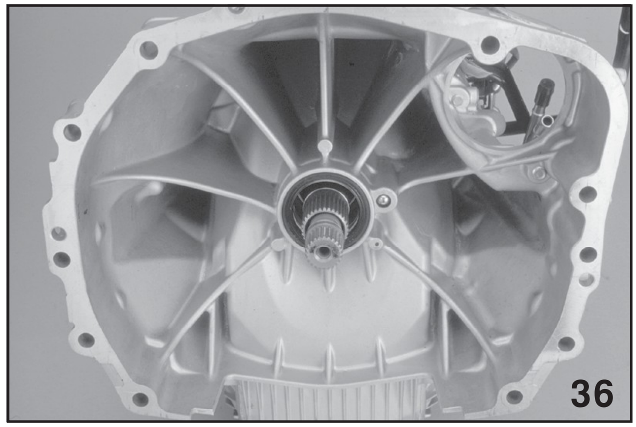


Park Position Switch

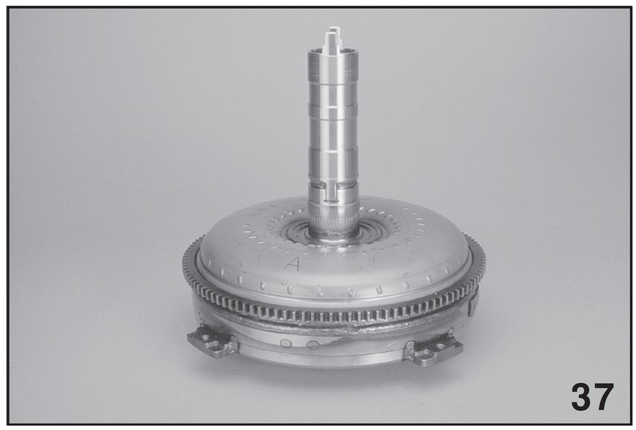
The "Park" position switch is located in the shifter assembly top plate and signals the BIU when the shifter is in or out of park. The BIU will use this signal to control the shift lock solenoid and "Park" light in the combination meter.

Signals from the inhibitor switch to the TCM are used for controlling the starter motor.

Disassemble



Converter Housing



Torque Converter

Begin disassembly by removing the torque converter and the oil pump drive shaft.

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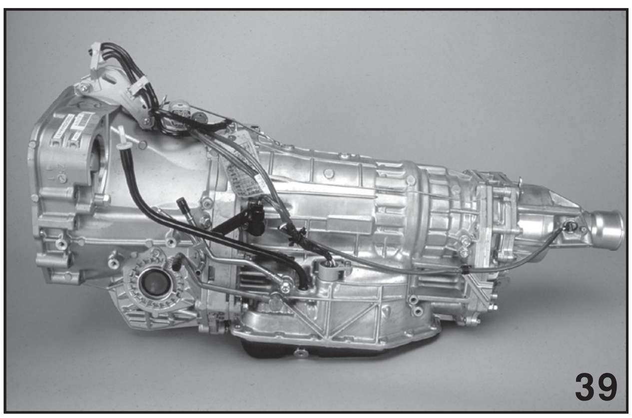
Separating Pump Drive

The oil pump drive shaft is connected to the torque converter with a circlip. The oil pump drive shaft can be separated from the torque converter by squeezing the two ends of the circlip together , allowing the circlip to clear the grooves in the torque converter.



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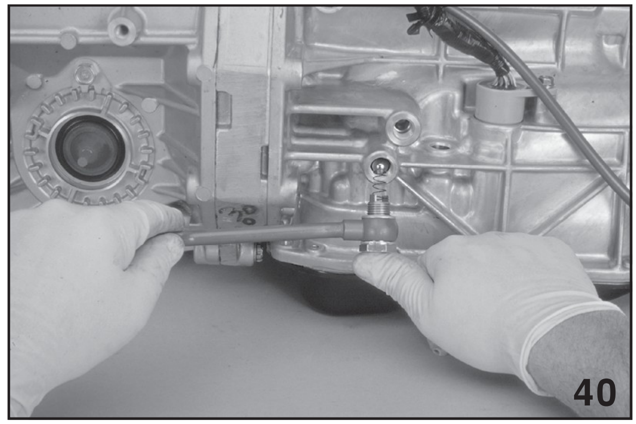
Transmission

Remove the transmission oil dip stick, atf inlet and outlet pipes.



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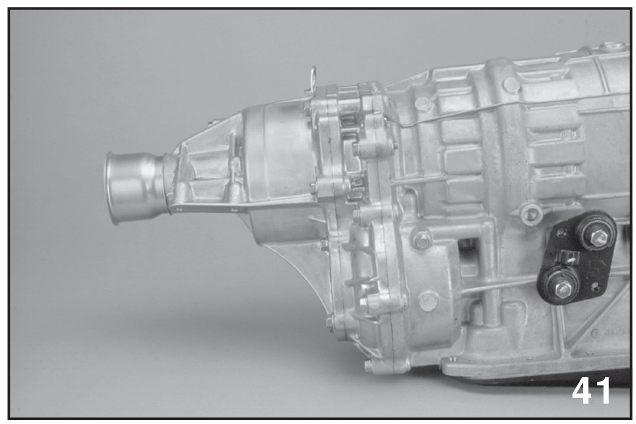
Check Valve

The ATF outlet pipe houses a spring and check ball that assist with preventing the drain down of atf from the torque converter when the engine is off.



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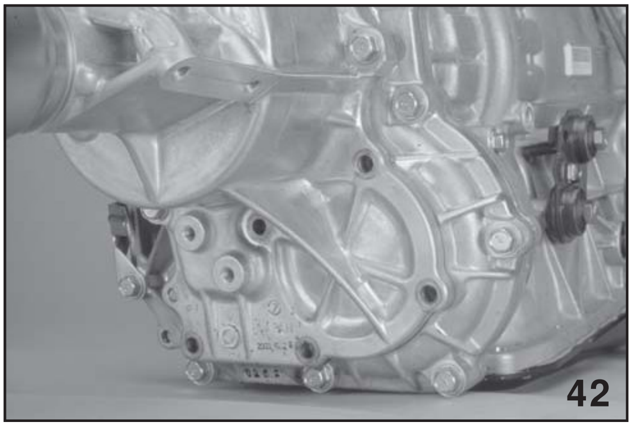
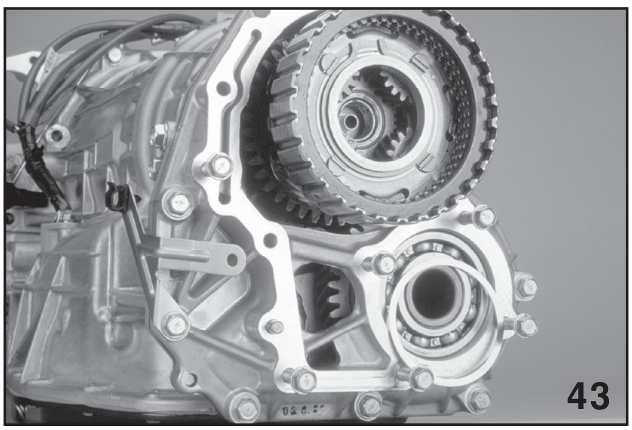
Extension Housing

Remove the bolt from the transmission harness main support and from speed sensor 1 and 2. Pull the sensors from the transmission case but be aware of their location to prevent damage to them during the remainder of the disassembly procedure.



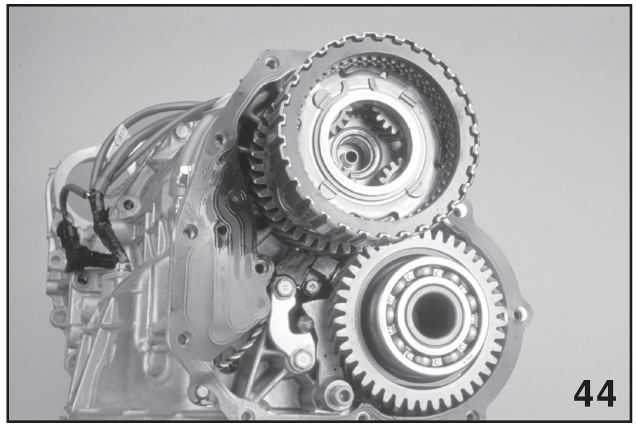
Extension Case 6 Bolts

Remove the extension case. Six (6) of these bolts are coated with thread sealing compound. Clean and recoat before installation.



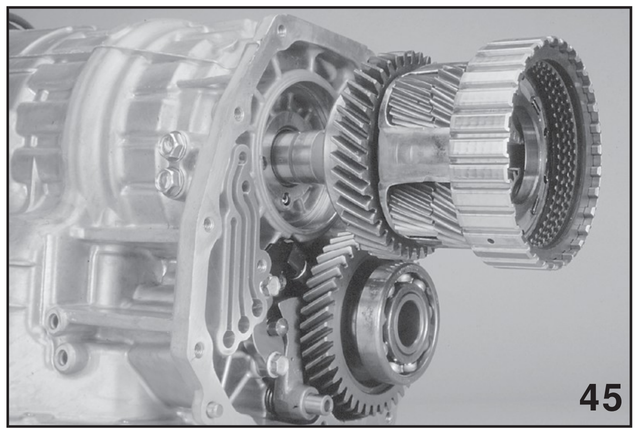
Shim and 6 Bolts

A shim will be found on the back side of the extension case or left on reduction driven gear bearing. Remove the shim for possible reuse during assemble. The shim controls the end play of the reduction driven gear.



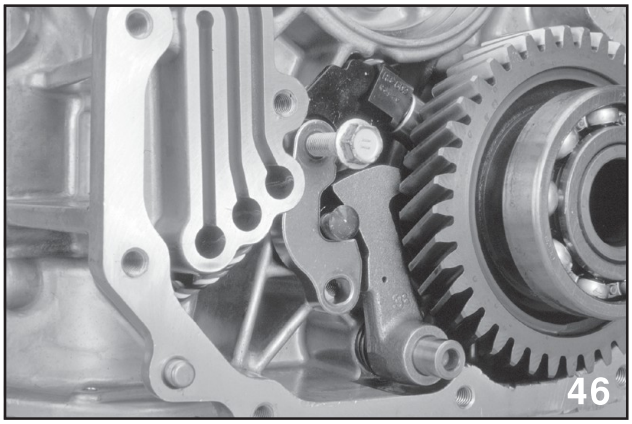
Transfer (VTD)

Remove the bolts from the intermediate case and gasket.



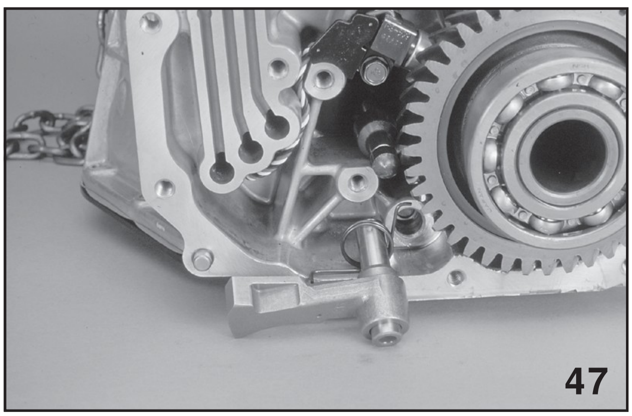
Transfer Drive Gear

Remove the VTD/reduction drive gear and intermediate shaft.



Parking Pawl

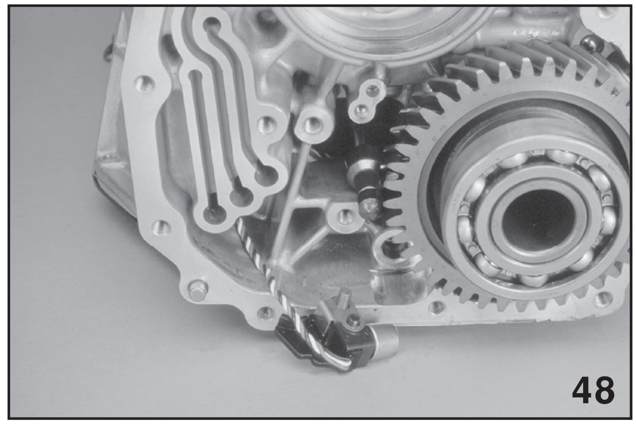
Remove the bolts that secure the parking support actuator and remove the parking support actuator.



Spring Location

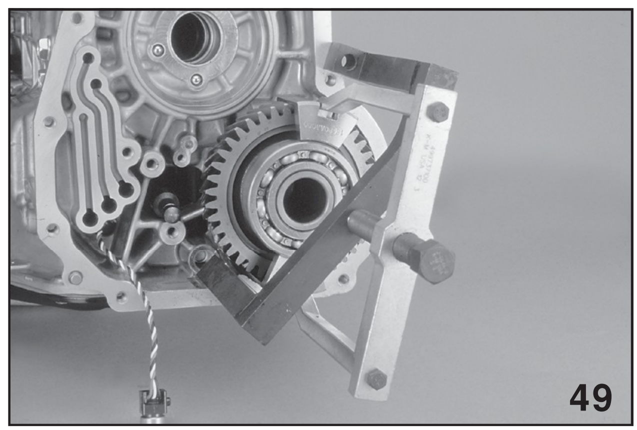
Remove the parking pawl shaft, spring and parking pawl.

NOTE: OBSERVE THE LOCATION OF THE SPRING BEFORE REMOVAL.



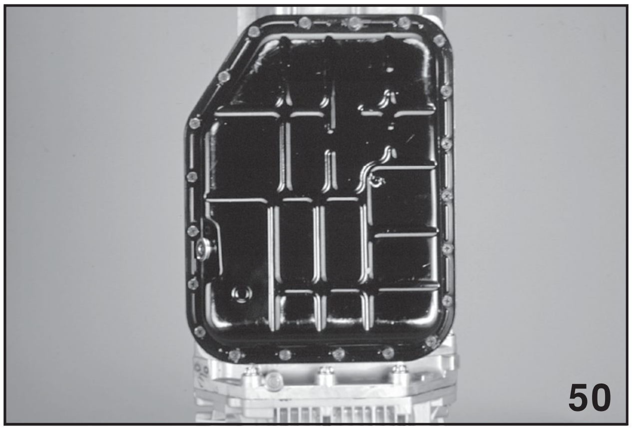
Front Speed Sensor

Remove the front vehicle speed sensor bolt, front vehicle speed sensor and sensor cover. The connector of the front vehicle speed sensor is not accessible until the oil pan is removed.



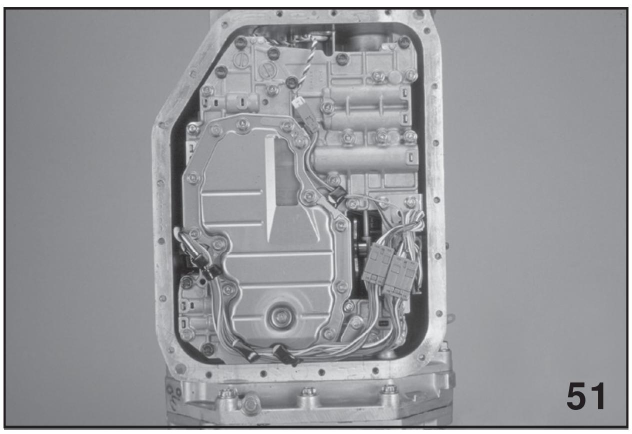
Removing VTD Driven Gear

Using special tool 499737100 puller set and new special tool 1868AA000 remove the reduction driven gear.



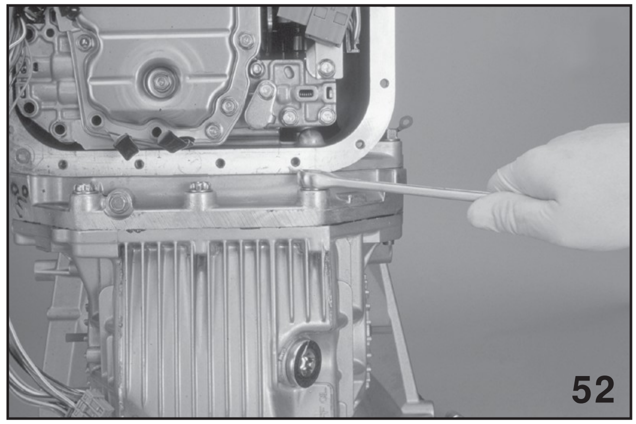
Oil Pan On

Vertically position transmission on the torque converter housing and remove the oil pan bolts.



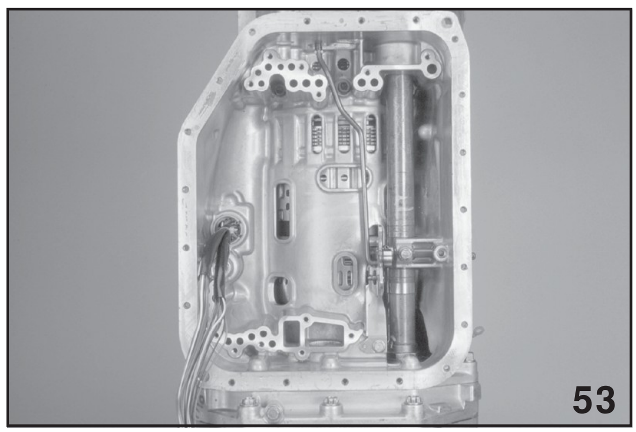
Oil Pan Off

Disconnect the control valve body from the transmission harness.



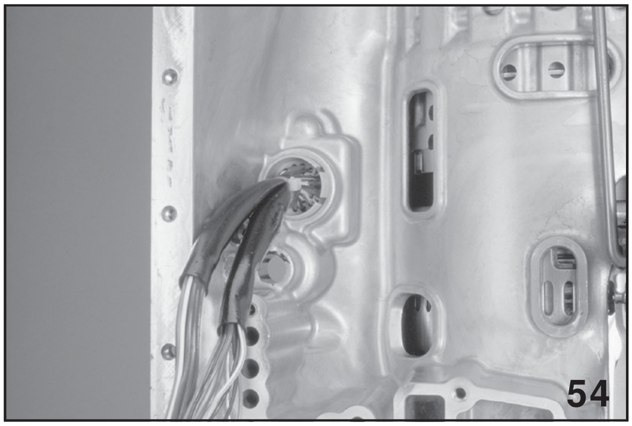
Torx® Bolts

Note the location of the three torque converter case alignment bolts. Special tool 1867AA020 Torx Wrench is used to remove these bolts. The bolts cannot be removed or installed with the control valve body in place.



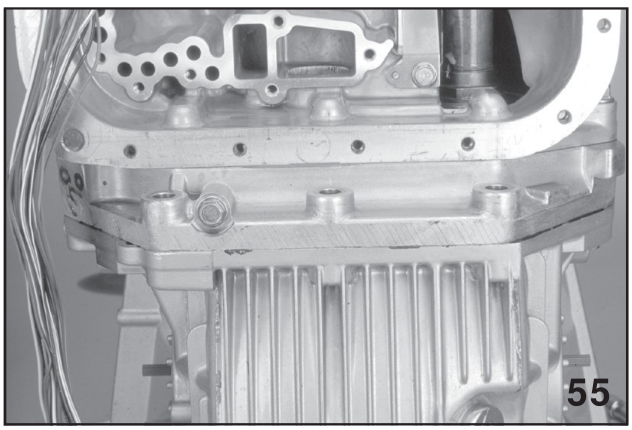
Valve Body Out

Remove the control valve body bolts and control valve body.



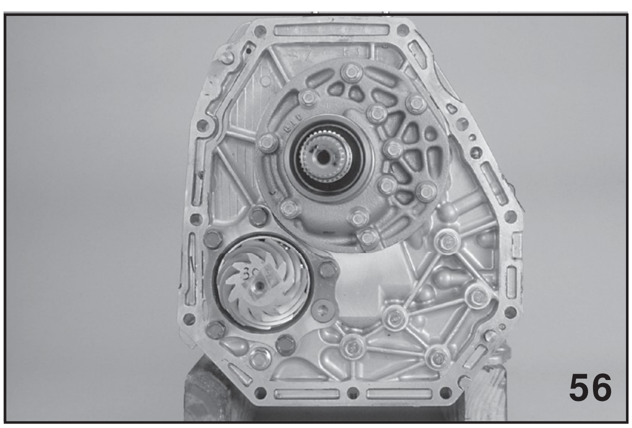
Harness Tabs

Lightly squeeze the release tabs of the transmission harness support and remove the harness from the transmission case.

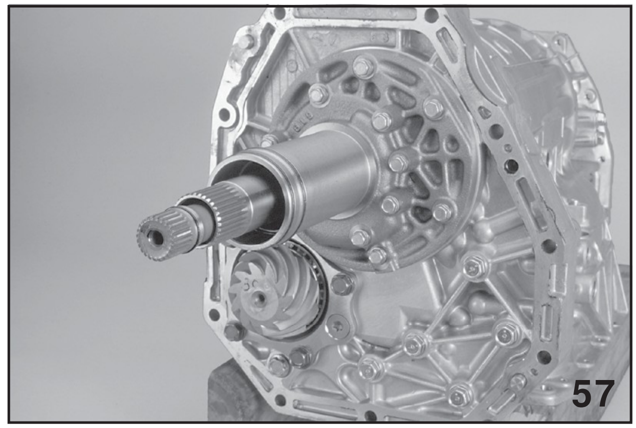


Torque Connector Case

Remove the Three (3) torque converter case alignment bolts.

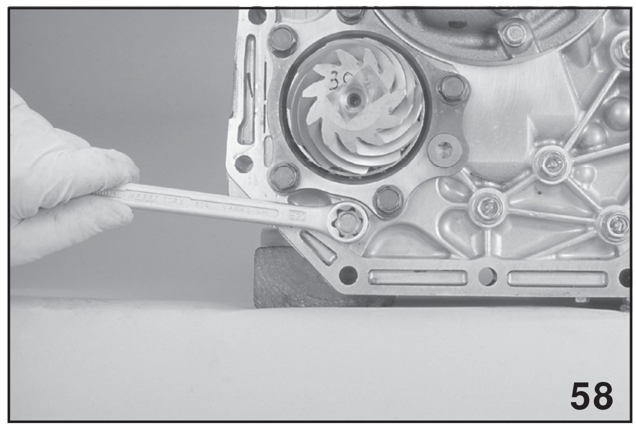


Transmission Pinion Gear View



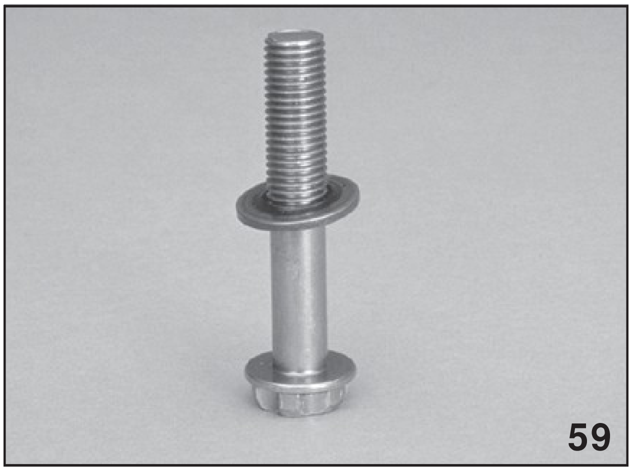
Oil Pump Cover

Horizontally position the transmission while supporting the control valve body area with wooden blocks.



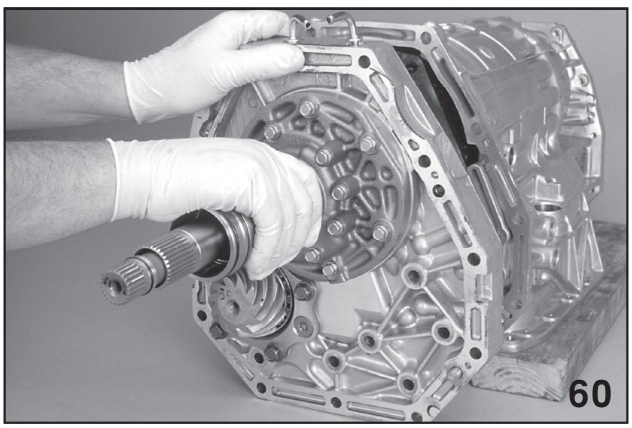
Removing Torx® Bolt

Remove the 6 bolts that secure the oil pump cover to the transmission main case. Note the Torx® Bolt below the pinion gear is removed with special tool 1867AA020 Torx Wrench.



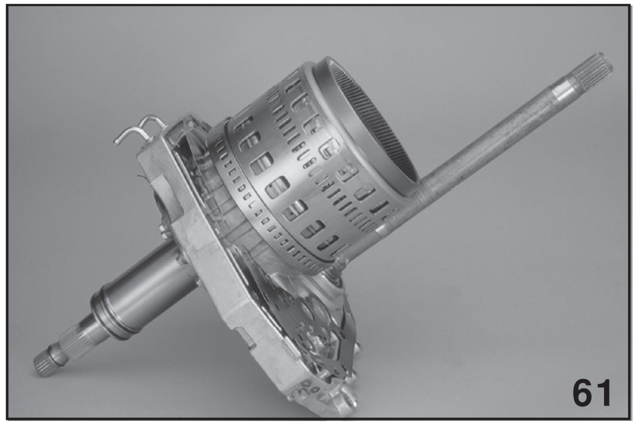
Torx® Bolt and Washer

The Torx® bolt uses a rubber inlay washer that prevents the mixing of transmission fluid with gear oil.



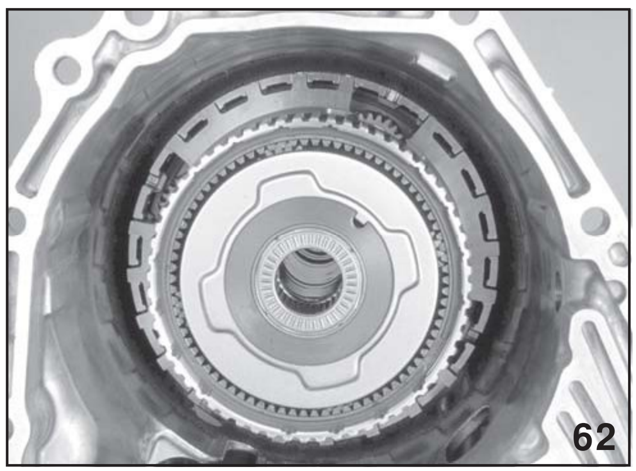
Separating Oil Pump Cover

Hold the oil pump cover and the oil pump housing while applying sufficient force to separate the oil pump cover from the transmission main case.



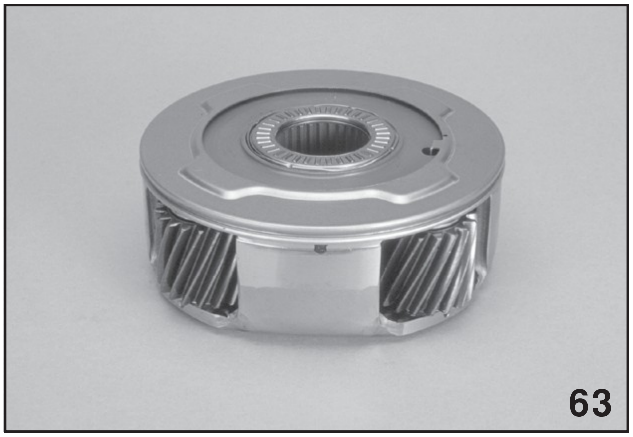
Oil Pump Cover Removed

The weight of the resulting separation will be heavy. The oil pump cover, input clutch and front planetary assemble with rear internal gear usually is removed together.



Middle Carrier case view

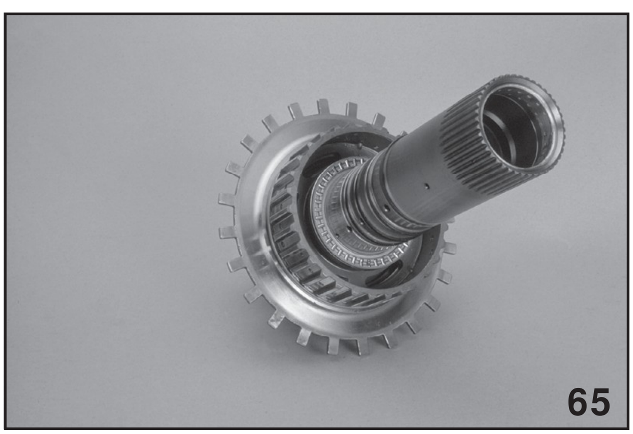
Remove the middle carrier assembly from the transmission main case.



Middle Carrier

Top View of Middle Rear Sun Gear

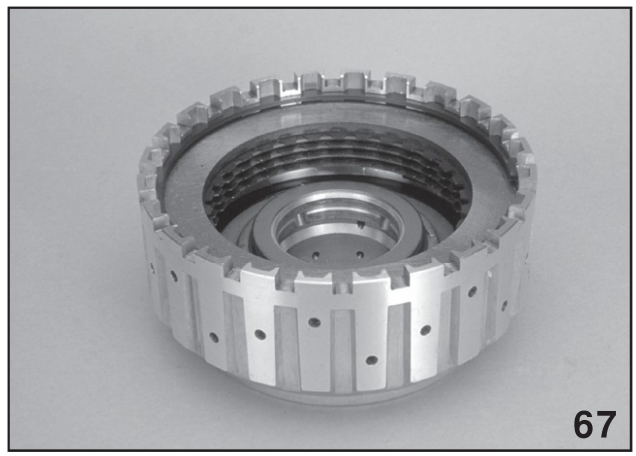
Remove the middle and rear sun gear assemble.



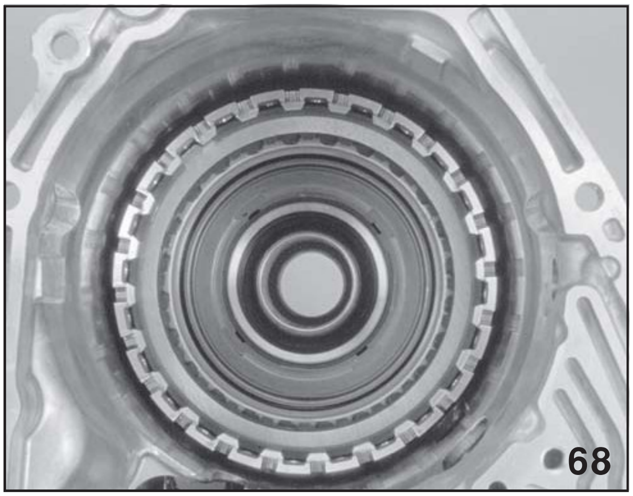
Middle and Rear Sun Gear

Top view of High and Low Reverse Clutch

Remove the high and low reverse clutch.

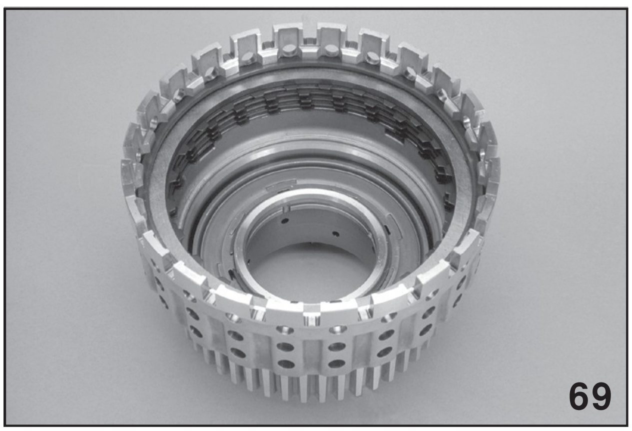


High and Low Reverse Clutch

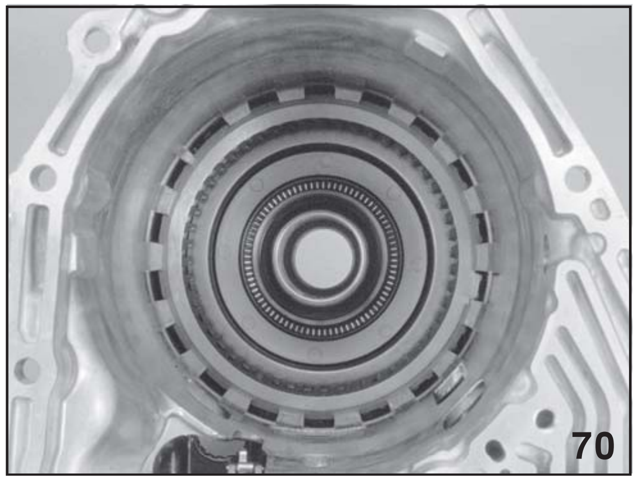


Top View of Direct Clutch

Remove the direct clutch.

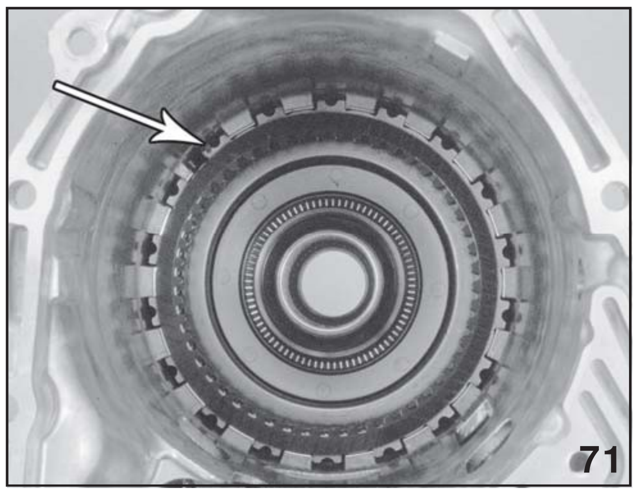


Direct Clutch



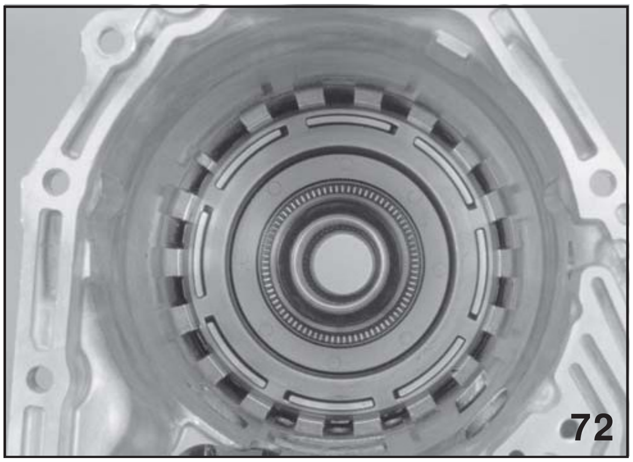
Reverse Brake Clutch Snap Ring

Remove the reverse brake clutch snap ring and the retainer plate.



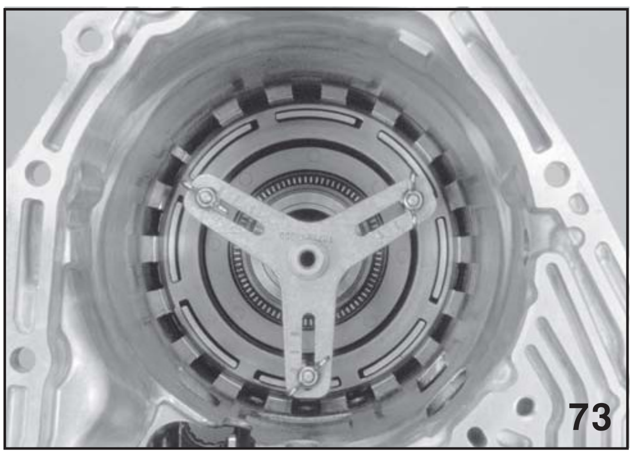
Leaf Spring Location

Not the location of the leaf spring and remove it.



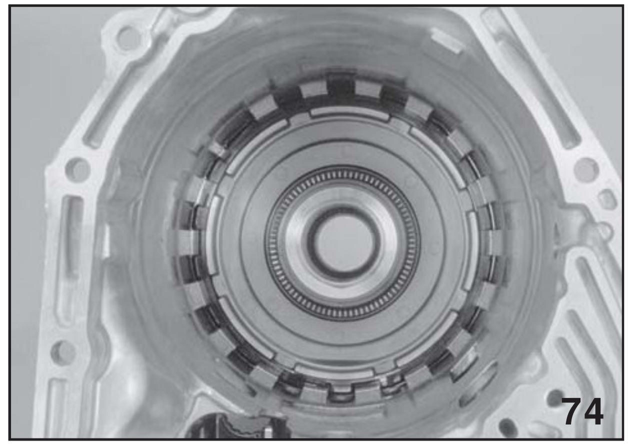
Reverse Brake Piston Snap Ring In

Remove the remainder of the drive and driven plates of the reverse brake. Note the orientation of the lower dish late which is directional.



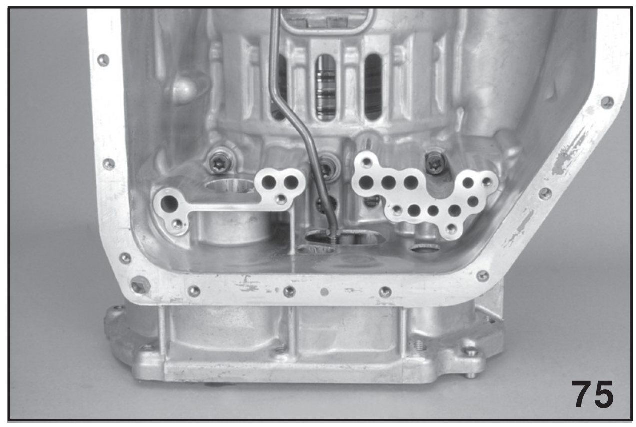
Special Tool 8762AA00

Install special tool 8762AA00 compressor, support and 18763AA00 compressor shaft over the reverse brake piston. Apply sufficient force to compress the return spring and remove the snap ring, spring retainer and return spring. Remove the special tools.



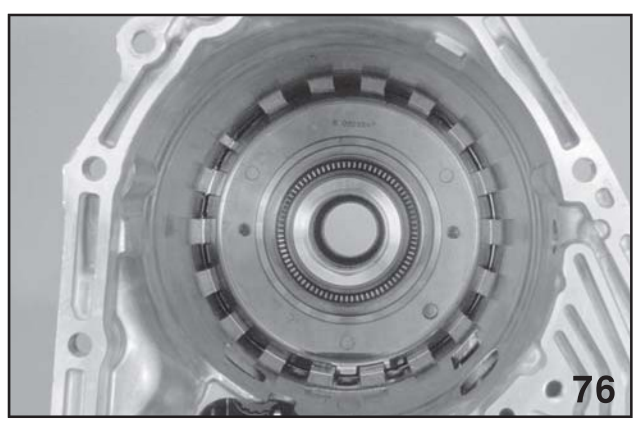
Reverse Brake Piston Snap Ring Out

The remaining components under the reverse piston are not serviceable.

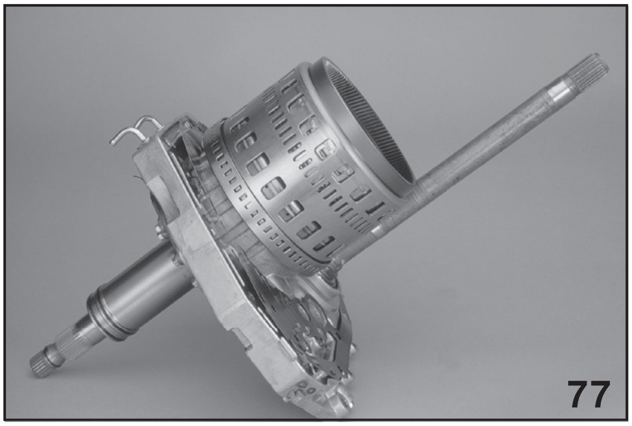


Center Support Bolts

NOTE: DO NOT REMOVE ANY COMPONENTS UNDER THE REVERSE PISTON OR THE BOLTS HOLDING THE CENTER SUPPORT TO THE TRANSMISSION CASE.

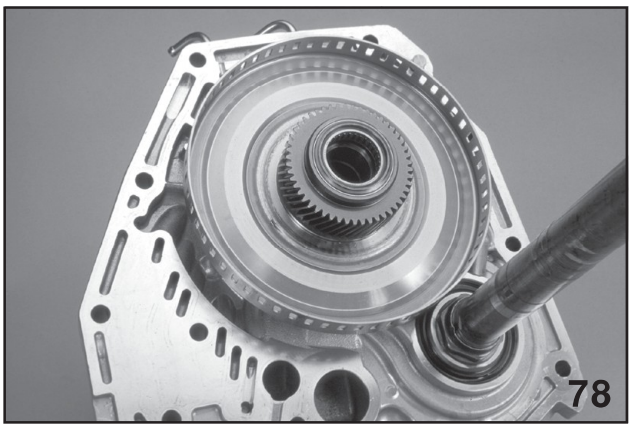


Center Support

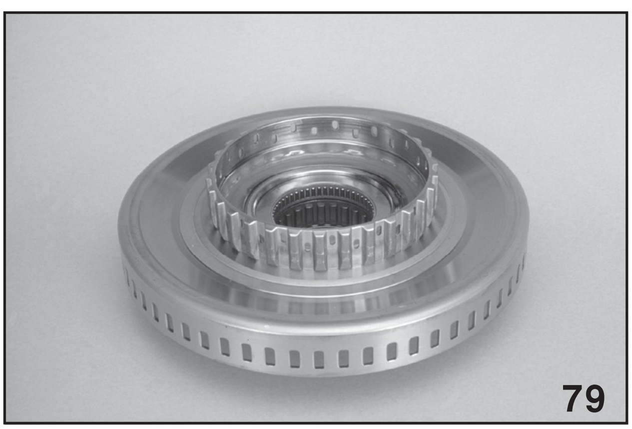


Input Clutch Drum and Oil Pump Cover

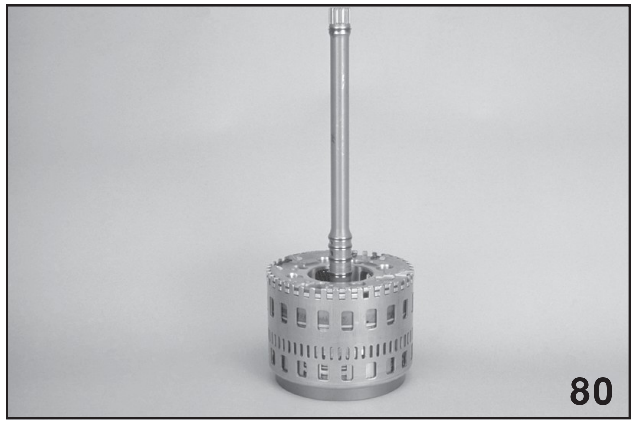
Separate the drive train components from the oil pump cover.



Back View of Front Sun Gear

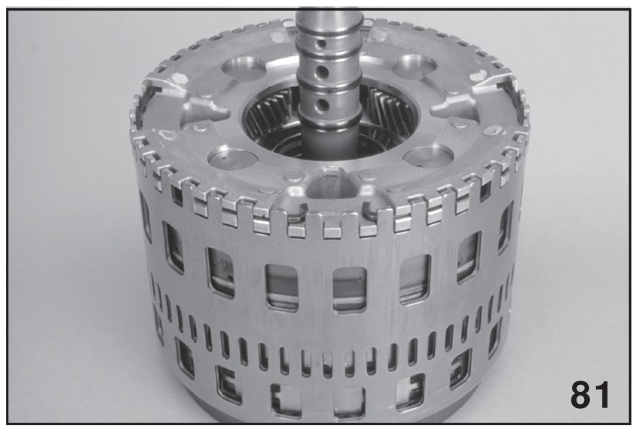


Front View of Front Sun Gear



Input Clutch Drum and Front Planetary Assembly

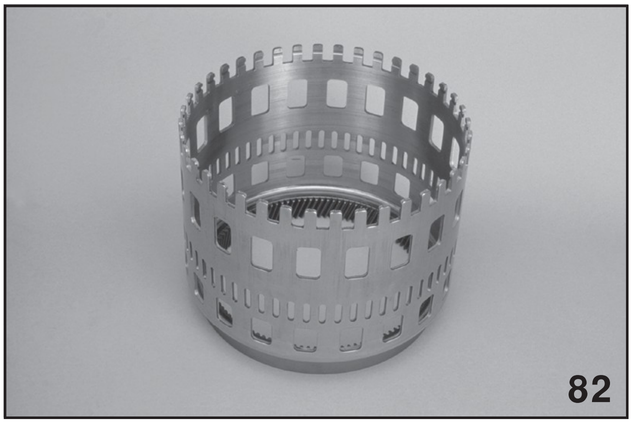
Remove the front sun gear from the back of the oil pump cover or front planetary carrier if it moved away with the reminder of the drive train components.



Snap Ring Release

The top side of the input clutch drum contains the front internal gear and houses the bearing, needle bearing side up, that supports the bottom of the front planetary carrier. The turbine or input shaft is also a part of the top side of the input clutch drum.

Squeeze the two ends of the snap ring that secure the front planetary carrier to the rear internal gear. Lift the front planetary carrier away from the rear internal gear.



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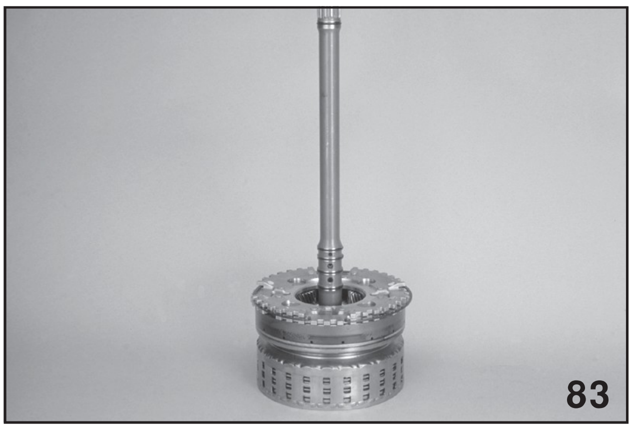
Rear Internal Gear

Remove the rear internal gear away from the input clutch drum.



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Front Planetary Carrier and Input Clutch Drum

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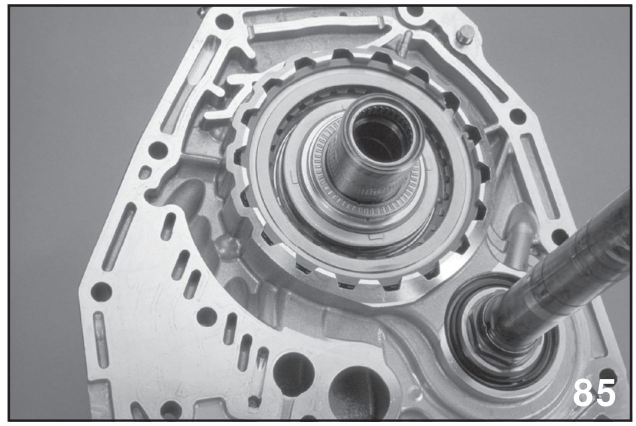
Front Internal Gear and Input Clutch Drum



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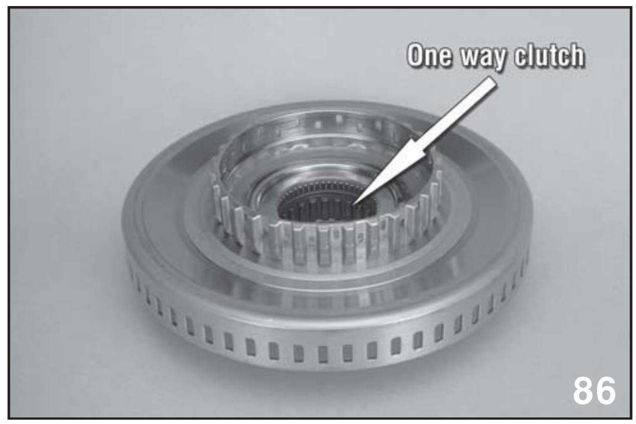
Front Brake Clutch



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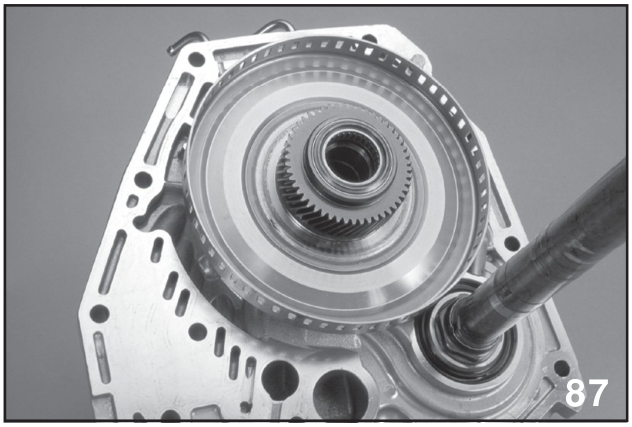
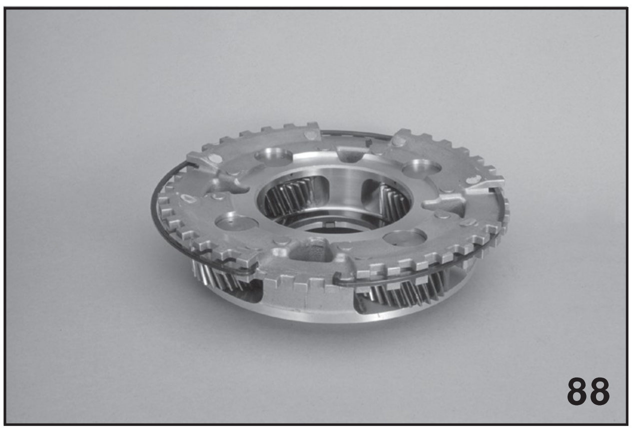
Top View Front Sun Gear

The top side of the front sun gear provides a bearing running surface that seats the bearing on the on the lower step of the front sun gear support.



Bottom Side of the Front Sun Gear

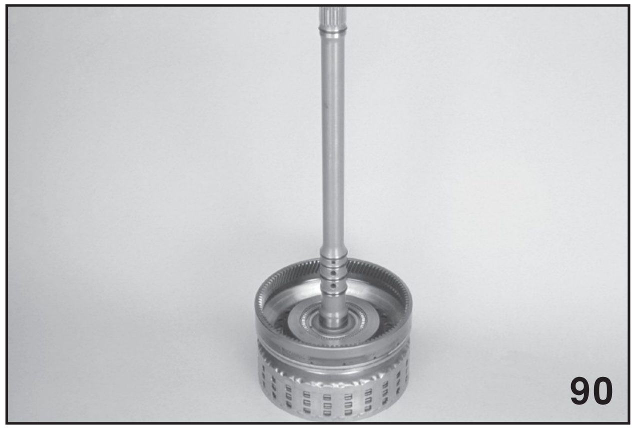
The bottom side of the front sun gear is supported by the captured bearing at the top of the front planetary carrier.



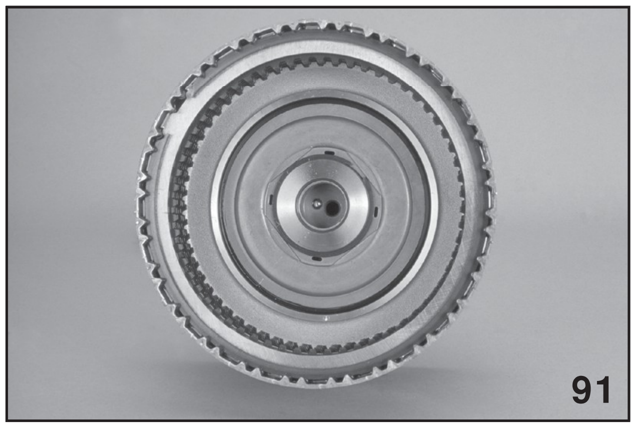
Front Planetary Carrier

Bottom of the Front Planetary Carrier

The bottom of the front planetary carrier seats a tanged washer that serves as a bearing running surface for the bearing located at the top of the input clutch drum.



Top View of Input Clutch Drum



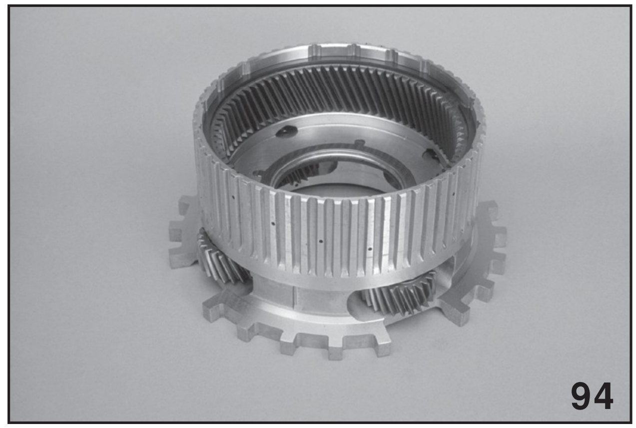
Bottom View of Input Clutch Drum

Top of the Middle Planetary Carrier

The top of the middle planetary carrier provides a seat for the bearing (Needles up) that supports the bottom of the input clutch drum.

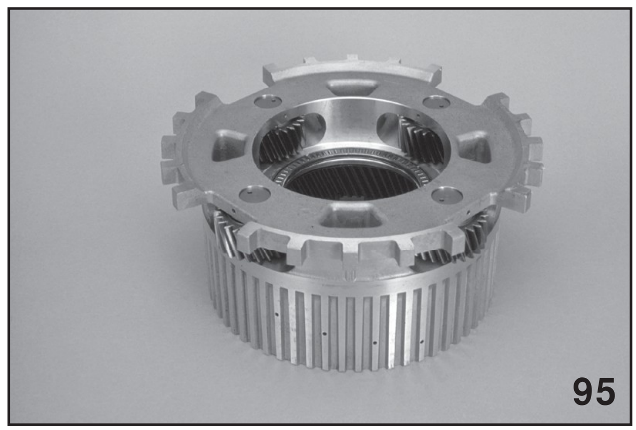
Bottom of the Middle Planetary Carrier

The bottom of the middle planetary carrier provides a bearing (Needles down) that seats against the tanged washer on the top of the rear planetary carrier.



Top of the Rear Planetary Carrier

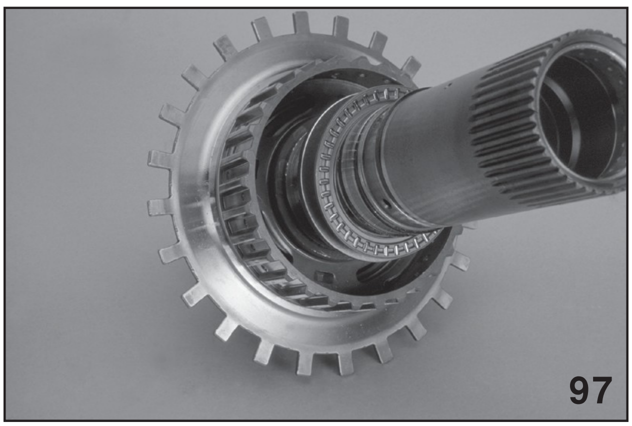
The top of the rear planetary carrier houses the middle internal gear and a tanged washer that provides a bearing running surface for the bearing on the bottom (Needles down) of the middle planetary carrier.



Bottom of the Rear Planetary Carrier

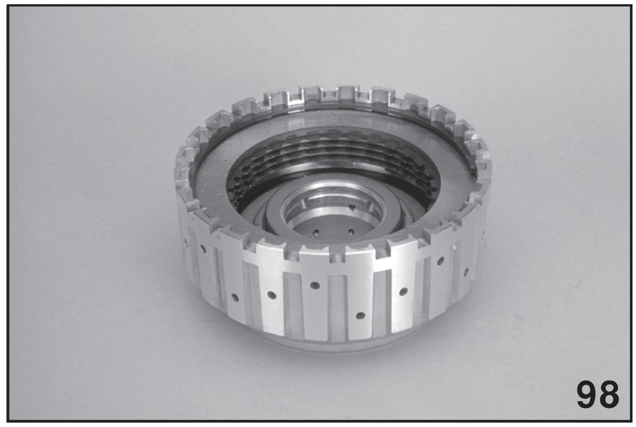
The bottom of the rear planetary carrier seats a bearing (Needles down) that sears against the bearing running surface of the rear sun gear.

Top View of the Middle and Rear Sun Gear

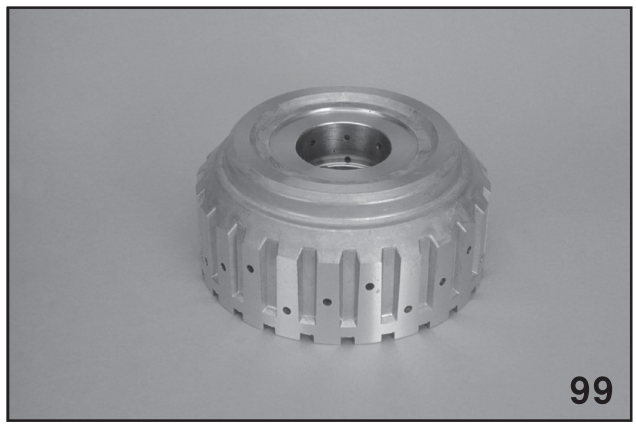


Bottom Side of the Middle and Rear Sun Gear

The bottom side of the middle and rear sun gear assemble seats a washer and a bearing (open) that seats against the washer seated on the center of the high and low reverse clutch.

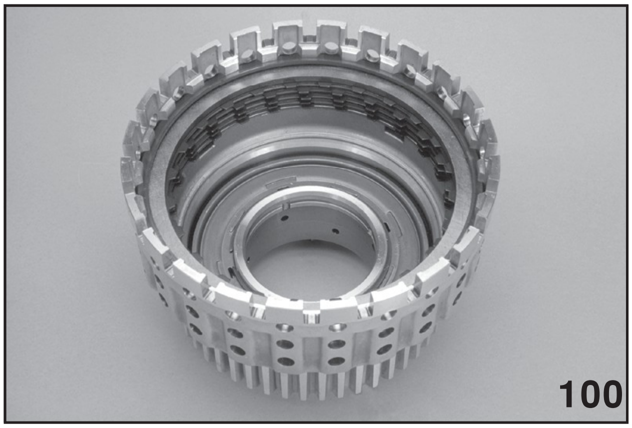


Top View of the High and Low Reverse Clutch

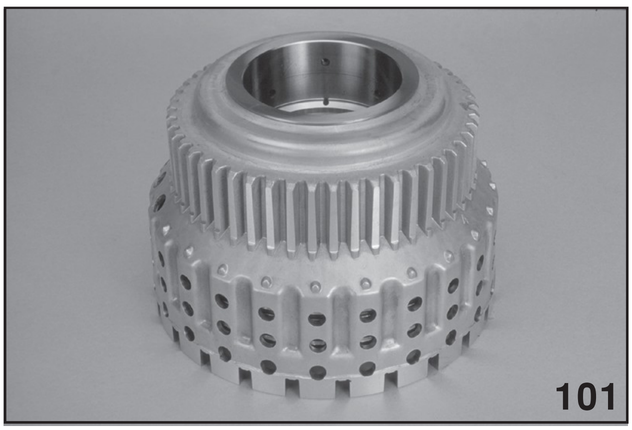


Bottom of the High and Low Reverse Clutch Drum

The bottom of the high and low reverse clutch drum provides a bearing running surface that seats the bearing on the top of the center support.



Top View of the Direct Clutch

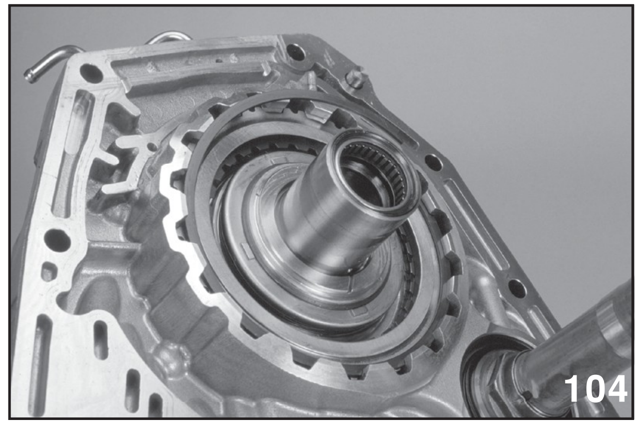


Bottom of the Direct Clutch Drum

The bottom of the direct clutch drum provide a bearing running surface that seats the bearing on the top of the lower step of the center support.

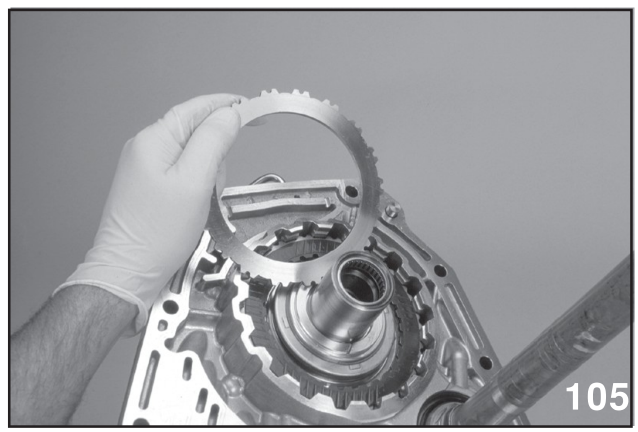
Center Support

Servicing The Front Brake



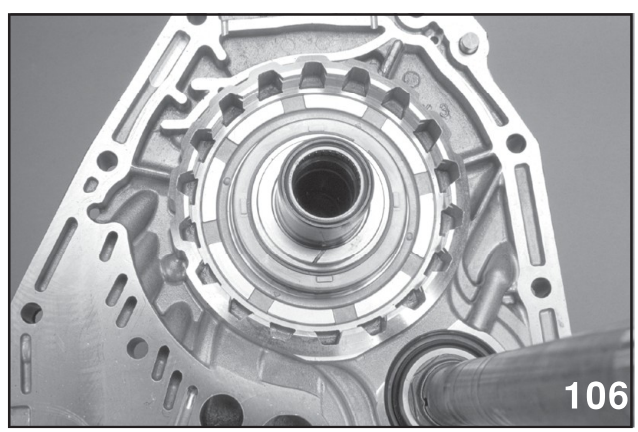
Snap Ring and Retaining Plate from the Front Brake

Remove the snap ring and retaining plate from the front brake.

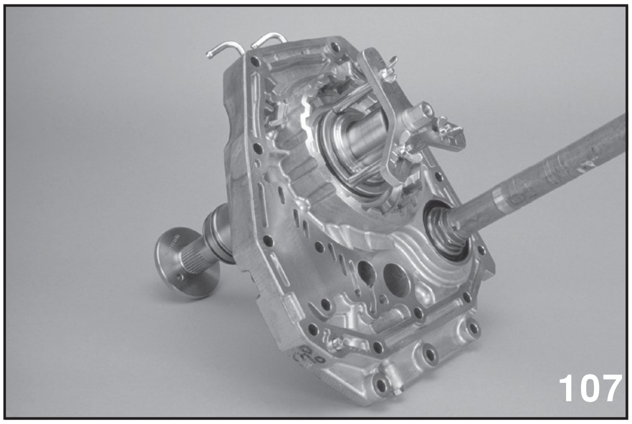


Retaining Plate

Remove the drive and driven plates.

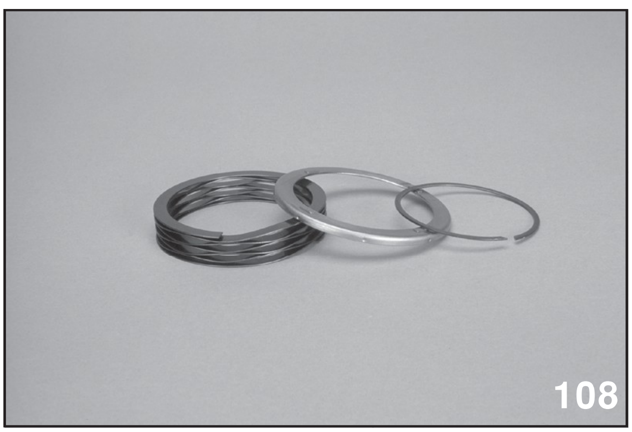


Front Brake Housing

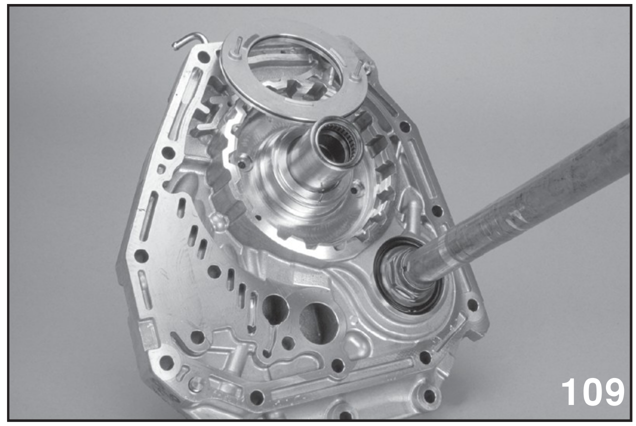


Removing Front Brake Snap Ring

Install special tools 18762AA00 compressor, support and 18763AA00 compressor on the front brake piston. Apply sufficient force to compress the front brake piston return spring. Remove the snap ring, retainer and return spring. Remove the special tools and apply air pressure at the indicated port.

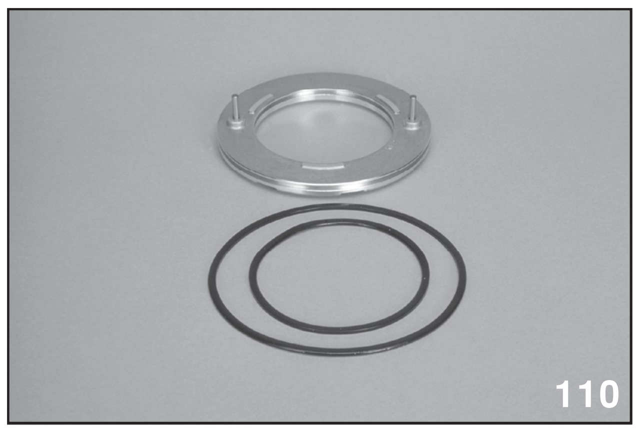


Spring Retainer and Snap Ring



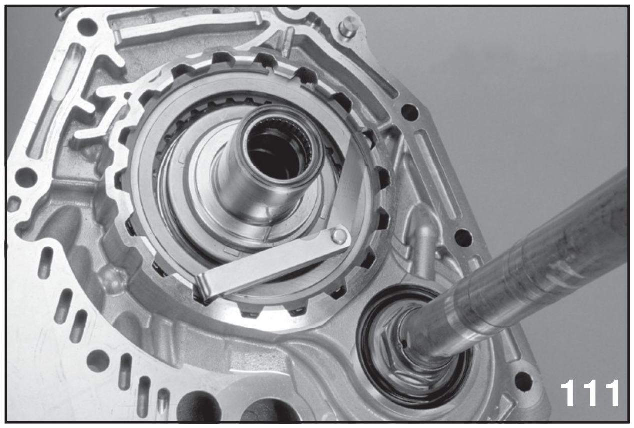
Front Brake Piston

Note the location of the arrows on top of the piston. The arrows will assist with properly positioning the piston during reassemble. Remove the piston and inner and outer o-rings.



Piston and O-rings

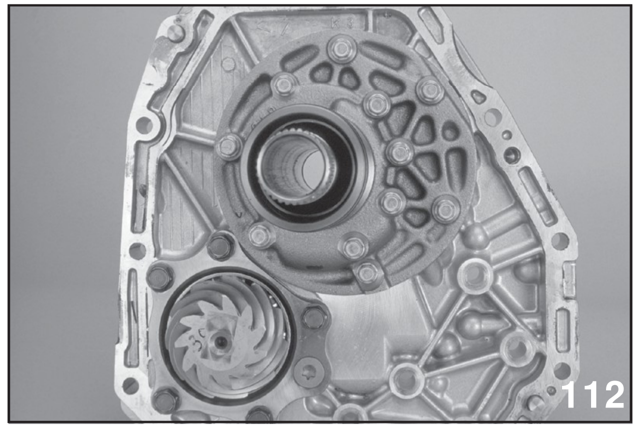
The square side of the O-rings face the piston while the rounded edge serve as the pressure sealing surfaces.



Measure the Clearance between the Snap Ring and the Retaining Plate

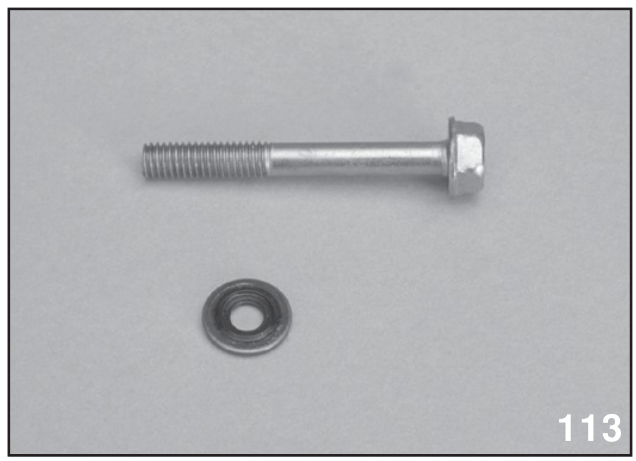
Install new o-rings and lubricate the piston with atf. Align the guide pins using the arrows on the top of the piston. Press down by hand until the piston bottoms in the bore. Reinstall the return spring and retainers. Install the special tools 18762AA00 compressor, 18765AA00 compressor support and 18763AA00 compressor. Compress the return spring with sufficient force for the retainer to clear the snap ring groove. Install the snap-ring and remove the special tools. Install the driver and driven plates. Install the retaining plate and the snap ring. Measure the clearance between the snap ring and the retaining plate.

Servicing the Oil Pump



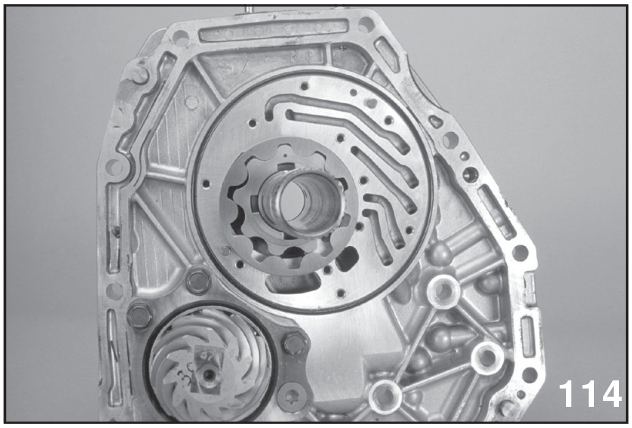
Oil Pump Outer Cover

Remove the Six (6) bolts from the pinion shaft bearing retainer. Vertically position the pinion shaft and remove the shaft from the oil pump housing.

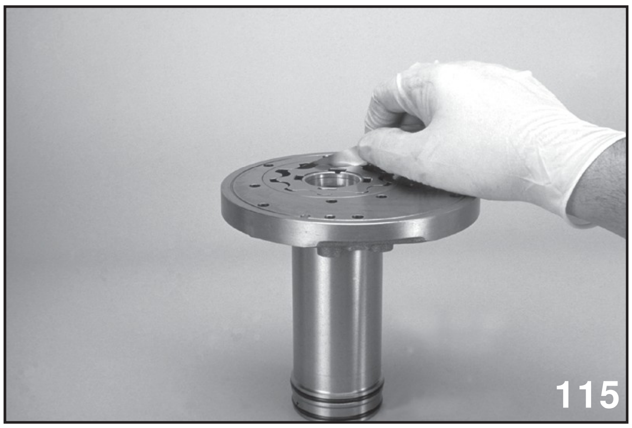


Oil Pump Cover Bolt

Remove the oil pump cover bolts. The bolts use washer with a rubber inlay to prevent the mixing of atf and gear oil.

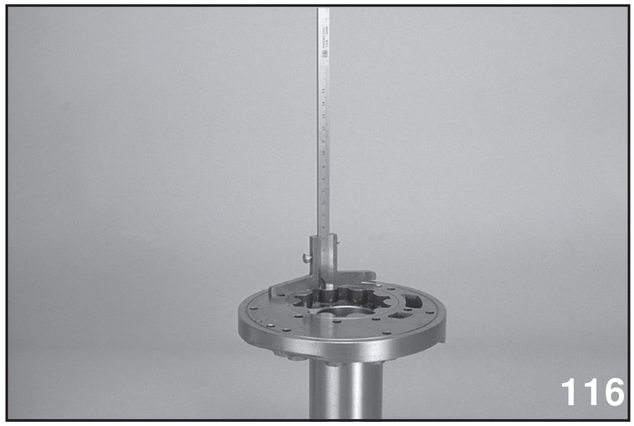


Oil Pump Inner and Outer Rotors



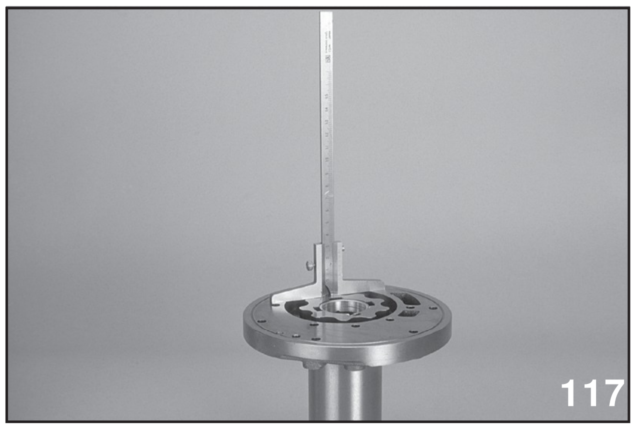
Rotor to Rotor Clearance

Place the inner and outer rotors of the oil pump into the oil pump cover. Measure the clearance between the inner and outer rotor tips.



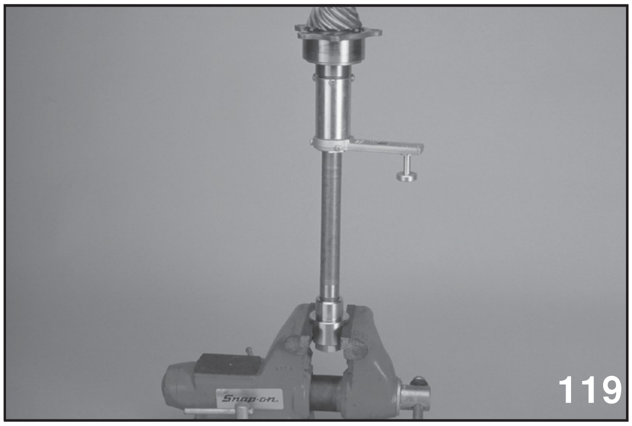
Clearance between the top of the Inner and Outer Rotor

Measure the clearance between the top of the inner and outer rotor and the oil pump cover surface.



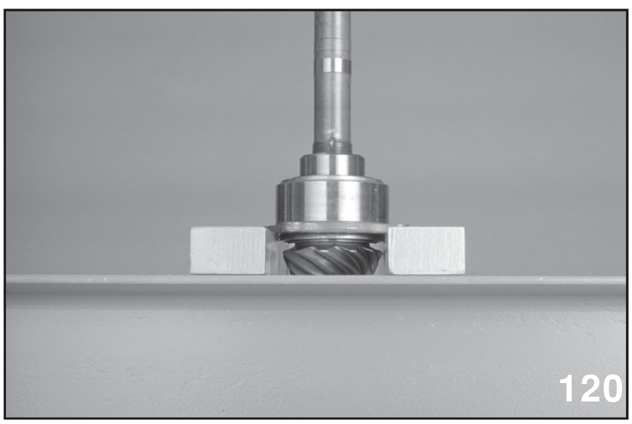
Checking Inner Rotor to Oil Pump Cover surface

Servicing the Pinion Shaft



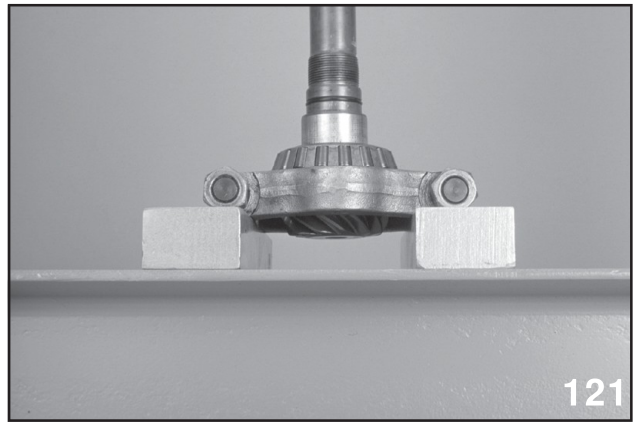
Pinion Shaft In Vise

Remove the pinion depth shim form the pinion bearing retainer. Position the pinion shaft on a press and support the pinion shaft bearing retainer while applying force to the end of the pinion shaft. This will remove the pinion shaft bearing retainer and the upper bearing and spacer.

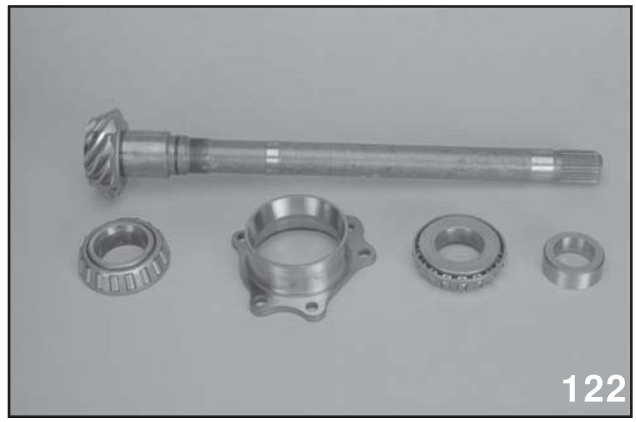


Removing Upper Bearing

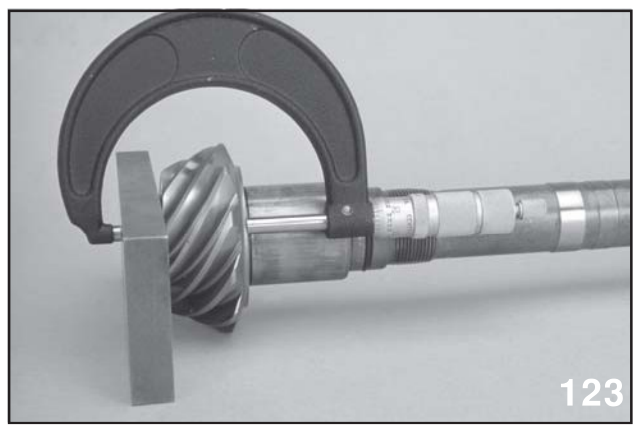
Support the inner race of the lower bearing and apply pressure to the end of the pinion shaft. Replace the o-ring on the pinion shaft only after installation of the all bearings is complete.



Supporting Bearing

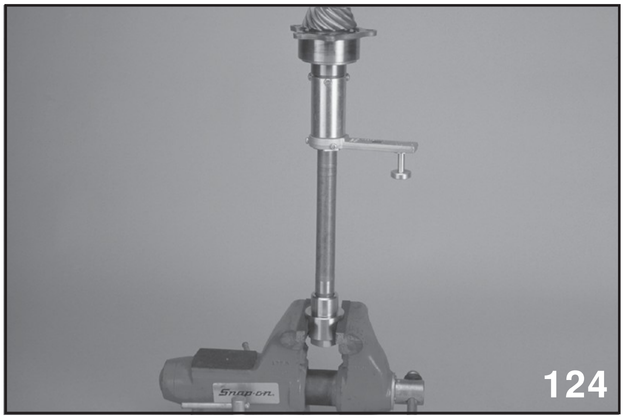


Pinion Shaft



Pinion Gear and Gauge Block "A"

Place a gauge block at the end of the pinion gear. Measure the distance from the back of the pinion gear to the top of the gauge block. This is dimension A.



Pinion Shaft in Vise

Install the lower bearing, retainer, upper bearing, new o-ring, spacer and new lock nut. Torque the lock nut.

Tighten new lock nuts using ST1, ST2 and ST3. Calculate the lock nut specifications using following formula.

T2 = L2/(L1 + L2) × T1

T1:116 N.m (11.8 kgf-m, 85.3 ft-lb) [Required torque setting]

T2: Tightening torque

L1: ST2 length 0.072 m (2.83 in)

L2: Torque wrench length

ST1 18667AA010 HOLDER

ST2 499787700 WRENCH

ST3 499787500 ADAPTER

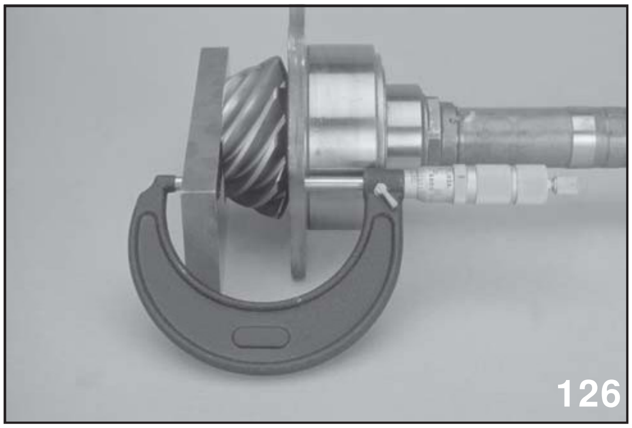
NOTE: INSTALL THE ST2 TO TORQUE WRENCH AS STRAIGHT AS POSSIBLE.

Measure the starting Torque of Bearing

Measure the starting torque of bearing. Make sure the starting torque is within the specified range. If the torque is not within specified range, replace the roller bearing.

Starting torque:

7.6 — 38.1 N (0.776 — 3.88 kgf, 1.7 — 3.88 kg)
Stake the caulking of lock nut at two points.



Pinion Bearing and Gauge Block "B"

Place the gauge block at the end of the pinion gear. Measure the distance from the back of the pinion bearing retainer to the top of the gauge block. This is dimension B.

Calculate the thickness “t” (mm) of drive pinion shim.

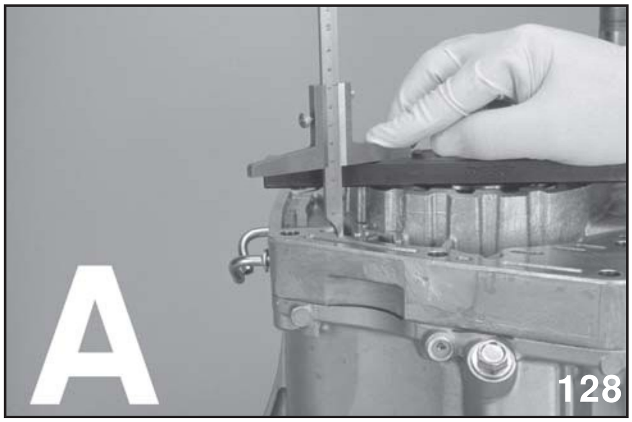
$t = 6.5 \pm 0.0625 - (B - A)$

Drive pinion shim	
Part Number	Thickness mm (in)
31451AA180	0.150 (0.0059)
31451AA190	0.175 (0.0069)
31451AA200	0.200 (0.0079)
31451AA210	0.225 (0.0089)
31451AA220	0.250 (0.0099)
31451AA230	0.275 (0.0108)

Select three or less shims from the table.

NOTES:

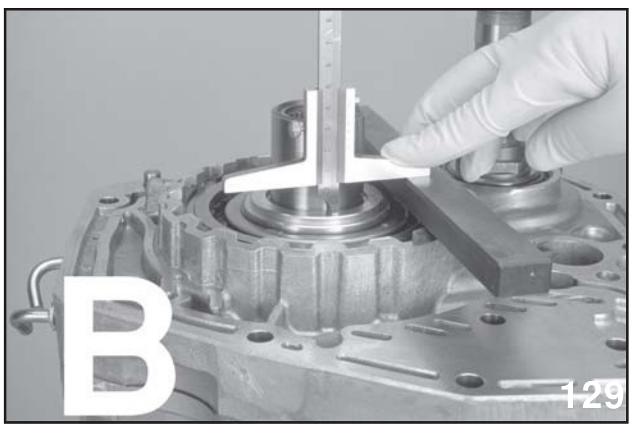
End Play Adjustment



Top of Pump Cover to Mating Surface "A"

1) Using the ST, measure the height “A” from AT main case mating surface to convex surface of oil pump cover.

ST 499575400 GAUGE



Top of Pump Cover to Mating Surface "B"

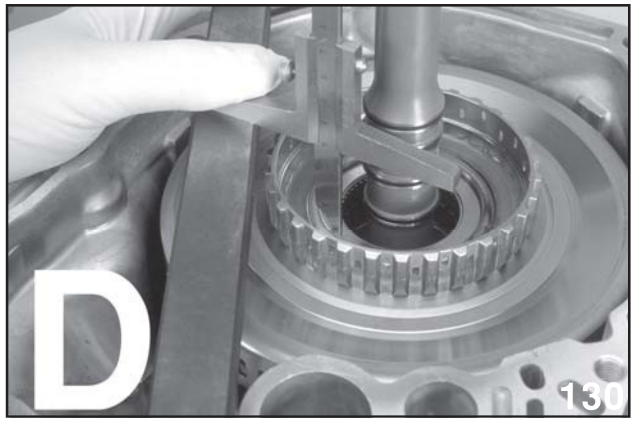
2) Using the ST, measure the depth “B” from the convex surface of oil pump cover to thrust bearing transferring surface.

ST 499575400 GAUGE

3) Calculate the measured value on step 1) and 2), and then set the calculated value as “C”

Calculation formula: C = A - B

AT Main Case



Mating Surface to Bearing Surface of the Front Sun Gear "D"

4) Using the ST, measure the depth “D” from AT main case mating surface to thrust bearing transferring surface of front sun gear.

ST 499575400 GAUGE

5) Set the value as “E” which subtract the thickness of ST GAUGE from measured value on step 4).

Calculation formula:

E (mm) = D - 15 [E (in) = D . 0.59]

Select a thrust bearing from the table to adjust clearance within

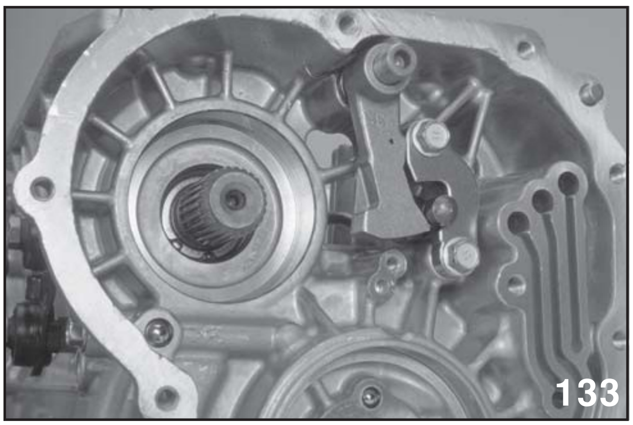
0.25 — 0.55 mm (0.0098 — 0.022 in).

Thrust bearing

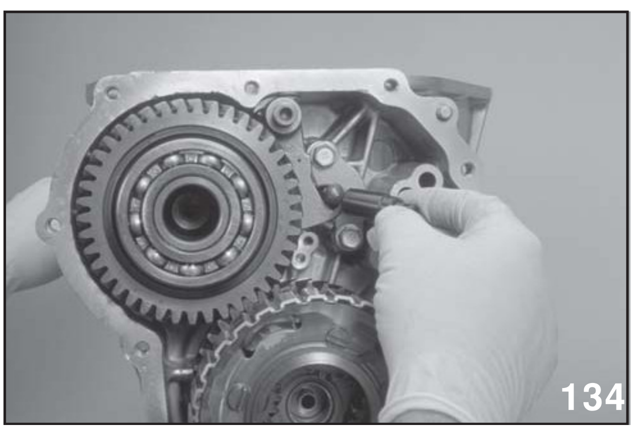
Part No.	Thickness mm (in)
806548020	3.2 (0.126)
606548030	3.4 (0.134)
806548040	3.6 (0.142)
806548050	3.8 (0.150)
806548060	4.0 (0.157)
806548070	4.2 (0.165)

Parking Pawl Installation

Parking Pawl and Spring



Parking Pawl Spring location



Installing Special Tool

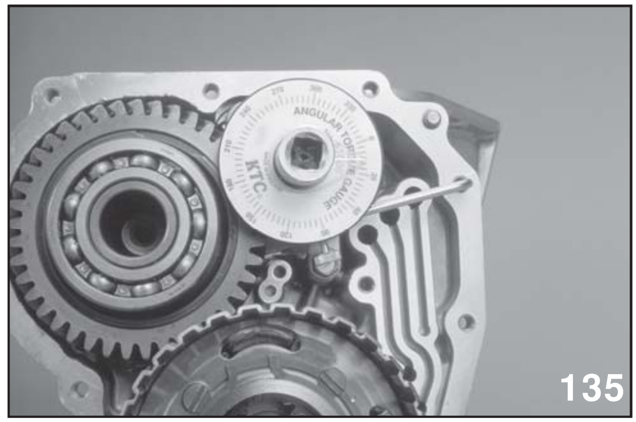
1) Set the transmission to “N” range.
2) Install the parking pawl, parking pawl shaft and return spring.
3) Temporarily secure the parking support actuator.
4) Set the ST between parking pawl and parking support actuator.

ST 18679AA000 ADJUSTER

5) Tighten the securing bolts while pressing parking support actuator with finger.

Tightening torque:

10 ±2 N .m (1.0 ±0.2 kgf-m, 7.4 ±1.5 ft-lb)



Angle Gauge

6) Using the ST, tighten the bolts which tightened in step 4) with specified angle.

Tightening angle: 18 °±2 °

ST 18679AA000 ADJUSTER

ST 18854AA000 ANGLE GAUGE

NOTE: DO NOT USE AN EXTENSION.

7) Install the center differential carrier.
8) Install the extension case and intermediate case.

During final reassemble, where the oil pump cover is placed onto the transmission case, a gasket must be installed. Use long bolts as a guide for holding the gasket in place while the oil pump cover is being installed (studs are on the oil pump cover) Remove the long bolts after the oil pump cover is making full contact with the gasket.

The top of the front sun gear must spline with the clutch plates of the front brake clutch. The center hub of the oil pump cover must engage with one way clutch in the top of the sun gear.

Rotate the front sun gear through the valve body area or install the output shaft and using a plastic tool, lock the pinions of the VTD assemble together and rotate the output shaft. This will turn the front sun gear, aligning the plates of the front clutch so the hub of the oil pump cover engages with the one way clutch. (DO NOT FORCE THE OIL PUMP COVER IN PLACE)

Gear position	Gear ratio
1st	3.540
2nd	2.264
3rd	1.471
4th	1.000
5th	0.834

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Gear Position

Final Gear Ratio

LEGACY					
2.5L SOHC				2.5L DOHC	
5MT	4AT			5MT	5AT
3.9	4.111			4.111	3.272
OUTBACK					
2.5L SOHC		2.5L DOHC		3.0L DOHC	
5MT	4AT	5MT	5AT		5AT
4.111	4.444	4.444	3.583		3.272

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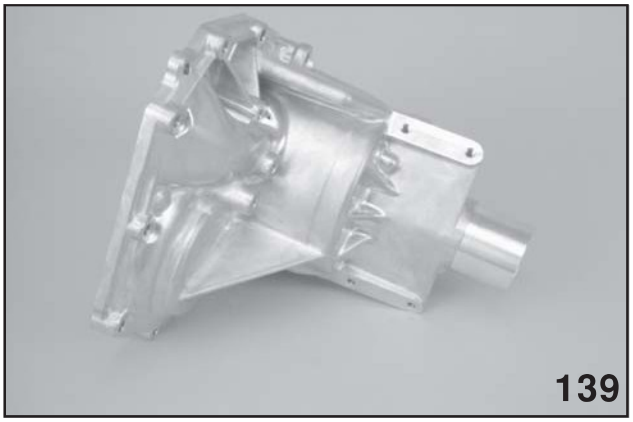
Final Gear Ratio

2006 New Features



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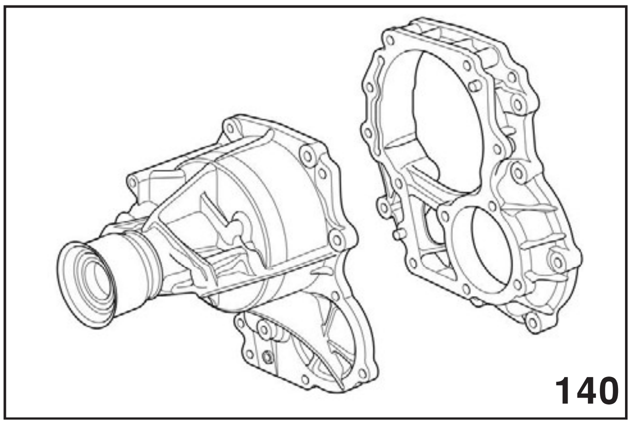
New Integrated Intermediate and Extension Housing



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Current Extension Housing (Artwork)

Integrated intermediate and extension housing provides for easier servicing.

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New Parking Pawl

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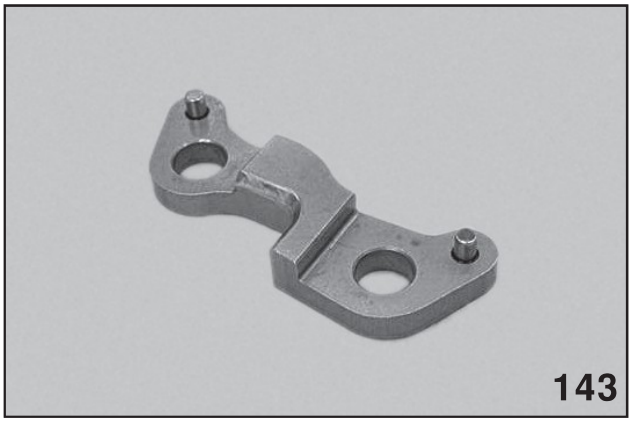
New Parking Gear

The parking mechanism construction has been made larger and stronger. The parking gear itself is serviceable separately from the reduction gear.



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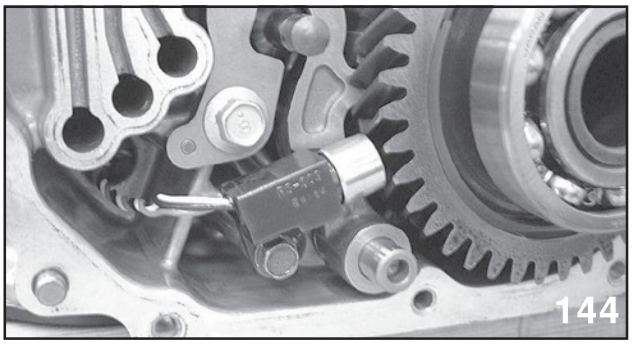
New Parking Actuator

The parking pawl actuator requires no adjustment and is positioned in the case with knock pins.



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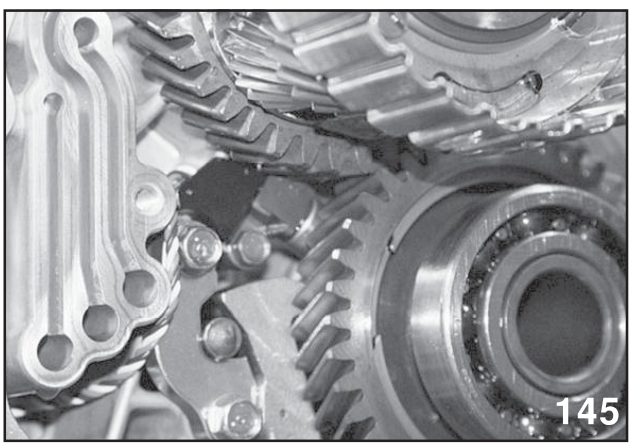
New Front Wheel Sensor



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Current Front Wheel Sensor

The front wheel speed sensor has been relocated and now senses revolutions of the reduction gear. The speed sensor harness locator bracket has been deleted due to the new routing to the speed sensor harness.

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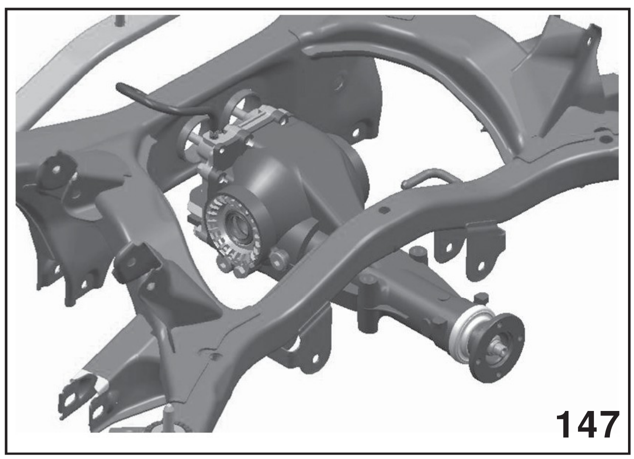
Warning Light

Rear differential

An open type differential is utilized to allow for more efficient operation of the VDC.

A temperature switch has been installed to advise the driver of high temperature in the rear differential.

Solid drive pinion shaft of front differential provides a stronger link in the drive train for operation of a heavier load.



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Rear Differential Vent Hose

Breather changed to hose type (from cap type of '05 Legacy)

Gear Ratios have changed for each gear which assists with increasing performance and fuel economy.

Engine			Subaru B9 Tribeca 3.0L NA	05 Legacy 3.0L NA
AT	Type		5AT	5AT
	Torque converter		C40	C40
	Gear ratio	1ST	3.842	3.540
		2ND	2.353	2.264
		3RD	1.529	1.471
		4TH	1.000	1.000
		5TH	0.839	0.834
		REV	2.765	2.370
	Final Gear. R		3.583	3.272
	A/T operation mode		Normal/Sport/Manual	Normal/Sport/Manual
Rear Differential	Type		New R160	New R160
	Rear LSD		None	Equipped
	R. Diff oil temp switch		Equipped	None
AWD Sys	Type		VTD	VTD
	Distribution rate		Fr:Rr = 45.7:54.3	Fr:Rr = 45.7:54.3

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Gear Ratio Chart

Sport Shift

Shifting in sport mode alters the shift point (delays upshift) to produce a sporty feel of driving. Manual mode allows driver controlled up shifts and downshifts. Starting in 2nd is allowed.

The TCU will upshift and downshift when manual mode is selected and neglected, however, the upshifts will occur near engine red line.

Sport mode is activated by placing the shift lever in the sport gate. Manual mode is activated by the shift lever in the sport gate and tapping up or down.

The indicator on the combination meter will display the current gear range.

Slide Sequence

Slide Sequence

Slide Sequence

Tools & Equipment

Service Bulletins

No.	Date	Title	Subject
01-160-05	05/06/05	2006MY B9 Tribeca Vehicles equipped with Automatic Transmission	Prevention for draw on batteries during initial vehicle transportation

Tech TIPS

Date Subject

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Technicians Reference Booklet

6 Speed Manual Transmission

Module 203

AUTOMOTIVE Youth Educational Systems

December 2005

MSA5P0473C

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of December 2005.

Table of Contents

6 Speed Manual Transmission

Outline

The AWD 6 Speed manual transmission is equipped with the following features:

- 1st, 3rd, and reverse gears are equipped with a three piece synchronizer.
- 2nd gear is equipped with a single synchronizer.
- Reverse gear is a constant-mesh type that ensures smooth shift lever operation, and a scissors gear is used in the reverse idler gear to reduce gear noise.
- A parallel-link type select return system is used to shorten the shift lever stroke.
- A slider ring is equipped below the shift knob to prevent accidental shifting into reverse gear.
- The lubricating system is equipped with an oil pump.
- A LSD front differential Cam Type (2004)
- A LSD front differential Helical Type (2005 to present)
- The center differential is Driver Controlled Center Differential (DCCD)

Shifter

Specification

Specification table

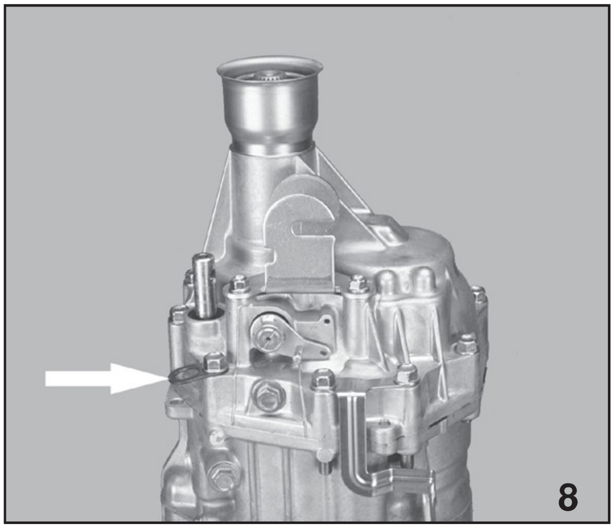
Type			6-forward speeds and 1 reverse
Transmission gear ratio		1st	3.636
		2nd	2.375
		3rd	1.761
		4th	1.346
		5th	1.062
		6th	0.842
		Reverse	3.545
Front reduction gear	Final	Type of gear	Hypoid
		Gear ratio	3.900
Rear reduction gear	Transfer	Type of gear	Helical
		Gear ratio	1.000
	Final	Type of gear	Hypoid
		Gear ratio	3.900
Front differential			Cam Type (2004) Helical Type (2005 to present)
Center differential			DCCD
Transmission gear oil			GL-5
Transmission gear oil capacity			4.1ℓ

6

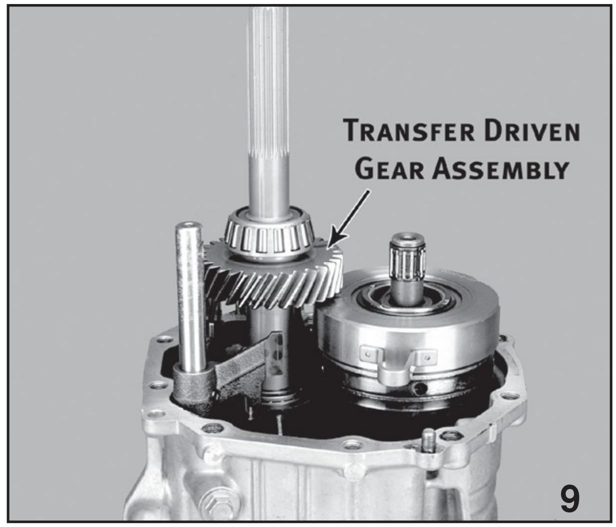
Specification Table

Transmission Overview Construction

REFER TO THE SERVICE MANUAL ON STIS WEB SITE FOR PROPER SEALING DURING REASSEMBLE.

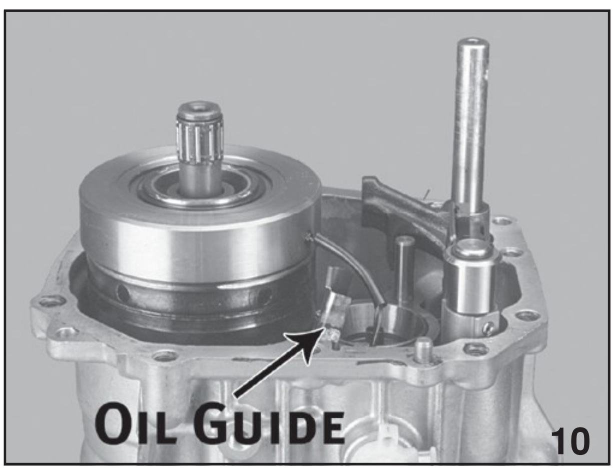


Extension Case

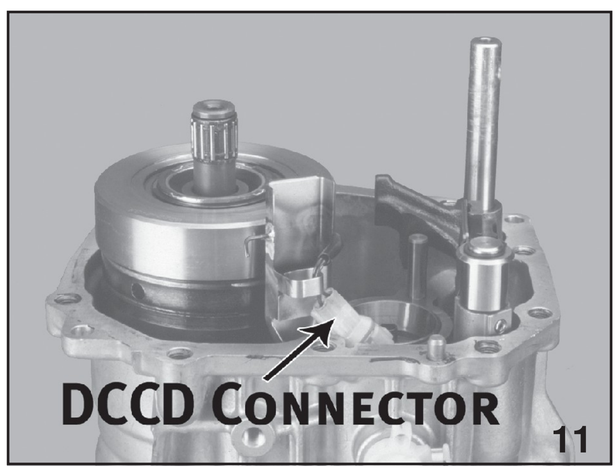


Transfer Driven Gear

1. Remove the bolts securing the extension case to the transmission main case. Separate the extension case with care from the transmission main case.
2. Note the location of the exposed components.

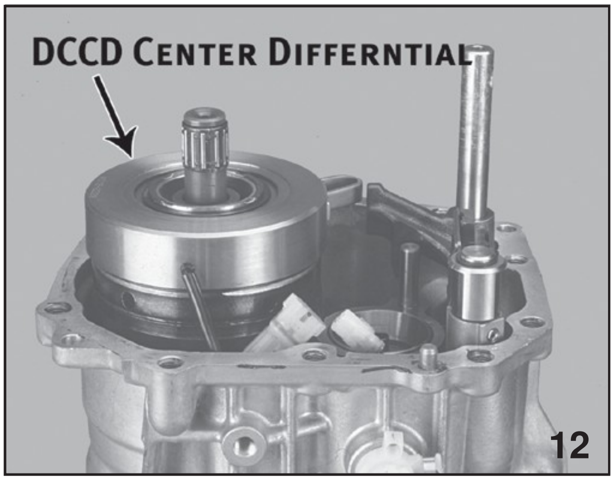


Oil Guide

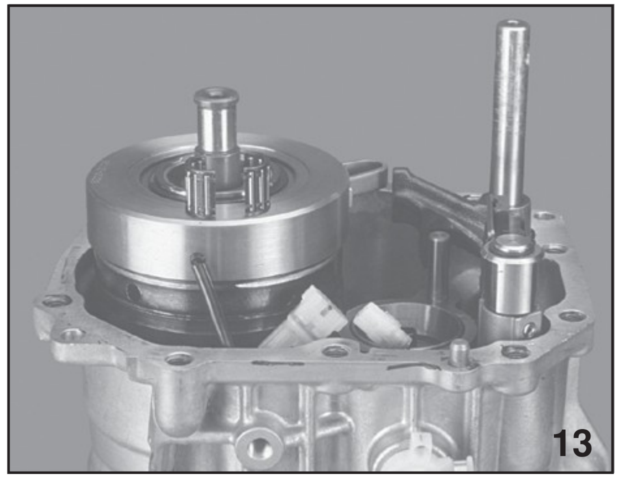


DCCD Connector

3. Remove the transfer driven gear assembly by lifting the assembly by hand.
4. Pull upward on the oil guide and position the connector so that it can be disconnected. Remove the oil guide and disconnect the connector of the Drive controlled center differential. (Do not remove the DCCD harness unless the harness is being replaced).
   - Remove harness, pipes and hoses.
   - Tape or secure harness to main case.

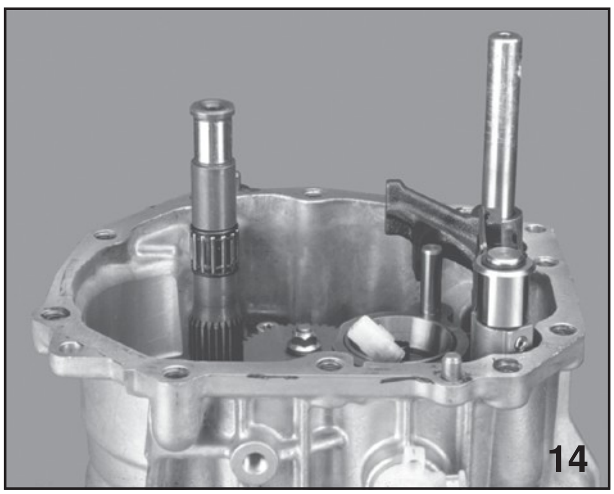


DCCD Center Differential

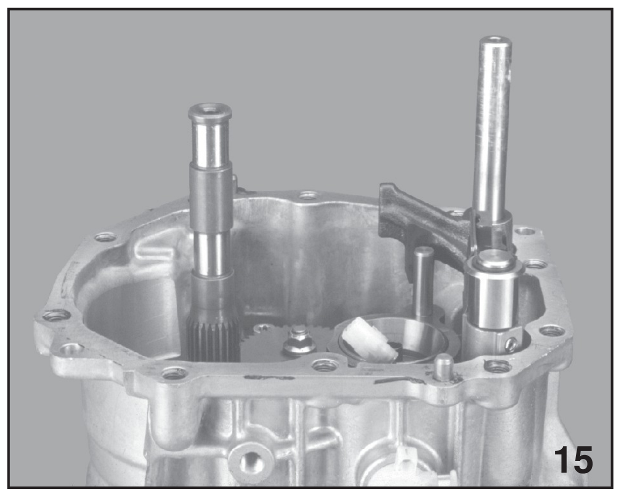


Upper Bearing Split

5. Separate the upper split bearing and maintain the orientation of the bearing so that it can be returned to its original position during reassembly.
6. Lift the driver controlled center differential from the pinion shaft.

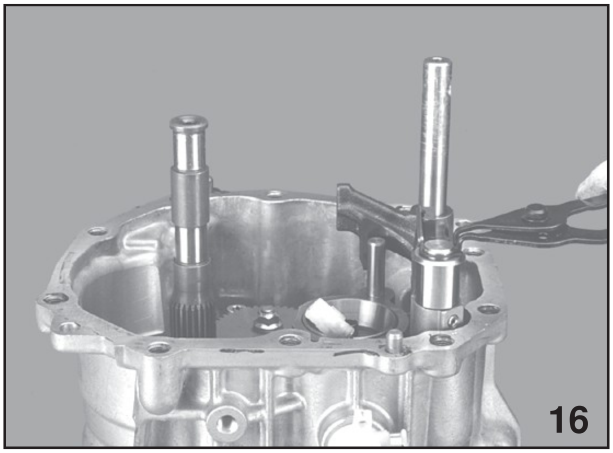


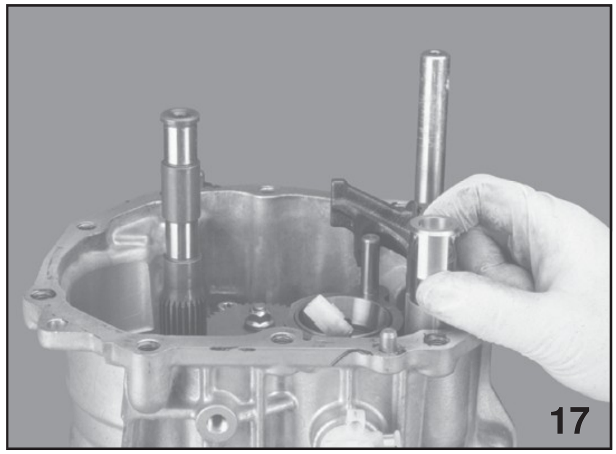
Lower Bearing Needle



Lower Bearing Split

7. Separate the lower split bearing and maintain the orientation of the bearing so that it can be returned to its original position during reassembly.

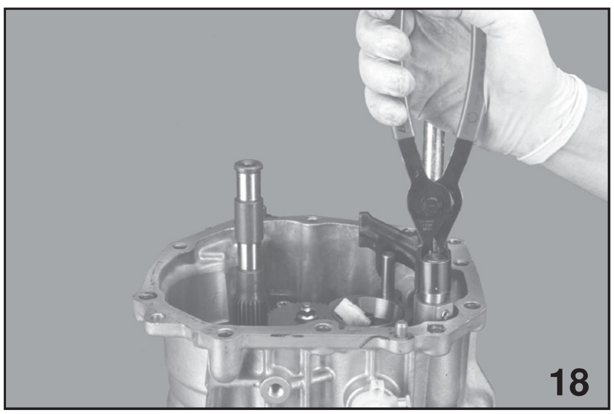


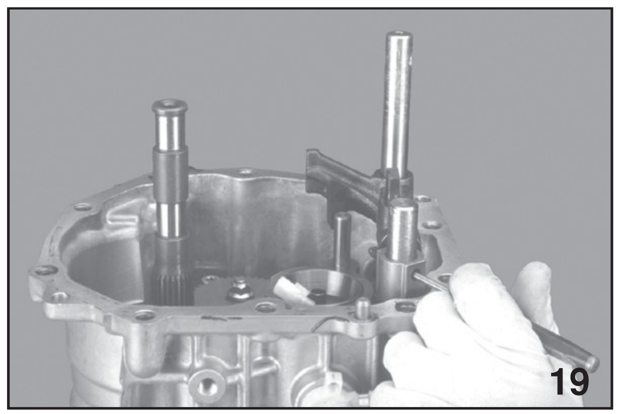


Striker Rod Snap Ring

Striker Rod Support

8. Remove the snap ring from the striker rod.
9. Remove the striker rod support. **Note: The shape and fit**. 2005MY design differs from 2004MY.

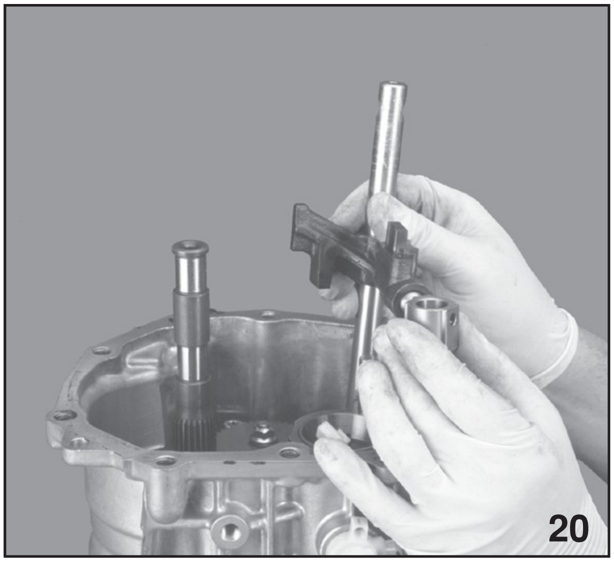




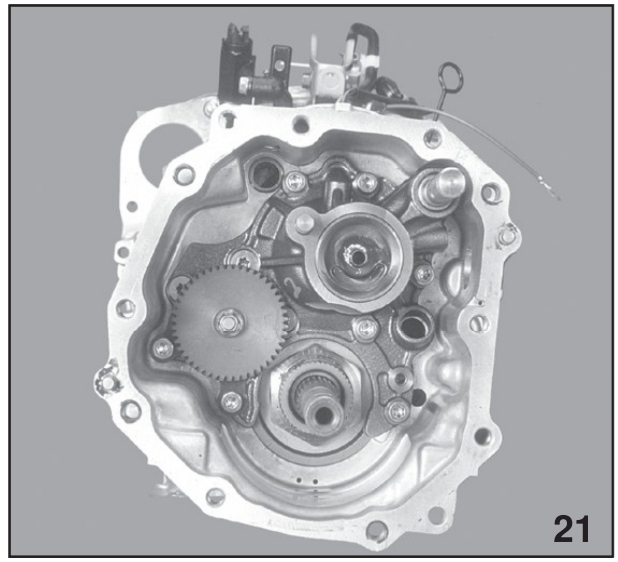
Neutral Set Spring

Selector Arm 2 Drift Pin

10. Spread the neutral set spring and remove from the striker rod.
11. Remove the drift pin from the selector arm number 2.

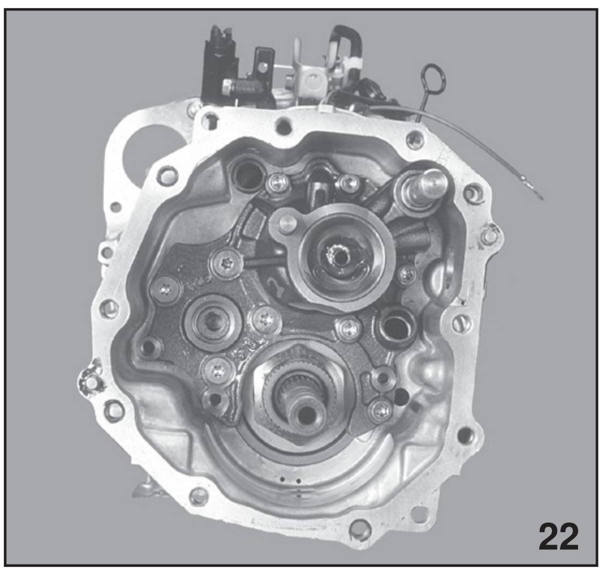


Removing Selector Arm 1 and 2

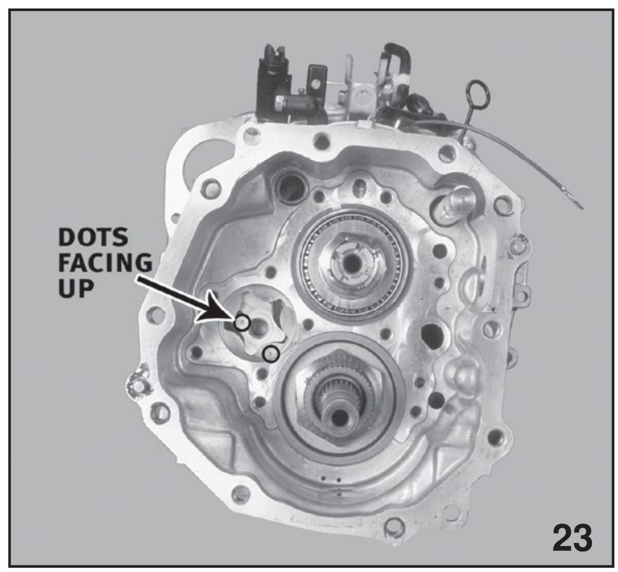


Oil Pump Driven Gear

12. Hold selector arm number one and selector arm number two together and remove in one motion.
13. Remove the oil pump driven gear and holder plate.



Oil Pump Cover



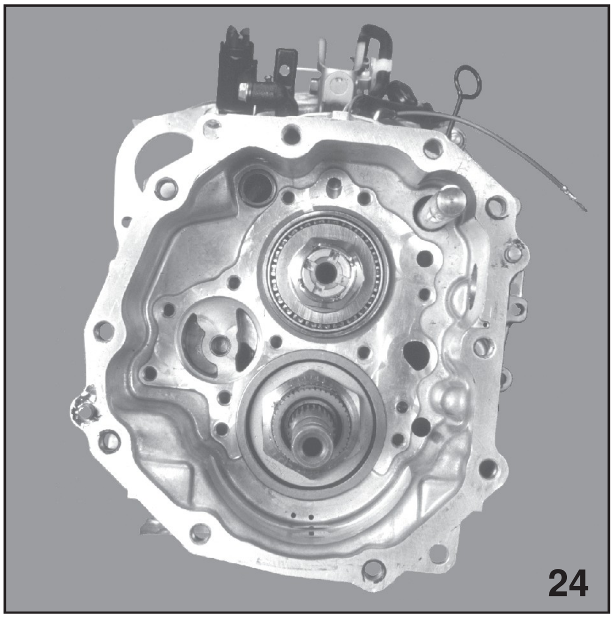
Oil Pump Rotors

14. Remove the bolts securing the oil pump cover, holder plate and drive gear.

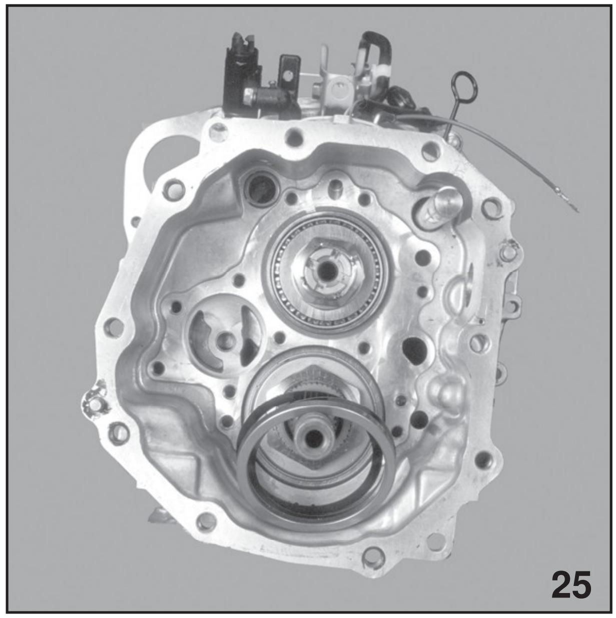
NOTE: PLUG OIL GUIDE AND SELECTOR ARM #1 PASSAGES TO PREVENT FOREIGN ITEMS FROM LODGING IN HOLES.

15. Remove the oil pump cover.

NOTE: THE MAIN SHAFT SHIM USUALLY COMES OFF WITH THE OIL PUMP COVER



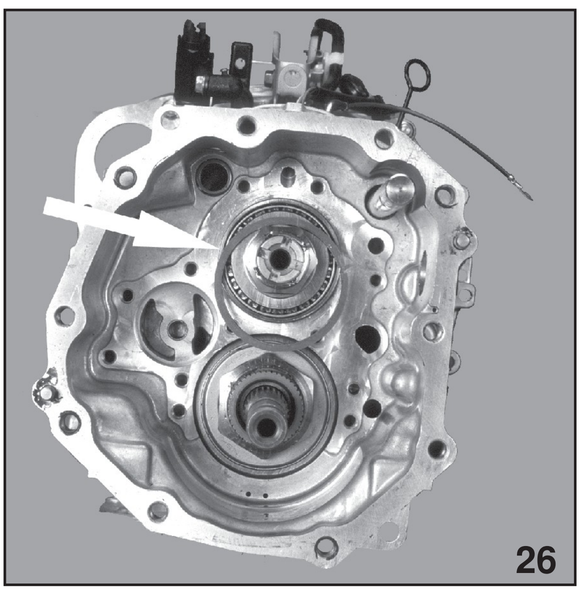
Oil Pump Rotors Removed



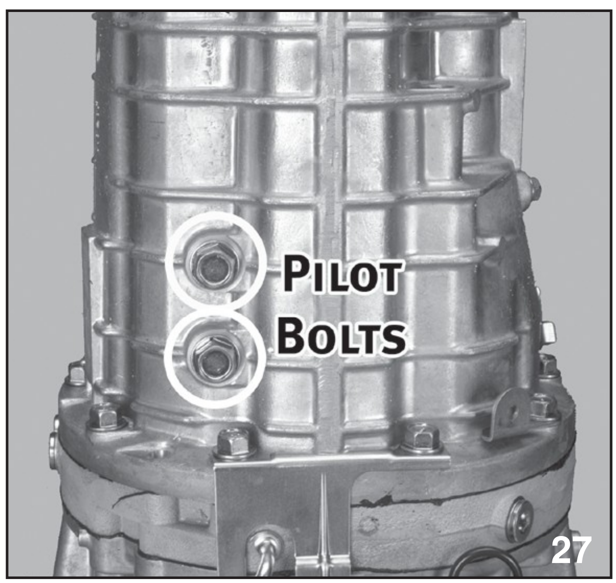
Shims and Collar

16. Remove the oil pump inner and outer rotor.
17. Remove the shim and collar from the top of the driven shaft and main shaft.

NOTE: SHIMS ON BOTH BEARINGS

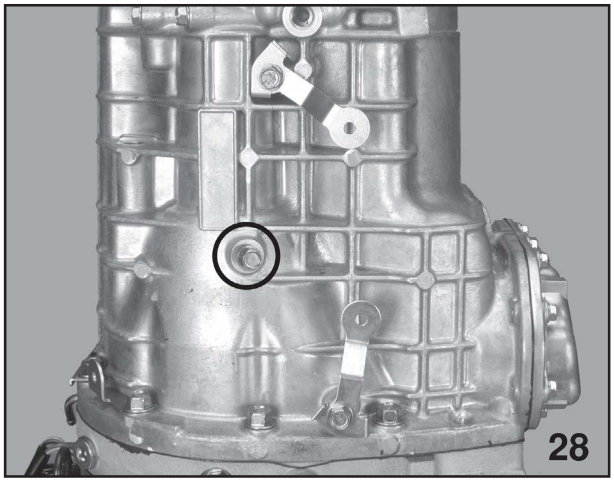


Main Shaft Snap Ring

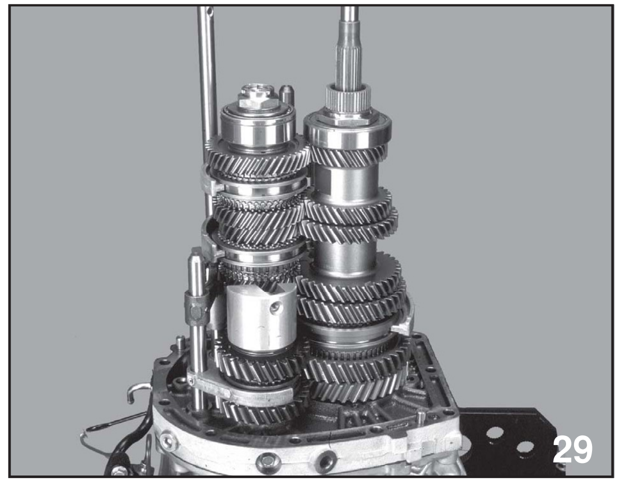


Pilot Bolts

18. Push up on the main shaft while removing the Snap Ring.
19. Remove the two pilot bolts.
20. Remove the two bolts securing the vent hose bracket and remove the bracket.

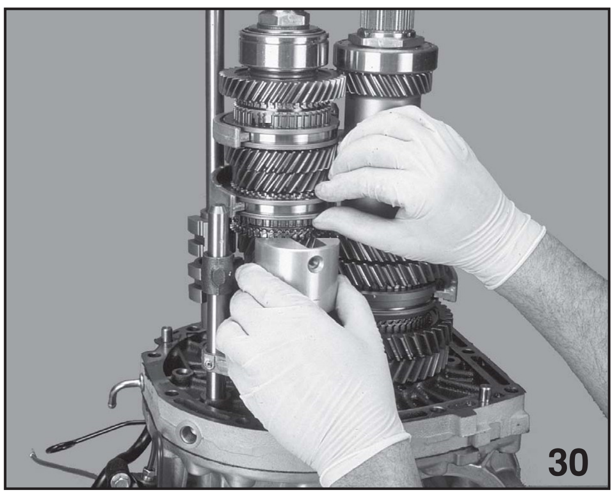


Reverse Idler Bolt

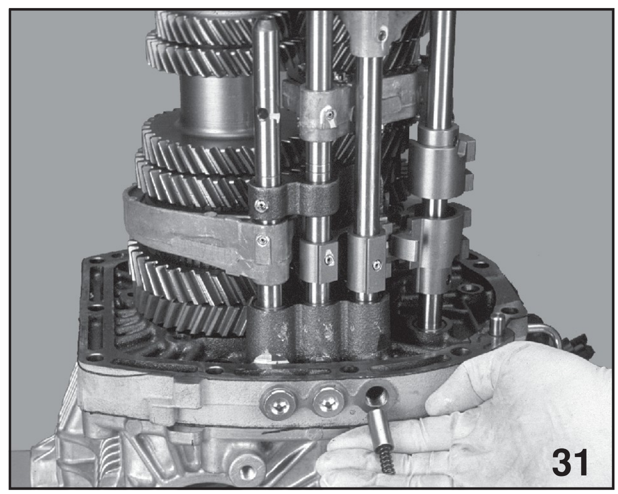


Main Case Removed

21. Remove the reverse idler holder mounting bolt and gasket.
22. Remove the bolts securing the transmission main case to the differential adapter plate. Remove the 3 lower nuts and then remove the main case.

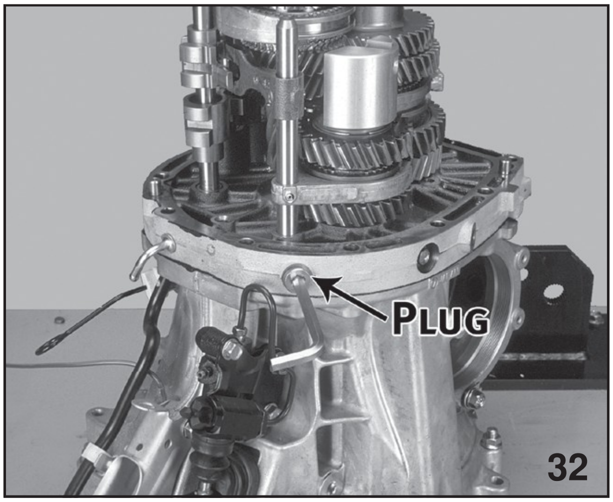


Reverse Idler Holder

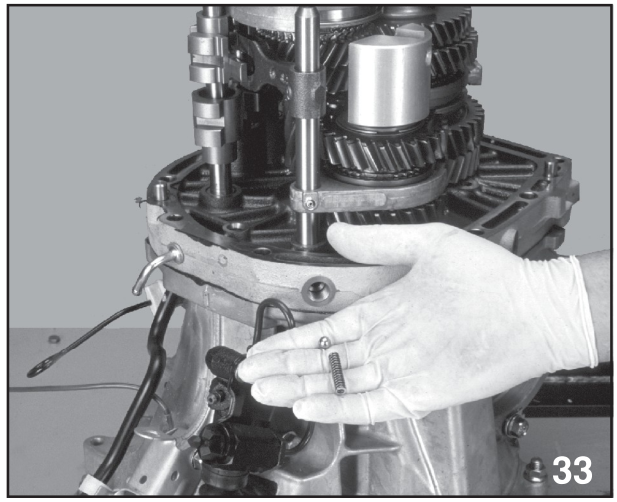


Detent and Spring

23. Set the transmission into 4th gear and slide the reverse idler holder from the reverse idler shaft.
24. Remove the shift arm plugs (3), gaskets (3), springs (3) and detent plungers (3).

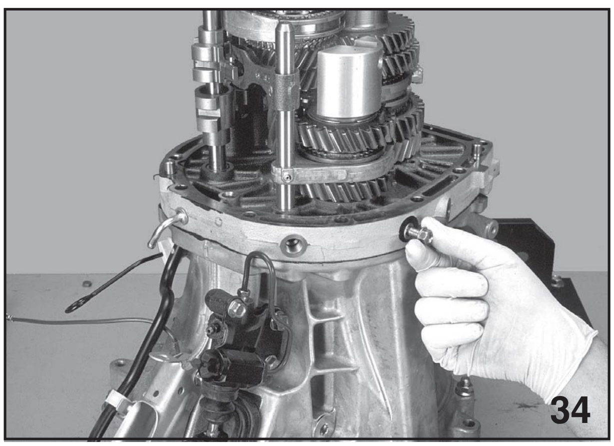


Plug

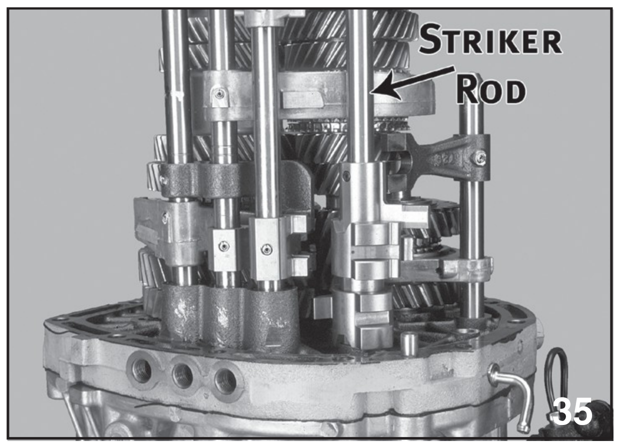


Ball and Spring

25. Remove the reverse shift arm plug, gasket, spring, and ball.



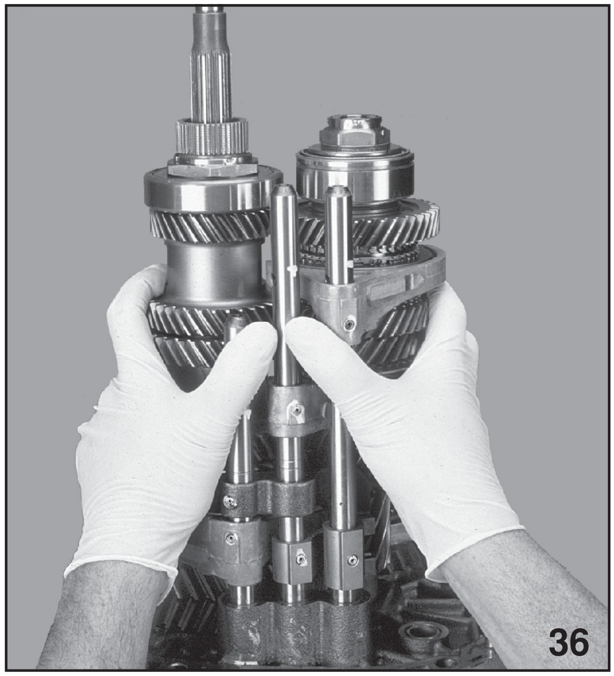
Reverse Idler Bolt



Striker Rod

26. Remove the reverse idler shaft mounting bolt.
27. Rotate the striker rod counter clockwise so that the interlock blocks clear the shifting gates of the shift forks. Remove the striker rod and interlocks together.

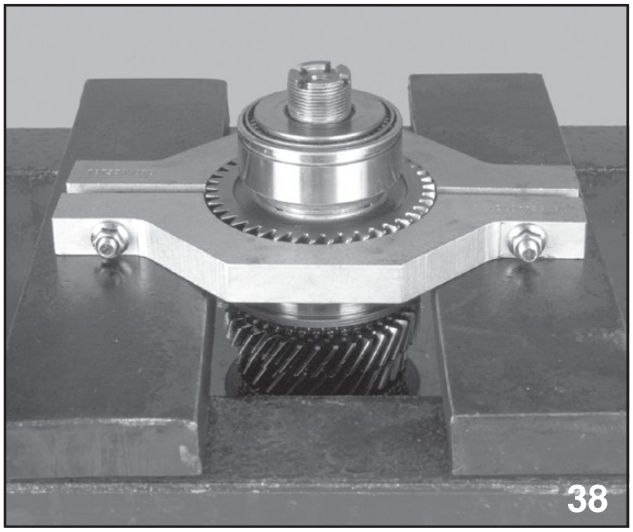
NOTE: ORIENTATION OF INTERLOCKS. BE CAREFUL NOT TO DROP INTERLOCKS DURING REMOVAL PROCESS.



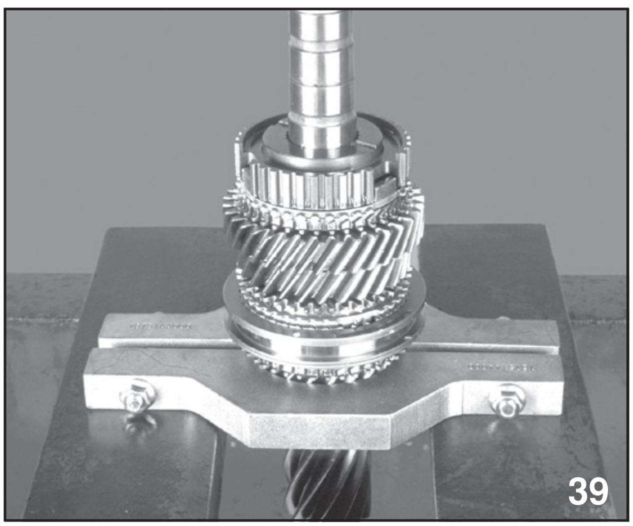
Removing Components

28. Hold the main shaft, driven shaft and shift rails together. Have a helper hold the reverse idler gear and shaft. All parts must be lifted at the same time.

Main Shaft Disassemble



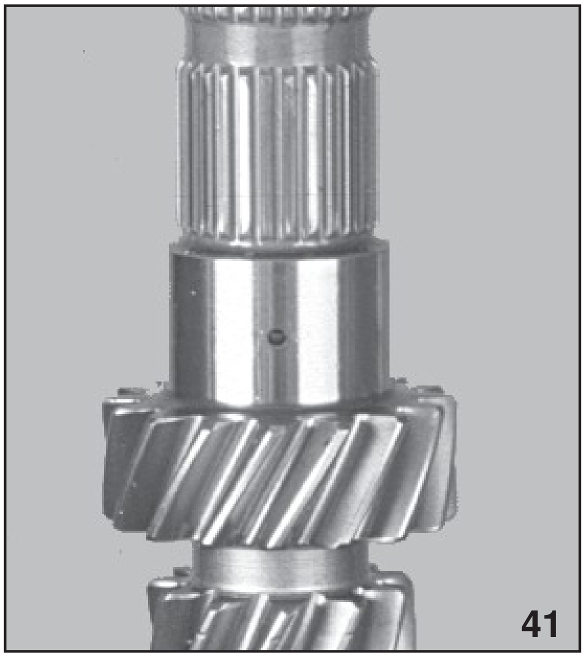
Main shaft in Remover 18722AA000



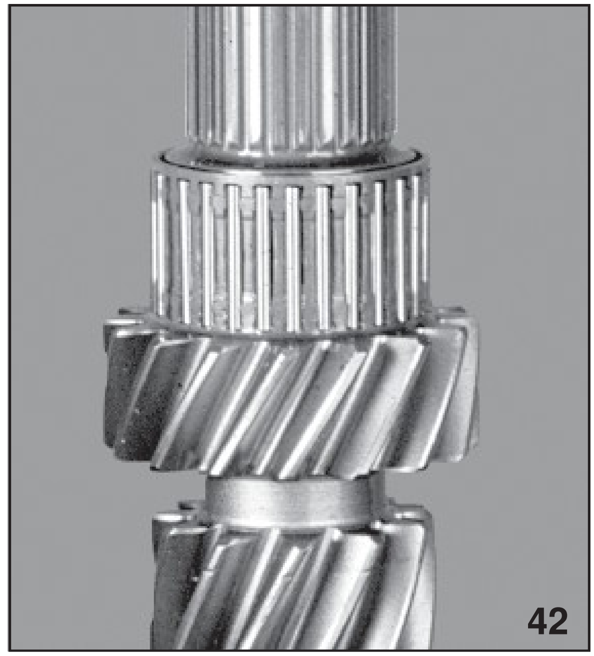
Remover 18720AA000

1. Insert the splines of the main shaft into the Base holder (18664AA000) while supporting the main shaft bearing and 6th gear with Holder (18665AA000).
2. Unstake the lock nut and remove the locknut using a 38 mm socket.
3. Support the main shaft in a press with Remover (18722AA000) positioned under the 6th gear.
4. Apply force to the main shaft using Remover (899864100) or similar tool.
5. Press off the 5th/6th hub with Remover (18720AA000) under the 3rd gear.

Main Shaft Assembly

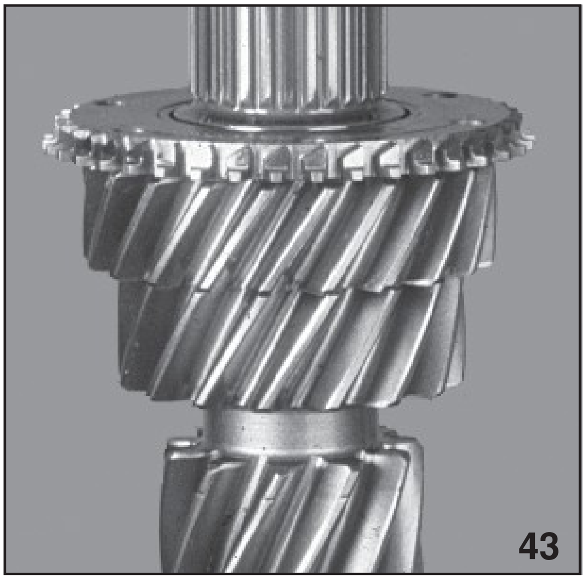


Main Shaft

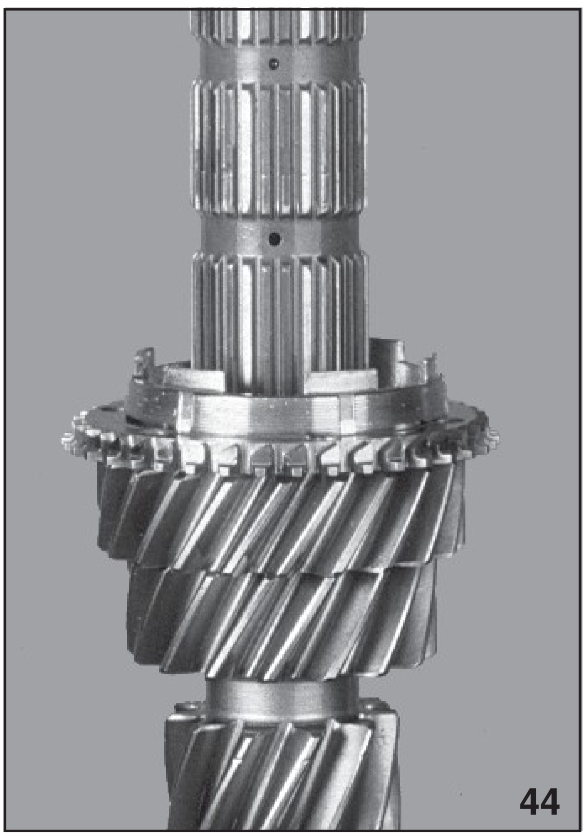


3rd Gear Bearing

1. Install the 3rd gear needle bearing.



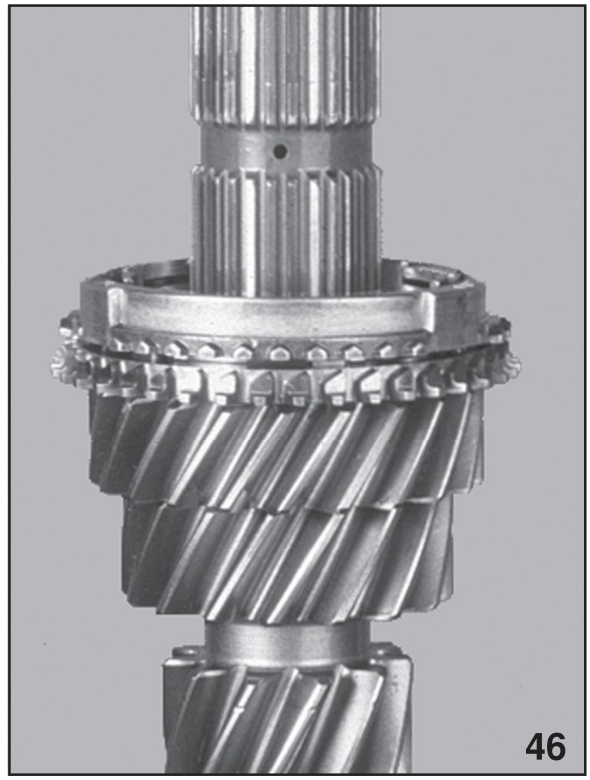
3rd Gear



3rd Gear Inner Baulk Ring

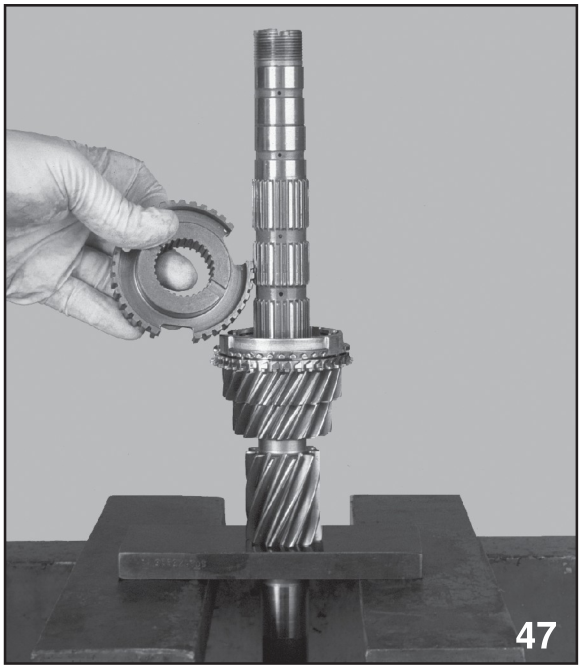
2. Install 3rd gear.
3. Install 3rd gear inner baulk ring.

3rd Gear Synchronizer Cone

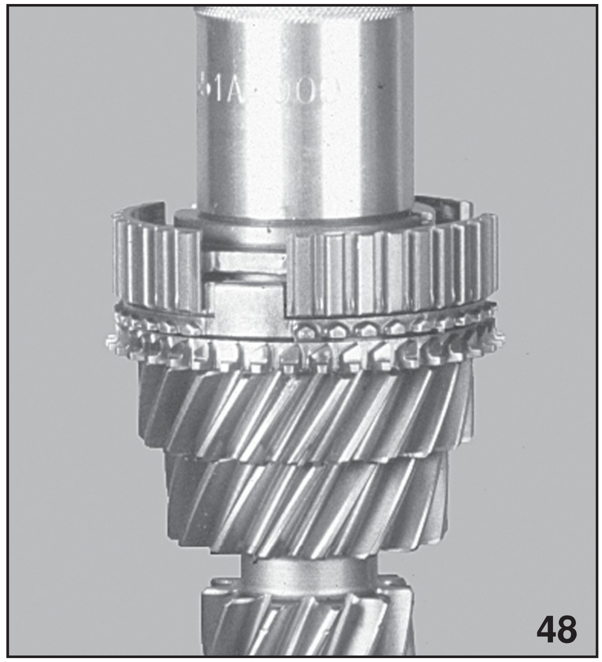


3rd Gear Outer Baulk Ring

4. Install the 3rd gear synchronizer cone.
5. Install the 3rd gear outer baulk ring.

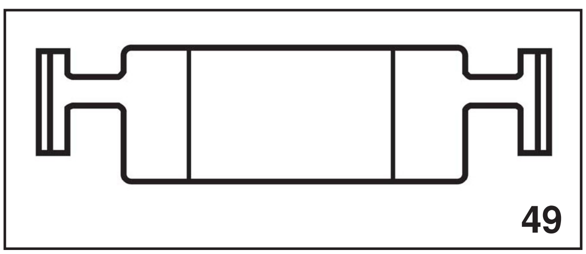


Main Shaft



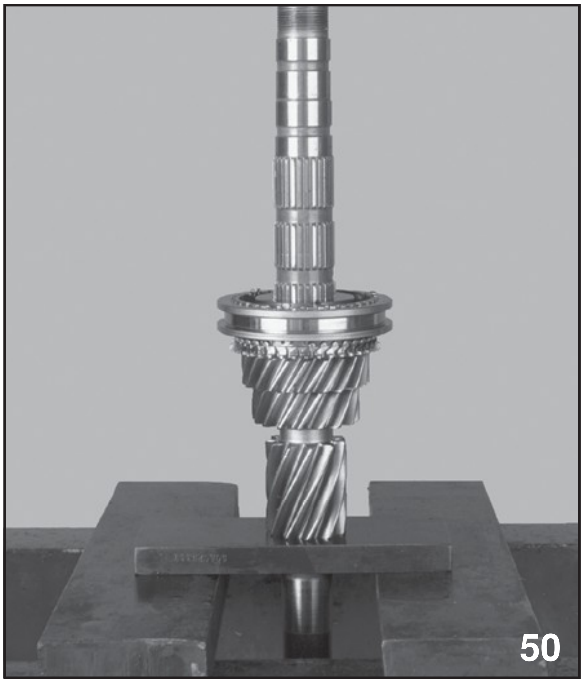
Installing 3rd/4th Hub

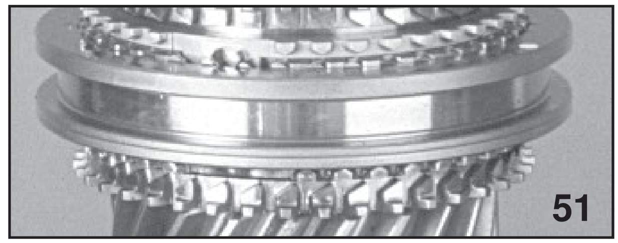
6. Support the main shaft in a press with holder (398177700) or similar tool under 1st gear.
7. Press the 3rd/4th hub (directional) on the main shaft using Installer (18651AA000).



Hub Artwork

CAUTION: POSITION THE OUTER BAULK RING PROTRUSIONS TO ENGAGE WITH THE CUT-OUTS IN THE HUB. THIS ALIGNMENT MUST BE EXACT AS THE HUB IS PRESSED ONTO THE MAIN SHAFT.

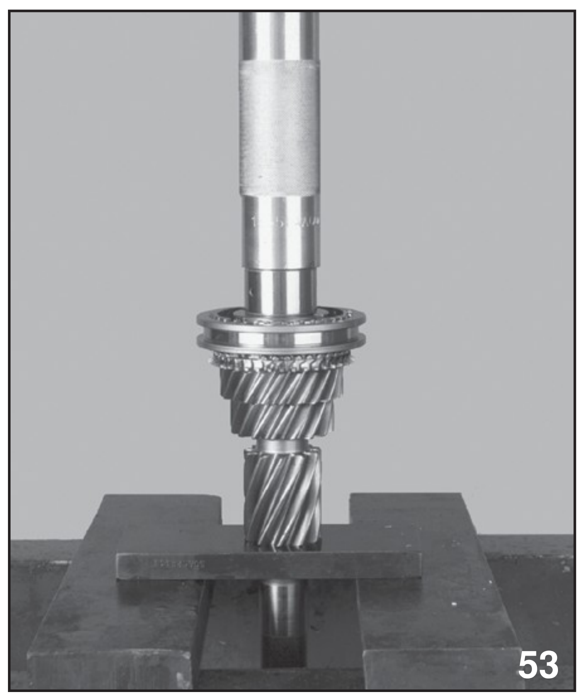




Installed Slider

Slider Close Up

8. Install the 3rd/4th slider on the 3rd/4th hub (Directional). Position the keys in the slider over the protrusions of the outer baulk ring.

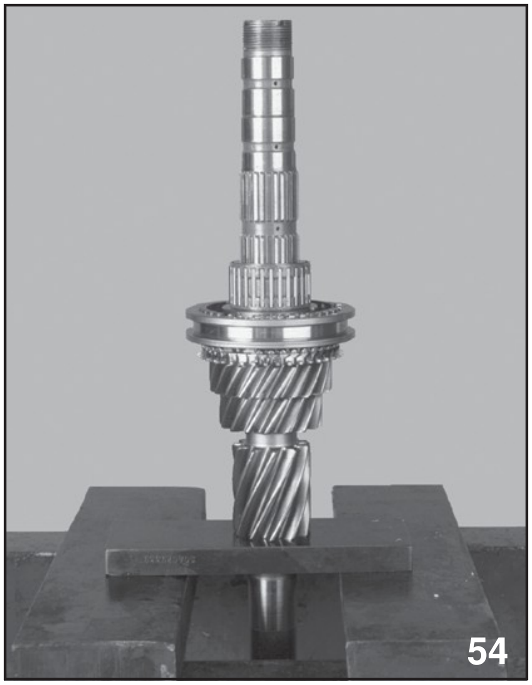


Installing Bushing

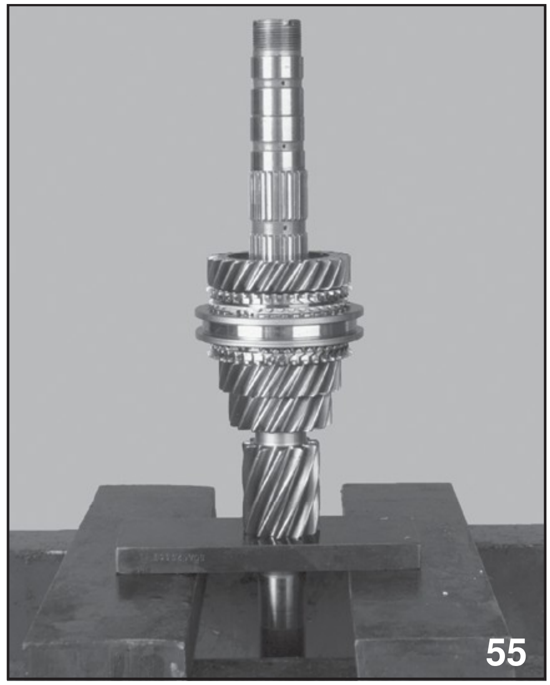
Bushing Installed

9. Press the 4th gear bushing on the main shaft. Position the oil hole in the bushing away from the oil hole in the main shaft.

SEE PAGE 24 FOR BUSHING ALIGNMENT.

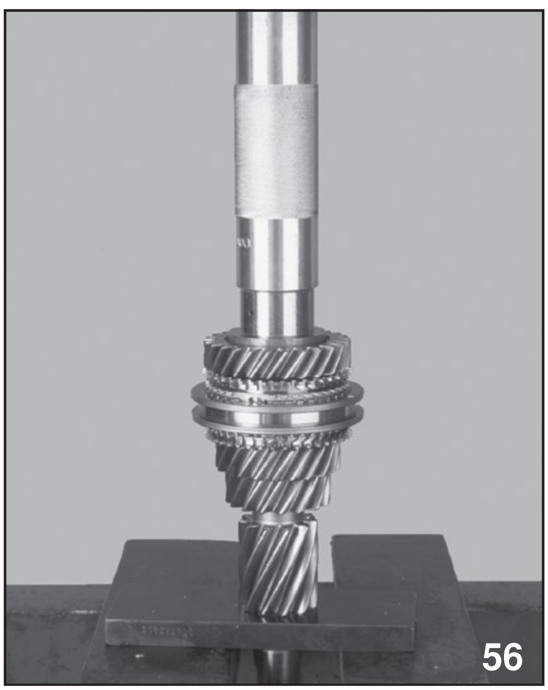


Bearing Installed



Gear Installed

10. Install the 4th gear needle bearing.

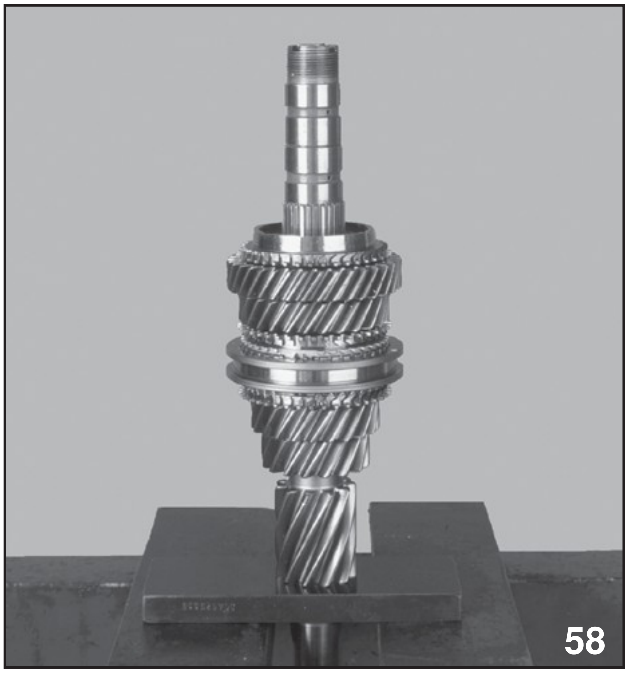


Bushing Installed

Bearing Installed

11. Install the 4th gear.
12. Press the 5th gear bushing on the main shaft. Position the oil hole in the bushing away from the oil hole in the main shaft.
13. Install the 5th gear bearing.

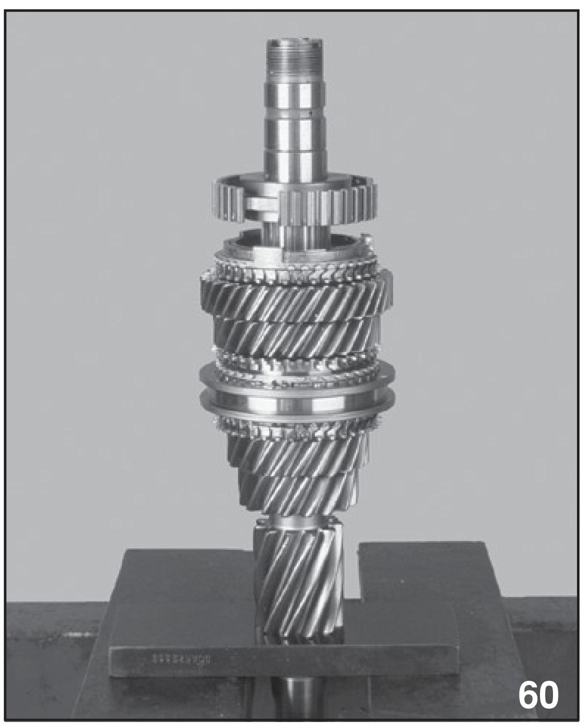
SEE PAGE 24 FOR BUSHING ALIGNMENT.



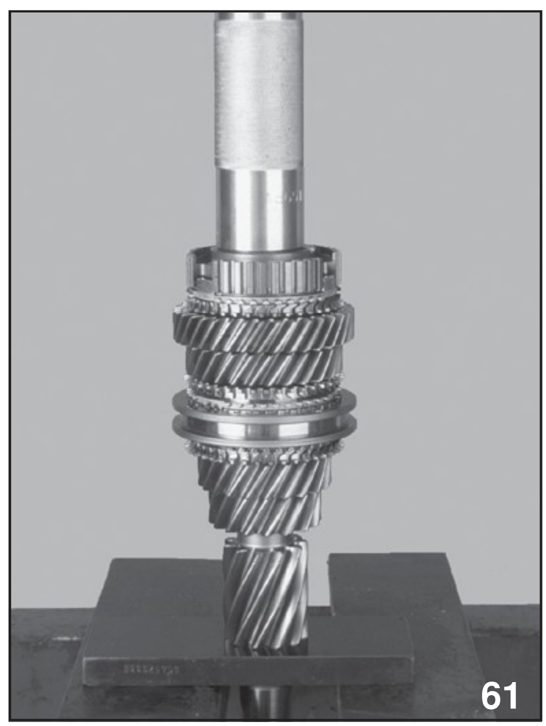
Gear Installed

Baulk Ring Installed

14. Install the 5th gear
15. Install the 5th gear baulk ring.

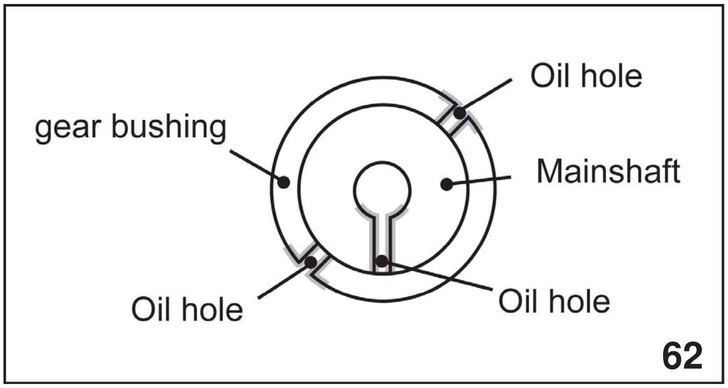


Installing 5th/6th Hub

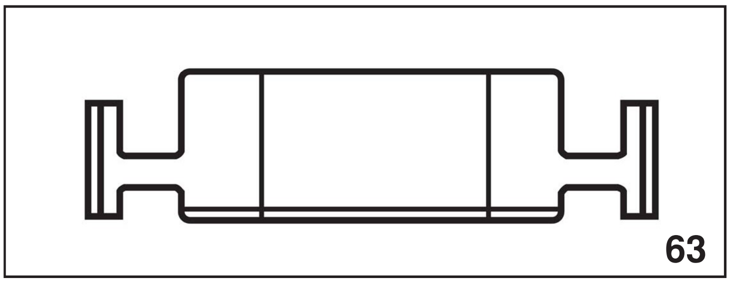


Hub Installed

16. Install the 5th and 6th gear synchronizer hub. The hub (Directional) must be installed as shown while aligning the slots in the hub with the baulk ring of 5th gear.



Bushing Artwork

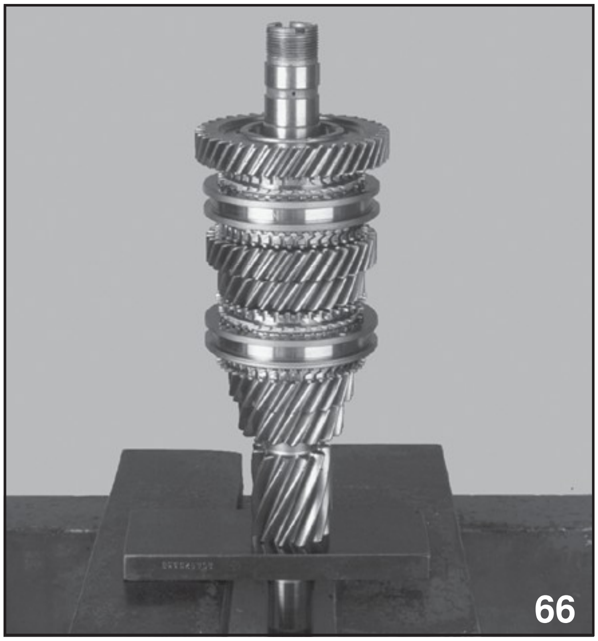


Hub Artwork

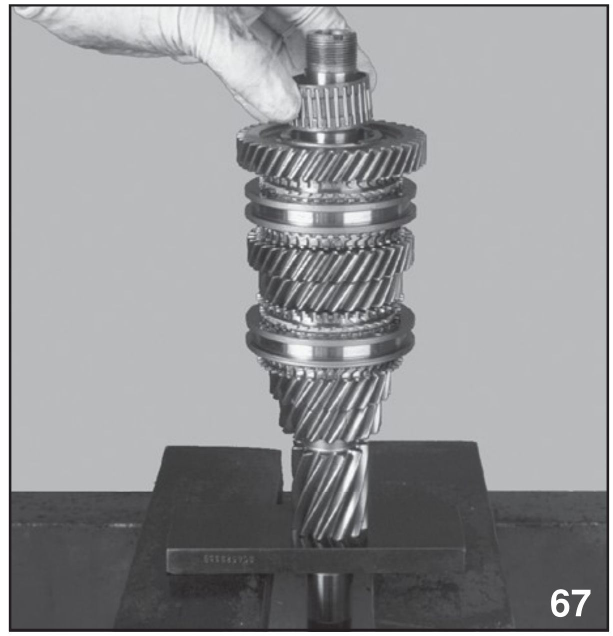
Slider Installed

Baulk Ring

17. Install the 5th and 6th gears slider (Directional) with the inserts aligned with the protrusions of the 5th gear baulk ring.
18. Install the 6th gear baulk ring while aligning the protrusions of the 6th gear baulk ring with the inserts of the 5th and 6th gear slider.



Gear Installed



Bearing Installed

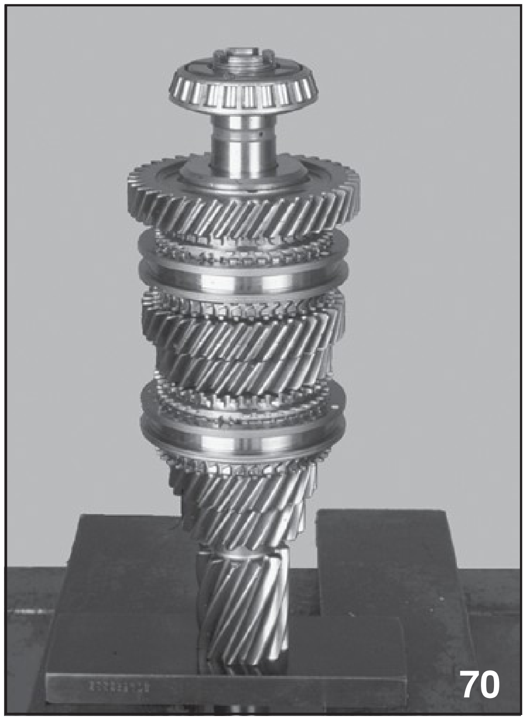
19. Install the 6th gear and 6th gear bearing.

Installing Bushing

Bushing Installed

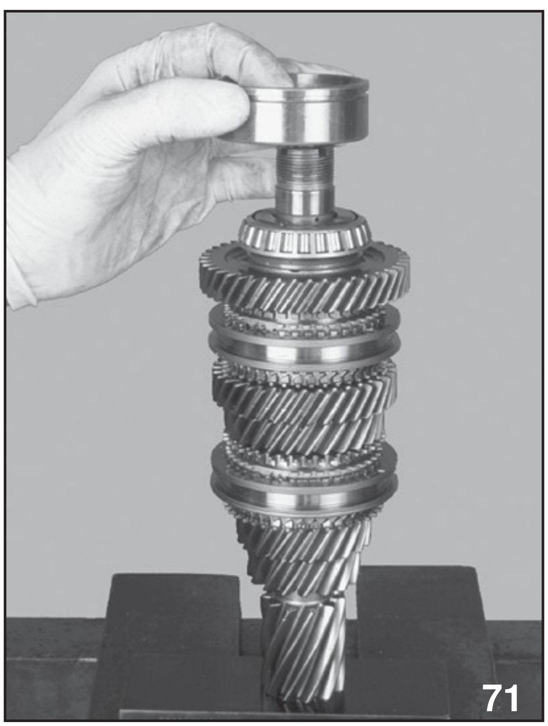
20. Press the 6th gear bushing onto the main shaft, taking care not to overlap the main shaft oil hole and the bushing oil hole.

SEE PAGE 24 FOR BUSHING ALIGNMENT.



Installing Bearing

21. Press the lower tapered roller bearing onto the main shaft.

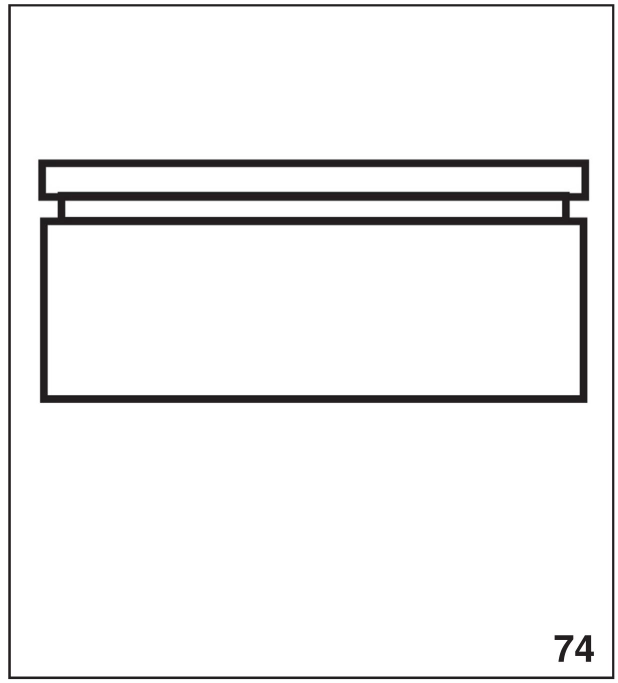


Installing Retainer

Installing Upper Bearing

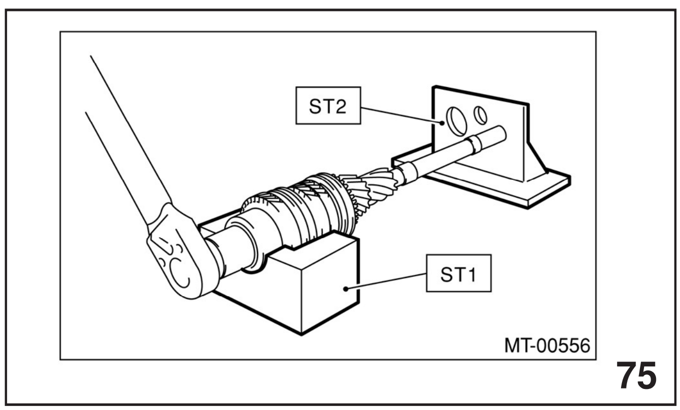
22. Install the bearing retainer into place with the snap ring groove facing the top side.

Bearing Installed



Retainer Artwork

23. Press the upper tapered roller bearing onto the main shaft.



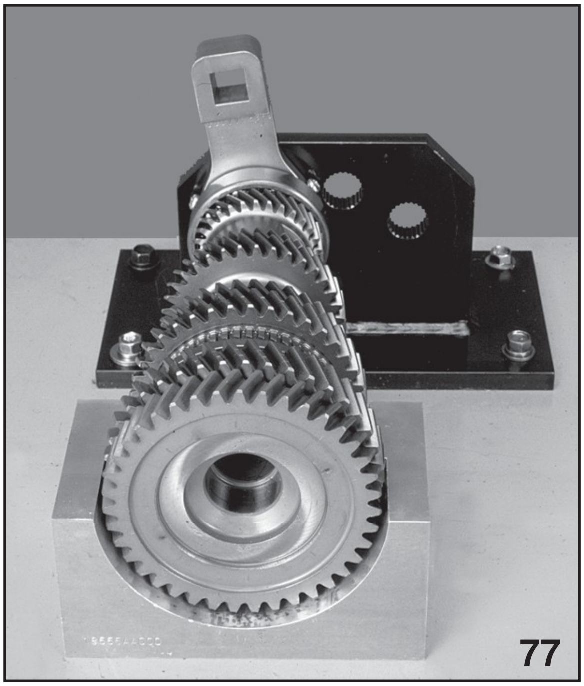
Torquing Main Shaft

24. Install a new washer and new lock nut. Torque to 289 ft. lbs. (392 N~m)
25. Stake the lock nut in four (4) places. **Do not crack the staking area.**

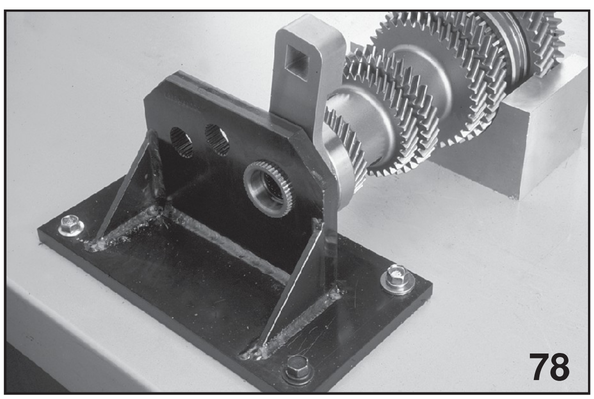
ST1 18665AA000

ST2 18664AA000

Driven Shaft Disassembly

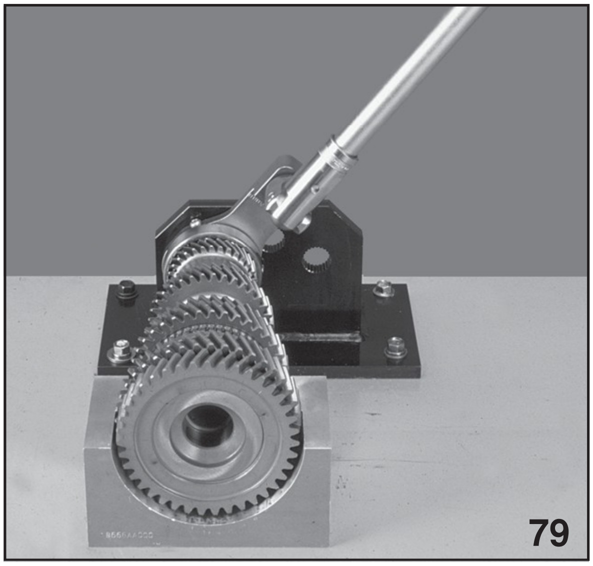


Driven Shaft Gear View

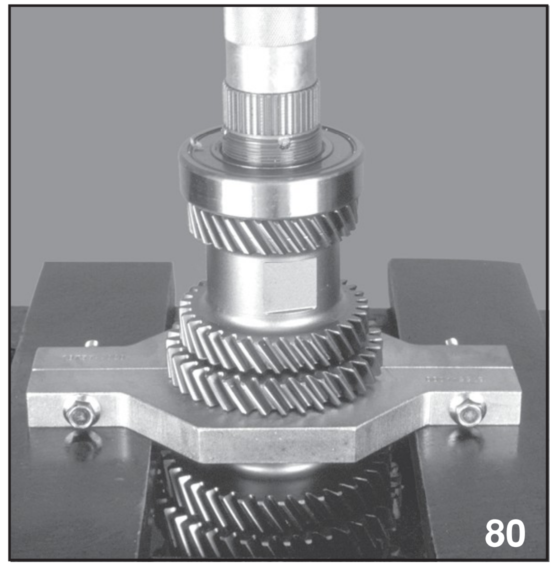


Driven Shaft Base Tool View

1. Secure the Base holding tool (18664AA000) to **a rigid** work bench. Unstake the locknut. Fit the Adapter Wrench (18620AA000) on the lock nut of driven shaft. Tighten the three screws to remove any looseness. Align the splines of the driven shaft with the Base holding tool while supporting the reverse and 1st gear with holder (18666AA000).



Breaker Bar

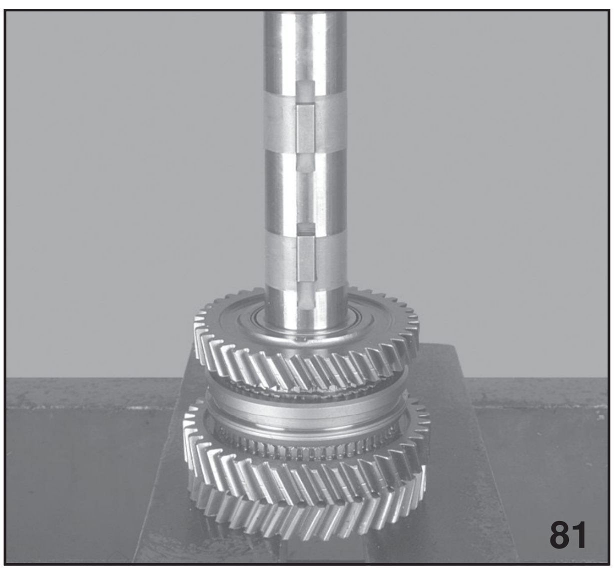


Driven Shaft on Press

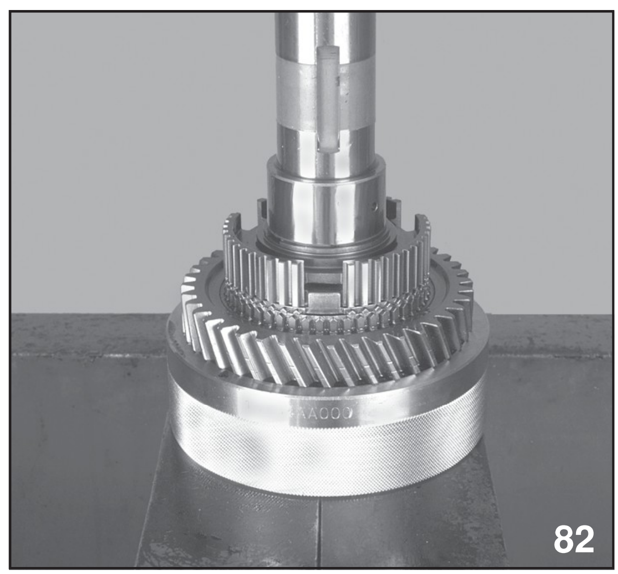
2. Loosen the locknut.

CAUTION: THE LOCK NUT IS TORQUED TO 391 FOOT LBS. USE CARE TO AVOID PERSONAL INJURY.

3. Place the driven shaft on a press supported with Remover (18723AA000) under 3rd gear. Apply pressure to the top of the driven shaft with Remover (499877000) or similar tool.

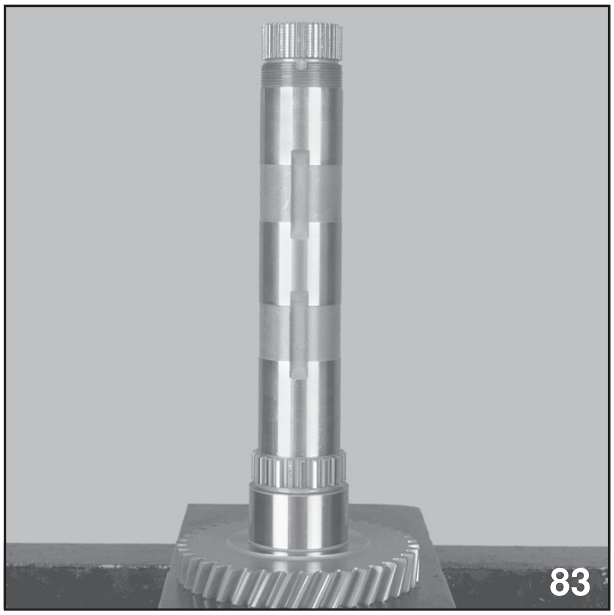


Woodruff Keys



Remover 18754AA000

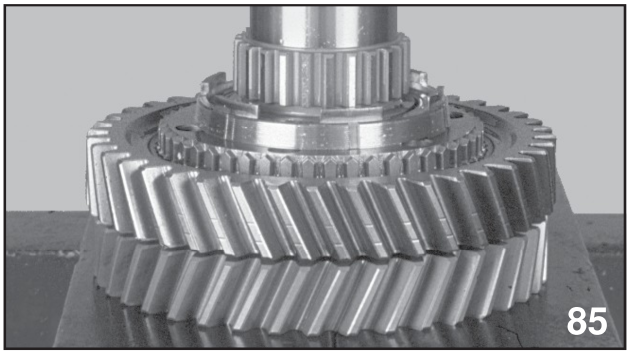
4. Remove the two woodruff keys from the driven shaft.
5. Support the driven shaft on a press with Remover (18754AA000) under 1st gear. Apply pressure to the top of the driven shaft with Remover (499877000) or similar tool.

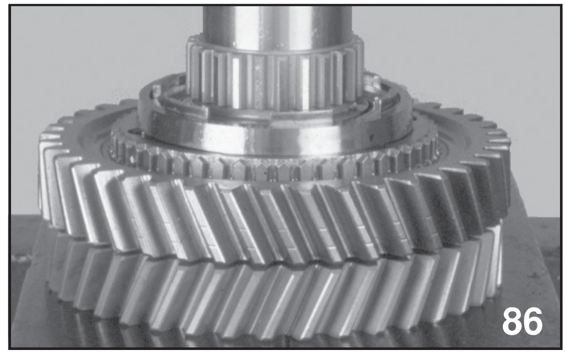


Driven Shaft

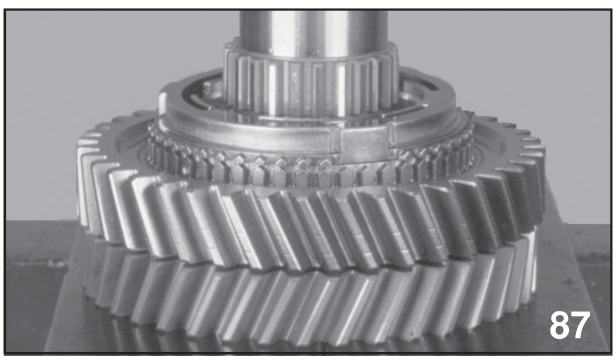
6. Inspect the driven shaft and reverse gear

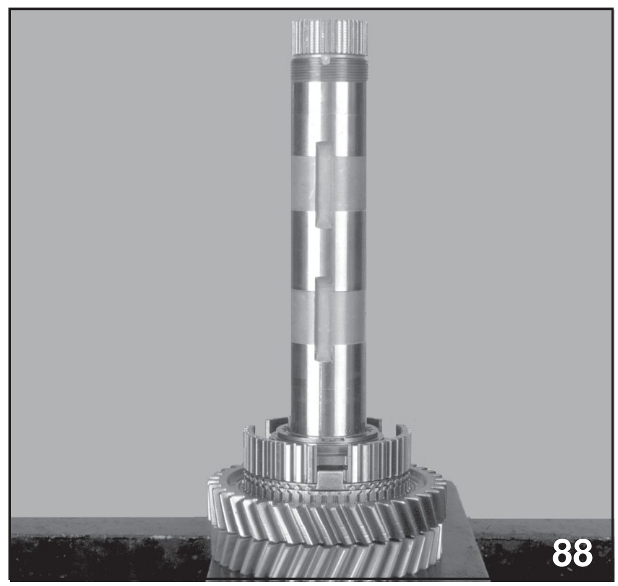
Driven Shaft Reassembly


1st Gear


1st Gear Inner Baulk Ring

1. Install the 1st gear on the driven shaft.
2. Install the 1st gear inner baulk ring.
3. Install the 1st synchronizer cone.


Outer Baulk Ring Installed


Hub Installed

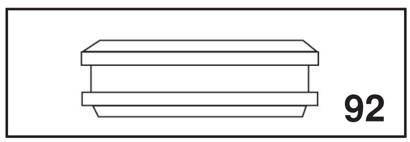
4. Install the 1st gear outer baulk ring.
5. Install the 1st/2nd gear hub (Directional) on the driven shaft.

Hub Artwork

Installing Bushing

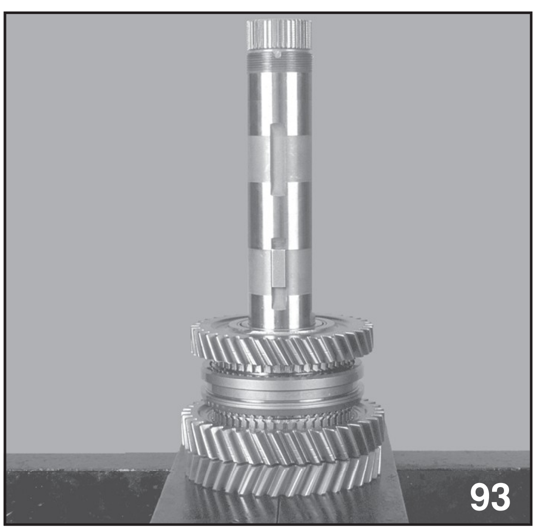
Slider and Bearing Installed

6. Press the 2nd gear bushing on the driven shaft using installer (18654AA000). The oil hole on the bushing must be positioned away from the oil hole located on the driven shaft.



Slider Artwork

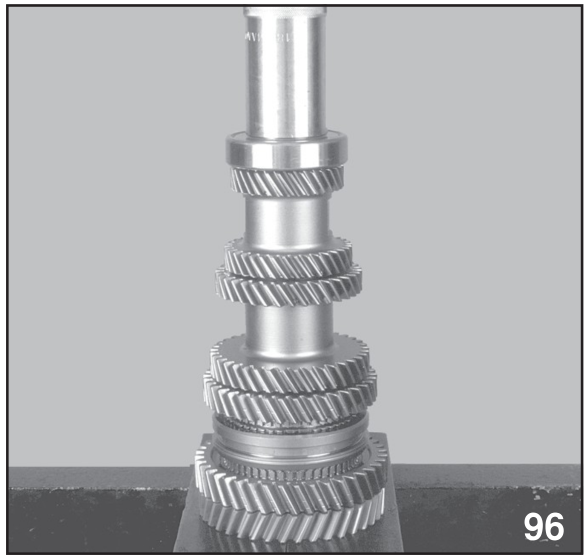
7. Install the 1st/2nd gear slider (Directional). Confirm that the slider key is positioned over the protruded portion of the outer baulk ring.
8. Install the 2nd gear needle bearing.



2nd Gear Installed and Lower Woodruff Key

3rd/4th Gear Installed and Upper Woodruff Key

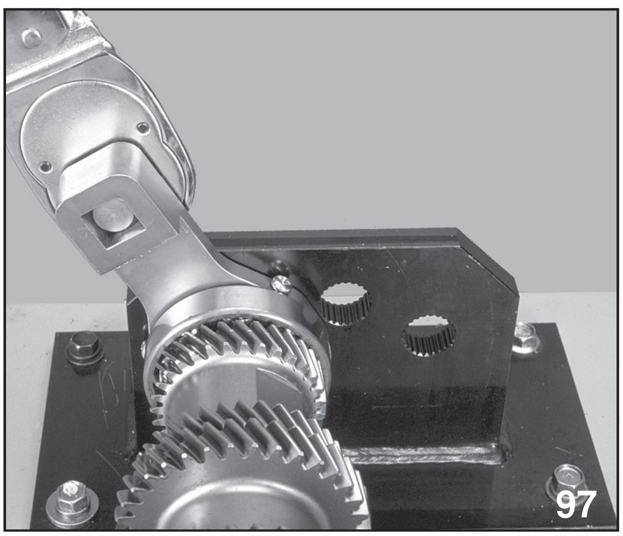
9. Install the 2nd gear outer baulk ring and the 2nd gear.
10. Install the lower woodruff key on the driven shaft.
11. Press the 3rd/4th gear set on the driven shaft using Installer (18654AA000).



5th/6th Gear Installed

Bearing Installed

12. Install the upper woodruff key and press the 5th/6th gear set on the driven shaft using Installer (18654AA000).
13. Press the ball bearing on the driven shaft (Directional) using Installer (18654AA000).



Torquing Driven Shaft Nut

14. Install a new locknut on the driven shaft and fit the Adapter Wrench (18620AA000) on the lock nut of driven shaft. Tighten the three screws to remove any looseness. Align the splines of the driven shaft with the Base holding tool while supporting the reverse and 1st gear with holder (18666AA000).
15. Torque the locknut to 391 ft. lbs. (530 N~m)

NOTE: THE TORQUE WRENCH SUPPLIED AS A SPECIAL TOOL IS DIFFERENT THAN TORQUE WRENCH USED TO WRITE THE SERVICE MANUAL. THIS MAKES IT NECESSARY TO RECALCULATE THE TORQUE SPECIFICATION WHEN USING THE ADAPTER WRENCHES. USE THE FOLLOWING FORMULA TO DETERMINE THE NEW TORQUE SPECIFICATION.

T = L1 / (A + L1) x T1

T = New Torque Specification

L1= Length of the torque wrench from the center of the handle to the center of the socket mount.

A = Length of the adapter from the middle of the socket mount to the middle of the wrench.

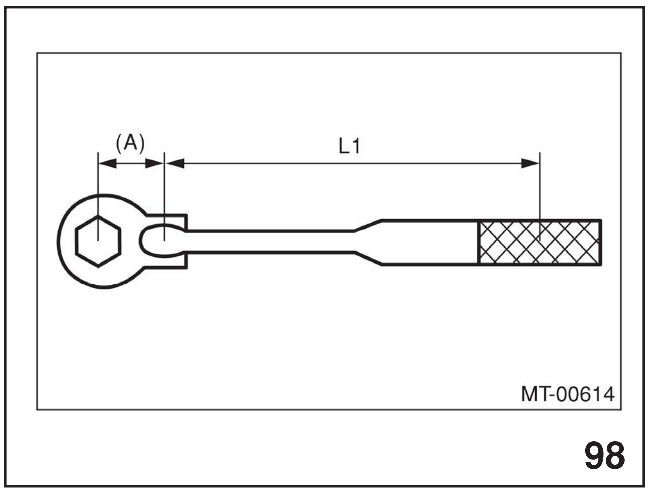
T1= Original torque specification

Example: T = 37.5 / (4 + 37.5) x 420

T = 37.5/ 41.5 x 420

T = .90 x 420

T = 378

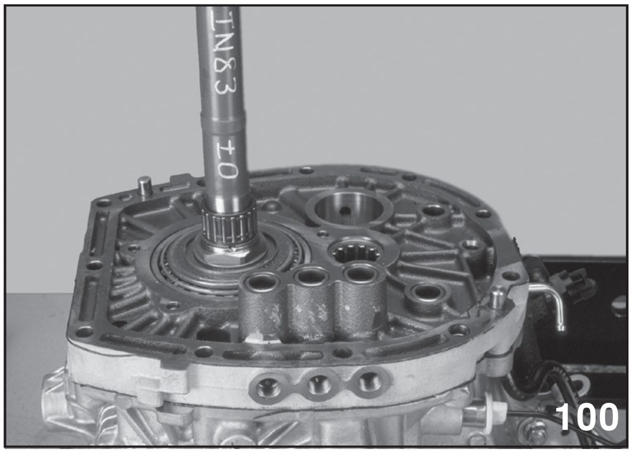


Torque Wrench Artwork

16. Stake the new locknut in 4 places.

Drive Pinion Shaft Assembly

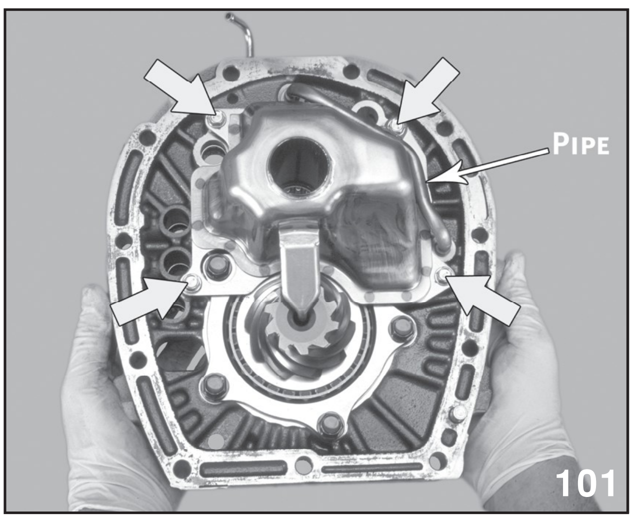
Removal



Back Side of Adapter Plate

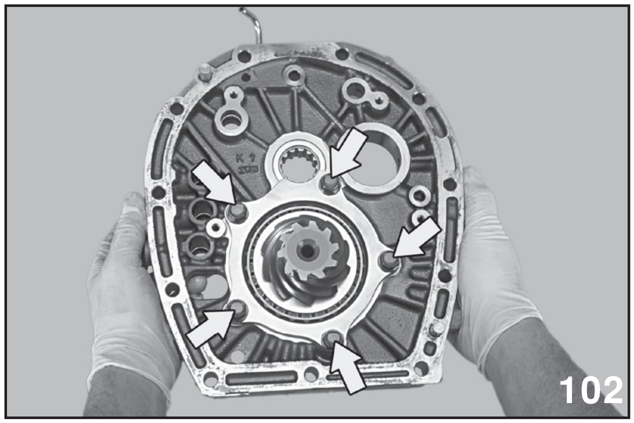
Disassembly

Replace the drive pinion shaft as a set with hypoid driven gear.



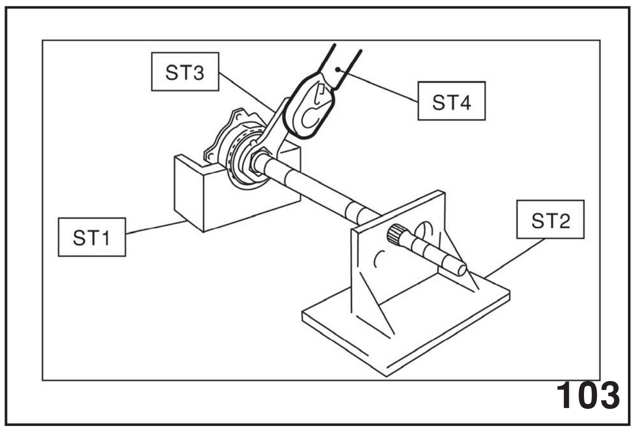
4 Oil Chamber Bolts

1. Remove the pipe and oil chamber (4 bolts).



Pinion Shaft Artwork

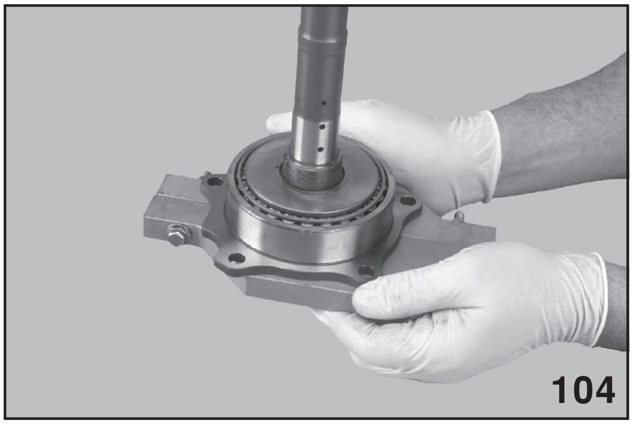
2. Remove the drive pinion shaft and shim from adapter plate.



Pinion Shaft Artwork

3. Secure the ST on workbench.
   ST 18664AA000 BASE
4. Unstake the lock nut.
5. Install the ST3 to lock nut, then install drive pinion shaft in ST. Remove the lock nut and washer.

ST1	18667AA000 Holder
ST2	18664AA000 Base
ST3	18621AA000 Adapter wrench
ST4	Breaker Bar

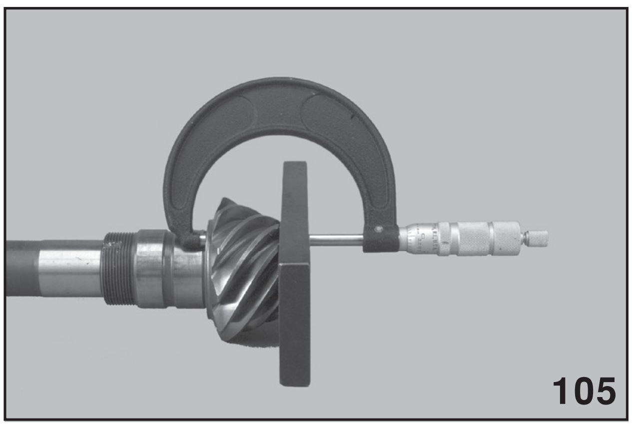


Press Plates

6. Using the ST, remove the taper roller bearing assembly.

   ST 18723AA000 Remover

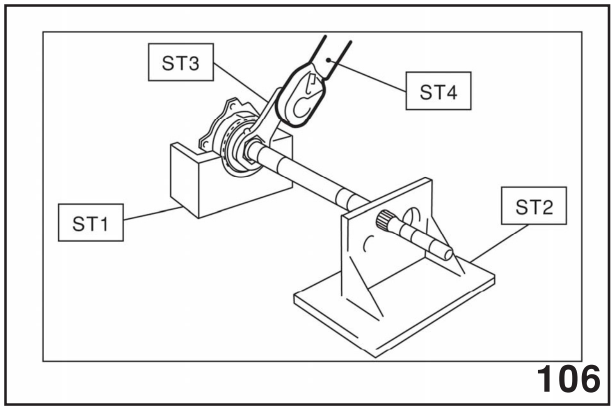
Assembly



A

1. Using the ST, measure dimension A of drive pinion.

   ST 398643600 Gauge



Pinion Shaft Artwork

Install a new washer and a new lock nut.

Install the ST to the drive pinion and insert into special tool (ST2) and support with (ST1). Then tighten the lock nut using special tool (ST3) and (ST4).

ST1	18667AA000	Holder
ST2	18664AA000	Base
ST3	18621AA000	Adapter Wrench
ST4	18852AA00	Torque Wrench

NOTE: TIGHTEN WITH THE (ST) AND TORQUE WRENCH (ST4) STRAIGHT-LINED.

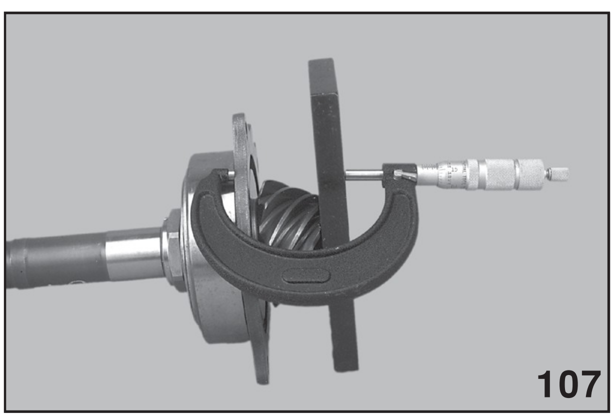
T = L1 / (A + L1) x T1

T = New Torque Specification

L1= Length of the torque wrench from the center of the handle to the center of the socket mount.

A = Length of the adapter from the middle of the socket mount to the middle of the wrench.

T1= Original torque specification



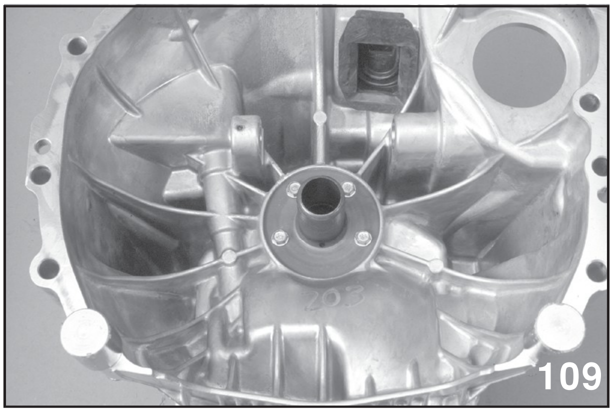
B

Using the ST, measure dimension B of the drive pinion.

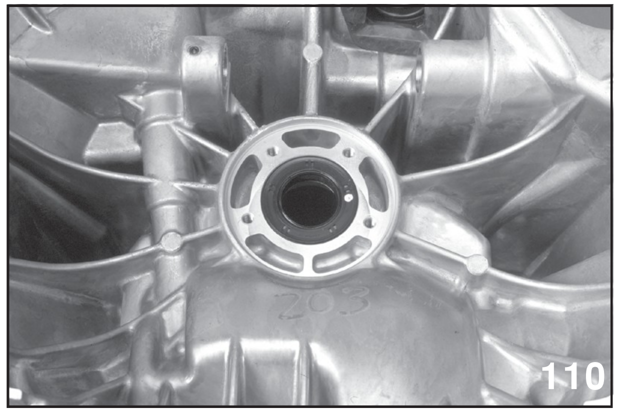
ST 398643600 Gauge

T= 6.5 ± 0.0624 mm - (B - A)

Main Shaft Seal Replacement



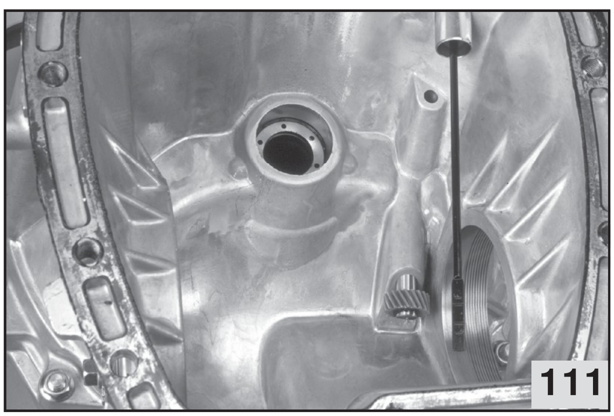
Release Bearing Guide



Main Shaft Seal Front View

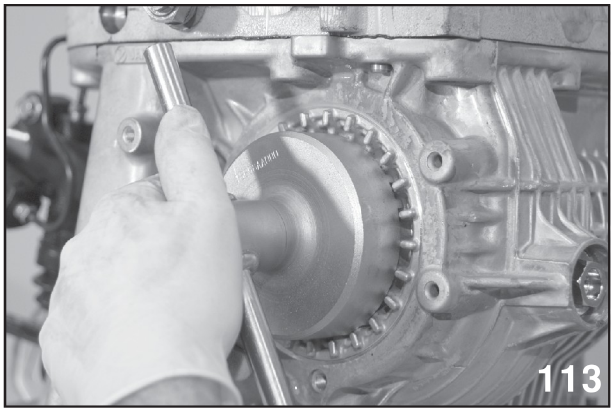
Remove the clutch release bearing guide and inspect for wear or damage. Remove the seal using a general seal removal tool, be careful to avoid scratching the main shaft sealing surface and the transmission case.

The seal can also be removed by a general tool from the back side, driving it towards the front. Install the new seal using general seal installation tool.

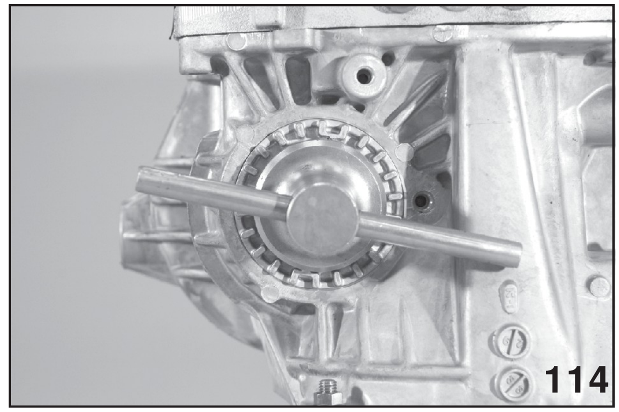


Main Shaft Seal Rear View

Hypoid Gear Backlash



Bearing Retainer Wrench in use Right Side



Bearing Retainer Wrench in use Left Side

1. Install the right and left side retainer. ST1 499787000 WRENCH ASSY (RIGHT SIDE) ST2 18658AA000 WRENCH ASSY (LEFT SIDE)

NOTE: SCREW IN THE RIGHT SIDE RETAINER A BIT FURTHER THAN LEFT SIDE.

2. Install the drive pinion shaft assembly, and then secure it with four bolts.

NOTE: USE THE OLD GASKET AND WASHER TO PREVENT DAMAGING, THE MATING SURFACE OF THE CASE .

TIGHTENING TORQUE: 50 N·M (5.0 KGF-M, 36.9 FT-LB)

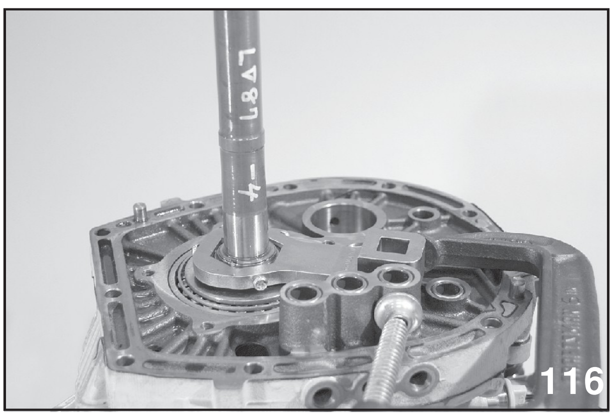
3. Using the ST, screw in the left side retainer until the drive pinion and hypoid driven gear contacts lightly. Then loosen the right side retainer.

ST1 499787000 WRENCH ASSY (RIGHT SIDE)

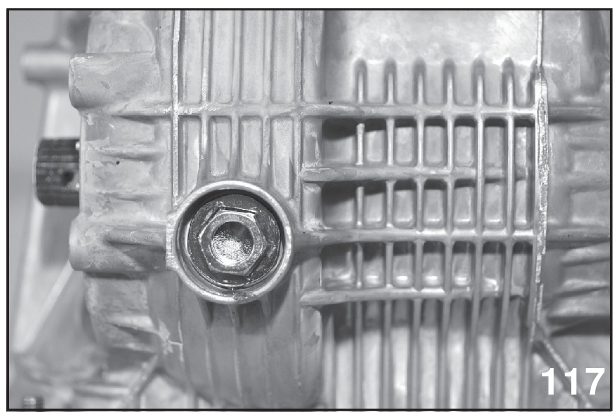
ST2 18658AA000 WRENCH ASSY (LEFT SIDE)

ST Handle

4. Using the ST, rotate the drive pinion shaft several times. ST 18631AA000 HANDLE
5. Repeat step 3 and 4 until the left side retainer can not be rotated. For the right side retainer, screw it in until the inner race and outer race contacts lightly. This condition is “0” backlash.
6. Mark an engagement point on the right and left side retainer and clutch housing.
7. Return the left side retainer for three teeth, and screw in the right side retainer for three teeth.



Pinion Shaft Held



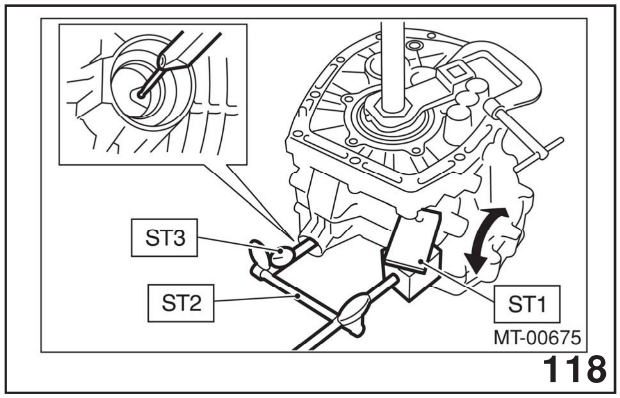
Drain Plug

8. After rotating the drive pinion shaft several times, measure the hypoid gear backlash using the ST.
9. Use the ST with "C" clamp to, secure the drive pinion shaft. ST 18660AA000 ADAPTER WRENCH

ST1 498255400 PLATE

ST2 498247001 MAGNET BASE

ST3 498247100 DIAL GAUGE



Backlash Artwork

HYPOID GEAR BACKLASH:

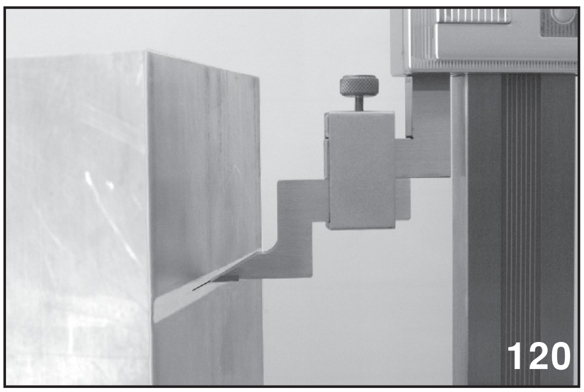
0.13 — 0.18 MM (0.0051 — 0.0071 IN)

10. If the backlash is out of specification, adjust it by turning the right and left side retainers equal amounts to maintain pre-load.
11. Screw in the right side retainer an additional 1.75 teeth.

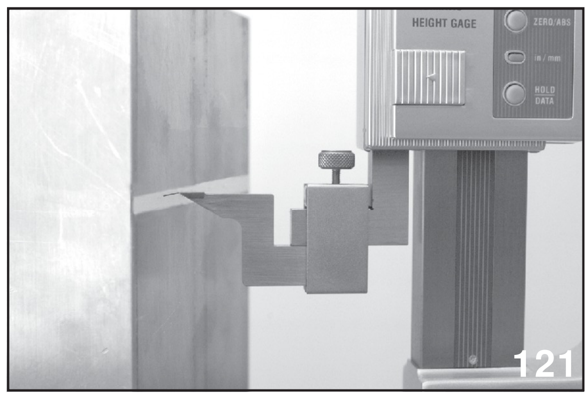
Scribe Differential

Determine Scribe Differential (SD) by performing the following:

1. Place a large aluminum block and height gauge on a flat machined surface.
2. Adjust the height gauge to about half of its maximum distance.
3. Carefully etch a mark into the aluminum block with the end of the scribe.
4. Turn on and zero the height gauge
5. Carefully move the height gauge away from the aluminum block while keeping the base of the height gauge on the machined surface. (Gauge 398643600)
6. Invert the scribe ensuring the center part of the scribe is positioned on the same side of the gauge extension arm used in step 3.
7. Move the height gauge back to the aluminum block and adjust the height so that the end of scribe is equal to the mark placed on the block in step 3.
8. The reading on the gauge is the scribe differential (SD).

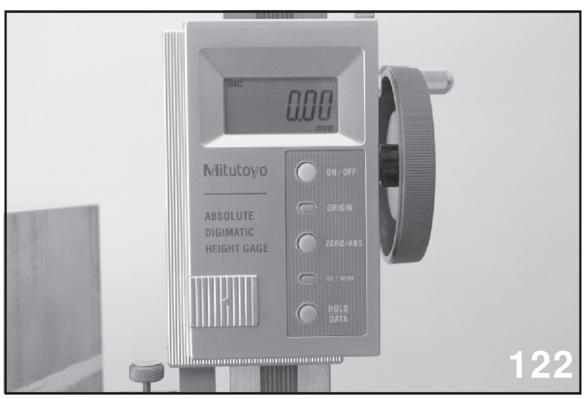

120

Step 3



121

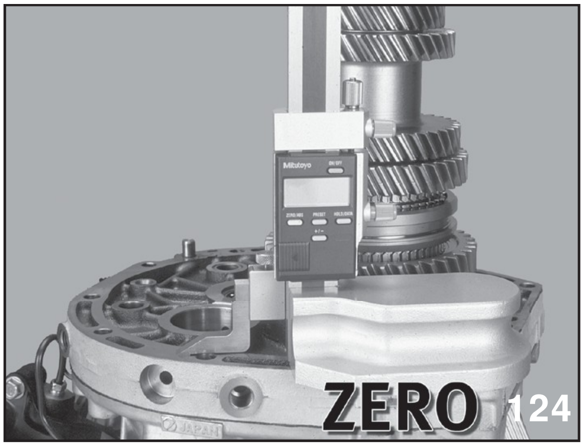
Step 7



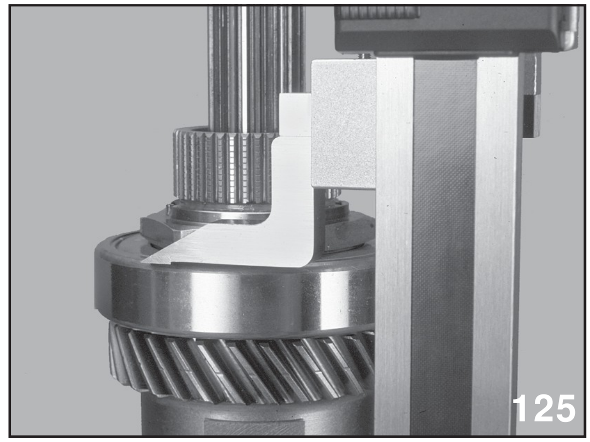
122

Step 4

Main Shaft Alignment and Main Shaft End Play



Zero



Top of Bearing

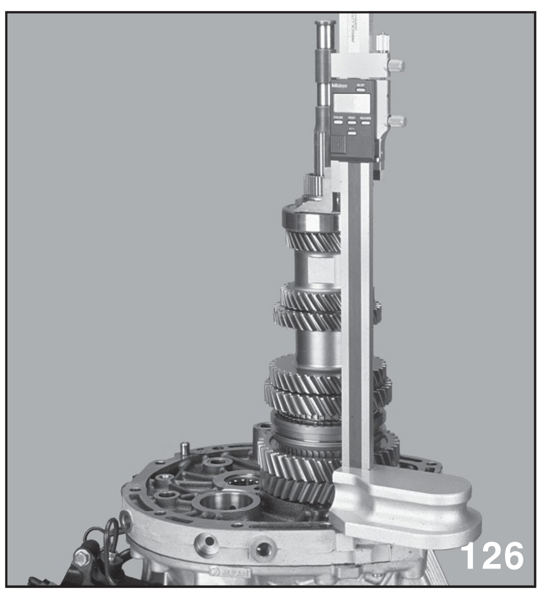
Main shaft snap ring and washer

1. Install the driven shaft assembly onto the drive pinion shaft and place the height gauge (18853AA000) onto the adapter plate matching surface.
2. Move the jaw of the height gauge downward until it touches the adapter plate matching surface and zero the gauge indicator.
3. Measure distance (A) between the ball bearing top surface and the adapter plate, using the height gauge.

   A=

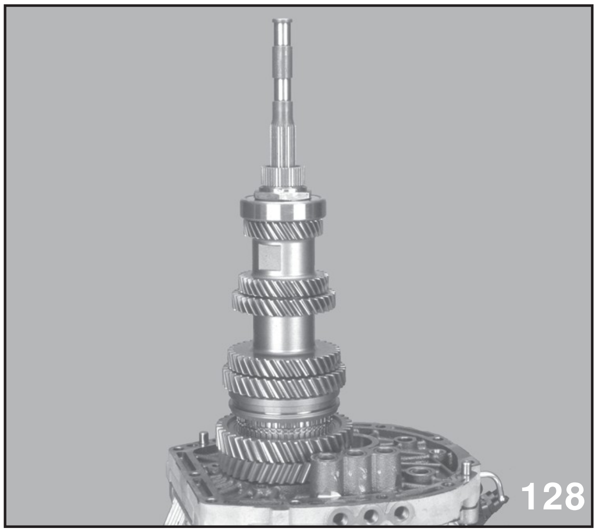
4. Select the correct snap ring and washer according to the value of (A) from the appropriate table in the Service Manual on STIS Web site.

The snap ring controls the main shaft alignment in the case. The washer controls the main shaft end play.

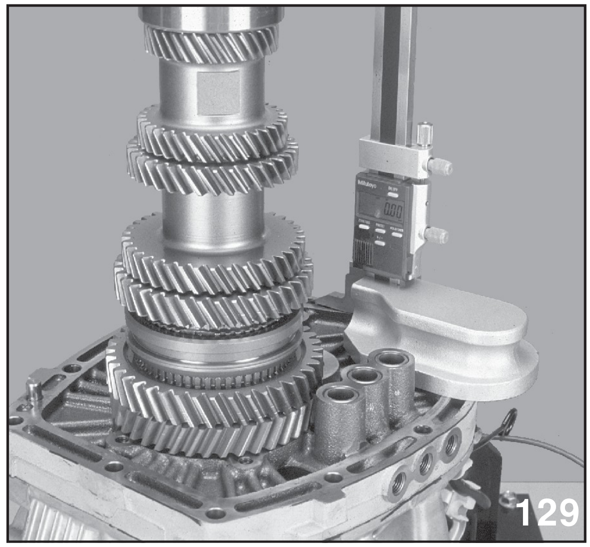


A

1^{st}-2^{nd} Fork Rod Measurement

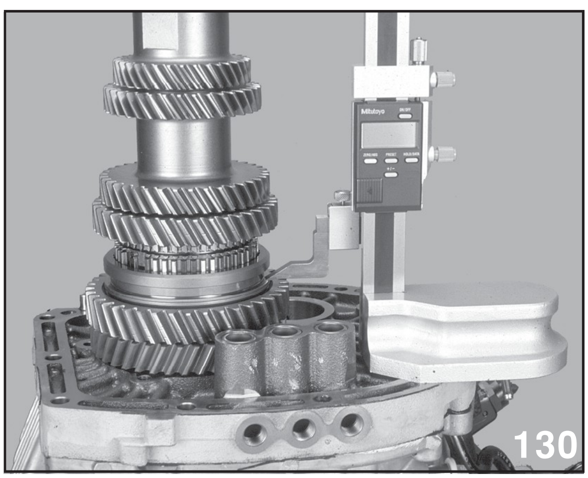


Driven Shaft on Pinion Shaft

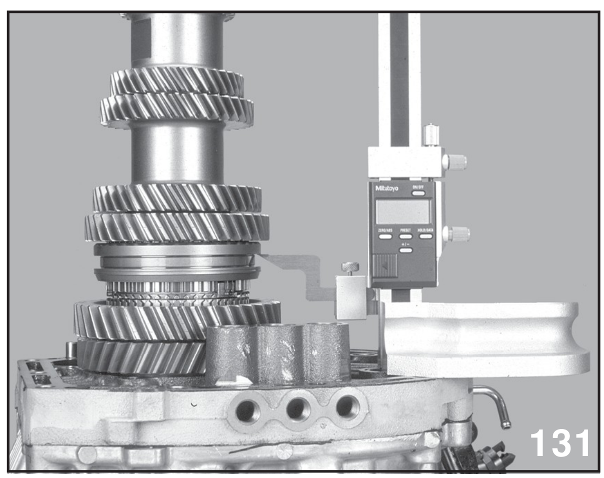


Zero

1. Install the driven shaft assembly onto the drive pinion shaft and place the height gauge on the adapter plate matching surface.
2. Move the jaw of the height gauge downward until it touches the adapter plate matching surface and zero the gauge indicator.



B1



B2

3. Shift the 1^{st}-2^{nd} sleeve into 1^{st} gear position fully, and then measure distance (B1) between the sleeve lower edge and the adapter plate, using the height gauge.
4. Remove the jaw from the height gauge and reinstall it upside down.
5. Shift the 1^{st}-2^{nd} sleeve into 2^{nd} gear position fully, and then measure distance (B2) between the sleeve upper edge and the adapter plate, using the height gauge.
6. Add Scribe Differential (SD) to the measured value of B2.

B3 = B2 + Scribe Differential (SD) =

See page 44 to determine Scribe Differential (SD)

NOTE: WHEN THE JAW IS INSTALLED UPSIDE DOWN COMPARED WITH ORDINARY POSITION, ADD SCRIBE DIFFERENTIAL (SD) (FIXING VALUE) TO THE MEASURED VALUE, FOR GETTING ACTUAL MEASUREMENT VALUE.

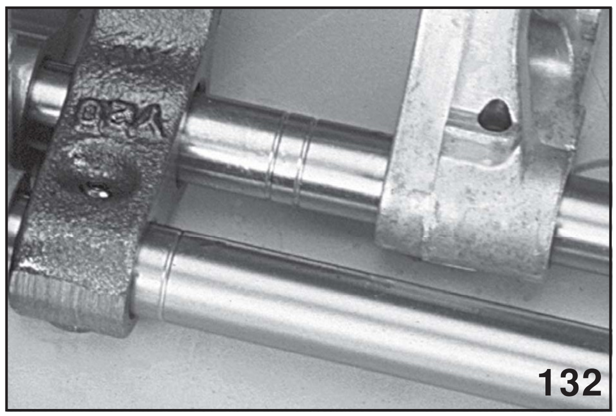
7. According to both measurement values (B1, B3), calculate the "Neutral position" of the 1st-2nd sleeve.

NOTE: MEASURE EACH SLEEVE AT 5 LOCATIONS (APPROXIMATELY 72° APART) UTILIZE A HELPER TO HOLD THE SLEEVE. ENSURE THAT HELPER HOLDS SLEEVE IN STRAIGHT UP POSITION. AVERAGE THE FIVE MEASUREMENTS.

D = (B1 + B3)/2 =

D: Distance between the "Neutral position" of the 1st-2nd sleeve and the adapter plate matching surface

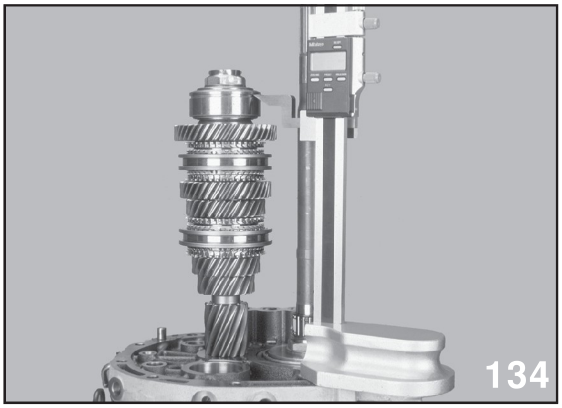
8. Select a suitable 1st-2nd shift fork rod from the table in the Subaru Service Manual on STIS Web site.



Lines on Shift Rod

The rods will have different numbers of lines machined around the circumference of the rod to identify it.

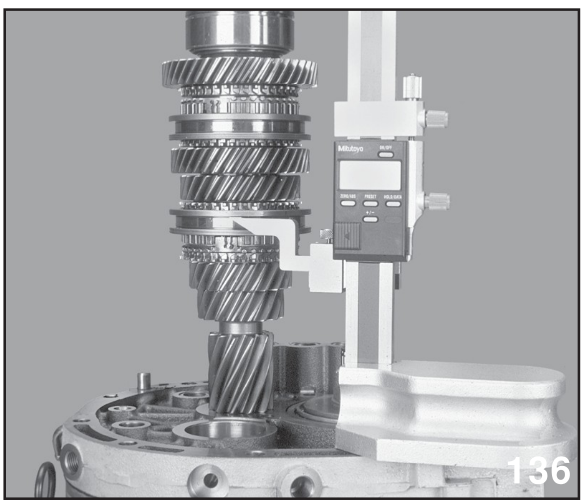
3rd -4th Fork Rod Measurement



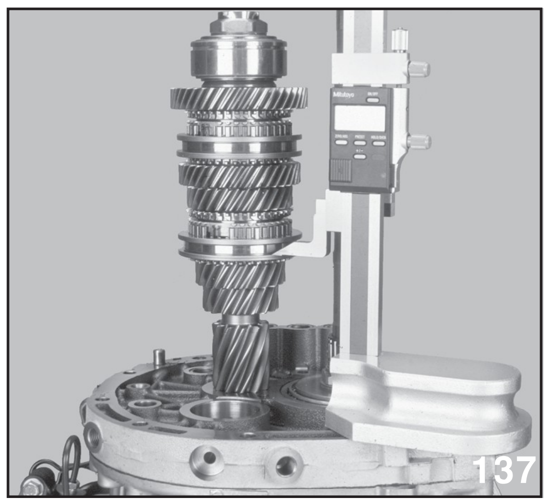
Height Gauge on Adapter Plate

Zero

1. Install the main shaft assembly onto the adapter plate and place the height gauge onto the adapter plate matching surface.
2. Move the jaw of the height gauge upward until it touches the top position of the snap ring groove on the taper roller bearing retainer, and then zero the gauge indicator.



Slider in 4th Gear



Slider in 3rd Gear

3. Shift the 3rd-4th sleeve into 4th gear position fully, and then measure distance (C1) between the sleeve upper edge and the groove top surface, using the height gauge.
4. Remove the jaw from the height gauge and reinstall it upside down. (The Jaw is flat on only one side)
5. Shift the 3rd-4th sleeve into 3rd gear position fully, and then measure distance (C2) between the sleeve lower edge and the groove top surface, using the height gauge.
6. Add Scribe Differential (SD) to measured value of C2.

   C3 = C2 + Scribe Differential (SD)

See page 44 to determine Scribe Differential (SD)

NOTE: WHEN THE JAW IS INSTALLED UPSIDE DOWN COMPARED WITH ORDINARY POSITION, SCRIBE DIFFERENTIAL (SD) (FIXING VALUE) TO THE MEASURED VALUE, FOR GETTING ACTUAL MEASUREMENT VALUE.

7. According to both measurement values (C1, C3), calculate the "Neutral position" of the 1st-2nd sleeve.

NOTE: MEASURE EACH SLEEVE AT 5 LOCATIONS (APPROXIMATELY 72° APART) UTILIZE A HELPER TO HOLD THE SLEEVE. ENSURE THAT HELPER HOLDS SLEEVE IN STRAIGHT UP POSITION. AVERAGE THE FIVE MEASUREMENTS.

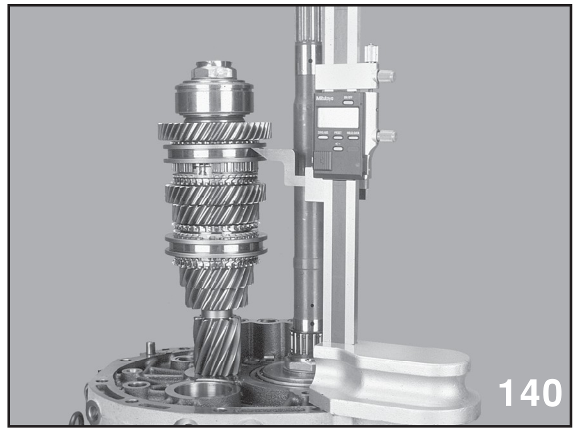
$D = (C1 + C3)/2 =$

D: Distance between the "Neutral position" of the 3rd-4th sleeve and the groove top Surface

8. Select a suitable 3rd-4th shift fork rod from the table in the Service Manual on STIS Web site. Main shaft snap ring thickness must be known to select proper shift fork rail.

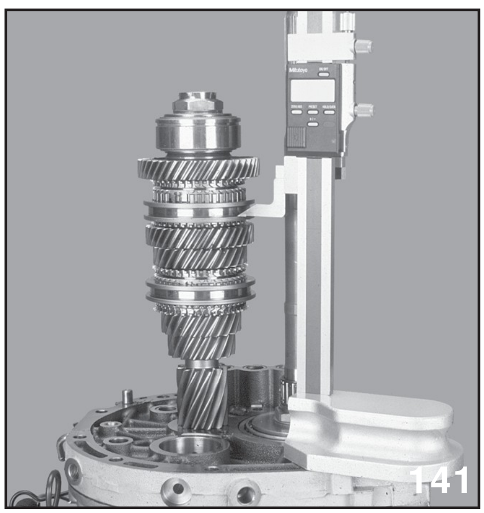
5th-6th Fork Rod Measurement

Zero



Slider in 6th Gear

1. Move the jaw of the height gauge upward until it touches the top position of the snap ring groove on the taper roller bearing retainer, and then zero the gauge indicator.
2. Shift the 5th-6th sleeve into 6th gear position fully, and then measure distance (D1) between the sleeve upper edge and the groove top surface, using the height gauge.



Slider in 5th Gear

3. Remove the jaw from the height gauge and reinstall it upside down.
4. Shift the 5th-6th sleeve into 5th gear position fully, and then measure distance (D2) between the sleeve lower edge and the groove top surface, using the height gauge.
5. Add Scribe Differential (SD) to measured value of D2.
   D3 = D2 + Scribe Differential (SD)

See page 44 to determine Scribe Differential (SD)

NOTE: WHEN THE JAW IS INSTALLED UPSIDE DOWN COMPARED WITH ORDINARY POSITION, ADD SCRIBE DIFFERENTIAL (SD) (FIXING VALUE) TO THE MEASURED VALUE, FOR GETTING ACTUAL MEASUREMENT VALUE.

6. According to both measurement values (D1, D3), calculate the “Neutral position” of the 5th-6th sleeve.

NOTE: MEASURE EACH SLEEVE AT 5 LOCATIONS (APPROXIMATELY 72° APART) UTILIZE A HELPER TO HOLD THE SLEEVE. ENSURE THAT HELPER HOLDS SLEEVE IN STRAIGHT UP POSITION. AVERAGE THE FIVE MEASUREMENTS.

$$D = (D1 + D3)/2$$

D: Distance between the “Neutral position” of the 5th-6th sleeve and the groove top Surface

7. Select a suitable 5th-6th shift fork rod from the table in the Subaru Service Manual on STIS Web site. Main shaft snap ring thickness must be known to select proper shift fork rail.

Reverse Idler Gear

Point of reassemble work

Reverse Idler Base Shaft

1. Install the knock pin in the lowest hole of the base shaft.

Washer Installed

2. Install the washer with the grooves facing up.

Lower Bearing and Reverse Idler Bushing Installed

3. Install the lower needle bearing and reverse idler gear bushing.

Reverse Idler Gear

4. Install the reverse idler gear number 2.

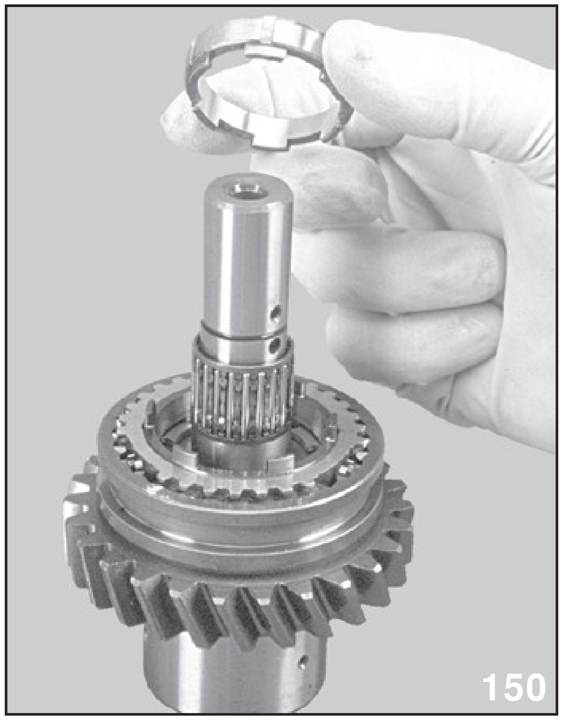
Coupling Sleeve and Installed

5. Install the reverse coupling sleeve, rounded edge down, ensuring the shifting inserts are properly positioned. (Directional)

Coupling Sleeve and Insert

*Outer Baulk Ring **Installed** &*
***Installing** Synchronizer Cone*

6. Install the outer baulk ring.
7. Install the synchronizer cone.



Installing Inner Baulk Ring

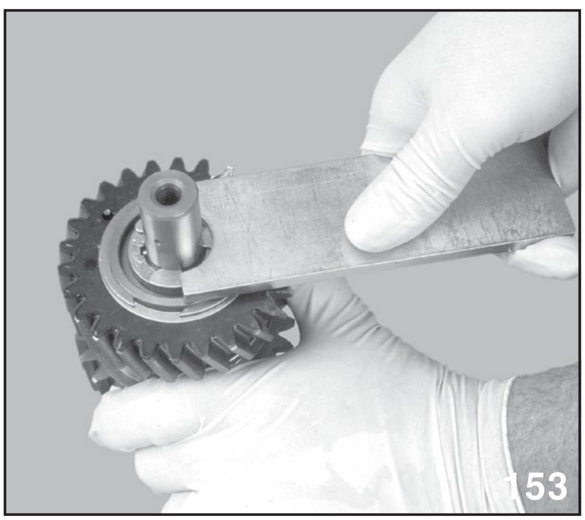
8. Install the outer baulk ring.

Inner Baulk Ring Installed

9. Install the upper needle bearing.
10. Install the Reverse idler gear while aligning the holes in the bottom of the gear to the protrusions of the synchronizer cone.

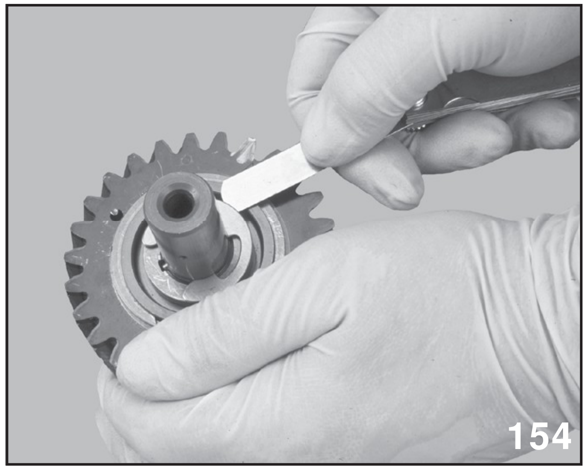
Washer and Upper Knock Pin Installed

11. Install the upper knock pin in the second hole from the top of the base shaft.
12. Install the upper washer with the groove facing down.



Installing Snap Ring

13. Install the snap ring using special tool. (18672AA000)



Checking Clearance

Using a feeler blade measure the clearance between the snap ring and the washer.

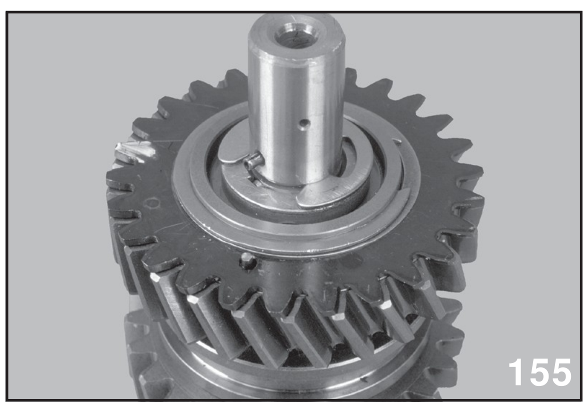
Standard clearance: 0.1 - 0.3 mm (0.0039 - 0.0118 in)

Select a snap ring from the following table.

Snap ring selection table:

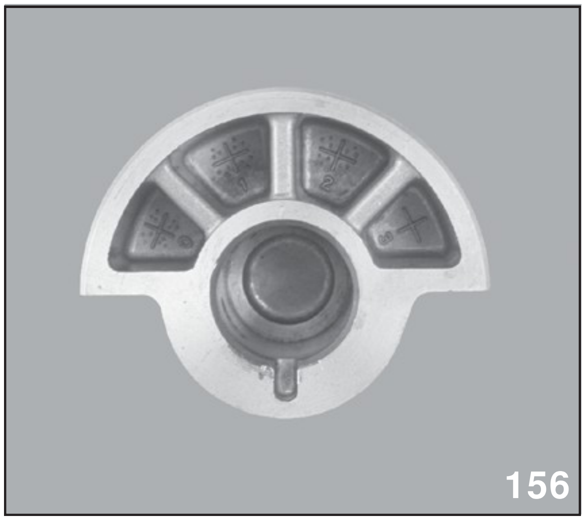
Snap ring

Parts No. Thickness mm (in)
031319000 1.50 (0.059)
805019030 1.60 (0.062)
805019010 1.72 (0.068)

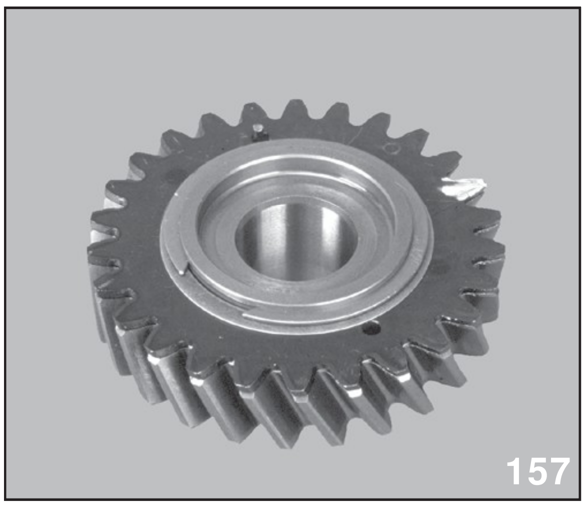


Spring Pin Installed

14. Install the spring pin in the top hole of the base shaft.

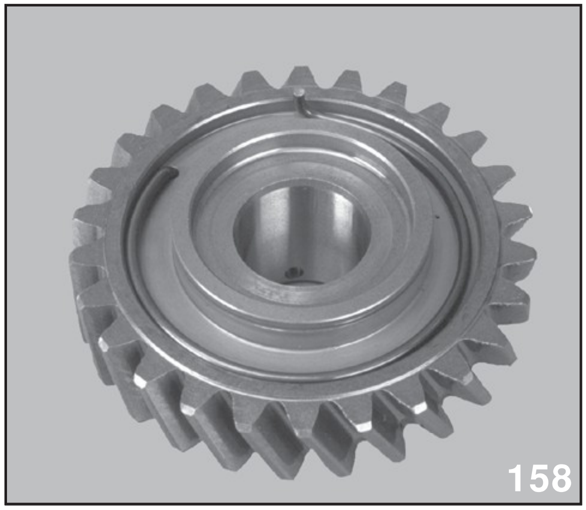


Reverse Shaft Holder



Sub Gear

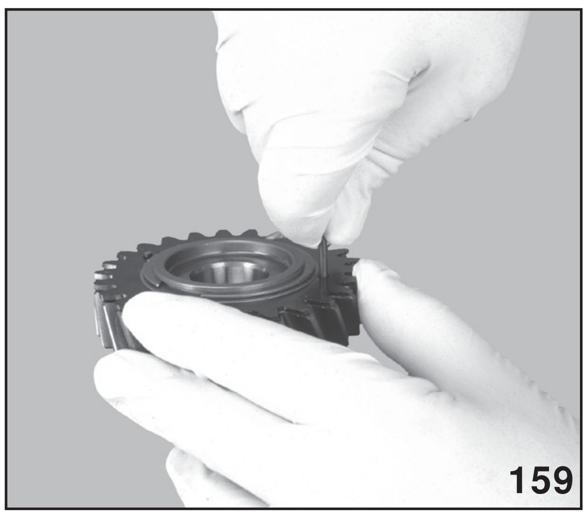
The upper reverse idler gear is equipped with a sub gear that reduces gear noise and assists with providing a smoother reverse gear engagement.



Sub Gear Spring

The top of the reverse idler gear has two holes. The sub gear also has two holes. These holes are used to secure the spring and to provide a method of preloading the sub gear during installation. Install the sub gear and spring on the reverse idler gear with white marking on hook part facing to the sub gear.

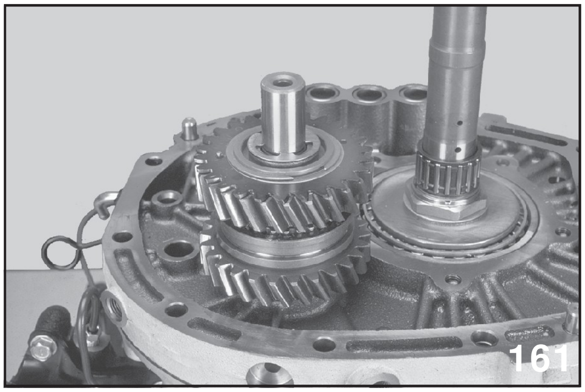
Install the snap ring using the special tool. (18672AA000)



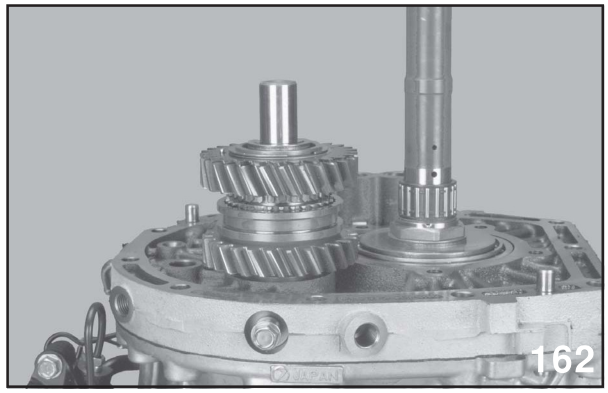
Preloading the Sub Gear

15. Turn the sub gear counter clockwise for approximately three teeth. Align the sub gear hole and reverse idler gear hole, and then insert the straight pin. (special tool 18757AA000)

Reverse Fork Rod



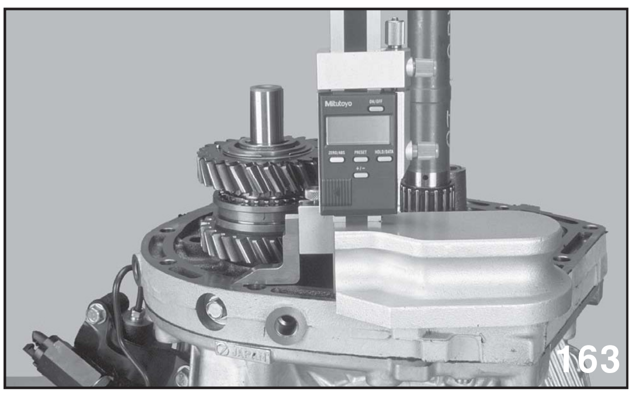
Reverse Idler Top View



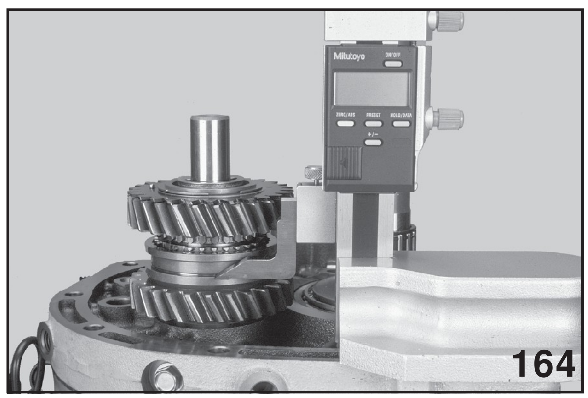
Reverse Idler Side View

Reverse Fork Rod

1. Install the reverse idler shaft assembly onto the adapter plate.
2. Secure the reverse idler shaft by the fixing bolt.
   Tightening torque: 25N-m (2.5 kgf-m, 18.1 ft.-lb.)



Zero



E

3. Place the height gauge onto the adapter plate matching surface and move the jaw of the gauge downward until it touches the adapter plate matching surface, and then zero the gauge indicator.
4. Push down the reverse sleeve fully, and then measure distance (E) between the sleeve lower edge and the adapter plate, using the height gauge.

NOTE: MEASURE SLEEVE AT FIVE (5) POINTS (APPROXIMATELY 72° APART) AVERAGE YOUR MEASUREMENT.

5. According to the measurement valve, calculate the “Neutral position” of the reverse sleeve.
   D = E + 4.80 mm =
   D: Distance between the “Neutral position” of the reverse sleeve and the adapter plate
6. Select a suitable reverse fork rod from the table in the Service Manual.

Selection of Driven Gear Shim

1. Measure the depth (D) between the top surface of the ball bearing and transmission case surface.

   D =

2. Select the proper shim using the following formula.

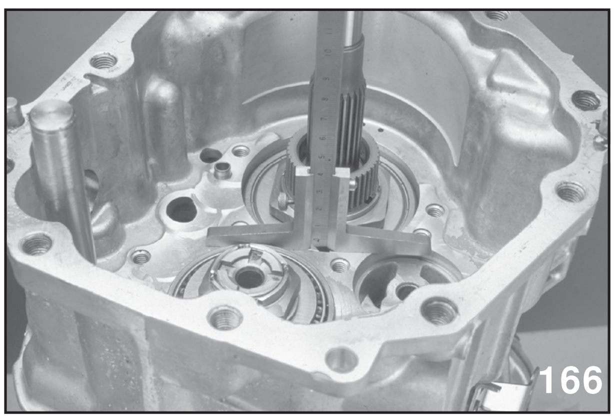
   T = D - (5.75 to 5.85) - (0.1 to 0.3)

   T: Shim thickness
   5.75 to 5.85: collar height
   0. to 0.3: Standard end play

NOTE: THE NUMBER OF SHIMS MUST BE THREE OR LESS.

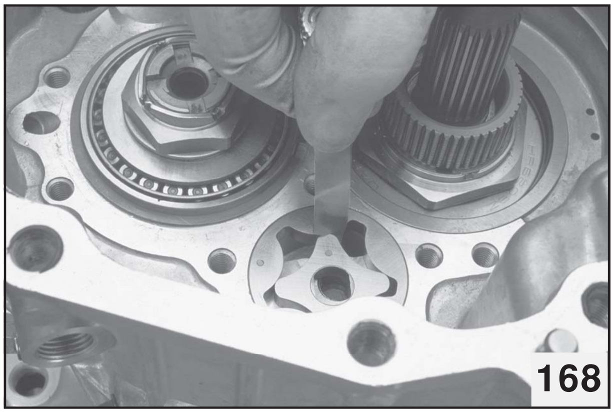
Shim section table:

Part No.	Thickness mm (in)
803072030	0.15 (0.0059)
803072031	0.30 (0.0118)
803072032	0.45 (0.0177)
803072033	0.60 (0.0236)

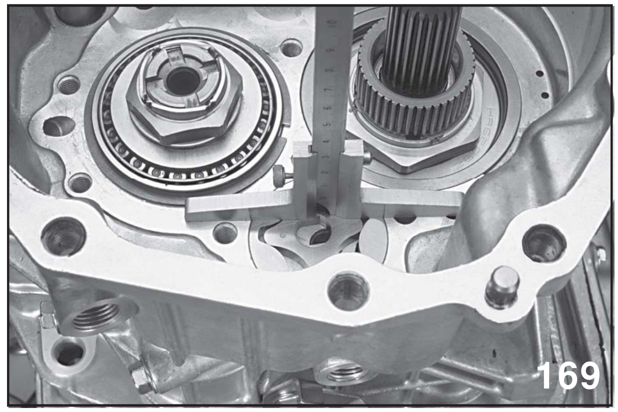


D

Oil Pump Inspection



Tip Clearance



Side Clearance

Visual Inspection

- Check the parts for damage, wear, seizing, etc.
- Check for clogged oil passages.

Measuring Inspection

1. Tip clearance.

   Align tips of the inner rotor and outer rotor, then measure the clearance.

   Standard clearance: Less than 0.15 mm (0.0059 in)

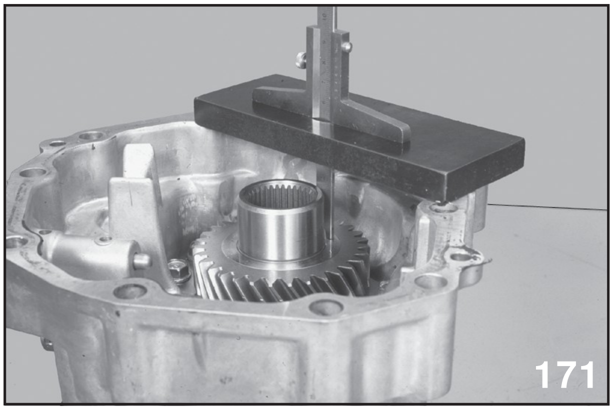
2. Side clearance

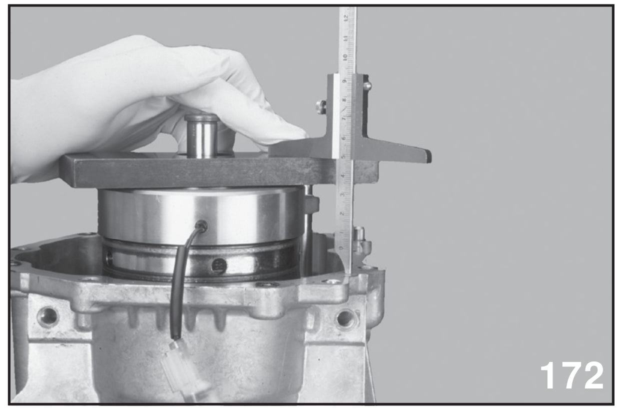
   Measure the clearance between the oil pump body mating surface and the rotor.

   Standard clearance: 0.03 - 0.10 mm (0.0012 - 0.0039 in)

NOTE: WHEN INNER AND OUTER ROTORS ARE INSTALLED, DOTS ON ROTORS SHOULD FACE UP.

Selection of Transfer Drive Gear Washer





D *H*

1. Place gauge tool (398643600) on the extension case end surface and measure the depth (D) between the top surface of the gauge and the transfer drive gear.

   D=

2. Place the gauge on the DCCD and measure the height (H) between the transmission case matching surface and the top surface of the gauge.

   H=

NOTE: ENSURE THAT DCCD IS SEATED PROPERLY BEFORE MEASURING.

3. Select the proper washer using the following formula.

   T = D - H - (0.45 to 0.65)

   T: Washer thickness

   0.45 to 0.65: Standard end play

Washer Section Table:

Thrust Washer (36.3 x 52 x T)

Part No Thickness mm (in)

803036070 0.80 (0.0315)

803036071 0.95 (0.0374)

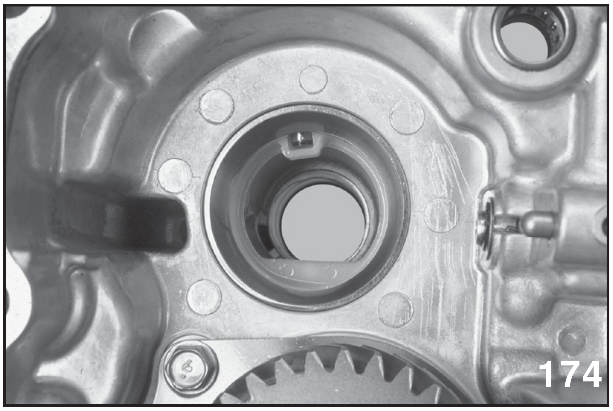
803036072 1.10 (0.0433)

803036073 1.25 (0.0492)

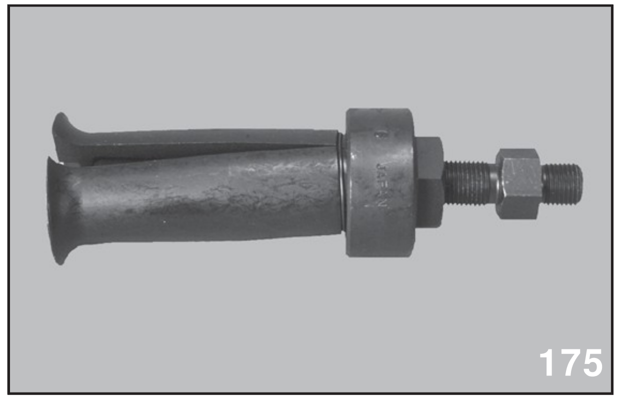
803036074 1.40 (0.0551)

803036075 0.65 (0.0256)

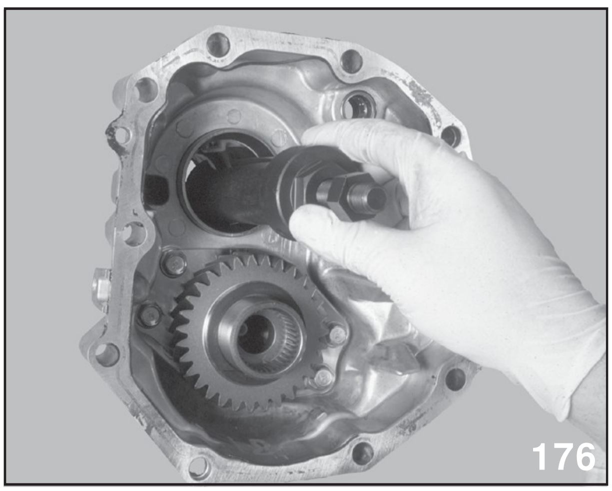
Selection of Transfer Driven Gear Washer



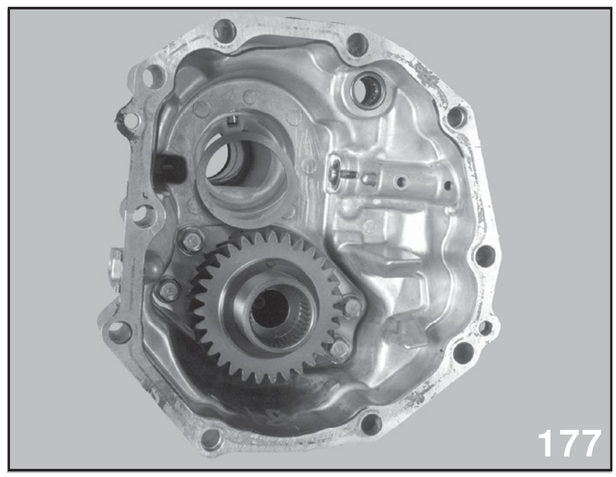
Bearing Race



Puller Tool

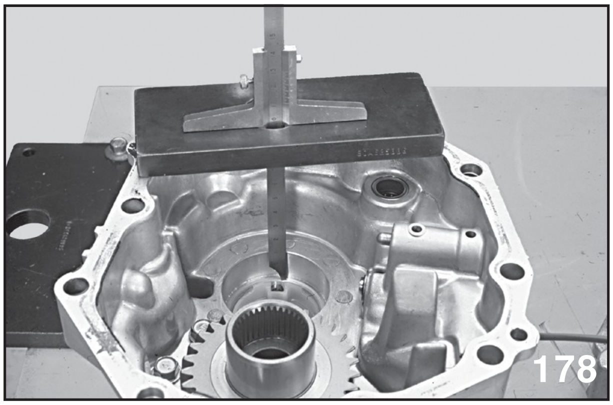


Tool in Use

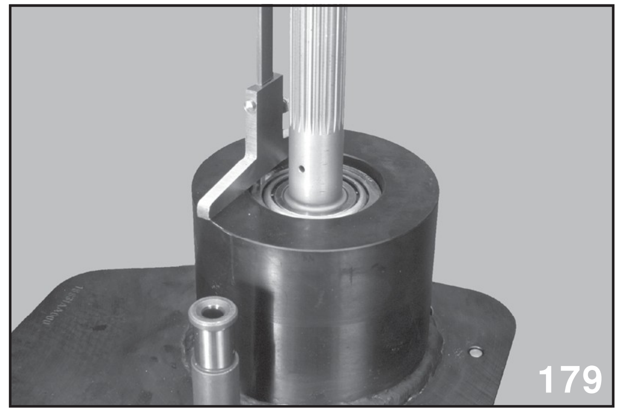


Driven Gear Washer Under Bearing Race

1. Pull the bearing cone out of the extension case, using the special tool (18758AA000), and remove a shim from bottom of the bearing holder on the extension case. Measure existing shim thickness.



A



B

2. Measure the depth (A) between the machined surface of the bearing seat and the extension case's machine surface.

   A =

3. Subtract 15.0 mm* (Gauge Thickness) from the measured value (A)

   A1 = A - 15.0 mm

   * *Measure the actual thickness of the gauge plate used as it may vary slightly from 15.0 mm.*

4. Install the bearing cone on the transfer driven gear, and then place transfer driven gear into the transmission case.
5. Position the gauge on the driven gear over the bearing cone with the two holes on the base of the gauge aligned with the two knock pins on the transmission case.
6. Rotate the transfer driven gear ten times to condition the bearing.
7. Measure the depth (B) between the top surface of the bearing cone and the gauge's machined surface.

   B =

8. Select the proper washer using the following formula.

   T = A1 - (100.0 mm - B) - (0.04 mm to 0.11 mm)

   T: Washer thickness

   **100.0 mm = Gauge height

   0.04 to 0.11: Standard end play

   Washer selection table:

   Thrust Washer (50 x61 x T)

   Part No. Thickness mm (in)

   803050060 0.50 (0.0197)
   803050062 0.60 (0.0236)
   803050064 0.70 (0.0276)
   803050066 0.80 (0.0315)
   803050068 0.90 (0.0354)
   803050070 1.00 (0.0394)
   803050072 1.10 (0.0433)
   803050074 1.20 (0.0472)
   803050076 1.30 (0.0512)
   803050078 1.40 (0.0551)

** *Measure the actual height of the tool used against a machined surface. The actual height may differ slighty from 100.0 mm*

Reverse Lock Out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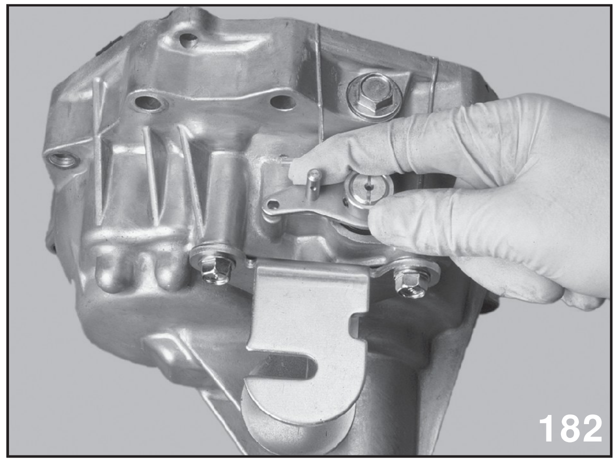
Shifter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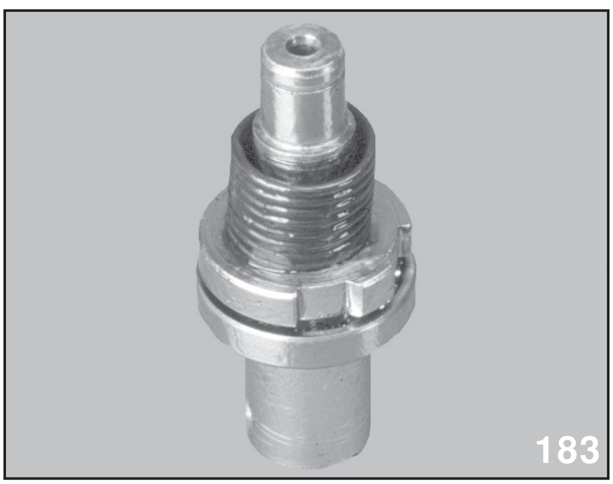
Reverse Check Lever

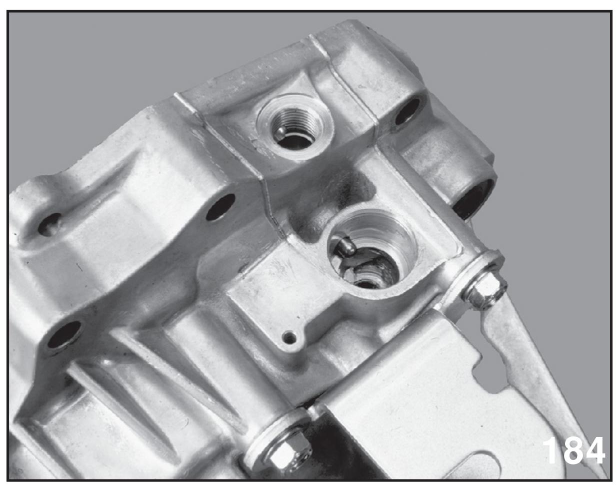
The reverse check system equipped on the new 6 speed manual transmission prevents the accidental attempt to shift into reverse while selecting 6th gear.

Normal shifting into reverse requires the motion of pulling up on a reverse slider while making the shift to reverse.

When the reverse check cable is activated the reverse check lever is pulled towards the rear of the transmission.

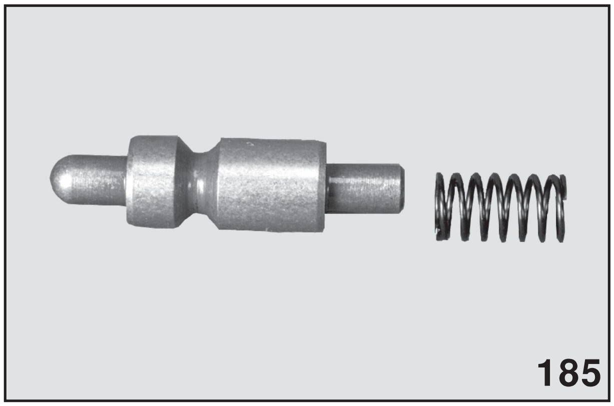

183

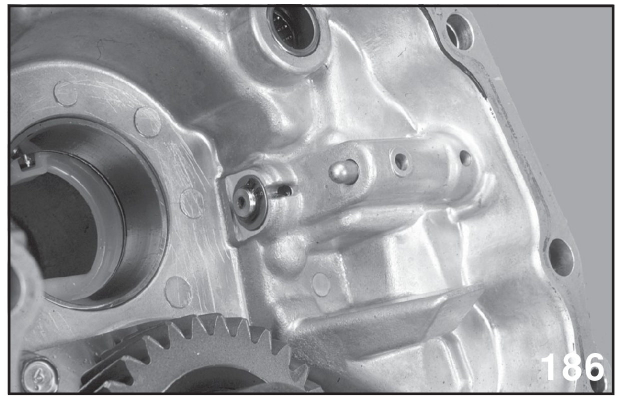
Reverse Check Plug


184

Plunger

The reverse check shaft, which is secured to the reverse check lever, will rotate at this time and position the plunger in line with a notch in the case.

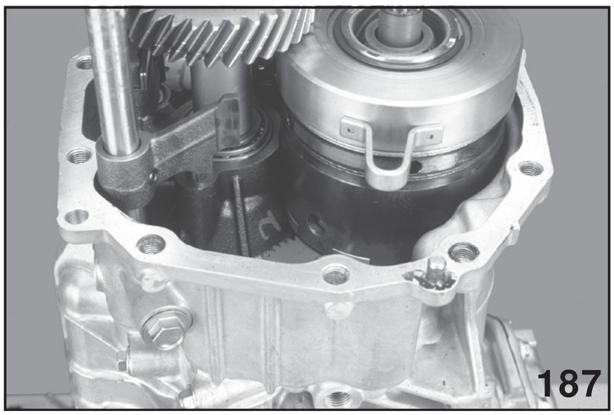




Spring and Reverse Check Plug

End of Reverse Check Plug Protruding

This provides the plunger with a space to move into when the spring loaded reverse check plug is forced up by the number one selector arm.

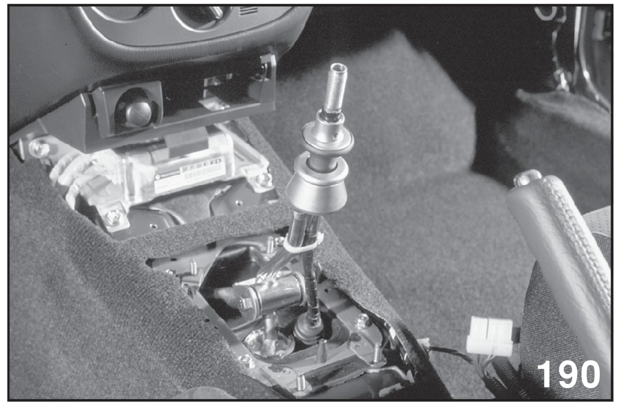


Number One Selector Arm

Fail-Safe Position

In the event the reverse check cable fails, the spring loaded reverse check lever will move towards the front of the transmission and will expose a fail safe notch for the plunger to align with. At that time no reverse lock out would be provided.

Cable into Shifter

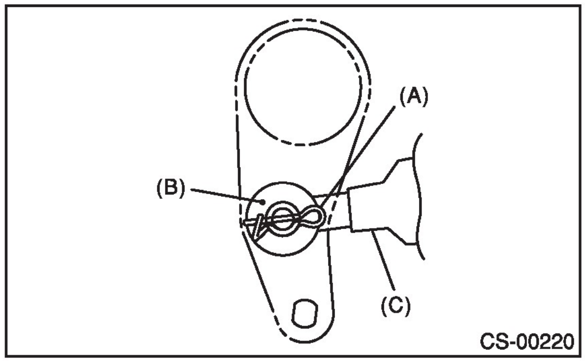


Shifter Area

The reverse check cable is routed into the passenger compartment through a grommet next to the shifter linkage.
The reverse check cable must be removed from under the vehicle. Turn the shift knob counter clockwise until the knob is removed form the threaded end of the reverse check cable housing.
Remove the spring pin from the reverse slider then remove the reverse slider, cover, and spring cut and remove the band clip.

Cable in View

Cable below View



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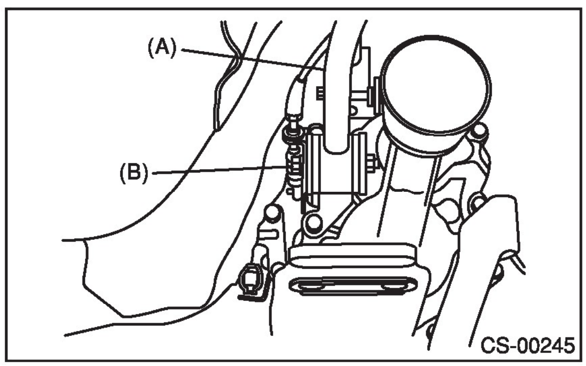
Snap Pin Artwork

Raise the vehicle and remove the rear exhaust pipe and muffler.
Remove the cross member.
Remove the snap pin and washer.



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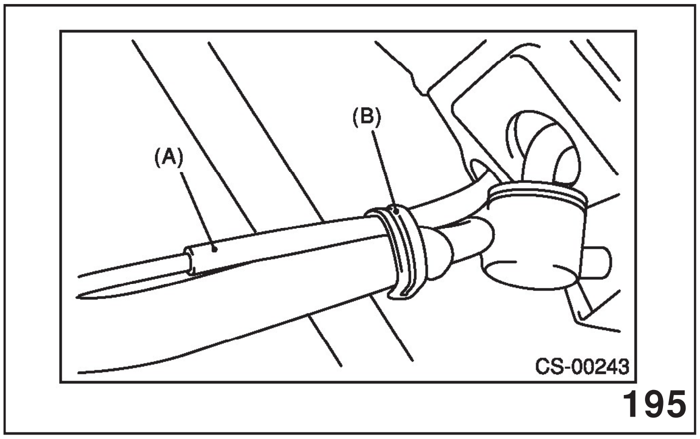
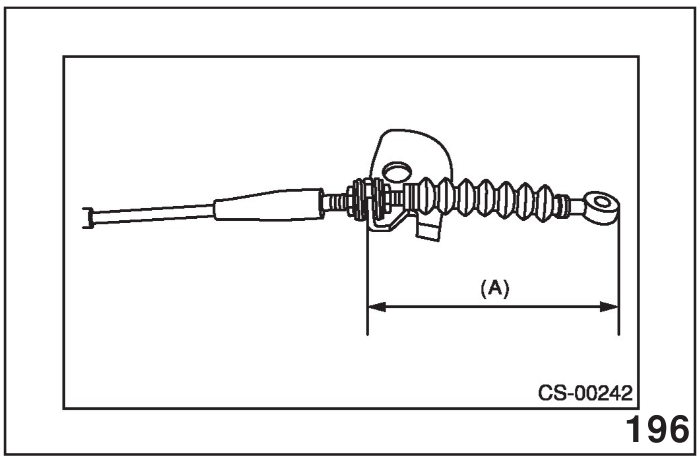
Stay Bolt Artwork

Move the transmission to the right side and remove the stay bolt.
CAUTION: FAILURE TO MOVE TRANSMISSION TO THE RIGHT WILL RESULT IN DAMAGE TO THE VEHICLE BODY.



Stay Clip Artwork

Remove the stay clip from the cable.
Remove the cable by pulling from the vehicle underside.

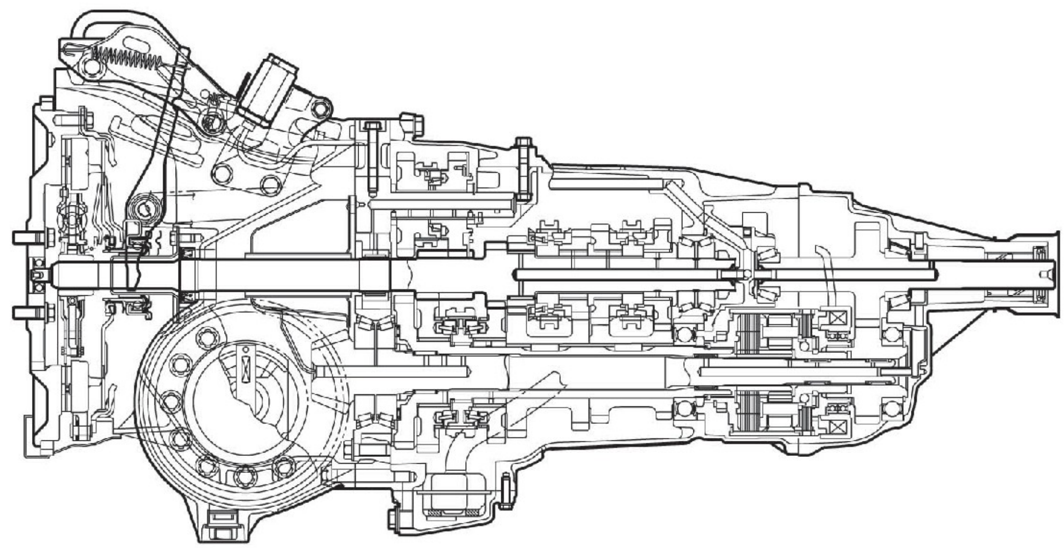


Cable

Adjust this length to 3.31 inches (84 mm) before installing new cable.

Driver Control Center Differential (DCCD)

Outline



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Transmission Artwork

The DCCD system is comprised of sensors, switches, DCCD control module and planetary gear type center differential with built-in LSD clutch.

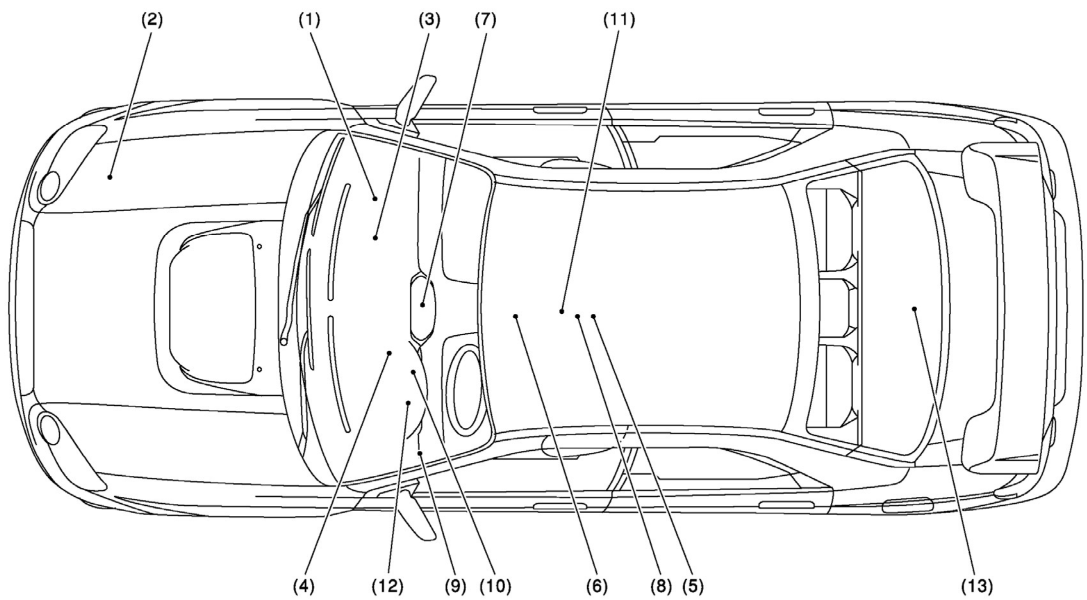
By varying the LSD clutch engagement torque from 0% to 100%, the DCCD control module can vary the drive torque distribution to the front wheels from 35:65 to 50:50 (direct AWD condition), using the planetary gear type center differential.

Utilizing the DCCD control module to suitably control the drive torque distribution to the front wheels according to the driving conditions, the system improves the running performance over rough roads and reduces tight cornering phenomenon.

Also, the driver can control the LSD clutch engagement torque by adjusting the DCCD control dial equipped beside the parking brake. (Manual Mode)

In the event of a system malfunction, a fail-safe control is activated to release the LSD clutch.

System Layout



(1) Engine control module (ECM)
(2) ABS control module & hydraulic control unit (ABSCM & H/U)
(3) Driver's control center differential control module
(4) Accelerator position sensor
(5) Lateral G sensor
(6) Center differential control dial
(7) Center differential
(8) Manual mode switch
(9) Driver's control center differential relay
(10) Driver's control center differential indicator (driver's control center differential diagnostic indicator)
(11) Parking brake switch
(12) Brake Light switch
(13) Rear differential oil temperature switch

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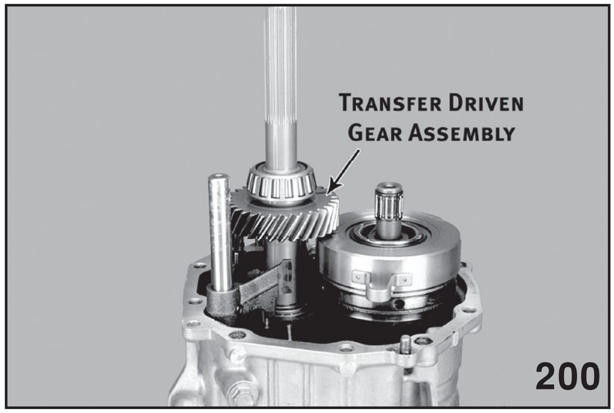
Car Artwork

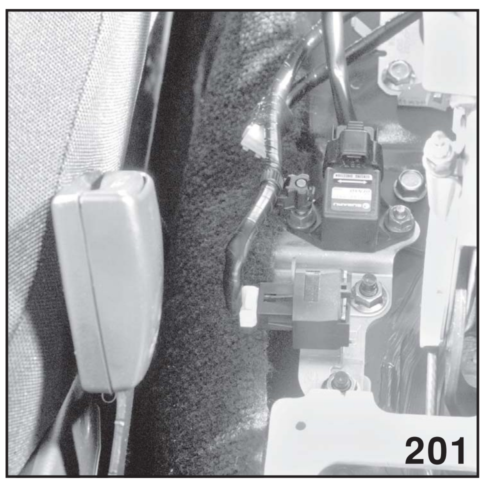
Center Differential



Transfer Section of Transmission

The center differential is comprised of the planetary type differential, LSD clutch, pilot clutch, DCCD coil assembly, and other parts. The DCCD coil assembly (electromagnet) is controlled by the DCCD control module duty drive signal, which sets up a magnetic force that the coil assembly uses to vary the LSD clutch engagement force.

Lateral G Sensor



Lateral G Sensor

This sensor detects the lateral acceleration of a vehicle while it is cornering. The DCCD control module determines the vehicle cornering conditions based on signals from this sensor and controls the LSD clutch engagement torque accordingly, improving stability when a vehicle is cornering.

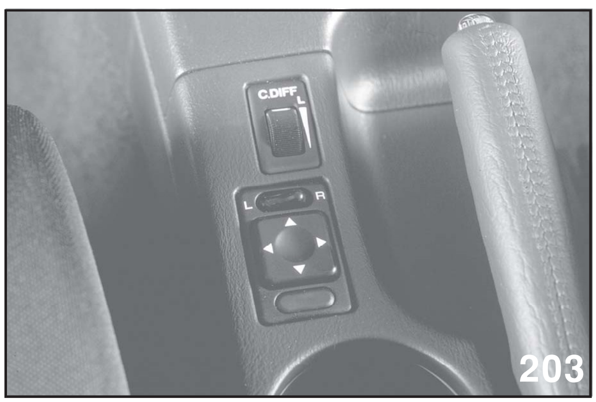
Manual Mode

Manual Mode Switch

The Manual Mode selector switch toggles between Manual Mode and Auto Mode each time it is pressed.

NOTE: ***WHEN THE ENGINE IS STARTED AUTO MODE IS ALWAYS SELECTED. EVEN IF MANUAL MODE IS SET WHEN THE IGNITION IS TURNED OFF, AUTO MODE WILL AUTOMATICALLY BE SELECTED THE NEXT TIME THE ENGINE IS STARTED.***

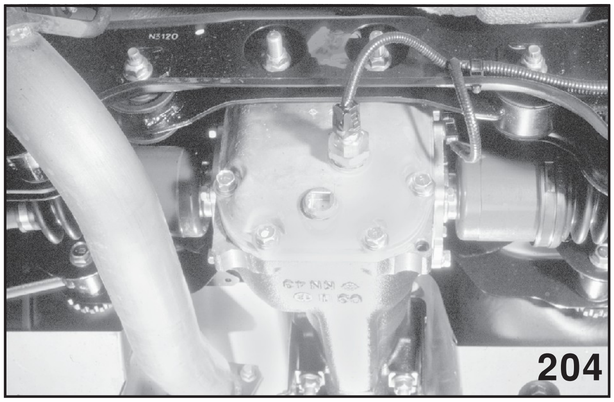
DCCD Control Dial



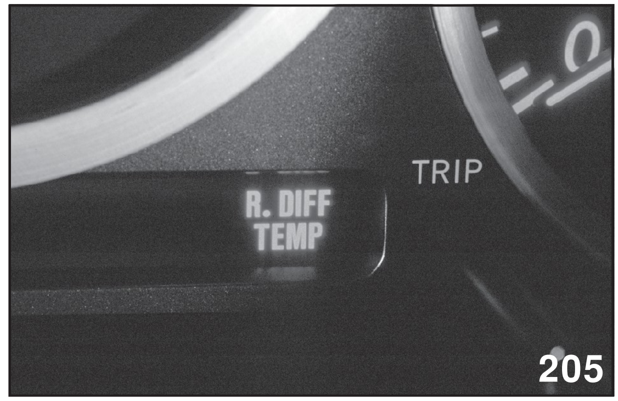
DCCD Control Dial

By operating this dial, the driver can adjust the LSD clutch engagement torque to any desired setting. The DCCD control dial setting will be displayed in the DCCD indicator in the instrument panel when Manual Mode is selected with the Manual Mode switch.

Oil Temperature Switch


204

Oil Temperature Switch



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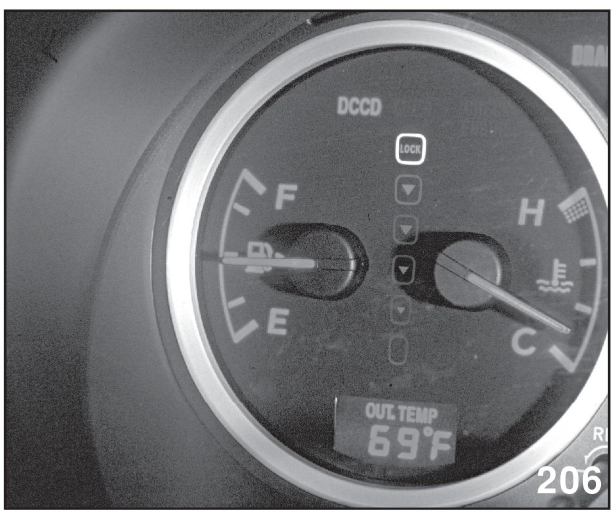
R. Differential Temp

This is the temperature switch that is mounted on the rear of the rear differential case. This switch detects the temperature of the lubricating oil inside the case, and it is activated when the oil temperature reaches approximately 302°F (150°C). When this happens, a warning light in the instrument panel is illuminated and at the same time an abnormal signal is sent to the DCCD control module.

DCCD Indicator



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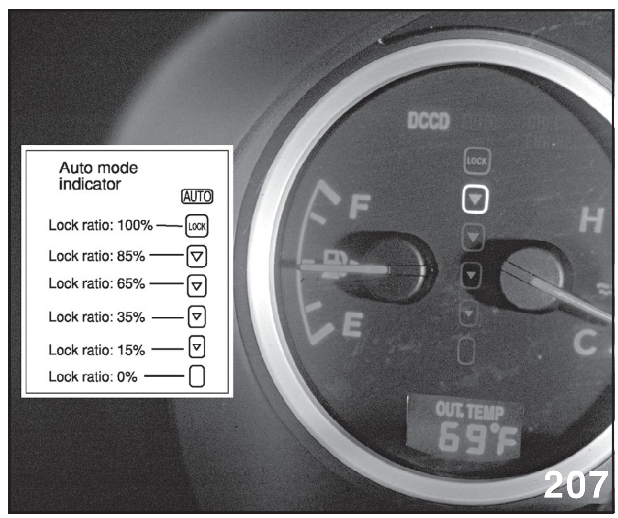
DCCD Indicator



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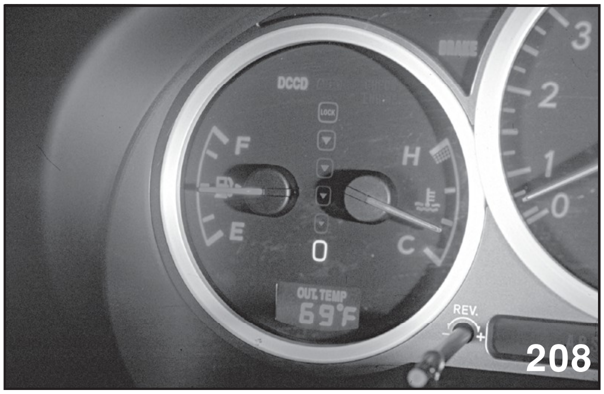
DCCD Indicator and Chart

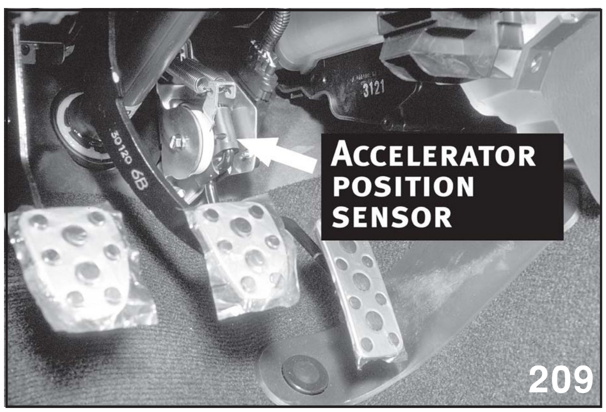
In Auto Mode the top DCCD indicator light is illuminated, informing the driver that Auto Mode is activated. In Manual Mode the DCCD control dial setting is displayed.



Lowest Light Illuminated

When trouble occurs, the bottom DCCD indicator light flashes, warning the driver that trouble has occurred. By operating the DCCD control dial and the parking brake lever according to a predetermined procedure, the service technician can read the trouble code stored in the DCCD control module memory from the flashing pattern of the indicator light. (2004MY)

Accelerator Position Sensor



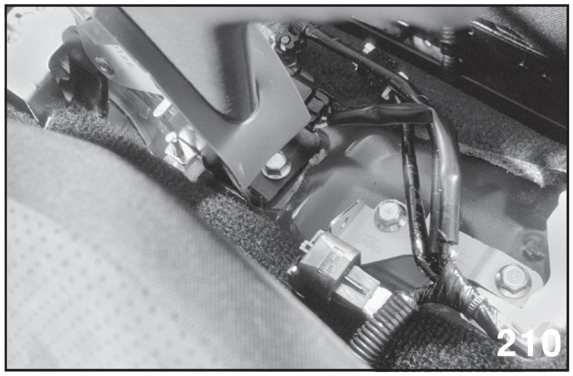
Accelerator Position Sensor

This sensor detects the position of the accelerator pedal as it is depressed by the driver.

Stop Light Switch

Mounted on the brake pedal bracket, this switch is activated when the driver operates the brake pedal.

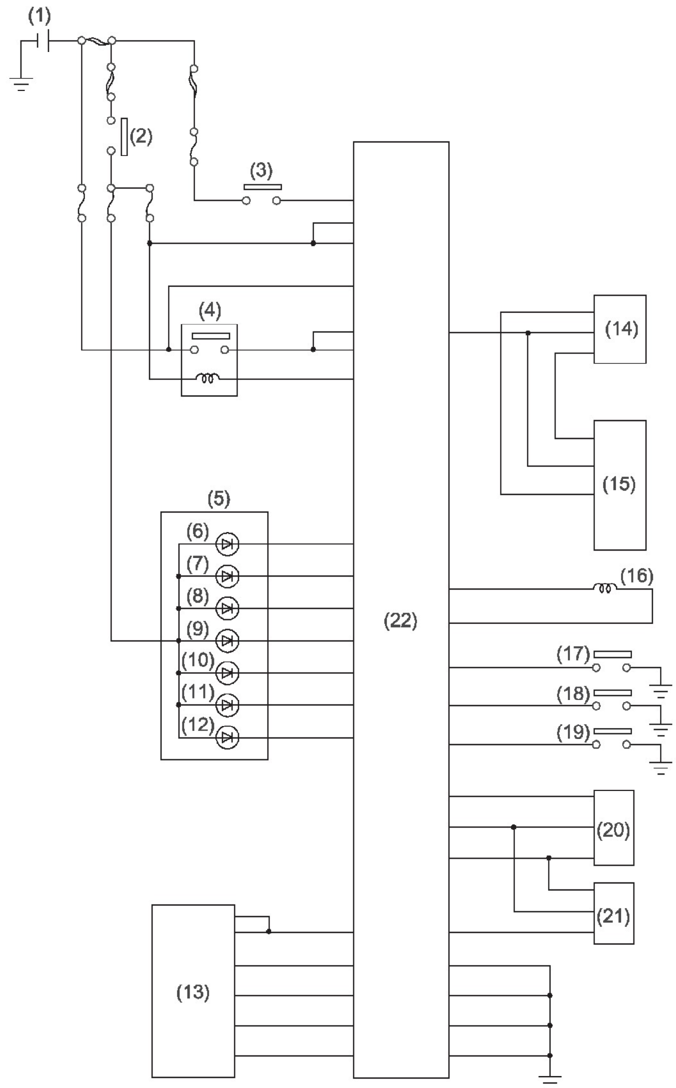
Hand Brake Switch



Hand Brake Switch

This switch is mounted at the bottom of the parking brake lever and is activated when the driver operates the parking brake lever.

System Circuit



(1) Battery
(2) Ignition relay
(3) Stop light switch
(4) Driver-controllable center differntial relay
(5) Combination meter
(6) Driver-controllable center differential indicator light (0% locked)
(7) Driver-controllable center differential indicator light (15% locked)
(8) Driver-controllable center differential indicator light (35% locked)
(9) Driver-controllable center differential indicator light (65% locked)
(10) Driver-controllable center differential indicator light (85% locked)
(11) Driver-controllable center differential indicator light (100% locked)
(12) Indicator light
(13) ABSCU & HU
(14) Throttle position sensor
(15) Engine control unit
(16) Driver-cotrollable center differential
(17) Parking brake switch
(18) Manual mode switch
(19) Rear differential oil temperature switch
(20) Control dial
(21) Lateral G sensor
(22) Driver-controllable center differential control unit

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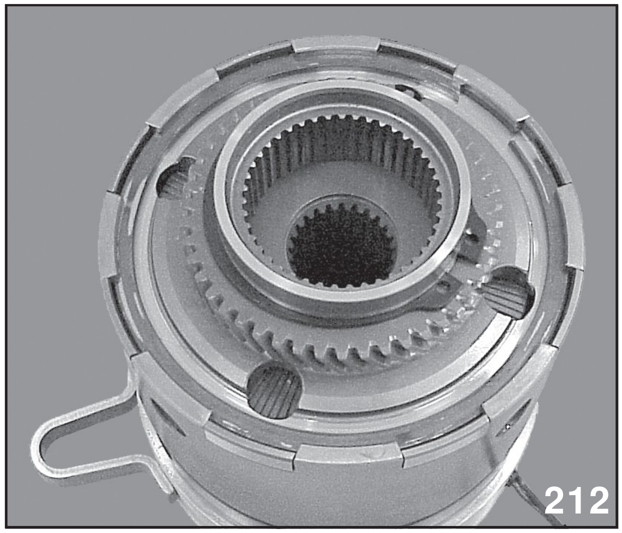
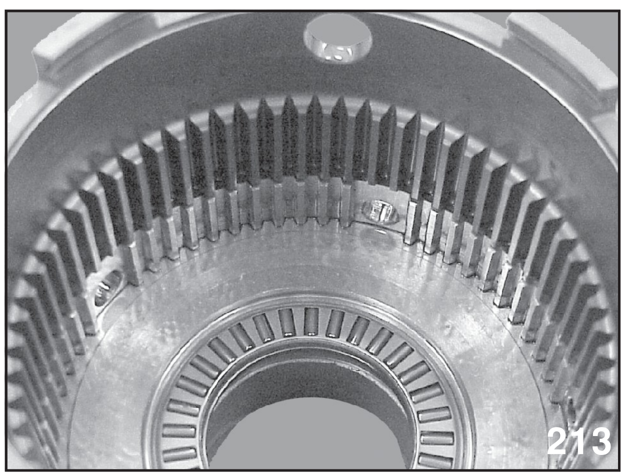
System Wiring Schematic

The following 11 pages explaining the DCCD are for general information only. Do not disassemble the DCCD center differential as it is not serviceable.



DCCD Top View

1. Controlled with chopper voltage signal (300 to 2 K HZ).
   Maximum current use is 4 amps.

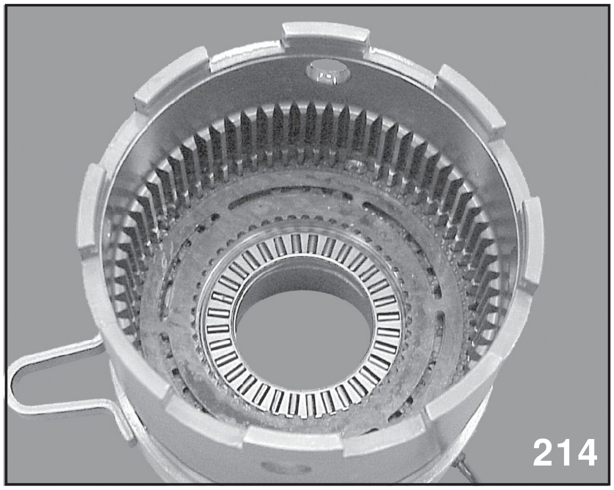


Empty Center Differential Case with Needle Bearing

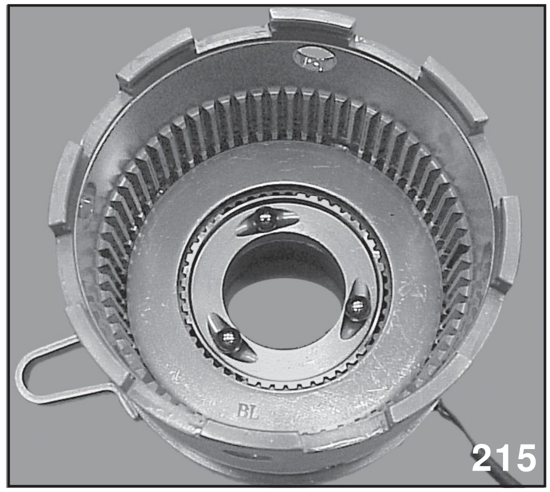
2. The electronic coil is press fitted to the differential case.

The lower splines are for the placement of the pilot clutch plates.

The upper teeth are for delivering power to the planet gears of the planetary assembly.



Pilot Clutch Plates in Place



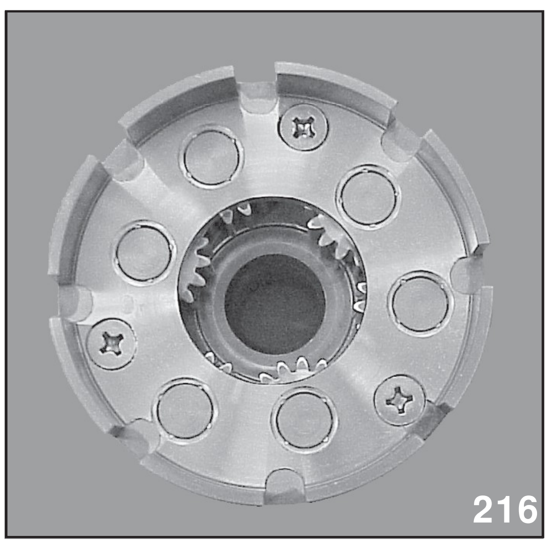
Armature, Pilot Clutch Hub and 3 Balls Installed

3. The needle bearing provides a support for the pilot clutch hub.

The inner splines of the pilot clutch plates engage with the pilot clutch hub.

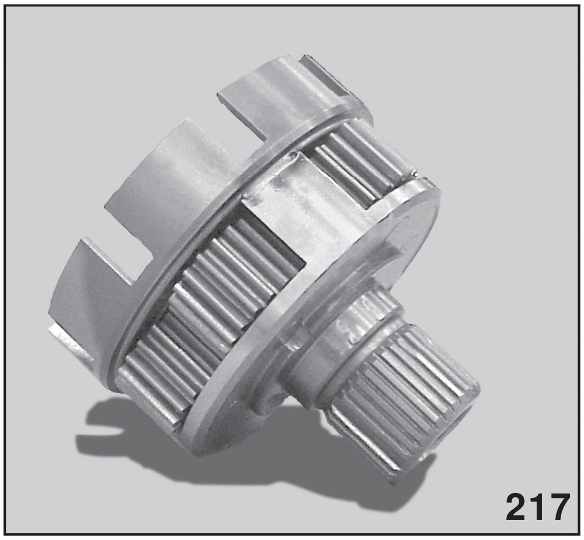
The armature is located on top of the pilot clutch plates to apply pressure, engaging the pilot clutch hub to the differential case.

The three metal balls are used to push up on the planetary assembly.

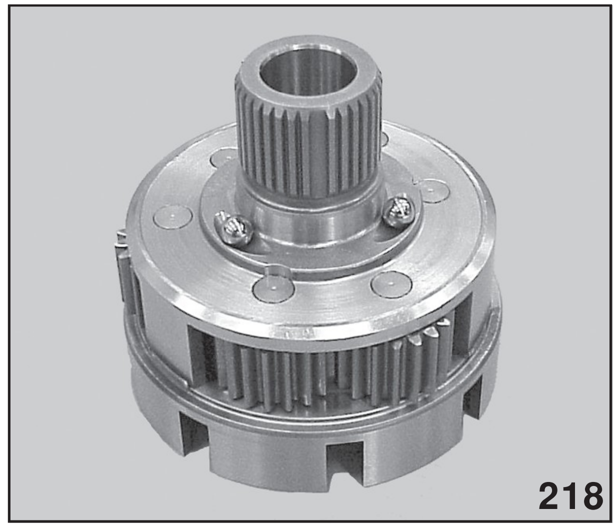


Planetary Top View

4. The top of the planetary assembly houses the LSD clutch which is used to control the speed of the sun gear and planetary carrier.

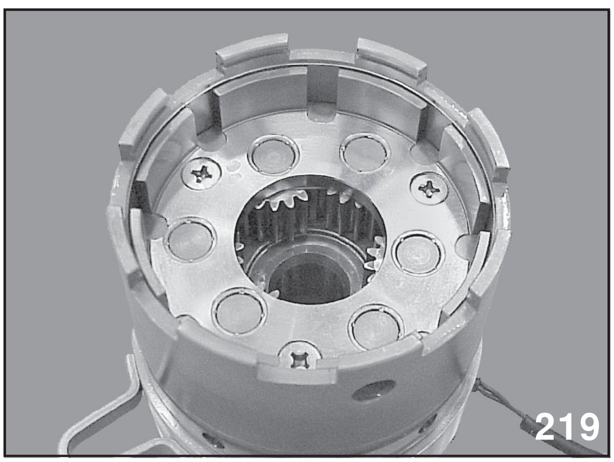


Planetary Side View

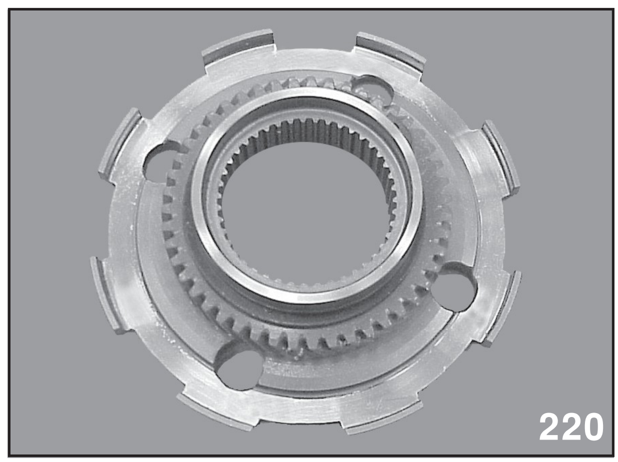


3 Balls on Planetary

5. The splines at the bottom of the planetary assembly are used to secure the transfer drive gear.



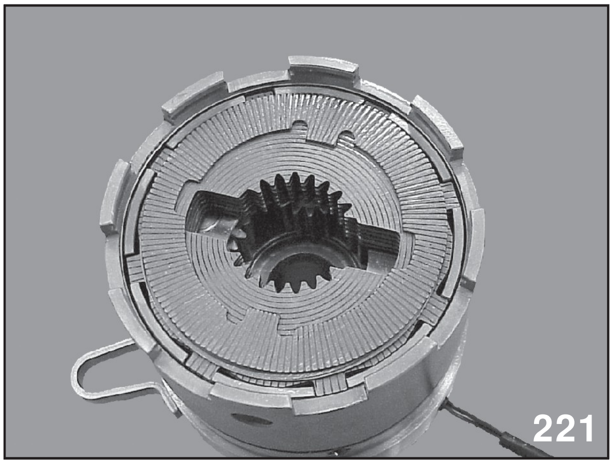
Planetary in Differential Case

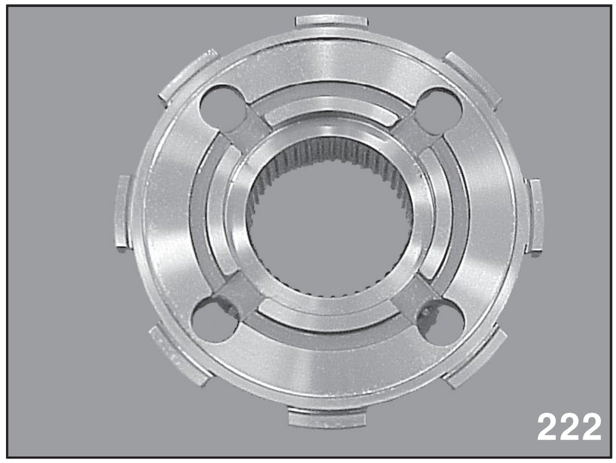


Differential Case Top

6. Power flows into the differential case to the planet gears. Power then splits, the planetary carrier driven by the planet gears power the rear wheels. The sun gear, powered by the planet gears powers the front wheels.

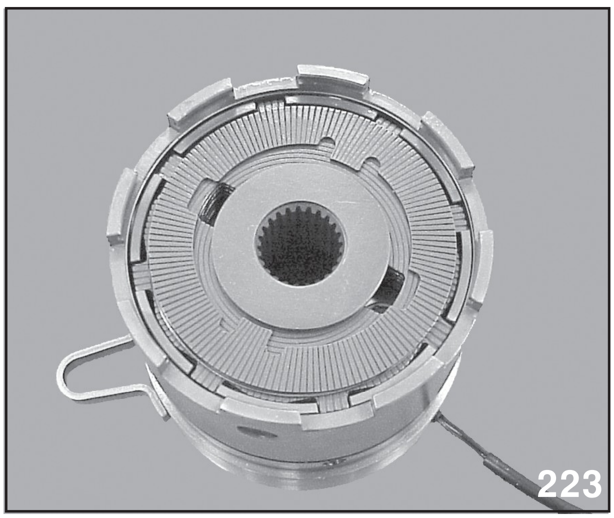
The speed of the sun compared to the speed of the planetary carrier determines the power split of the front and rear wheels.





Limited Slip Differential Clutch Plates in Place *Bottom Side of Differential Top*

7. The limited slip differential clutch is used to hold the sun gear and push down on the planetary carrier. This braking action changes the output distribution of power.



Case with Sun Gear Installed

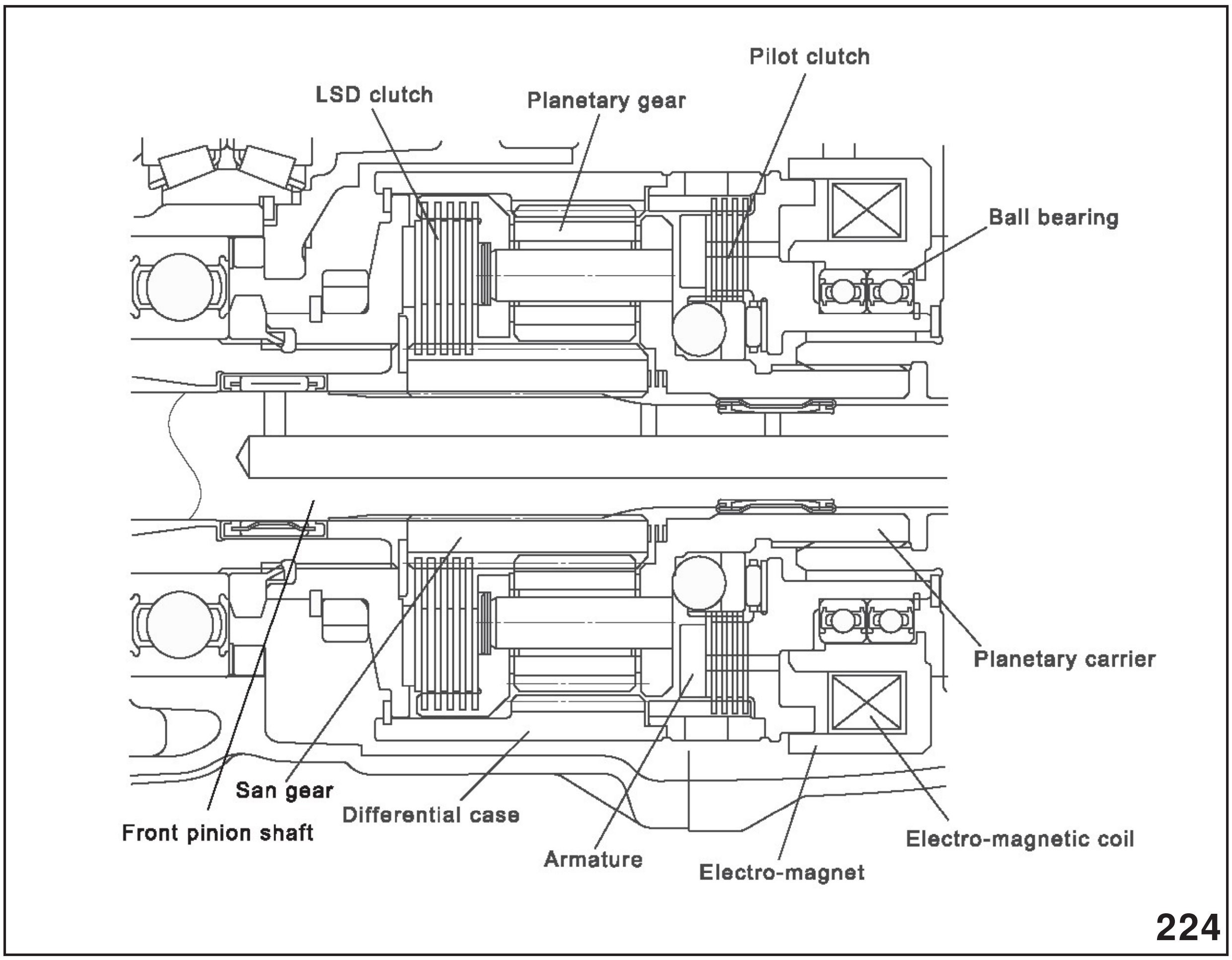
8. Case with sun gear installed.

No current applied to the DCCD coil results in a power split of 35% to the front wheels and 65% to the rear wheels.
The more current is applied to the coil, the faster the transfer rate changes towards a 50% front and 50% rear.
The armature pulls down on the pilot clutch in proportion to the amount of current applied to the coil. This results in the pilot clutch hub partially or fully rotating with the differential case.

The differential carrier, rotating in the same direction as the pilot clutch hub is now used as reference of the rear wheel power output. When the planetary carrier rotates faster than the pilot clutch hub the alignment of the three balls to the recesses in the bottom of the planetary carrier changes. This will force the planetary carrier to move into the LSD clutch, slowing down the sun gear and planet carrier. The resulting action removes power from the rear wheels and redirects it to the front wheels. Power split is determined by the difference in rotation of the sun gear and planetary carrier and the difference in rotation of differential case to the planet gears. If the planetary carrier slows down or stops rotating the power from the differential case passes straight through the planetary assemble as if the planetary assembly was part of the case.

The center differential consists of a planetary gear type differential mechanism, a pilot clutch that is engaged by the DCCD coil assembly, and an LSD clutch placed between the planetary gear unit sun gear and the planetary carrier.

The planetary gear unit sun gear is connected to the front drive pinion shaft, which turns the front wheels, and the planetary carrier is connected to the transfer drive gear, which turns the rear wheels. When the LSD clutch is released, the center differential distributes the drive torque to the front and rear wheels in a 35:65 proportion.

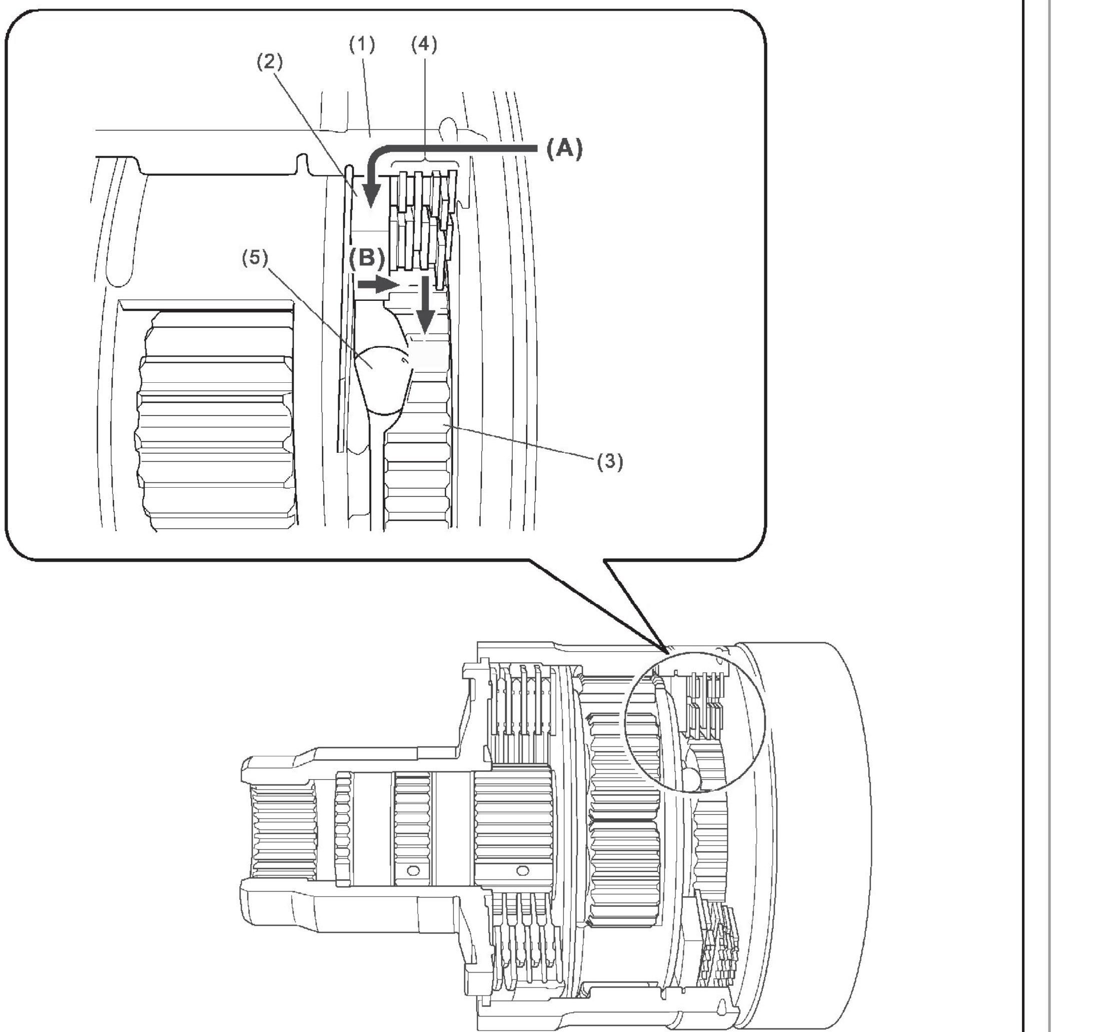


Center Differential Artwork

Three steel balls are equipped between the pilot clutch hub and planetary carrier inside the center differential case. These steel balls are mounted in hollows in the clutch hub and planetary carrier, and they work to widen the clearance between these parts when their relative position changes. In this explanatory note, the clutch hub hollow is referred to as cam 1 and the planetary carrier hollow as cam 2.

When current flows through the electromagnetic coils, magnetism is generated at components in the following sequence: electromagnet, differential case, armature (A). The armature is moved to the right (B) by this magnetism causing the pilot clutch to engage, and a magnetic field is formed in the area from the electromagnet, differential case, armature, and to the pilot clutch.

The pilot clutch locks the differential case side and cam 1 side together, thus the rotational speed of the cam 1 and differential case are synchronized. The engagement of the pilot clutch is controlled by adjusting the current flowing through the electromagnetic coils.



(1) Differential case
(2) Armature
(3) Cam 1
(4) Pilot clutch
(5) Steel ball

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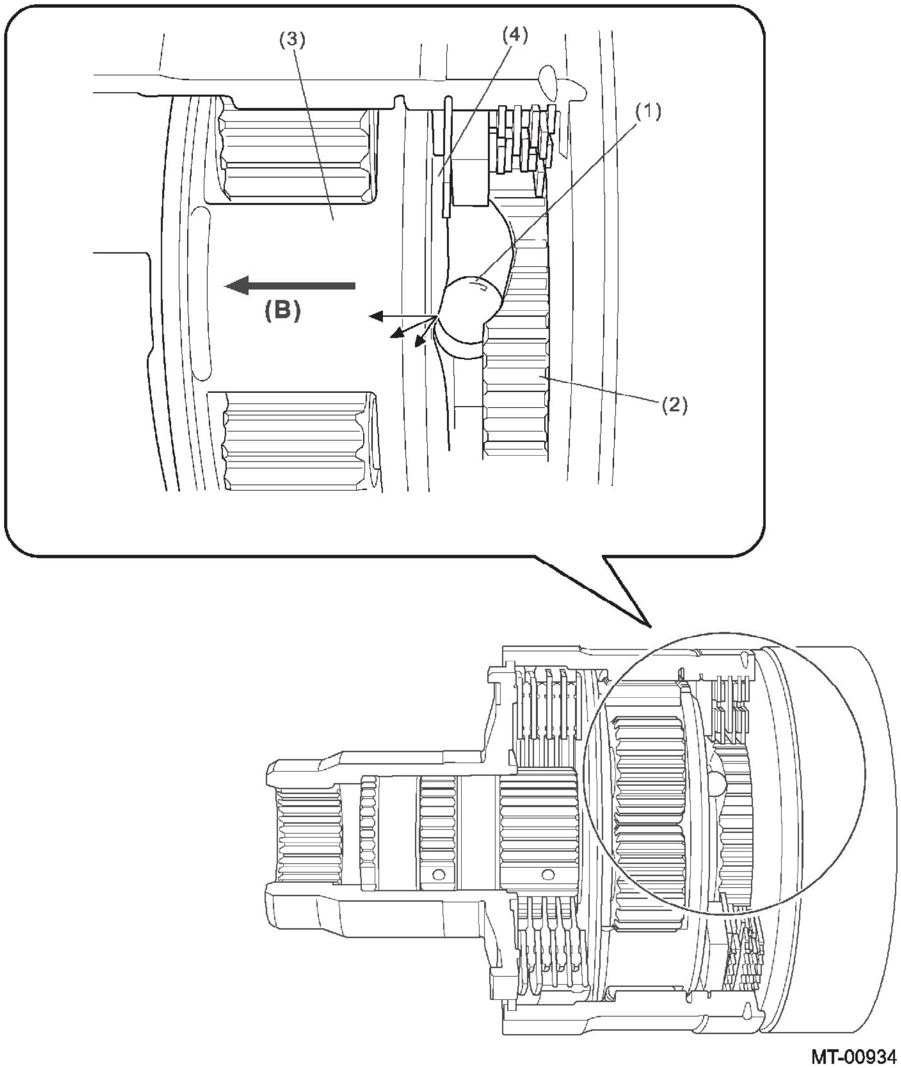
Cam 1 and Cam 2

When a speed difference occurs, a force (B) pushing the cam 2 to the left is generated at the steel balls that are sandwiched between cam 1 and cam 2. This pushes the planetary carrier to the left.



(1) Steel ball
(2) Cam 1
(3) Planetary carrier
(4) Cam 2

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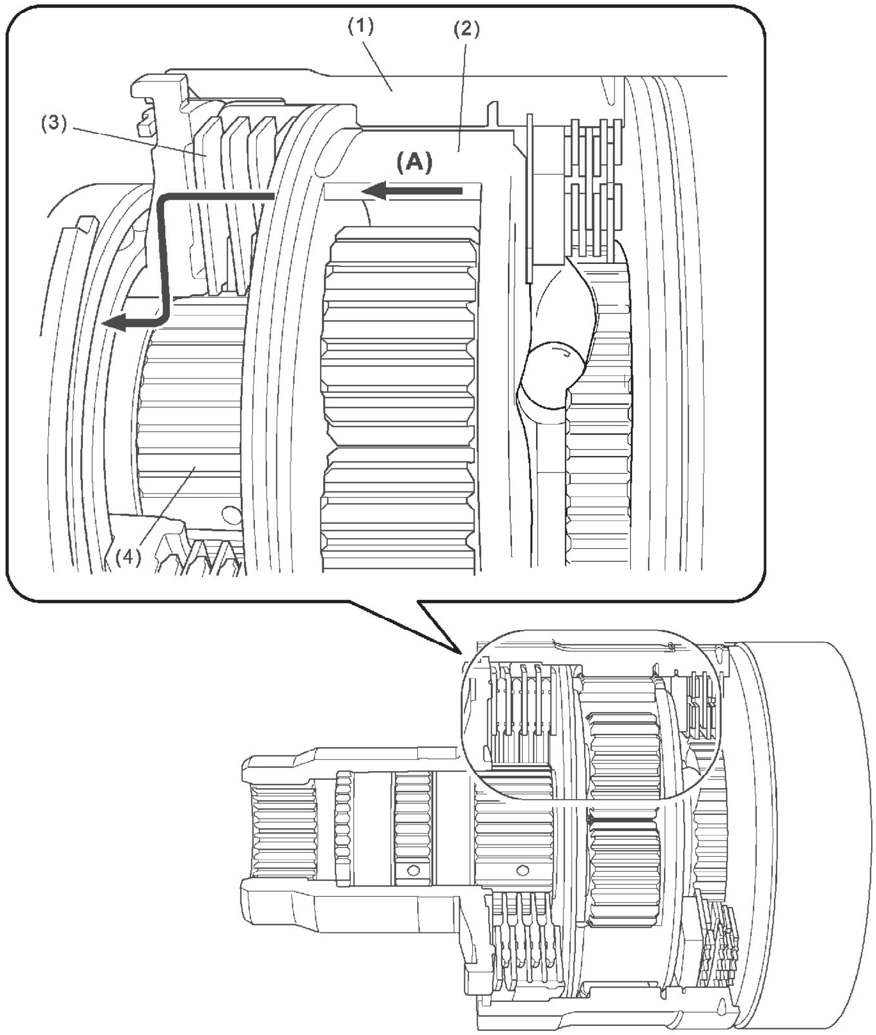
Speed Difference

The planetary gears and the sun gear generate a differential action.



(1) Differential case
(2) Planetary carrier
(3) Main clutch
(4) Sun gear

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LSD Clutch Application

DCCD System Operation

The DCCD system has two modes: Manual Mode and Auto Mode. In Manual Mode, operation of the DCCD control dial (to whatever setting the driver wants) is given priority, and the LSD clutch engagement torque is increased or decreased accordingly. In Auto Mode, on the other hand, the LSD clutch is automatically controlled according to various input signals, such as, the lateral G sensor input signal (turn status signal) and the wheel speed sensor input signal.

The most fundamental control in the DCCD system is the throttle-response engagement-torque control. This control increases or decreases the LSD clutch engagement torque according to the driver's operation of the accelerator pedal (accelerator position sensor signal). (The basic control theory is the same as that of the VTD transfer system.)

Besides the throttle-response engagement-torque control, the DCCD system also executes the following controls.

CONTROL	AUTO MODE	MANUAL MODE
Throttle-response engagement-toque control	○	○
ABS actuation signal input control	○	○
Brake switch signal input control	○	○
Parking brake signal input control	○	○
Tight cornering control	○	○
Slip control	○	X
Cornering control	○	X
DCCD control dial control	X	○
Fail-safe control	○	○
Rear differential oil temperature control	○	○

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X means not available

Logic Chart

ABS Actuation Signal Input Control

Once the ABS Actuation signal has been inputted to the DCCD control module from the ABS
CM & H/U, the DCCD control module decreases the LSD clutch engagement torque.

(Purpose: To reduce the number of factors that will disturb the ABS control.)

Brake Switch Signal Input Control

Once the brake switch signal has been inputted to the DCCD control module, the module reduces the LSD clutch engagement torque.

(Purpose: To prevent delays in the start of the ABS control and prepare the system for when all the wheels slow down simultaneously.)

Parking Brake Signal Input Control

Once the parking brake switch signal has been inputted to the DCCD control module, the module releases the LSD clutch.

(Purpose: To enable the vehicle to drift when the rear wheels lock by the operation of parking brake lever.)

Tight Cornering Control

In order to prevent the tight cornering phenomenon, this control determines the vehicle driving conditions from the left and right wheel speed ratios and the vehicle speed, as well as reduces the LSD clutch engagement torque accordingly.

Slip Control

This control determines the amount of slip for each wheel, based on signals from all four wheels speed sensors, and corrects the LSD clutch engagement torque according to the amount of slip.

Cornering Control

In order to improve stability when a vehicle is cornering, this control determines the cornering conditions on the basis of the throttle position sensor signal, lateral G sensor signal, all four wheel speed sensor signals, and other signals, and optimally controls the LSD clutch engagement torque.

Control Based on Lateral G Sensor Signal

In the DCCD system, the purpose of control based on the lateral G sensor signal is to improve the road handling characteristics of a vehicle. Accordingly, the philosophy behind this control is different than that of the Vehicle Dynamic Control System (which works to maintain vehicle stability when the tires lose their grip).

The DCCD control module varies the LSD clutch engagement conditions as described below, according to the lateral G sensor signal (vehicle cornering conditions). This distributes the drive torque to the front and rear wheels in suitable proportions, according to the cornering conditions.

If the lateral G force is large

LSD clutch engagement strength is reduced —> Drive torque distribution to rear wheels increases —> Pushing force of rear wheels increases —> Vehicle cornering performance is given priority.

If the lateral G force is small

LSD clutch engagement strength is increased —> Drive torque distribution to front wheels increases —> Pushing force of all wheels is equal —> Vehicle acceleration performance is given priority.

Control Based on Accelerator Position Sensor Signal

When the LSD clutch is released completely, 35% of the drive torque is distributed to the front wheels and 65% to the rear wheels. When the LSD clutch operates and distributes 45% of the drive torque to the front wheels and 55% to the rear wheels, it takes 10% of the drive torque from the rear wheels and transfers it to the front wheels.

When the drive torque input into the center differential from the engine increases, the LSD clutch engagement strength must increase to maintain the 45% drive torque distribution to the front wheels and 55% to the rear wheels. Consequently, when the throttle opening is large (the drive torque generated by the engine is large), the LSD clutch engagement strength increases.

Control Based on Wheel Speed Sensors

The difference in speed of the left and right wheels is determined on the basis of signals from four wheel speed sensors. The LSD clutch engagement strength is reduced in order to prevent the tight cornering phenomenon, which occurs in low-speed situations such as when a vehicle is being put into a garage.

DCCD Control Dial Control

The LSD clutch engagement torque increases or decreases according to the DCCD control dial setting selected by the driver. (Manual mode)

Fail-safe Control

When the DCCD control module detects any trouble in the system, it illuminates the bottom DCCD indicator light to inform the driver that trouble has occurred.

When a major malfunction related to the DCCD coil assembly occurs, the DCCD control module will turn the DCCD coil assembly off and fully release the LSD clutch. The DCCD control module will preserve as much of the system operation as it can, provided that the malfunction does not involve a sensor or other critical part.

Rear Differential Oil Temperature Control

If the rear differential oil temperature rises abnormally (to approximately 302°F (150°C) because of continued hard driving or for any other reason, the rear differential oil temperature switch will turn on and the rear differential oil temperature warning light in the combination meter will come on. At the same time, the DCCD control module will reduce the LSD clutch engagement torque. (Normal control will automatically be restored once the oil temperature drops.)

LSD Clutch Engagement Torque Control Applied to Cornering Vehicle by DCCD System

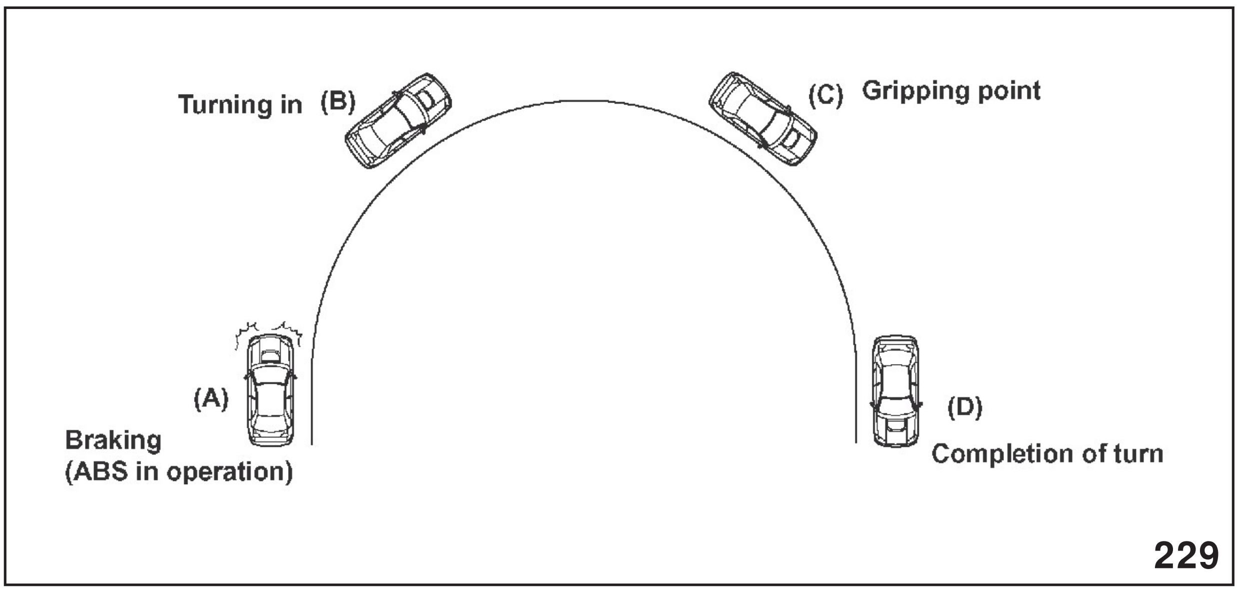
Let's consider the LSD clutch conditions at points A, B, C, and D, using slow-in quick-out cornering as a model.

A: The vehicle is decelerating and has not yet started to turn. Since the brake pedal is depressed and the ABS is working, the system is operating under ABS actuation signal input control conditions and the LSD clutch is practically released.

B: The vehicle is starting to corner, generating a lateral G force. Since the accelerator pedal is not depressed, the system gives cornering performance priority, so the LSD clutch engages weakly.

C: The vehicle has passed the top of the curve and is starting to accelerate. Although the lateral G force is large, the accelerator pedal is depressed, so the LSD clutch engagement strength is increased proportionally to the increasing engine driving force.

D: The vehicle has finished cornering and is traveling straight ahead. Since the lateral G force is small, the system gives priority to acceleration performance, so the LSD clutch engages strongly, approaching direct AWD conditions.



Vehicle in Turn Artwork

Diagnostics

How To Read the Diagnostic Trouble Code (DTC) with diagnostic indicator light.

(1) Engage the parking brake.

(2) Turn the ignition switch to the ON position.

(3) Set the DCCD control dial to the MIN or MAX position.

(4) Fully depress the accelerator pedal and hold in that position.

(5) Turn the DCCD control dial from MIN to MAX and back to MIN, and repeat 10 times.

(6) Release the accelerator pedal.

If no trouble code has been recorded
The bottom indicator light repeatedly flashes at approximately 2Hz.

If a trouble code has been recorded
The trouble code is read from the flashing pattern of the bottom indicator light.

The Bottom DCCD indicator light flashes the code corresponding to faulty part.

The long segment (1.2 sec on) indicates a “ten”, and the short segment (0.2 sec on) signifies a “one”.

D-Check Procedure

(1) Engage the parking brake.
(2) Set the DCCD control dial to the MIN position.
(3) Start the engine.
(4) Set the DCCD control dial to the MAX position.
(5) Release the parking brake.
(6) Set the DCCD control dial to the MIN position.
(7) Engage the parking brake.
(8) Repeat steps 4 to 7 twice within 30 seconds.

NOTE: THE INDICATOR WILL DISPLAY THE TROUBLE CODE FOR A WHEEL SPEED SENSOR MALFUNCTION.

Continue the procedure listed below.

(9) Operate the parking brake.
(10) Operate the brake pedal.
(11) Operate the Manual Mode switch.
(12) Operate the DCCD control dial and then set it to the MAX position and wait 3 seconds.
(13) Drive the vehicle (above 15 km/h for at least 5 seconds) and check the ON/OFF status of the bottom indicator light.

If no trouble code has been recorded
The bottom indicator light repeatedly flashes at approximately 2Hz.

If a trouble code has been recorded
The trouble code is read from the flashing pattern of the bottom indicator light.

NOTE: AFTER THE TROUBLE HAS BEEN REPAIRED, IF A DIAGNOSTIC CHECK IS EXECUTED AND THE SAME TROUBLE IS FOUND NOT TO RECUR, THE RECORDED TROUBLE CODE WILL BE ERASED FROM THE SYSTEM MEMORY THE NEXT TIME THE IGNITION SWITCH IS TURNED ON.

NOTE: ONLY SEVEN TROUBLE CODES STORED IN THE MEMORY APPLY TO TROUBLE DETECTED BY THE DCCD CONTROL MODULE. THESE ARE: CODES 11, 12, 13, 14, 21, 22, AND 23. THE DCCD MODULE WILL CAUSE THE BOTTOM INDICATOR LIGHT TO FLASH AND WARN THE DRIVER OF TROUBLE ONLY WHEN ONE OF THESE SEVEN CODES IS DETECTED.

THERE ARE NO TROUBLE CODES RELATED TO THE REAR DIFFERENTIAL OIL TEMPERATURE SWITCH. IF FOR ANY REASON THE REAR DIFFERENTIAL OIL TEMPERATURE RISES ABNORMALLY AND ACTIVATES THE TEMPERATURE SWITCH, THE REAR DIFFERENTIAL OIL TEMPERATURE WARNING LIGHT IN THE COMBINATION METER WILL COME ON TO WARN THE DRIVER THAT THE OIL TEMPERATURE IS TOO HIGH. AT THE SAME TIME, THE DCCD CONTROL MODULE WILL START THE BOTTOM INDICATOR LIGHT FLASHING. NEVERTHELESS, THE DCCD CONTROL MODULE HAS NO TROUBLE CODES RELATED TO THIS PROBLEM. (NORMAL CONTROL WILL AUTOMATICALLY BE RESTORED ONCE THE OIL TEMPERATURE DROPS.)

Component Parts Test

Lateral G sensor

Measure the sensor output voltage with the sensor connector disconnected.
Between connector terminal No. 1(+) and connector No. 2(-)
In horizontal position: 2.3 - 2.7V
Inclined 90° to the right: 3.5 - 4.1V
Inclined 90° to the left: 0.8 - 1.5V

DCCD coil assembly

Measure the coil resistance.

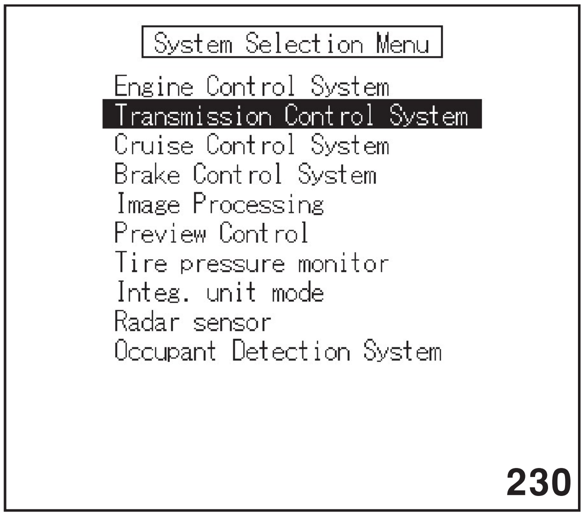
Resistance value: 1.0 - 2.0 ohms

Check the DCCD control module drive voltage (duty signal).

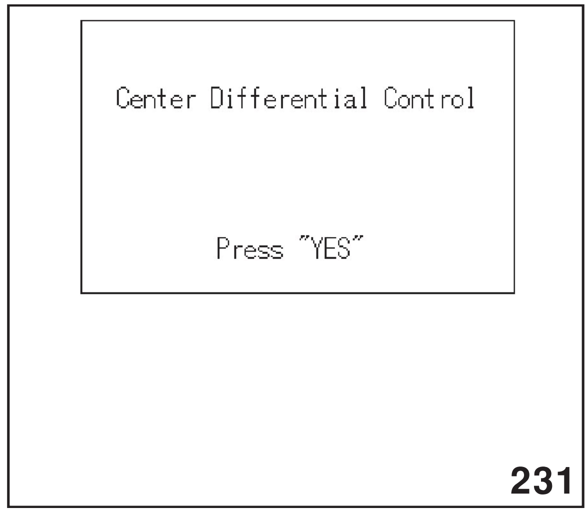
Voltage value: 6.0 - 7.0V

2005 DCCD Diagnostics

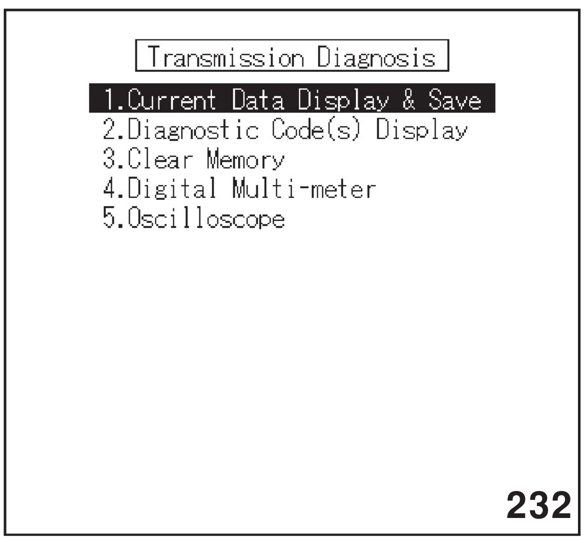
Beginning with the 2005 WRX STi, the Select Monitor can be used to diagnosis the DCCD. Select Transmission Control System and follow the instructions on the Select Monitor Display to access the DCCD operational and diagnostic information.



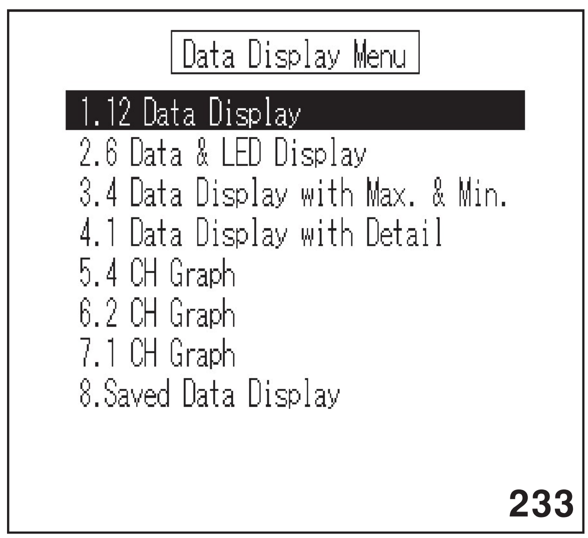
Select Monitor image 1



Select Monitor image 2

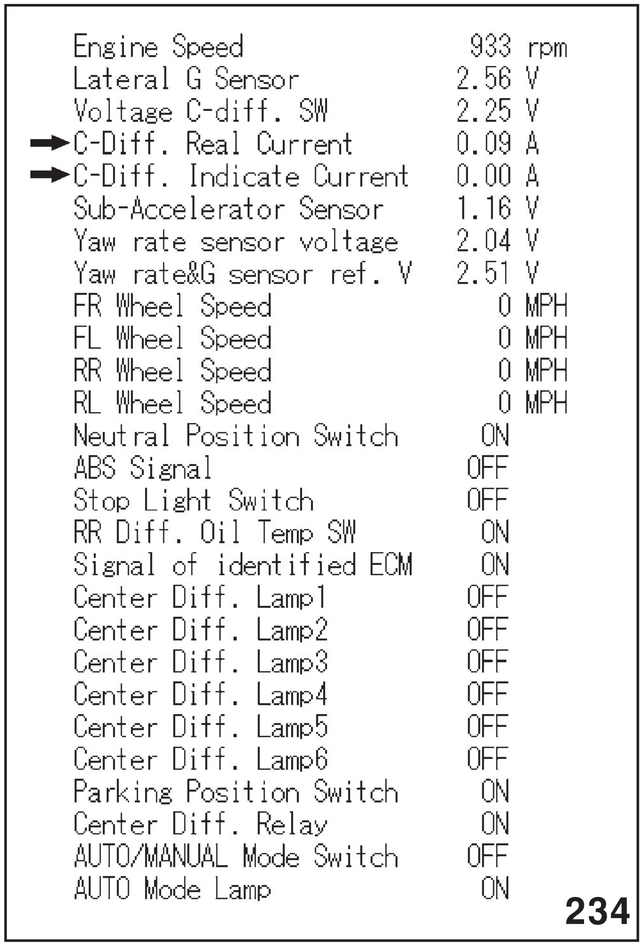


Select Monitor image 3



Select Monitor image 4

The DCCD coil current (C-Diff. Real Current) is displayed along with Target Current (C-Diff. Indicate Current). These two displays indicate the value of the present coil current and the coil current targeted by the DCCD control unit that will provide the best operation for present driving condition or a manual setting controlled by the driver.



Engine Speed	933 rpm
Lateral G Sensor	2.56 V
Voltage C-diff. SW	2.25 V
➡ C-Diff. Real Current	0.09 A
➡ C-Diff. Indicate Current	0.00 A
Sub-Accelerator Sensor	1.16 V
Yaw rate sensor voltage	2.04 V
Yaw rate&G sensor ref. V	2.51 V
FR Wheel Speed	0 MPH
FL Wheel Speed	0 MPH
RR Wheel Speed	0 MPH
RL Wheel Speed	0 MPH
Neutral Position Switch	ON
ABS Signal	OFF
Stop Light Switch	OFF
RR Diff. Oil Temp SW	ON
Signal of identified ECM	ON
Center Diff. Lamp1	OFF
Center Diff. Lamp2	OFF
Center Diff. Lamp3	OFF
Center Diff. Lamp4	OFF
Center Diff. Lamp5	OFF
Center Diff. Lamp6	OFF
Parking Position Switch	ON
Center Diff. Relay	ON
AUTO/MANUAL Mode Switch	OFF
AUTO Mode Lamp	ON

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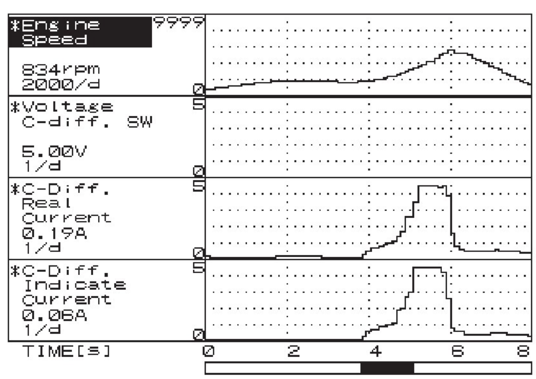
Select Monitor image 5



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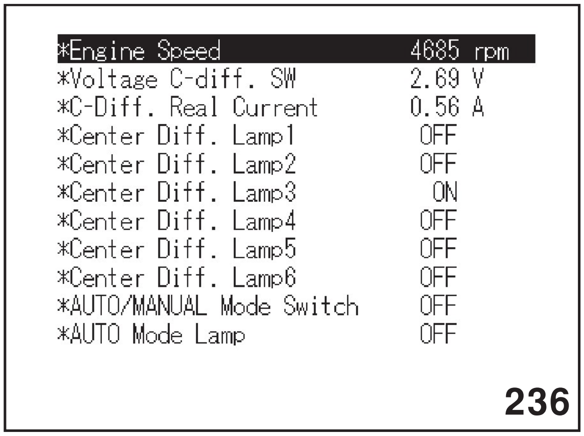
Select Monitor image 6

The DCCD manual control switch value display will indicate the value of the switch setting but it will not influence the DCCD coil until the manual switch has been activated.



*Engine Speed	4685 rpm
*Voltage C-diff. SW	2.69 V
*C-Diff. Real Current	0.56 A
*Center Diff. Lamp1	OFF
*Center Diff. Lamp2	OFF
*Center Diff. Lamp3	ON
*Center Diff. Lamp4	OFF
*Center Diff. Lamp5	OFF
*Center Diff. Lamp6	OFF
*AUTO/MANUAL Mode Switch	OFF
*AUTO Mode Lamp	OFF

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Select Monitor image 7

The Auto/Manual mode switch is a momentary contact type. The Select Monitor display will indicate "ON" only while the switch is being pushed.

The "AUTO Mode Lamp" display indicating off is a result of the manual mode being activated.

Driver Control Center Differential System (2006MY)

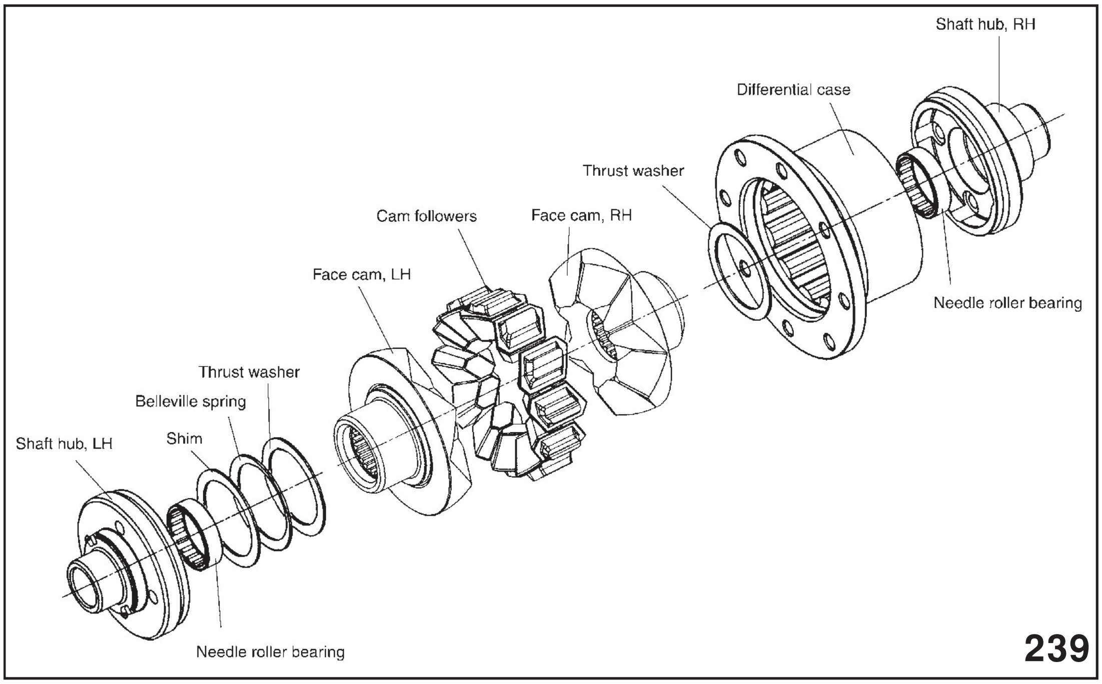
Beginning with the 2006 model year, a mechanical limited slip differential has been added to the DCCD. This enhances DCCD operation by controlling large speed differences between the front and rear wheels even when the driver has set the DCCD into free mode.

Servicing the transmission is not affected as the DCCD must be replaced as a unit.

Additional enhancements to the STi include a yaw rate, lateral G sensor and steering angle sensor. These components are utilized by the DCCD control unit to determine the driver’s intended path and make corrections to the DCCD to assist with controlling under and over steering.

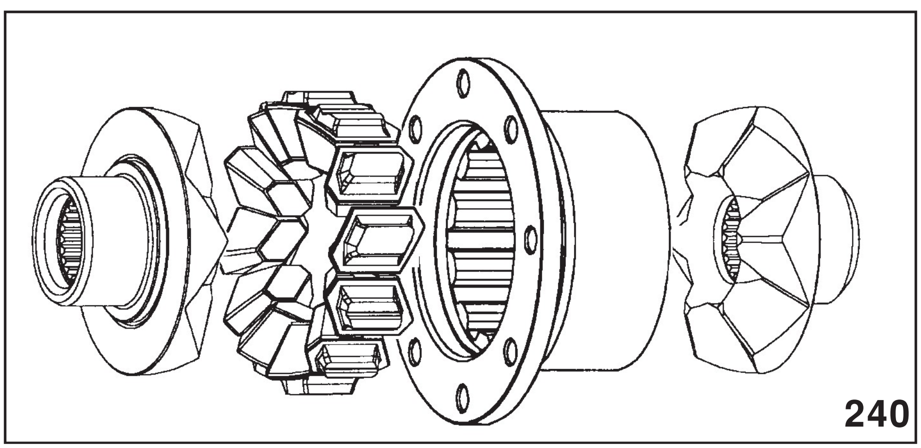
These new components are not able to be zeroed with the select monitor, relying only on the correct steering wheel angle for proper neutral placement.

Front Differential (Cam Type)



Front Differential

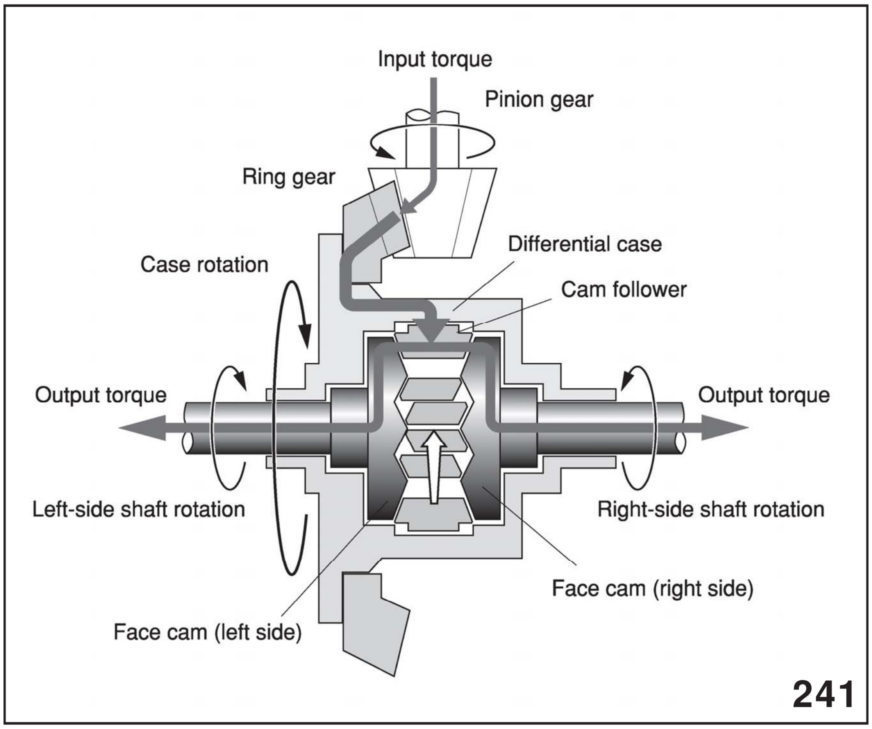
On the 2004MY WRX STi the front differential is a cam type limited slip differential. It is a sealed unit and must be replaced as an assembly. The main components of the differential are a differential case, cam followers and two face cams. The bottom side of the cam followers is shaped to fit into slots made into the inner diameter of the differential case. These slots allow the cam followers to slide left and right as well as deliver power from the differential case to the left and right face cams. The top side of the cam followers are shaped to work with the shape provided to the cam followers.



Cam Followers and Face Cams

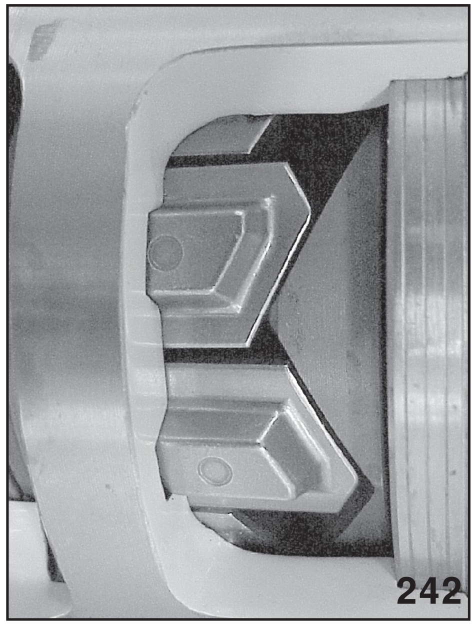
The cam followers have two different cam shapes (the shapes of the surfaces in contact with the face cams), which are alternately arranged. Because of this design, the left and right face cams each have 6 teeth.

Operation



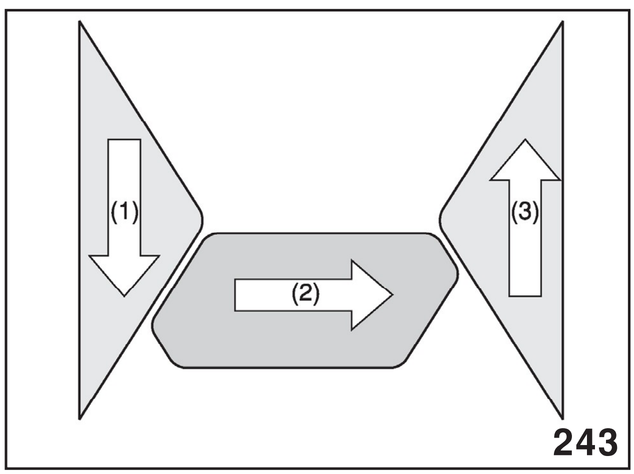
Complete Differential in Operation

When the vehicle is driving on a level, uniform road surface, the left and right wheels are turning at the same speed, so there is no difference in the rotational speed of the left and right face cams. The drive force transmitted from the drive pinion gear to the ring gear is transmitted to the 12 cam followers via the slots on the inside of the differential case.



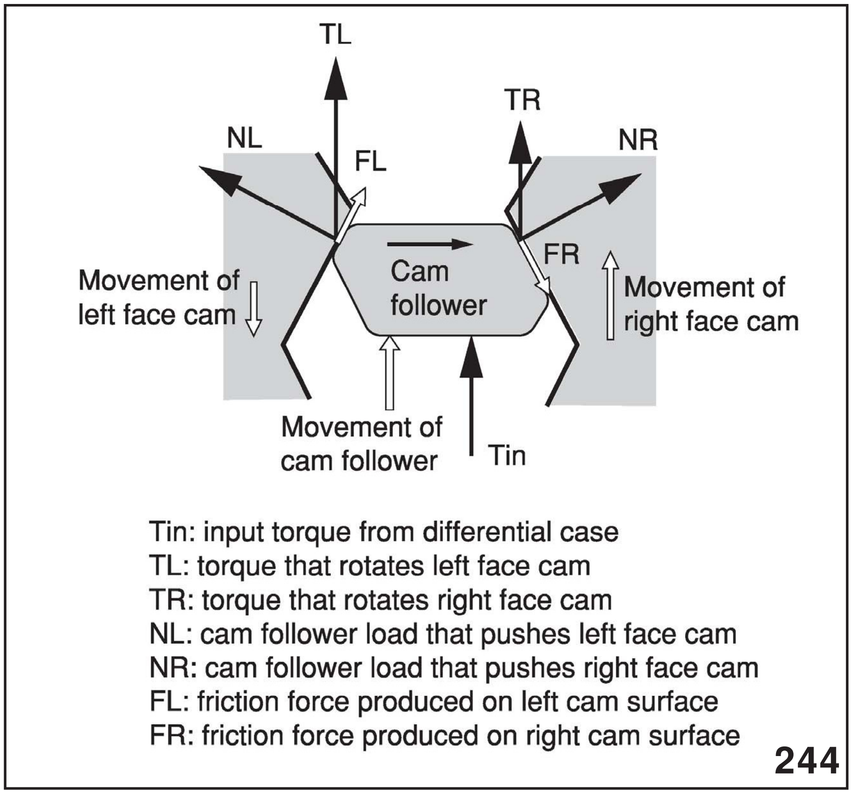
Cut Away-Cam Followers and Face Cam

The drive force is uniformly transmitted to the left and right face cams by the cam followers in contact with the left and right face cams. This causes all the cam followers and the left and right face cams to rotate together as a single unit.



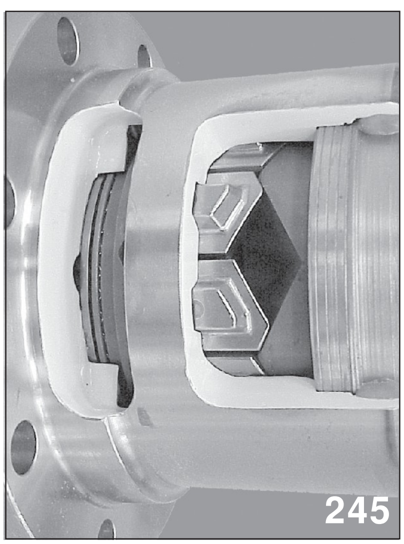
Face Cam - Cam Follower - Face Cam

When a vehicle turns, producing a difference in rotational speed between the left and right wheels, there is a shift in the relative position of the left and right face cams. When the left face cam moves downward, the cam followers are pushed by the left face cam to the right. This pushes the right face cam upward. As a result, the upward movement of the right face cam is equal to the downward movement of the left face cam. This operation between the left and right face cams and the cam followers in contact with them occurs continuously thus it absorbs the difference in rotational speed between the left and right wheels produced by the turning vehicle.



LSD Forces

The limited slip function is created by the friction between the cam followers and the face cams. When the relative position of the left and right face cams change the cam followers start to move producing forces on the face cams. At the same time frictional forces which counteract the movement of the left and right face cams are produced.



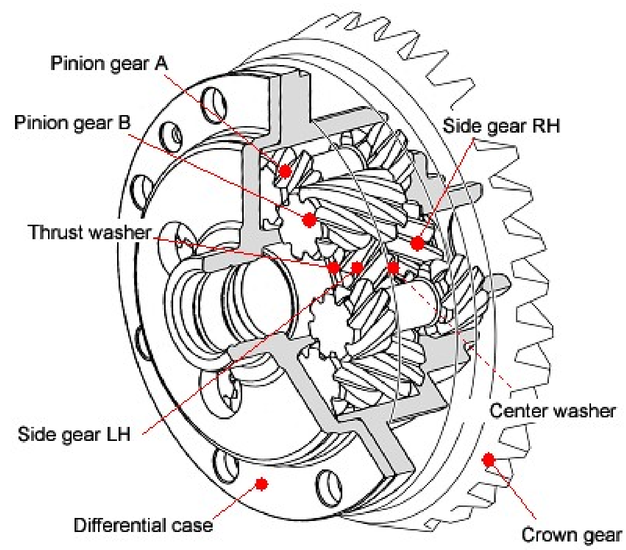
LSD Cutaway

Additionally the friction created between the cam followers and the slots in the differential case and the friction between the face cams and the differential case enhance the LSD effect.

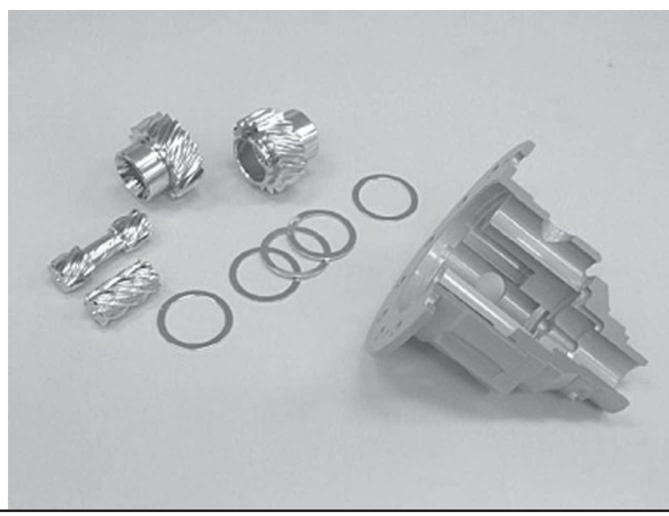
Front Differential (Helical Type)

Starting with 2005MY STi, front differentials are a helical type design.

The shape of all gear teeth are Helical type.



Helical LSD



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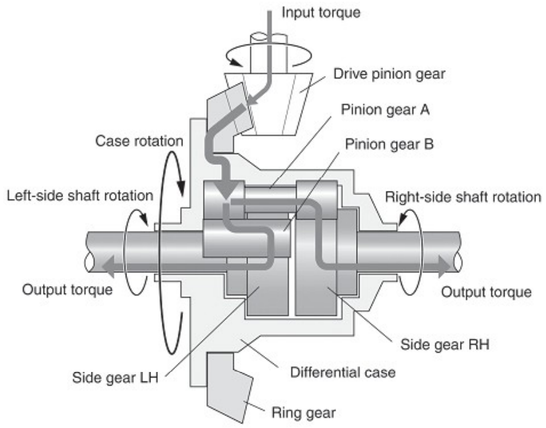
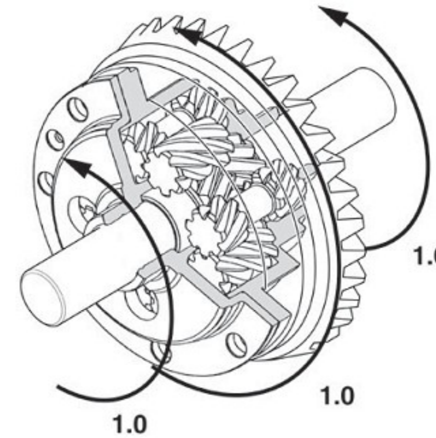
Component Parts

The components of the helical LSD are side gears, four sets of pinion gears A and B, four thrust washers and a center washer. These component parts are encased within the differential case and a crown gear is bolted to the flange of the differential case. The front differential must be replaced as an assembly.

Differential Function





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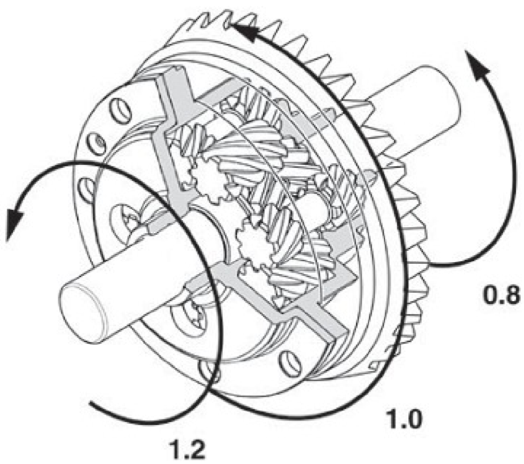
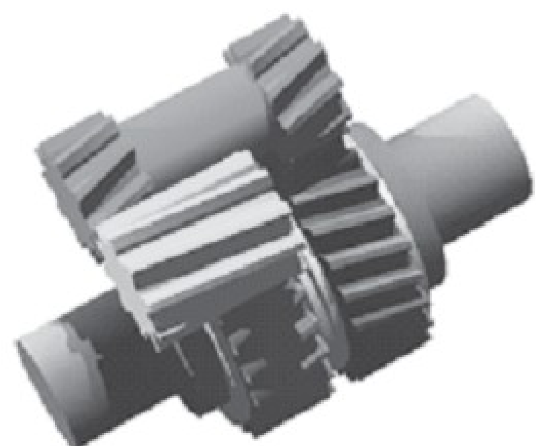
Power Transfer *Straight Driving*

When the vehicle is moving down a straight road, the left and right wheels are turning at the same speed, so there is no difference in the rotational speed of the left and right side gears. Therefore, pinion gears do not rotate against other gears and all component parts rotate as a unit.





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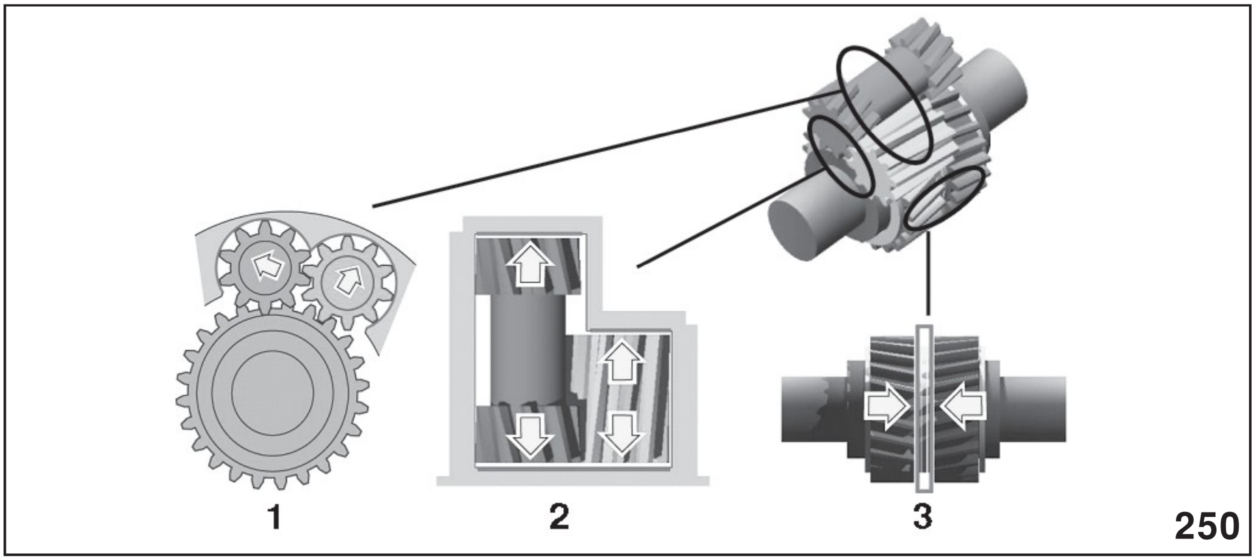
Right Turn *Pinion Gears A and B*

When a vehicle turns, it produces a difference in rotational speed between the left and right side gears, the pinion gear A and B start to rotate. This is because the pinion gear A or B must revolve around the slower-turning side gear. This means that they carry additional rotary motion to the faster-turning side gear.

LSD Function

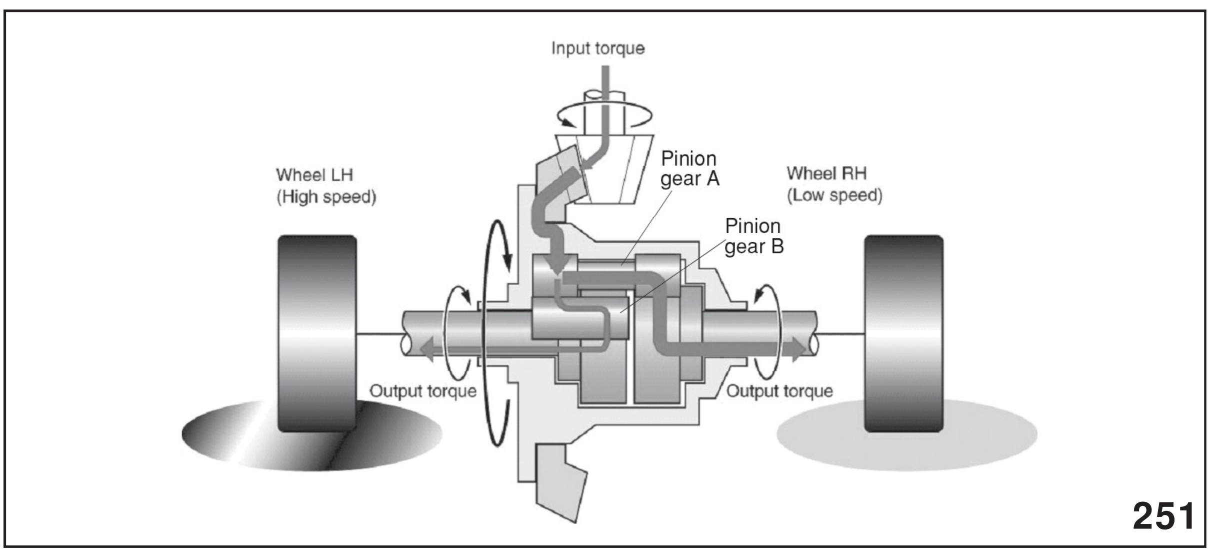
When one wheel attempts to spin, the pinion gears start to rotate and there are three types of friction forces produced in the differential case.



Three Types of Friction Forces

1. The friction between pinion gear tooth and differential case
2. The friction between pinion gear end surface and differential case
3. The friction between LH and RH Side gears

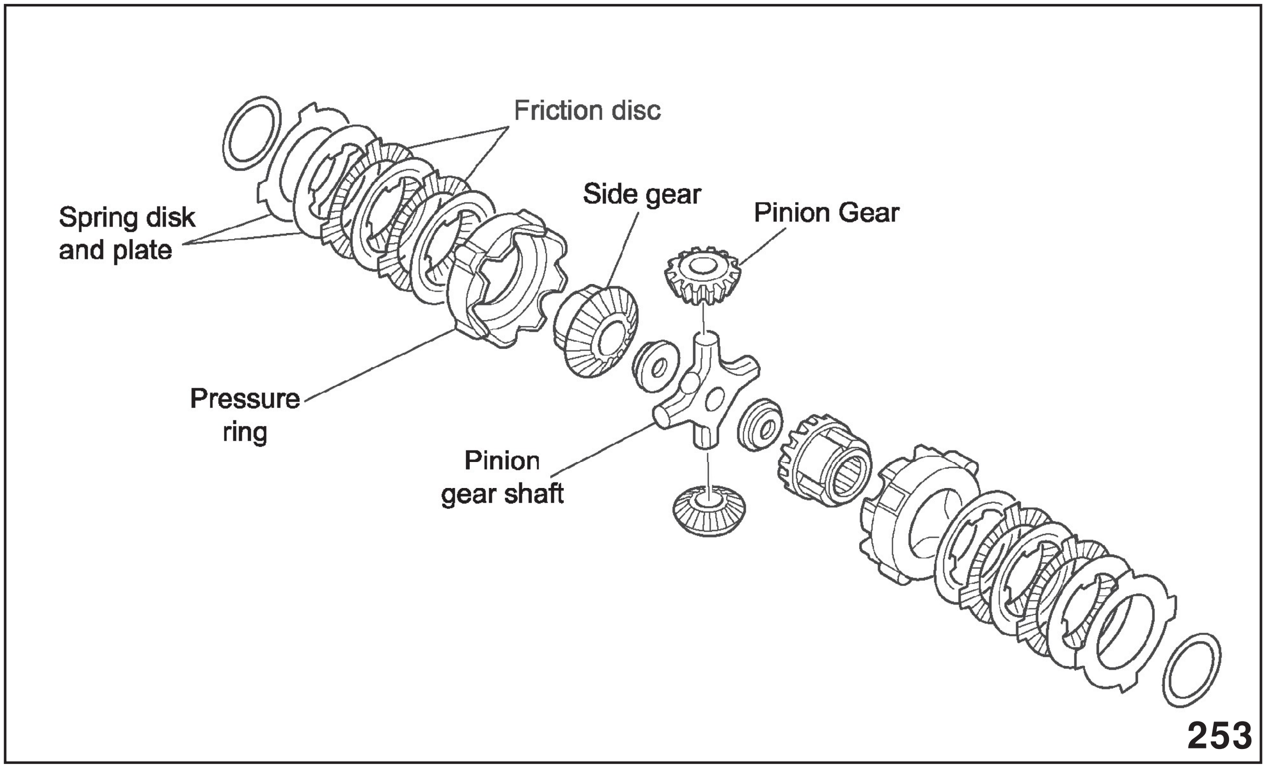
These friction forces work against rotation of the two side gears, pinion gear A and pinion gear B, and the speed differences of the side gears are limited.



Torque Distribution

As a result, the input torque from the crown gear is distributed along the left and right side gears according to the sum of three types of friction forces.

Rear Differential



Rear Differential Artwork

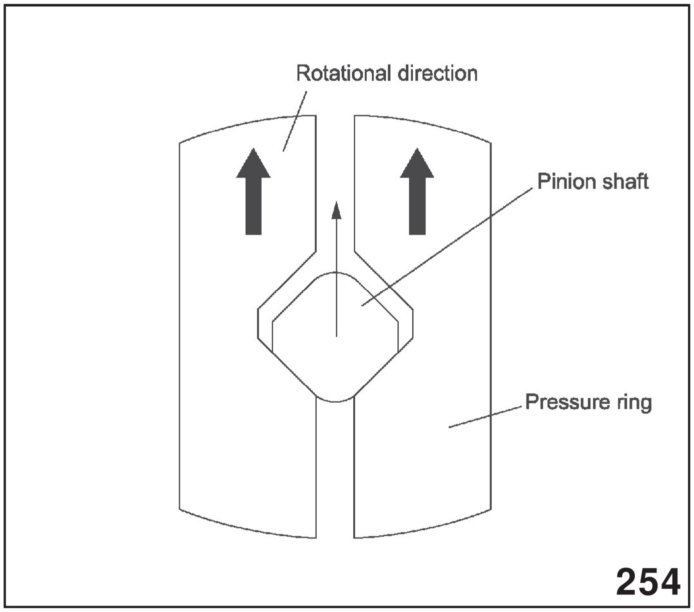
The rear differential of the WRX STi is equipped with a Mechanical Type Limited Slip Differential. The rear differential is non serviceable and must be replaced as an assembly. The Limited Slip Differential functions by slowing down the rear wheel with reduced or low traction and transfers that power to the wheel with the most traction.

Another feature of the Mechanical Type Limited Slip Differential is the ability to lock the rear differential into a 50% left and 50% right power split of the rear wheels under very high engine output conditions.

Mechanical Type Limited Slip Differential operation is accomplished through the mechanical application of a set of friction plates that are splined to the differential side gears and the differential case. The friction plates are applied by a set of pressure rings, one for each side of the differential, which are acted upon by the pinion gear shaft.

The pressure rings are splined to and rotate with differential carrier, but the pressure rings can move in and out. The force required to move them out is determined by the spring tension from a set of spring disks and plates, one set for each side of the differential. It is also this spring force that assists with returning the pressure rings back to the static position.

The outward movement of the pressure rings pushes on and applies the friction plates. The degree of friction plate application is determined by how much outward movement is applied from the pressure rings.



Pressure Rings and Pinion Shaft

The force that moves the pressure rings outward is generated by the pinion gear shaft. The static position of the pinion gear shaft is in the center of a space created by the pressure rings as they surround the pinion and side gears.

Power from the differential carrier is delivered to the pressure rings and depending on the amount of force created by the movement of the pressure rings into the pinion gear shaft, pulls the pinion gear shaft in the direction of forward movement or uses the pinion gear shaft to split or move the pressure rings outward.

This will apply the friction plates and allow the power to flow partially into the side gears and partially through the differential pinion gears to the side gears and finally to the rear wheels. Higher degrees of friction plate application result in the power flowing from the differential carrier straight to the side gears and to the rear wheels.

NOTES:

Tool List

Tool Number	Description
398177700	Installer
398497701	Seat
398643600	Gauge
499247400	Installer
499757002	Installer
899864100	Installer
498515700	Remover
18620AA000	Adapter Wrench
18621AA000	Adapter Wrench
18630AA000	Wrench Assembly
18631AA000	Handle
18632AA000	Stand Assembly
18651AA000	Installer
18654AA000	Installer
18657AA000	Installer
18657AA010	Installer
18663AA000	Socket
18664AA000	Base (Tool Kit)
18665AA000	Holder
18666AA000	Holder
18667AA000	Holder
18668AA000	Punch
18669AA000	Punch
18670AA000	Punch
18671AA000	Oil Seal Guide
18672AA000	Guide Clip
18720AA000	Remover
18722AA000	Remover
18723AA000	Remover
18754AA000	Remover
18757AA000	Straight Pin Remover
18758AA000	Puller
18831AA000	Gauge
18852AA000	Torque Wrench
18853AA000	Height Gauge
42099AE000	Full Line Disconnect
J-47711	Tool Tags

Service Bulletins

No.	Date	Subject	Applicability-Title
01-156-03	11/18/03	Warranty Information Update	All Manual Transmission Vehicles
01-162-05	06/28/05	Towing Recommendations	STi Vehicles, All Model Years
03-53-04 16-54-04	08/20/04	Transmission Rear Cross-Member	All A/T amd M/T Vehicles
18-73-03	12/01/03	Service Manual Corrections	2001-2004MY Legacy, Forester, and Impreza Service Manuals
18-88-05	06/03/05	Service Manual Corrections	2004MY Impreza Vehicles

Tech TIPS

Date	Subject
07/05	STi - Towing behind motor home
07/05	STi - Rear differential oil

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CERTIFIED
SUBARU
TECHNICIAN

AUTOMOTIVE
Youth Educational Systems
PROUD PARTNER

Technicians Reference Booklet

Advanced Electrical Theory & Diagnosis

Module 602

MSA5P0135C

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of June 2001.

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Introduction

This Technicians Reference Booklet contains information pertaining to advanced automotive electrical technology, and the Subaru electrical system. It reviews solid state devices, operation and diagnosis of Subaru starting and charging systems, operation and diagnosis, computer terminology and operation, and the troubleshooting and diagnosis of intermittent faults. In addition, the use of the Select Monitor is also explained during the presentation of the module and will be demonstrated during the lab exercises.

The text and illustrations are derived from the classroom lecture and slide presentation material and are intended to reinforce previous classroom instruction and lab participation.

Technicians Worksheets provided by your instructor will be completed during the "hands-on" Lab Work segments of the Advanced Electrical Theory & Diagnosis Module. Always refer to the appropriate model year Subaru Service Manual and the applicable service bulletins for all specifications and detailed service procedures.

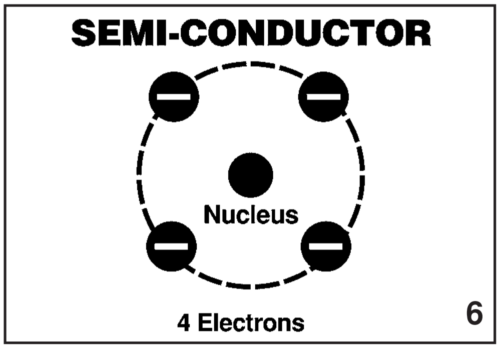
Solid State Devices

The charging circuit will be used for the purpose of explaining semiconductors (diodes and transistors) and the functions of semiconductors. These principles may also be applied to other types of circuits.

Basic electrical terms for the study of advanced electrical theory and diagnosis:

1. Alternating current (AC) — an electric current which constantly changes polarity from positive to negative. (or an electric current that reverses its direction regularly and continually).
2. Direct current (DC) — an electric current which flows in one direction only.
3. Sine wave — a wave that alternately moves between a positive and a negative value over an equal length of time.
4. Square wave — a square or rectangular-shaped wave that alternately assumes a "ON" or "OFF" mode. The length of the "ON" time compared to the "OFF" time indicates a "duty ratio".

This booklet contains a Glossary of electrical terms for your reference. Refer to the Glossary when appropriate throughout the duration of this module.



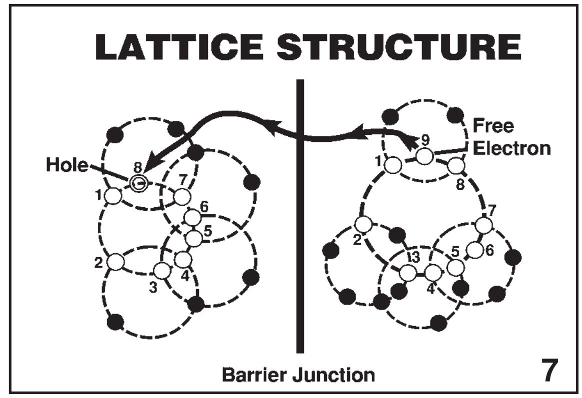
Diodes

We begin our study of advanced electrical theory with an explanation of the construction and operation of diodes.

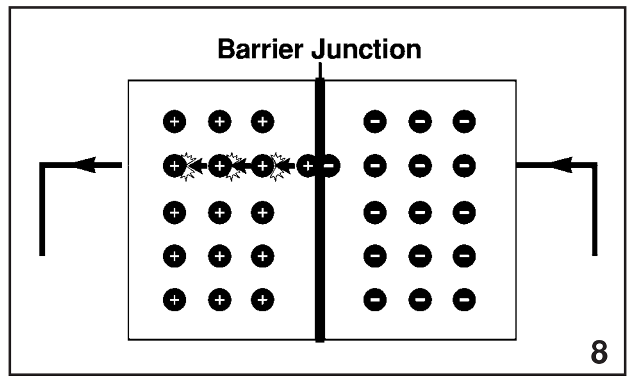
Diodes are commonly constructed of one of two materials:
- Silicon
- Germanium

These two materials possess the unique property of having exactly four electrons in the outer valence ring of their atoms. To create a diode, one of four impurities, (Gallium, Indium, Arsenic, or Antimony) may be combined with either Silicon or Germanium to form a new lattice structure. The maximum number of electrons that can reside in a valence ring is eight (8).

NOTE: THE PROCESS OF COMBINING IMPURITIES SUCH AS GALLIUM, INDIUM, ARSENIC, OR ANTIMONY WITH EITHER SILICON OR GERMANIUM IS CALLED DOPING.



Lattice structure

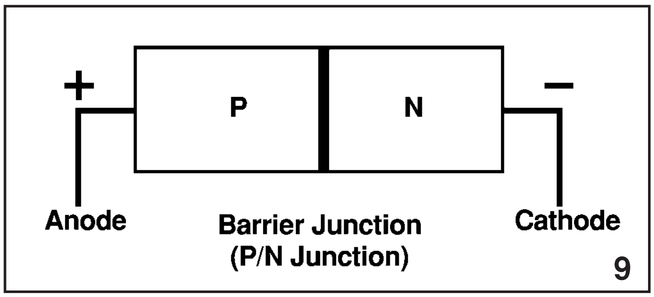


Structural changes to the atoms

The impurities Gallium and Indium each have three (3) electrons in the outer orbit (valence ring) of their atoms. When either of these impurities is mixed with Silicon or Germanium, (4 electrons), the result is a new atom which has seven electrons in the valence ring (4 + 3 = 7). This situation is equal to a deficiency of one electron (hole) in the valence ring. The result is that the new material takes on a positive (+) charge.

Arsenic and Antimony each have five (5) electrons in their atom's outer orbit (valence ring). When either of these impurities is mixed with Silicon (or Germanium) the result is an atom with nine electrons, (5 + 4 = 9). Nine electrons cannot reside in a valence ring, and therefore is equivalent to one excess or "FREE" electron. This ninth electron rejected by the valence ring has a negative charge.

Negative charges are attracted to positive charges at the barrier junction, when the proper polarity voltage is applied. When the negative and positive charged atoms meet at the barrier junction, the electrons will then move in a chain reaction toward the positive terminal of the diode. This is equal to current flow through the diode.



Diode polarity

The negative pole of a diode is called the cathode and the positive pole is the anode. In the center of the diode is the positive (+)/negative (-) junction (P/N junction).

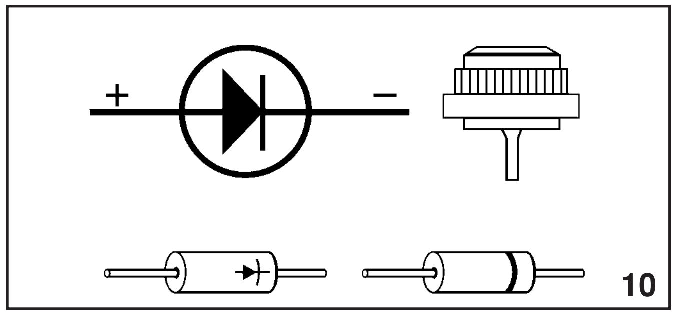
This is also called a "barrier junction". The P/N junction determines the maximum allowable current flow of the diode and it is this feature which allows the diode to function as a one-way switch.

A silicon diode normally requires approximately 0.7v to cause a current to flow in the normal forward bias mode. Forward bias means the polarity of the input voltage will allow current to flow through the diode. However, if current flow is reversed, (reverse bias mode), the polarity causes the semiconductor's barrier junction to resist current flow. It may require up to 1000 volts to cause a current to flow through the diode in the reverse bias mode. This is called the P.I.V. (peak inverse voltage) rating.

Exceeding the amperage rating of the diode may:

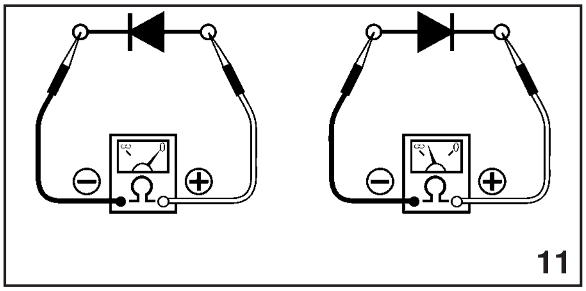
- Fuse the P/N junction, creating a short circuit. The diode will then act like a solid wire conductor, or
- Open the P/N junction creating an open circuit through which no current may flow.

The automotive industry primarily uses silicon diodes because of their excellent heat tolerance characteristics.



Schematic/pictorial symbols

A line (mark) on the body of most diodes will always identify the cathode or negative end of the diode for testing and installation purposes.



Testing diodes

You may use an ohmmeter of a voltmeter to test the operation of a diode.

1. Ohmmeter test
   - Connect the meter positive lead to the cathode (-) lead of the diode and the meter negative lead to the anode (+) lead of the diode. The result should be high resistance meter reading, ex: 5k ohms or more. This is due to the "unlike" charges of the voltage source (ohmmeter) and the diode material. The electrons and "holes" are pulled to the outside ends of the diode causing a large depletion region at the P/N junction. A low resistance reading would indicate that the diode is "shorted", and requires replacement.
   - If you now reverse the meter lead connections, the result should be a low resistance reading, ex 100 ohms or less. This is due to the "like" charges of the voltage source (ohmmeter) and the diode material. The electrons and "holes" are repelled (pushed) to the P/N junction which allows current to flow. A high resistance reading indicates that the diode is "open", and must be replaced.

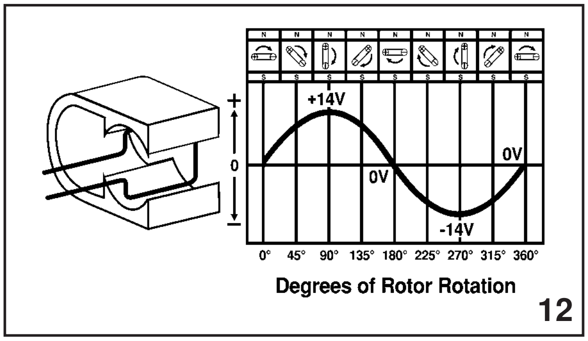
NOTE: WHEN USING AN OHMMETER TO TEST A DIODE, MAKE SURE THE POWER IS TURNED "OFF", OR WHERE POSSIBLE, REMOVE THE DIODE FROM THE CIRCUIT.

2. Voltmeter test
   - The diode must in an operating circuit. Connect the voltmeter leads to the diode leads, (observe polarity). Refer to the appropriate wiring diagram to determine the voltage that should be in the circuit. In most automotive applications this will be B+ voltage. The diode is "OK" when the meter readout is as follows:
     - Silicon diode — approx. 0.7 voltage drop (dynamic resistance)
     - Germanium diode — Approx. 0.2 voltage drop (dynamic resistance)

The voltage drop reading always identifies the diode type. Any other reading indicates a circuit or diode defect, and further testing will by required.

If the meter readout voltage is equal to the circuit voltage, the diode is open (all current is flowing through the voltmeter). When the meter readout voltage is equal to 0.0 volts, the diode is fused (shorted). All the current is flowing through the diode.

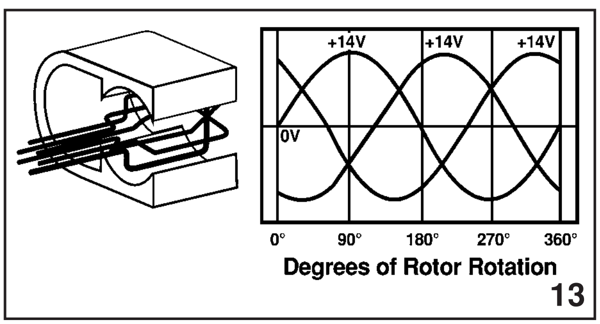
NOTE: A DIODE'S PERFORMANCE DOES NOT DETERIORATE WITH TIME OR USE. THEREFORE, WHEN TESTING, THE RESULT WILL EITHER BE "GOOD" OR "BAD", HOWEVER, IT IS POSSIBLE FOR A DIODE TO BE INTERMITTENTLY "GOOD" OR "BAD".



Full wave rectification

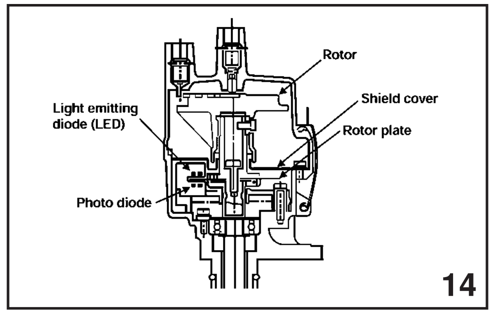
A diode may be used to convert (rectify) AC voltage to a pulsing DC voltage. Because of the diode's polarity, current is only allowed through the diode in one direction. Remember that opposite polarity is denied conduction due to the high P.I.V. (peak inverse voltage rating) of the diode.

The negative pulses (opposite polarity) are then sent through an additional diode to the ground terminal of the battery. The result is single phase (DC) current.



Three phase current

Place three stator windings, positioned 120 degrees apart, within a stator assembly. During each rotation of the field, three (3) separate voltage charges/pulses will be produced. When the voltage is passed through six (6) diodes, (3 positive and 3 negative), the result is three phase DC current. The three phases overlap each other which maintains a sufficient voltage level to properly charge the battery.

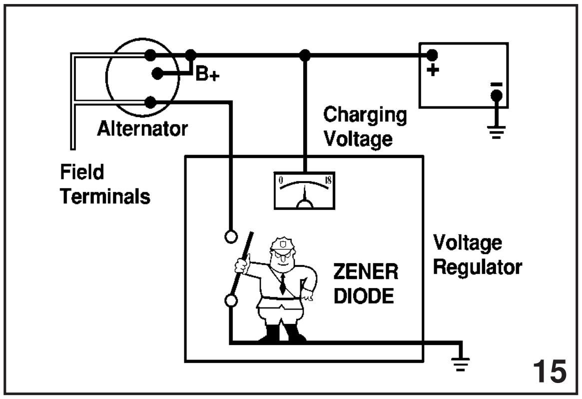


LED/PSD

A light emitting diode (LED) is similar to a P/N diode. It can act as rectifier, converting current to infrared or visible light. The color of the light produced by the LED is determined by the color of the lens over the LED. Because the LED only requires a very low operating current of 20 ma, it has a long life which makes it most suitable for automotive uses. When testing LED operation, Always check the operation of the component in which the LED is used. It is usually difficult to test LED operation by itself.

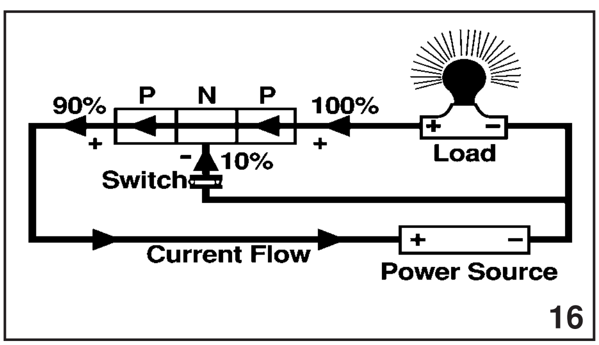
A photo sensitive diode (PSD) is similar to an LED, however, it will conduct current when exposed to light. The PSD can also act as a rectifier. As with the LED, it is better to test the operation of the component than the PSD itself.

NOTE: AN LED AND A PSD ARE EMBEDDED AS ONE UNIT IN THE DISTRIBUTOR ON SOME SUBARU MODELS, AND IS USED AS A CRANK ANGLE SENSOR.



Zener diode

The zener diode allows reverse bias (voltage) at a predetermined level based on the impurity added to the adhesive between the P and N materials. This places the P.I.V. rating of the zener diode at a required specific value, i.e., 14 volts. Remember that silicon diodes may gave a P.I.V. of a 1000 volts. This allows the zener diode to modify current flow by switching the circuit rapidly :ON" and "OFF" when the applied voltage increases or decreases. The zener diode is used in voltage regulators to prevent overcharging or undercharging of the battery.



PNP transistor

A transistor is a solid state device used to control current flow. Two of many types of transistors which may be identified by their polarity/lead designation are:

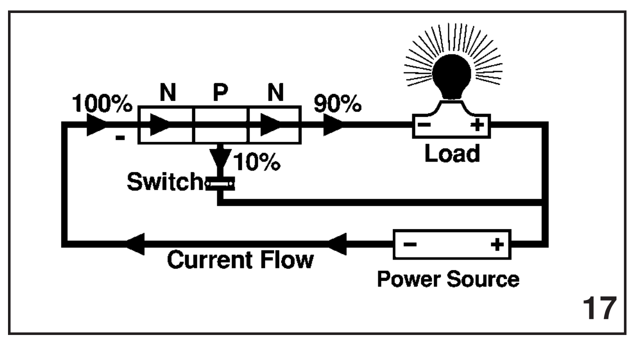
- PNP = positive/negative/positive
- NPN = negative/positive/negative

While a diode is formed by the joining of two specially doped materials, a transistor is formed by the joining of three doped materials.

- Emitter material emits current
- Collector material collects current.
- Base material supplies the path used to initiate or control current flow.

The base material is formed using a different doping process than the emitter/collector material and is thus the opposite polarity of the emitter/ collector material.

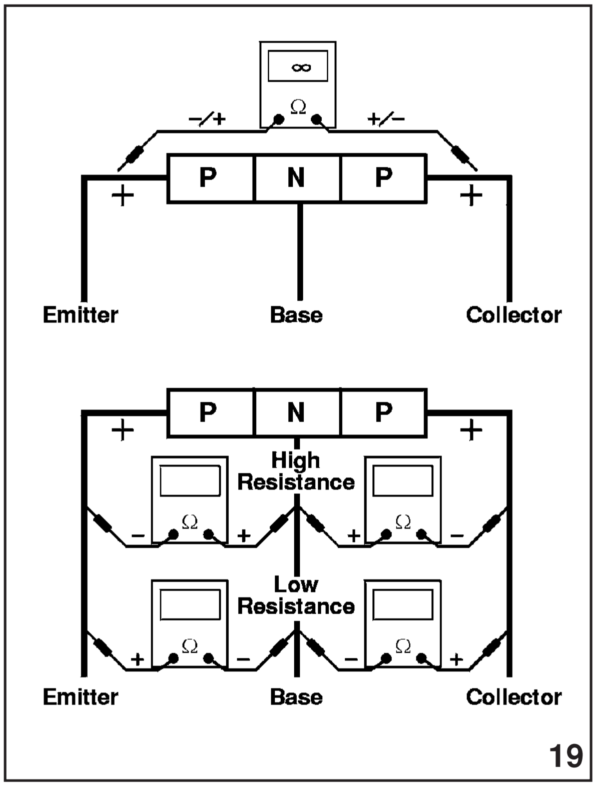
Operational control of a transistor is determined by the polarity of the base material which determines the polarity of the voltage supplied to the base. Thus, a PNP transistor operates by flooding the base material with free electrons (negative polarity). This allows the transistor to act as a switching relay, initiating current flow from the emitter to the collector. One of many applications of a PNP transistor is in the electronic ignition system.



NPN transistor

Construction and operation of the NPN transistor is similar to the PNP transistor. In this case however, the base material is flooded with holes (positive polarity) to control current flow from the emitter to the collector. The NPN transistor is often used as an amplifier in audio systems and other solid state circuits. This is the transistor which has allowed the miniaturization of electrical circuits by eliminating bulky vacuum tube circuitry.

Testing Transistors



PNP transistor testing

You may use an ohmmeter to test the operation of a transistor.

1. Always use the diode testing scale of an ohmmeter to test a transistor.
2. Test the transistor an two diodes.
   - First test the emitter to base (E-B)
   - Then test the collector to base (C-B)
3. The result will be "good" or "bad". Meter readings will vary depending on transistor type.

Ohmmeter test (PNP)

1. Connect the meter positive lead to the emitter lead of the transistor.
2. Connect the meter negative lead to the base lead of the transistor.
3. The result should be a LOW resistance reading.
   - Example: 100 ohms or less
4. Reverse the meter lead connections.
5. The result should be a HIGH resistance reading
   - Example: 5 K ohms or more
6. Connect the meter positive lead to the collector lead of the transistor.
7. Connect the meter negative lead to the base lead of the transistor.
8. The result should be LOW resistance.
   - Example: 100 K OHMS or LESS
9. Reverse the meter lead connections
10. The result should be a HIGH resistance.
    - Example: 5 K OHMS or MORE
11. Meter readings will vary depending on the transistor type.
12. A final rest includes a continuity test between the emitter and collector terminals of the transistor. Results should equal infinite regardless of meter polarity.

Ohmmeter test (NPN)

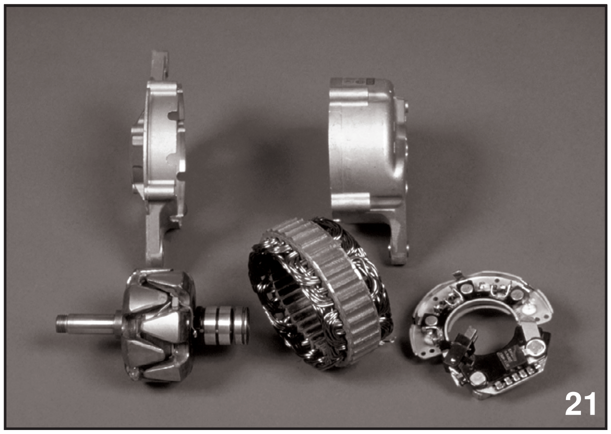
1. Reverse the lead connections in the above test steps.

NOTE: REVIEW THE TRANSISTOR LEAD IDENTIFICATION CHART SHOWN IN THIS TRB.

A voltmeter test of transistor operation is not practical in most automotive applications.

NOTE: A TRANSISTOR'S PERFORMANCE DOES NOT DETERIORATE WITH TIME OR USE.

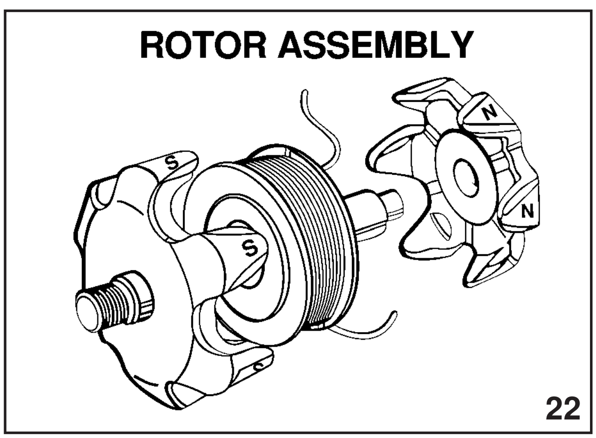
Alternators



Alternator components

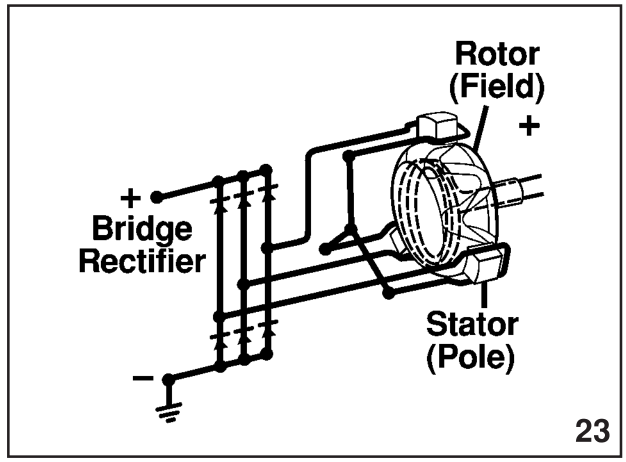
The components of a Subaru alternator are:

- Pulley
- Front cover/bearing
- Rotor (field coil)
- Stator
- Voltage Regulator
- Brush assembly
- Rectifier
- Rear cover/bearing
- Cooling fan



Alternator component operation

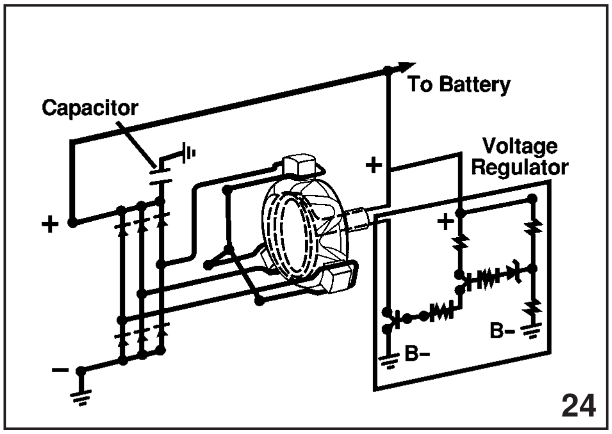
Because the field winding (rotor assembly) is lighter in weight and therefore easier to rotate, it rotates inside a stationary stator. Alternating north and south magnetic fields are created by bending the front and rear plates over the coil in a star-shaped interwoven type pattern.



Stator contruction

The standard stator design is a 3 phase "Y" configuration with three coils connected at one end. The coil of the "Y" are spaced at 120 degree intervals. Full wave rectification is accomplished through the use of six diodes, (3 positive and 3 negative). As the field coil rotates, current is induced into each stator winding, charging the winding. Negative (-) and positive (+) polarities are created at the ends of the stator winding. Each stator winding end is connected to a respective diode in the rectifier assembly. The charge in each winding causes the diode to allow charging current to flow to the battery for that period of rotation ONLY. As the field continues to rotate, it sequentially charges the remaining stator windings, causing their respective diodes to allow charging current to flow to the battery.

Four phase rectification incorporates a fourth winding which spaces the windings at 90 degrees intervals. Four phase units use 8 silicon diodes, (4 positive and 4 negative). The advantages of four phase rectification are an increase in current output and a reduction of ripple voltage output.



Capacitor operation

The capacitor maintains stator voltage between phases by charging at peak voltage and discharging as the phase voltage drops. This has the effect of smoothing the "ripple" voltage produced by the phases of the alternator. The capacitor also reduces radio frequency interference (RFI).

Solid State Voltage Regulator
The internal solid state type of voltage regulator controls voltage within a specified range (usually 14.1 - 14.8 volts). The regulator provides an "ON" and "OFF" voltage pattern to the field coil. The field coil is turned "OFF" by the regulator when the battery voltage reaches a preset level. This stops the alternator from charging. When the battery voltage drops below the preset level, the regulator charges the field coil to the maximum. The "ON" and "OFF" threshold level is determined by a zener diode that is incorporated into the regulator assembly.

Alternator Testing Precautions
Disconnect all connectors properly.

Do not ground circuits with tools.

Never lay tools on the battery.

Always disconnect the battery prior to alternator replacement.

Secure loose harness/wiring to prevent damage caused during alternator removal/replacement.

When full-fielding the alternator, never exceed 16.0 volts. Voltage levels in excess of this specification may cause damage to electrical system components.

Never disconnect the battery during an alternator test.

An alternator performance test should only be made with a serviceable battery.

Conduct an alternator performance test when any of the following conditions are present:
- The battery is dead (discharged), but holds a charge when charged. Also, the battery performance test indicates a good battery.
- The vehicle voltmeter indicates a discharging condition or the charge warning light is illuminated during normal vehicle operation.

Conduct the alternator performance test in accordance with the operator's instructions for the test equipment you are using.

Conduct an alternator charging test, a voltage regulator test, and a diode/stator test. Compare the results of the tests to the specifications listed in the appropriate MY Subaru Service Manual. Repair and or replace components as required.

Conduct a charging system requirements test in accordance with the operator's instructions for the test equipment you are using. Be sure to connect the D-Check connectors so that the fuel pump and other fuel system components operate.

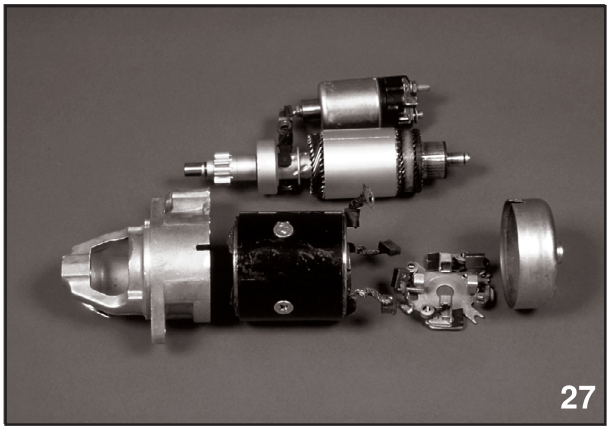
Restore the D-Check and alternator connections to the normal operating condition.

Listed in the appropriate MY Subaru Service Subaru Starting Systems.

Starters

Starter Types

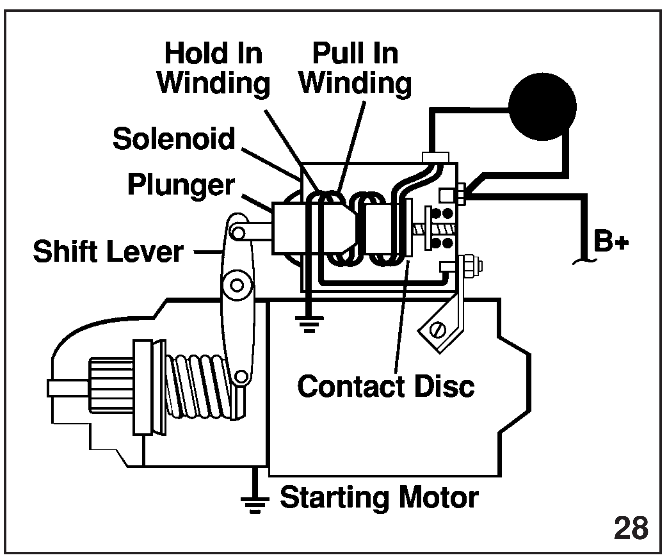
- Reduction Gear
- Direct Drive



Starter components

The components of the starter assembly are:

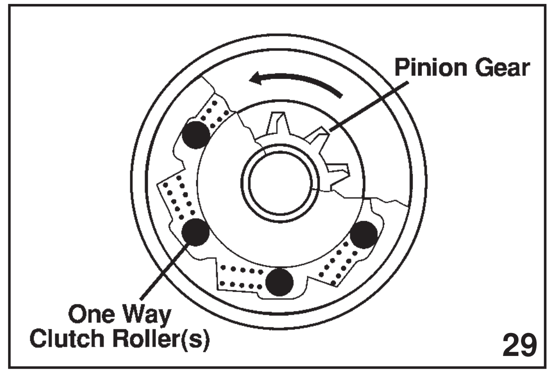
- Pinion (drive)/one-way clutch
- Armature
- Commutator
- Field shoes
- Brushes/brush holders
- End caps/bushings



Magnetic switch/solenoid

The components of the magnetic switch/solenoid are:

- Pull-in winding
- Hold-in winding
- Plunger
- Return spring
- Shift lever
- Starter motor contacts



Operation

When the ignition switch is turned to the "START" position, battery voltage (B+) is allowed to energize the magnetic switch/solenoid pull-in and hold-on coils. The field created by the coils moves the plunger which in turn moves the shift lever engaging the starter pinion with the flywheel. The movement of the plunger also activates the starter motor switch contacts. This allows B+ voltage from the battery cable to flow to the starter motor through the magnetic switch.

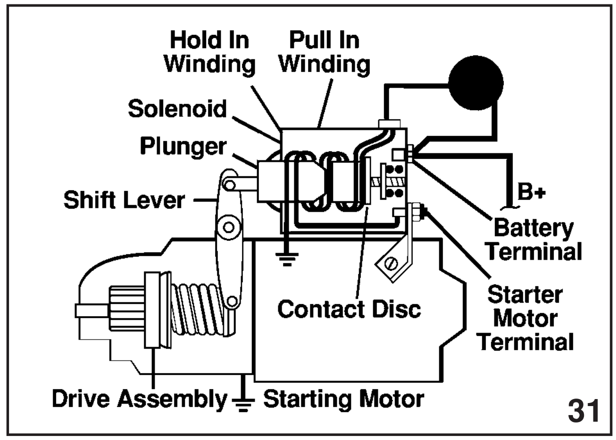
The starter rotates the pinion which rotates the flywheel to crank the engine. When the engine "starts", the one-way clutch "freewheels" to protect the starter armature and commutator from an "overspeed" condition.

When the ignition switch is released from the "START" to the "ON" position, this eliminates the flow of B+ voltage to the magnetic switch/solenoid which collapses the field. The plunger spring returns the plunger to its original position moving the shift lever which disengages the pinion from the flywheel. The plunger also releases the switch contacts and the starter motor stops rotating.

An occasional problem with starting systems is a defective hold-in winding in the solenoid. In this situation, the solenoid will "click" rapidly. This occurs because the pull-in winding moves the plunger but the hold-in winding is not energized. Since no hold-in field is created and the pull-in winding field is released as the start switch is engages, the plunger return spring returns the plunger to the pre-start position. This process repeats and the plunger moves back and forth rapidly. This action will momentarily engage the flywheel, and occasionally may rotate the flywheel enough to start the engine.

NOTE: THESE SYMPTOMS ARE SIMILAR TO THOSE CAUSED BY A DEFECTIVE BATTERY OR BATTERY CONNECTIONS. THEREFORE, A BATTERY PERFORMANCE TEST, AND AN INSPECTION OF THE BATTERY CONNECTIONS MUST ALWAYS BE PERFORMED PRIOR TO TROUBLESHOOTING THE STARTER SYSTEM.

Starter/Solenoid Testing Procedures



Magnetic switch/solenoid

Use an ohmmeter to test the pull-in and hold-in windings. Always refer to the appropriate MY Subaru Service Manual, Section 6-1.

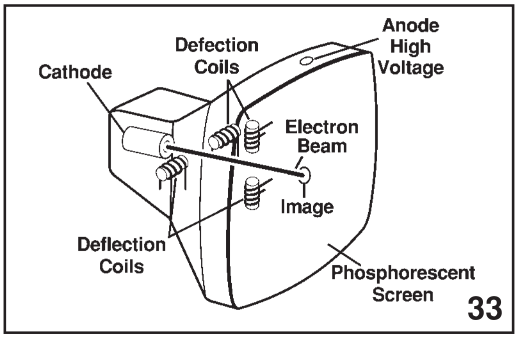
Use a voltmeter to conduct a starter motor test for intermittent operation. Complete the following steps:

1. Connect the voltmeter leads to the starter motor terminal and to a ground.
2. By-pass the solenoid by connecting a jumper cable from the solenoid B+ terminal to the solenoid starter motor terminal. This spins the starter, but dies not engage the magnetic switch/solenoid.
3. If there is a steady voltage reading the starter motor components are OH.
   - Brushes
   - Commutator
   - Armature

4. A variable voltage reading indicates a problem in:
   - Brushes are arching
   - Commutator is dirty or has a defective segment
   - Armature is open or has a shorted winding

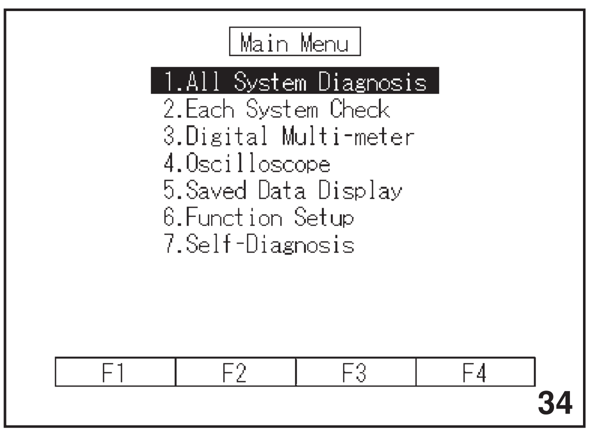
Finally, be sure to test all cables using the voltage drop method.

Oscilloscope Testeing and Diagnosis

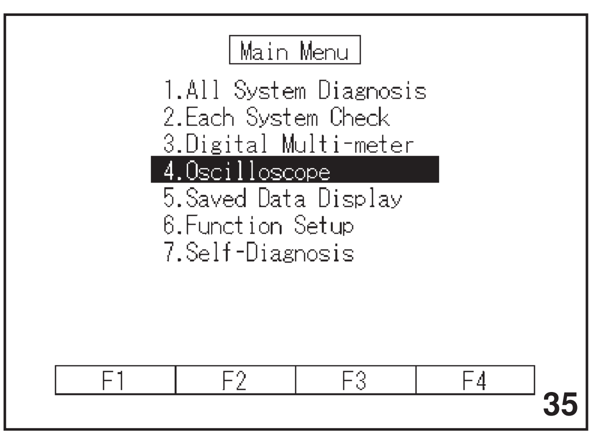


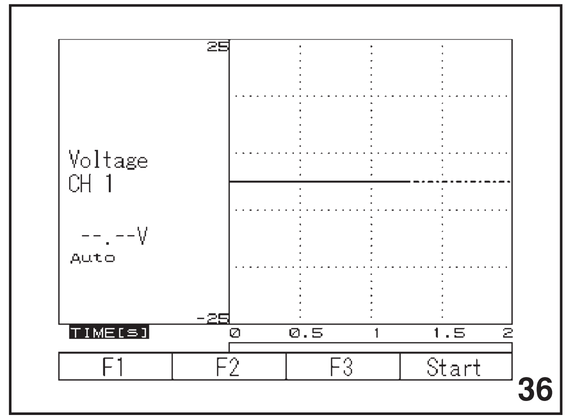
Ocilloscope CRT

Oscilloscope usage during diagnostics can help with finding intermittent or unusual problem conditions

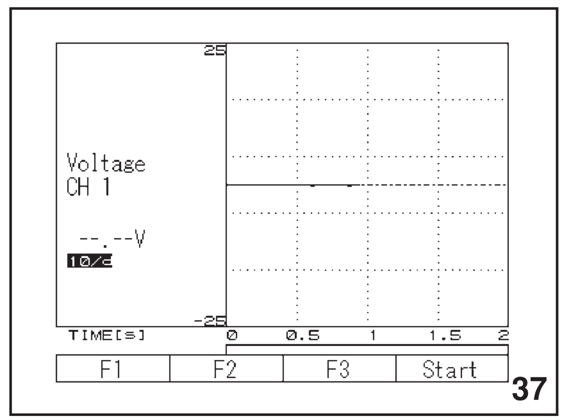


An Oscilliscope function is included on the Select Monitor. From the main menu cursor over item "4. Oscilliscope." Press the "YES" key.





This will give you one or two channel operation.



Press the F3 range key to adjust the voltage per division or cursor down to the TIME[s] and adjust the seconds or milliseconds per division.

Many other features are included for the Select Monitor Oscilloscope and your instructor will guide you through them in the lab section of this module.

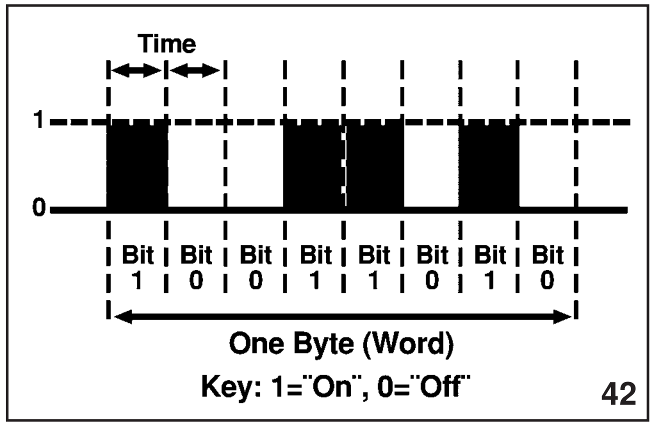
Computer Terminology and Operation

Computer Hardware
Automotive computer hardware is the electronic and tangible componentry used for its operation.

a. The CPU (central processing unit) is the area in which all arithmetic and logic decisions are calculated/computed.
b. The address register is similar to a file cabinet. It is where the computer sets up unique file locations to store data in the memory.
c. The data register is used by the CPU to "read" and "write" information to/from the memory files.
d. The ROM (read only memory) contains information that is programed into the computer during the manufacture of the computer. These operating commands cannot be changed or updated.
e. RAM (random access memory) is where information is continually updated by the inputs from the various engine sensors. The RAM is often called the "scratch pad" of the computer.

Computer Software
The software consists of the programs and data used by the computer to perform specific tasks.

a. The PROM (programmable read only memory) is information programed into the computer "chip". It contains the operating characteristics of a specific model or engine family and can be added to the computer during vehicle assembly to "fine-tune" vehicle operation.
b. The EPROM (erasable programmable read only memory) is similar to the PROM in operation. Information can be:
   - Erased under ultra-violet light.
   - Reprogrammed to a new set of values.



Terminology
BIT (binary digit) This is the smallest unit of information in the binary system used by the computer. The computer uses binary numbers to build letters, numbers, and other characters used to record and display information.

The only binary numbers generated and used by the computer are either zero ("0") or one ("1"). Zero equals power "OFF", and one equals power "ON". Switching the power "ON" and "OFF" to specific circuits in the computer, codes the information that is entered or displayed. It requires 8 BITS or 8 binary digits to equal 1 BYTE.

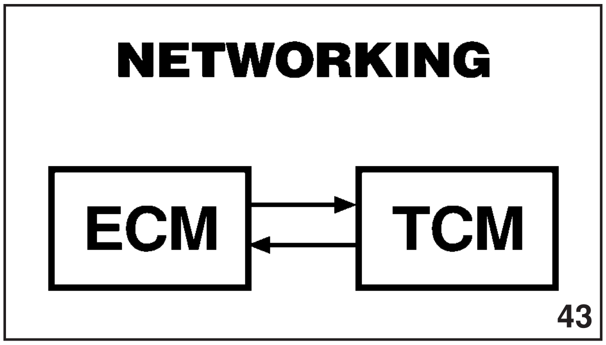
BYTE (binary element string)

A BYTE is equal to 1 character, such as the letter "a". Therefore a BYTE contains a combination of eight "1's" or "0's" (BITS).

Example: 1 0 0 1 1 0 1 0

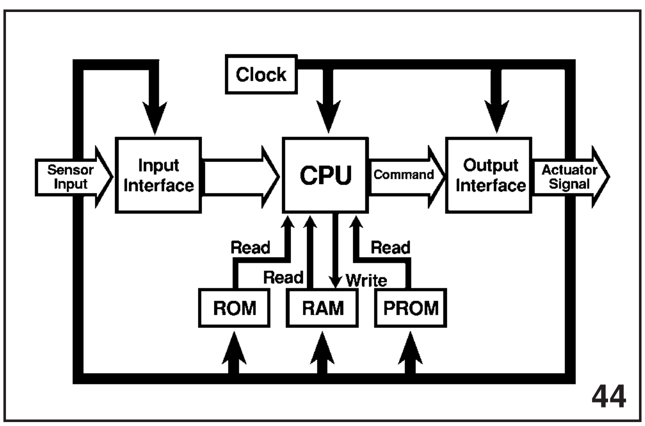
"K" = 1000 or kilo (as in metrics). This term is used to indicate toe amount of memory space available in a computer. If it has 32K BYTES, then it can store 32,000 characters in its memory.

Mega hertz (Mhz) This term defines the processing speed of the computer in millions of cycles per second.



Handshaking

This term refers to the exchange of predetermined information that establishes a connection between two or more computers. Without handshaking one computer would not be able to understand another computer's data input and vice-versa. The ROM's initiate the connection while the RAM sections exchange information. This process is also called networking.



Computer operation

The CPU sends an information request to the ROM (memory) over the address buss line (connecting wires) to the address register. The CPU then temporarily stores this information in the CPU register while it compares the information to data stored in the RAM. The RAM data is the inputs received by the computer from the various vehicle sensors.

When the data in the CPU register matches the data in the RAM, no action is required. If the data in the CPU register does not match the data in the RAM, the CPU generates a command signal to the appropriate device to alter vehicle or specific component operation.

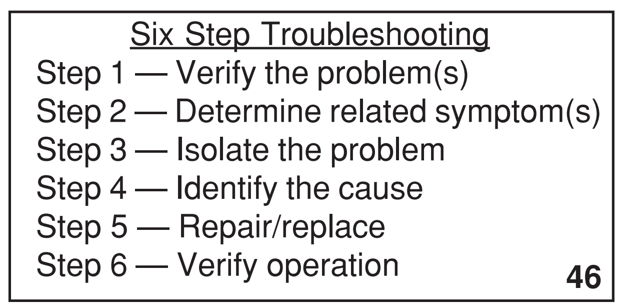
- Example: The O2 sensor voltage is too high and the fuel mixture is too rich. The response is that the computer narrows the fuel injection pulse width.

If the data received is illogical to or from the computer, the computer generates a fault code.

All information, both to and from the CPU is resented almost simultaneously. However, it is synchronized by an internal clock. The clock also controls the overall processing speed of the computer. Speed is measured in mega hertz

(Mhz), which equal millions of cycles per second. During networking the clock pulse will determine which computer is sending and which computer is receiving.

Troubleshootingn Diagnosis of Intermittent Faults



NOTE: REFER TO THE SUBARU BASIC ELECTRICAL THEORY & DIAGNOSIS MODULE, STEP 10 FOR ADDITIONAL INFORMATION CONCERNING THE SIX STEP METHOD.

Intermittent Faults

Thermal and Mechanical

1. Thermal intermittent
    - This type of problem occurs most often in solid state devices, connectors, switches, etc. Usually as the operating temperature of a component increases, it causes an expansion of the material which causes the circuit to "OPEN". Current flow stops, the material cools and contracts, and restores circuit operation.

2. Mechanical intermittent
    - This is caused by a component or connection bending or shifting during normal vehicle operation.
    - You may sometimes solve intermittent problems using the following strategies:
        - Use a hair dryer to heat a component or connection to simulate a severe operating failure condition which you believe to be heat related.
        - Mist water on a malfunctioning component to determine if heat is causing the problem. This simulates a cooler operating temperature.

NOTE: DO NOT MIST COMPONENTS THAT CANNOT TOLERATE MOISTURE. MAY CAUSE DAMAGE TO THE COMPONENTS.

- Use a component cooler which will quickly cool solid state components without damage to the components. This method will identify intermittent diode or transistor problems because the component will usually malfunction when cooled quickly.

NOTE: DO NOT USE FREON WHICH CAUSES DAMAGE TO THE ENVIRONMENT!

- Jumper leads may be used to bypass connectors, switches, and cables to check an intermittent problem.

NOTE: DO NOT UNDER ANY SITUATION BYPASS A FUSE OR CIRCUIT BREAKER. SEVERE DAMAGE TO THE VEHICLE AND POSSIBLE PERSONAL INJURY MAY OCCUR.

Select Monitor Usage

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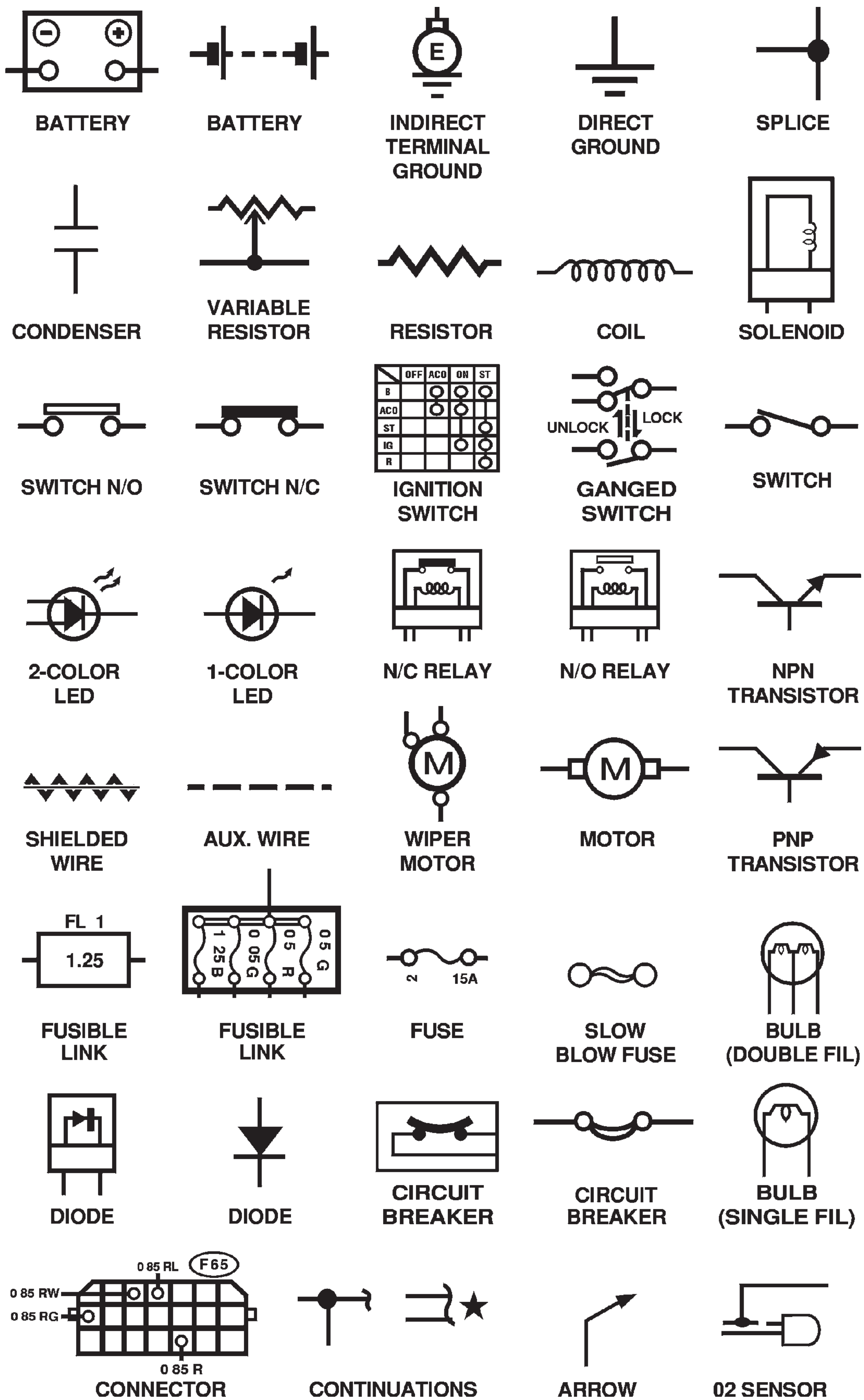
Select monitor

The select monitor allows a review of the actual information processed by the computer. For instance, thermosensor input is displayed as the actual temperature of the coolant. You can then compare the select monitor coolant temperature reading with the actual coolant temperature to determine possible sensor problems. (With a cold engine, the coolant temperature should be equal to the ambient air temperature).

Likewise, computer outputs may also be checked: The select monitor will display the computer output to a system component such as the fuel injector. This signal (injection pulse width) is displayed in milliseconds. We know that thermosensor input will effect injection pulse width. With increased coolant temperature, injection pulse time (duration) should be reduced and the fuel mixture should become leaner. With decreased coolant temperature, injection pulse time should increase and the fuel mixture should become richer. No change in the select monitor injector signal could indicate thermosensor circuit problems.

NOTE: REFER TO SELECT MONITOR INTROCUCTION VIDEO REFERENCE BOOKLET MSA5AV148B AND THE APPROPRIATE MODEL YEAR SERVICE MANUALS FOR DETAILED SELECT MONITOR INFORMATION.

Electrical Symbols



Electrical Terms Glossary

Alternating Current (AC)
an electric current which constantly changes polarity from positive to negative, (or an electric current that reverses its direction regularly and continually).

Direct Current (DC)
an electric current which flows in one direction only.

Sine Wave
a wave that alternately moves between a positive and a negative value over an equal length of time

Square Wave
a square or rectangular-shaped wave that alternately assumes a "ON" or "OFF" mode. The length of the "ON" time compared to the "OFF" time indicates a "duty ratio".

Resistance
Property of an electrical circuit that tends to prevent or reduce the flow of current.

Dynamic Resistance
Effect of a resistor or resistance in a circuit.

Voltage Drop
The difference in voltage between one point in a circuit and another, or the difference in measured voltage from one side of a component to the other side.

Resistor
Device that permits a predetermined current to flow aat a given voltage. Examples are a SPFI ballast resistor and a 4EAT dropping resistor.

Rheostat
See Variable resistor.

Variable Resistor/Rheostat
a device that adjusts the amount of resistance required. An example is a sliding contact resistor. The position of the contact determines the amount of resistance. The fuel sending units of a vehicle equipped with an analog dash use a variable resistor.

Potentiometer
A resistive element with a sliding wiper contact that is used in applications in which a division of resistance is required (such as a three-terminal adjustable resistive divider). Example: The throttle sensor on SPFI and MPFI fuel systems.

Splice
Joining of two or more conductors at a single point.

Terminal
Device attached to the end of a wire or cable to make an electrical connection.

Ground/Chassis ground
Negative side of a complete circuit. In automotive applications the negative side of the battery or any wire connected to the engine, frame, or body sheet metal.

Relay
Electromagnetic switching device using low current to open or close a high-current device.

Solenoid
an electromagnetic device consisting of a tubular soil of wire containing a core that moves when the coil is energized. Movement of the core can open/close a circuit. A solenoid converts electrical energy to mechanical energy.

Filament
A fine high resistance wire or thread which glows and produces light when current is forced through it.

Diode
solid-state device that permits current to flow in one direction only; performs like a one-way check valve.

Transistor
Solid-state semiconductor that is a combination current amplifier and switch (similar to a solenoid in the starter circuit or a relay in function). It uses low control current to channel high current.

Capacitor (Condenser)
Device used to store an electrical charge.

Notes:

SUBARU

Technicians Reference Booklet

Automatic Transmissions (4EAT)

Module 302

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of February 2001.

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Introduction

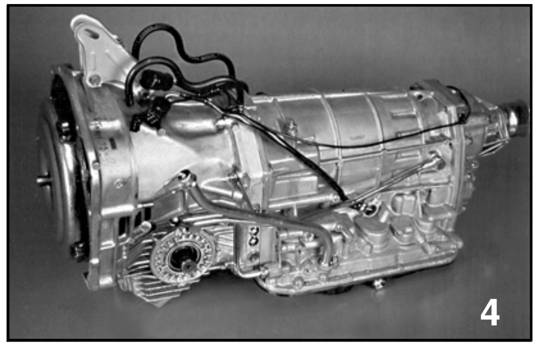
This Technicians Reference Booklet introduces the first generation of Subaru Four Speed Electronic Automatic Transmissions. It covers the components and their operation, its self-diagnostic system, troubleshooting, transmission removal, inspection, reassembly, and reinstallation procedures. The differences between the front-wheel-drive (FWD) and the four-wheel-drive (4WD) transmissions are also illustrated.

This booklet is designed to support the 4EAT Transmission Core Course and in no way should it be used to replace the service manual. The text and illustrations are derived from classroom instruction and lab participation.

Ample room has been left throughout the booklet for note taking. It is recommended that after completing the course, this booklet should be filed in your personal **Technical Training Reference Booklets Binder**, which is sold through Subaru of America Parts department (MSA5T0100B).

ALWAYS refer to the appropriate model year Subaru Service Manual and applicable service bulletins for all specifications and detailed service procedures. For your convenience, a service bulletin and Service Help Line Update index pages have been added to the back of this booklet.

General Overview


4

The 4EAT Transmission, is a 4 speed, microprocessor controlled transmission. It is not a 3 speed Transmission with overdrive. It features a lock-up torque converter, which locks up in all forward gears except 1st. It is available in FWD or Full Time 4WD.


5

The shift quadrant has been designed in accordance with the four forward speeds. In P, R, or N, there aren't any special features. With the selector in "D", the transmission shifts through all four gears. With the selector in "3", the transmission shifts 1, 2, 3. When the selector is in the "2" position, the transmission shifts through 1st and 2nd. If necessary, 3rd gear is computer selected to prevent the engine from over-revving.

Manual 1st gear is only activated when the 1-HOLD button is depressed and the shifter is in manually selected "2". This will provide engine braking. The transmission will up-shift through 2nd and 3rd if necessary, in order to prevent the engine from over-revving.

The 1-HOLD indicator is displayed on the combination meter when the button is activated. When the computer overrides the 1-HOLD gear selection the display will change.

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An enhanced version of the 4EAT was introduced with the 1990 MY Legacy. Although similar in design to the existing 4EAT, the shift quadrant is different. The Legacy 4EAT has a seven-position quadrant: P-R-N-D-3-2-1. The 1-HOLD button has been deleted and a manual button has been added.

When the selector is in 3rd range, manual switch “ON”, the transmission will start in 2nd gear and shift to 3rd. In 2nd range manual, the transmission starts and stays in 2nd gear, but will up-shift to 3rd gear at 6500 RPM to prevent damage to the engine. In 1st range manual the transmission stays in 1st gear and also will up-shift to second at 6,100 RPM to prevent damage to the engine. Additionally, on 4WD vehicles, the TCU applies a more aggressive 4WD map when the selector is in the 1st position, manual switch “ON” or “OFF”. These changes result in improved drive ability on low friction road surfaces.

In 1995 the manual button was deleted. 3 select, shifts 1st, 2nd, and 3rd. 2 select, shifts 1st, 2nd. 1st select, stays in 1st. 1995 through 1998 model year vehicles the TCU controlled up-shift logic was replaced by a fuel cut logic.

The 1993 Impreza was introduced with fuel cut logic, never having an auto up shift logic.

1992 through 1997 SVX used the same shift logic as the 1990 through 1994 Legacy. Retaining the Manual button until production of the vehicle was discontinued in 1997.

GEAR RATIOS

1st	2.785
2nd	1.545
3rd	1.000
4th	0.694
REV	2.272

Final Drive: 3.70:1 or 3.90:1

Legacy Final Drive: 4.11:1 4WD
3.70:1 FWD

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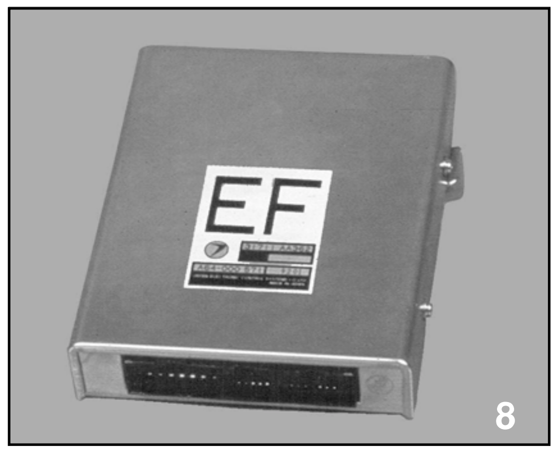
Refer to Service Manual for specific model gear ratios.



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The TCU monitors various engine and vehicle inputs, i.e., throttle position and vehicle speed, etc. It also controls the electronic shift solenoids in the transmission. Refer to the appropriate MY service manual, section 6-3 for the location of the TCU.

Features

TRANSMISSION FEATURES

- Lock-up Torque Converter
- Variable Displacement Oil Pump
- Double Planetary Gear Set
- Multi-Plate Transfer Clutch (4WD)
- Electronic Control System

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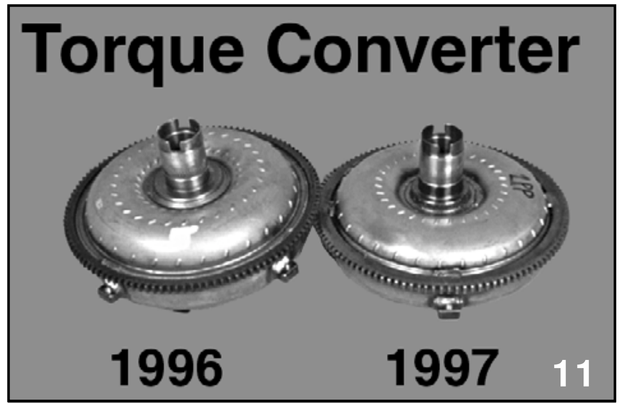
The 4EAT features a double planetary gear set, a lock-up torque converter, and variable displacement oil pump. The 4WD system includes a Multi-Plate Transfer Clutch (MPT).

The electronic control system is designed to reduce shock during shifting, improve driving performance, and improve fuel economy. A self-diagnostic system is incorporated in order to improve serviceability and reliability.

The electronically controlled Multi-Plate Transfer (MPT) System provides for controlled transfer clutch torque. It is designed to slip in order to eliminate torque bind on cornering.

Shift control cable is a push pull type. Allowing for a compact operating area and quiet operation.

Major Components



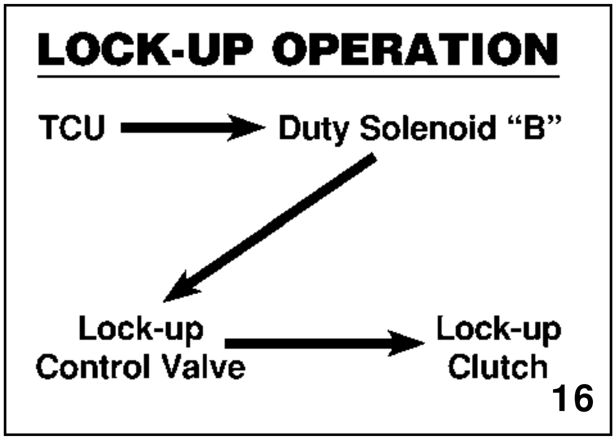
Lock-Up Torque Converter

The torque converter developed for the 4EAT is designed to match a wide range of engines from large to small displacement. It is also designed to improve acceleration from a stop and reduce fuel consumption.

1997 model year turbine shaft was redesigned as a result of a torque converter change. The new shaft has 23 splines' verses 22 splines.

The torque converter has an electronically controlled, hydraulic lock-up clutch system that prevents slip loss during medium to high-speed operation. This system replaces the previous centrifugal lock-up type clutch.

There is a friction surface on the back of the lock-up clutch (piston) which locks against the back of the impeller housing. Clutch engagement shock is minimized in part, because of the torsional clutch dampers and the wave spring/friction washer combination.



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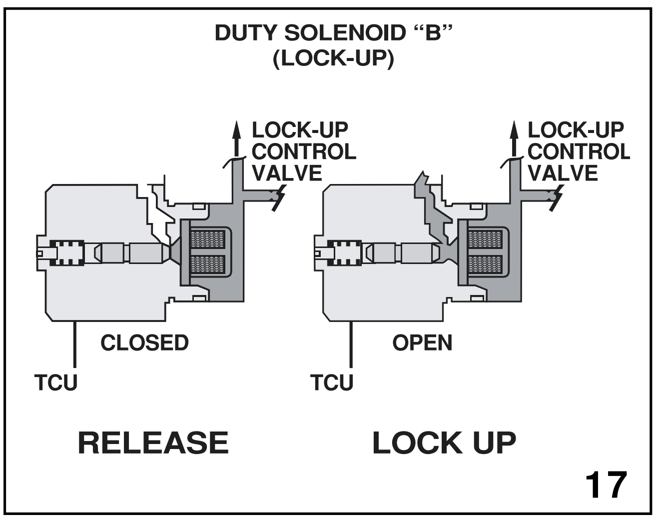
The lock-up operation is controlled by the TCU which then regulates Duty Solenoid "B" mounted on the lower valve body. This solenoid provides control of the lock-up valve located in the transmission upper valve body. Finally, the lock-up valve activates the lock-up clutch (piston) located in the torque converter.

Lock Up Operating Modes



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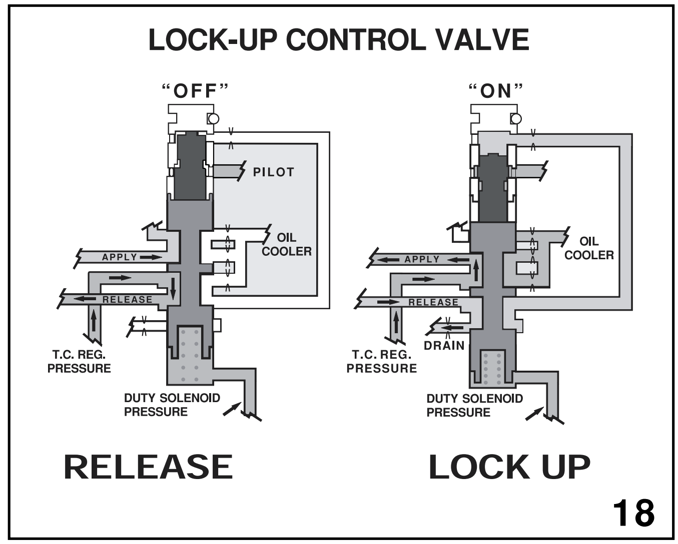
The TCU regulates the cycle of Duty Solenoid "B". When the duty solenoid operates at 5% duty, i.e., substantially more "OFF" than "ON", pilot pressure is directed to the lock-up control valve.

When Duty Solenoid "B" operates at 95% duty, i.e., substantially more "ON" than "OFF", it reduces pilot pressure to the control valve.



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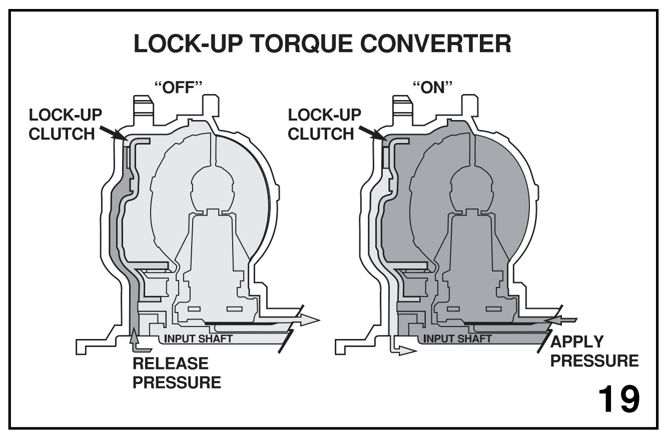
In this condition, the control valve is pushed UPWARD by the combined pilot pressure and spring force. This allows regulated hydraulic pressure to enter the lock-up release circuit.

In this condition, the control valve is pushed DOWNWARD due to the reduced pilot pressure. As a result, regulated hydraulic pressure is directed to the lock-up apply circuit and the release circuit drains.



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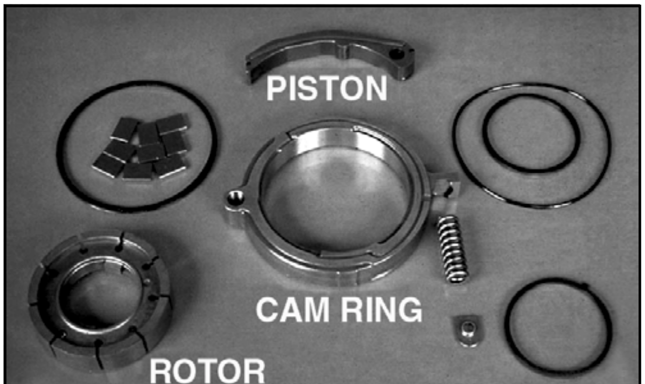
The release pressure then pushes the lock-up clutch (piston) rearward and the lock-up clutch is released from the impeller cover. On the other hand, oil drains through the apply circuit to the oil cooler in the radiator.

The apply pressure then pushes the lock-up clutch (piston) forward which engages the lock-up clutch with the impeller cover. When engaged, the transmission is coupled directly to the engine.

Oil Pump Assembly

A variable rate vane type pump is used for optimum flow rate control with minimum energy loss. In addition to pressurizing the oil, the pump provides lubrication oil for the torque converter, the valves, the clutches, low / reverse brake and the band.



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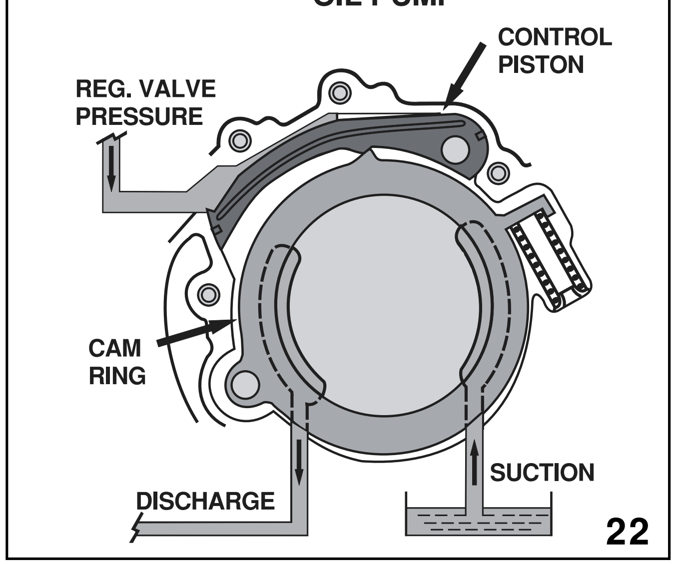
The pump consists of the following components:

1. Rotor
2. Vanes
3. Control Piston
4. Vane Rings
5. Cam Ring
6. Return spring
7. Seal Ring
8. Oil Pump Cover

NOTE: THE ROTOR, VANES, CAM RING AND CONTROL PISTON ARE ALL SELECTIVE.

The pump rate is variable because of the cam ring eccentricity. The eccentricity is adjusted automatically corresponding to pressure from the regulating valve acting upon the control piston.



22

Oil Pump Operation

During low speed operation, filtered ATF is drawn into the pump suction port. The pump is driven directly at engine speed and the ATF is then compressed by the rotor vanes and discharged through the delivery port in the oil pump cover. The pressurized ATF then flows to the rest of the transmission case.

During high-speed operation, as the engine speed increases, the delivery rate normally increases. However, feedback pressure generated from the regulator valve is applied to the control piston, which pushes down the cam ring. This changes the relationship between the cam ring and the rotor. In this way, the pump delivery rate remains at a constant value.

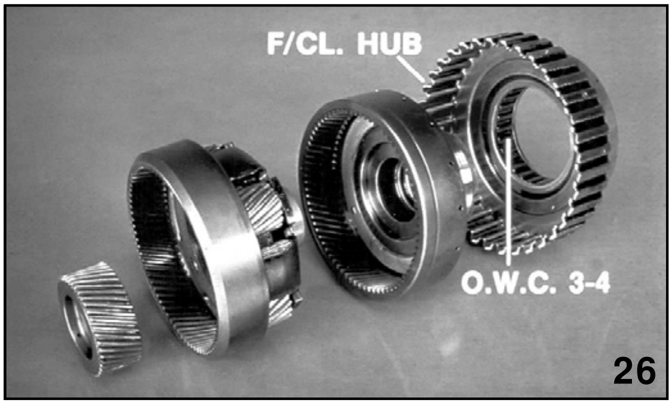
Cases were modified to prevent flexing of the line pressure passage. This condition could cause a gasket failure and reduced line pressure. As a result damage to the high clutch and reverse clutch plates would occur.

Transmission Gear Train

This compact unit features, a double planetary gear set. It has a wide ratio between gears for improved fuel efficiency as well as high performance.

Operating Principles: Rear Gear Set

The input shaft always powers the rear sun gear. The rear planetary carrier (front internal gear) always transmits power to the output shaft.



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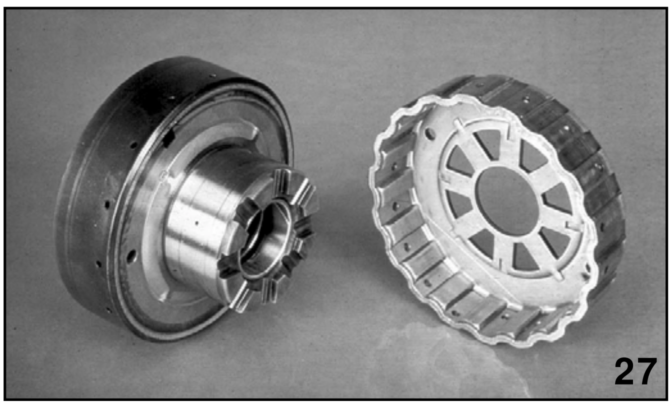
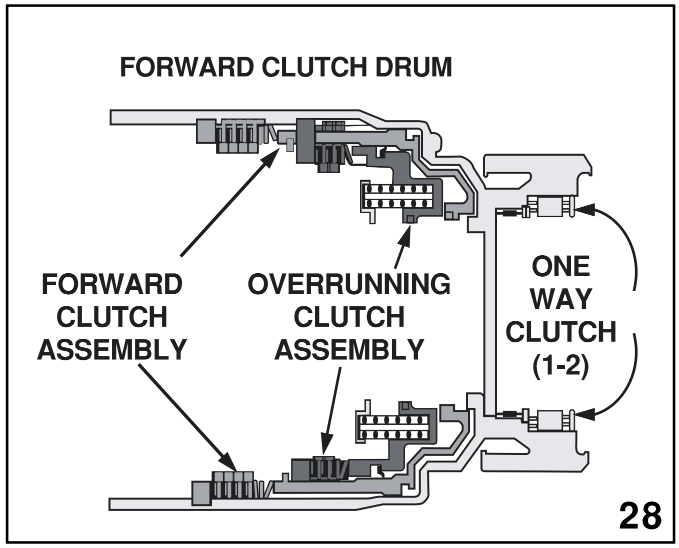


27

The one way clutch (O.W.C.) 3-4 prevents the rear internal gear from turning counterclockwise. Its inner race is the rear internal gear and its outer race is the forward clutch hub. The overrunning clutch hub is also connected to the rear internal gear by dogs.



28

The forward clutch connects the rear internal gear to the front planetary carrier (splined to the forward clutch drum) through the O.W.C. 3-4. The overrunning clutch is also used to connect the rear internal gear to the forward clutch drum and the front planetary carrier.

The O.W.C. 1-2 (Sprague) prevents the forward clutch drum from rotating counterclockwise. The sprague is applied when the transmission is operating in D-1 or 3-1.

The Low/Reverse brake is splined to the case. It holds the forward clutch drum in order to prevent it from turning when the transmission is in Reverse, 2-1, and 1-HOLD.

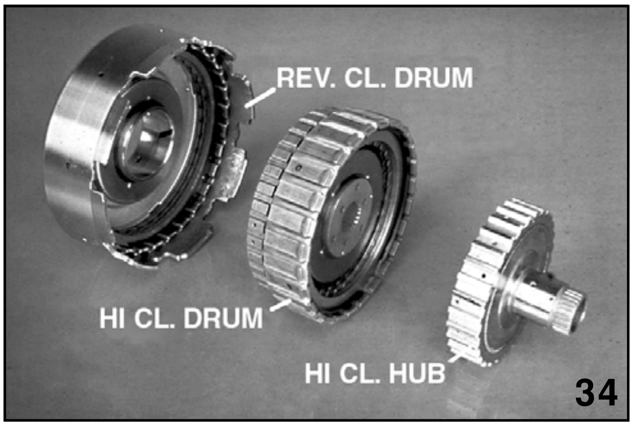
The overrunning clutch provides engine braking during deceleration except in D-1 and 3-1.

The O.W.C. 3-4 is used in 1st, 2nd, and 3rd gears. The forward clutch is used in all forward gears.

The rear internal gear is controlled by the forward clutch through the O.W.C. 3-4. Additionally, the rear internal gear is controlled by the overrunning clutch. Functioning as an input member in 3rd. Fixed member in 1st and free member in reverse.

High Clutch and Reverse Clutch

The high clutch drum (reverse clutch hub) is splined to the input shaft. It supplies power to the reverse clutch and the high clutch. The high clutch hub is splined to the front planetary carrier. When the reverse clutch is applied for Reverse gear it powers the front sun gear. When the high clutch is applied in 3rd and 4th gear it powers the front planetary carrier via the high clutch hub.



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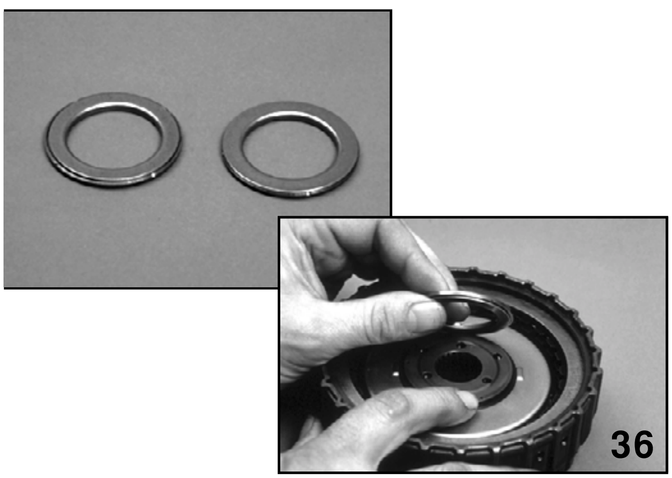
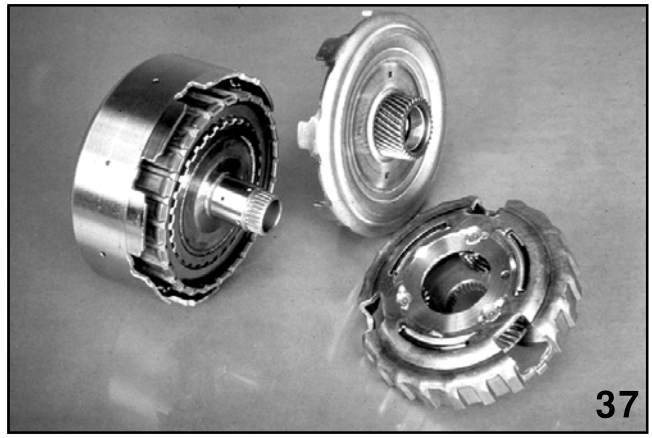
Lubrication holes for the high clutch bearing were changed from the original, with 3 – 1mm holes. The second version had 3 – 1.5mm holes. The third and final version has 6 – 2mm holes.


36

The high clutch bearing race was modified to improve lubrication. Race width was reduced to work better with the enlarged lubrication holes (the bearing on the left pictured above has the modified race) of the high clutch. Bearing position is critical when installed.

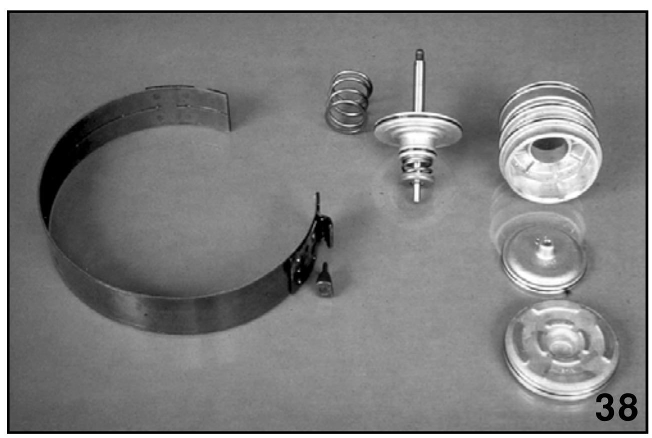
Operating Principles: Front Gear Set


37

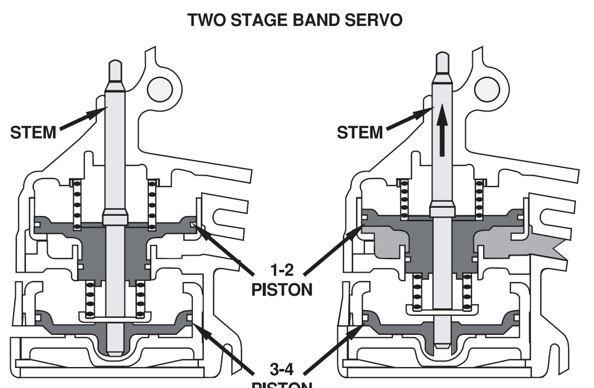
The front sun gear is dogged to the reverse clutch drum. It functions to be the main input member in reverse, never used as an output member. It serves as a fixed member in 2nd & 4th gear. Is a free rotating member in 1st & 3rd gear.

The front planetary carrier is splined externally to the high clutch drum. It functions, as an input member in 3rd & 4th, never used as an output member. It serves as a fixed member in 1st & reverse. And a free rotating member in 2nd.

Band Servo Operation


38

The band is applied in 2nd and 4th gears by a two-stage servo, which is controlled by accumulators.



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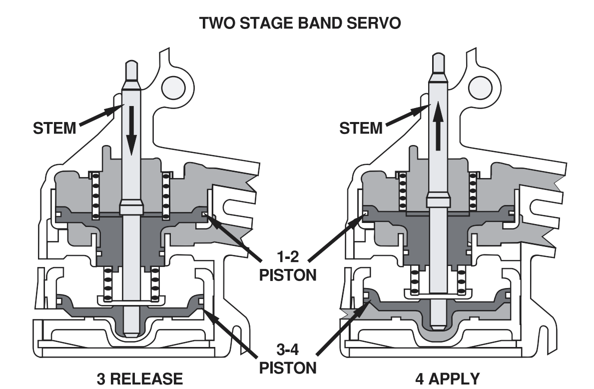
In order to obtain second gear the servo is in the 2-Apply mode. Hydraulic pressure from the 2A accumulator pushes the 1-2 piston UPWARD, which tightens the band.



40

For third gear, the servo is in the 3-Release mode. In this case, hydraulic pressure from the 3R accumulator aided by the return spring pushes the 1-2 piston DOWNWARD in order to release the band.

For fourth gear 4-Apply mode, hydraulic pressure from the 4A accumulator pushes the 3-4 piston UPWARD in order to apply the band.

Operating Principles: AWD

Transfer Clutch Assembly (AWD)

The transfer unit consists of a hydraulic multi-plate clutch and a hydraulic control system incorporating a duty solenoid. It is housed in the extension case at the rear of the transmission. A caged needle bearing supports the clutch on the reduction drive shaft and a ball bearing supports the clutch in the case.

Duty solenoid “C” regulates the MPT clutch. It is controlled by the TCU, which determines the degree of AWD by altering the duty ratio. As the duty ration increases the amount of AWD decreases.

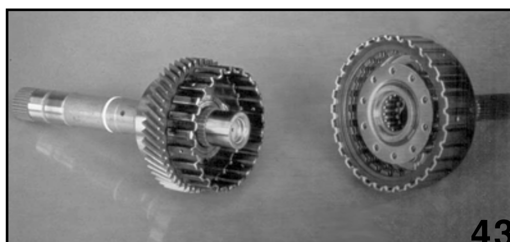
The clutch itself features friction discs that are designed to slip. This eliminates torque binding during tight cornering. In order to get power to the front wheels; the reduction gear powers the reduction driven gear, which is attached to the drive pinion shaft.

AWD component details

For the rear wheels, power goes from the reduction drive shaft to the MPT clutch hub, which is welded to the drive gear. The power is transferred through the MPT clutch where it outputs to the rear drive shaft.

Reduction shaft seal rings direct fluid from the hollow shaft to the lubrication circuits inside the transmission.

Beginning in the 1990 model year a new transfer piston was added. This improved torque split control, preventing the MPT clutch from further applying during high speed driving. Cancels centrifugal pressure buildup affect, behind the clutch apply piston.



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Transfer clutch hub is welded to the reduction drive gear. Bringing power into the MPT clutch assembly.

The reduction shaft seal rings direct fluid from the hollow shaft to the lubrication circuits inside the transaxle.

The plug on the end of the shaft has a small hole for maintaining lubrication pressure and directing lubrication oil to the clutch drum caged needle bearing.

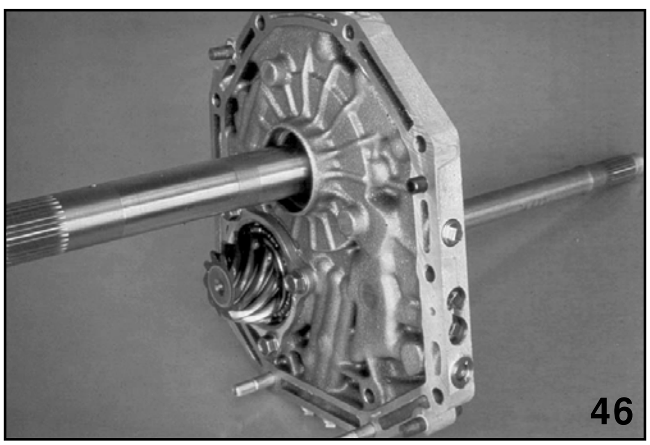
The transfer clutch drive and driven plates are sold as a set. The plates are “broken in” as part of the manufacturing process. It is necessary to keep in specific order they are packed when installing them into the old drum. Also to order the correct set you must measure the existing clutch pack clearance selective plate.

Final Drive

The hypoid gear set is mounted in the aluminum torque converter case. Supported by tapered roller bearings. Differential carrier housing has removable stub axle shafts. The pinion is mounted through the oil pump housing.

Oil Pump Housing Features

The housing is made of cast iron for greater rigidity. Double taper roller bearings are used to support the pinion. This allows for the thermal expansion of two dissimilar metals: aluminum and cast iron. These bearings also improve the durability and reliability of the unit. The bearings are preloaded by a locknut, which allows for easy serviceability.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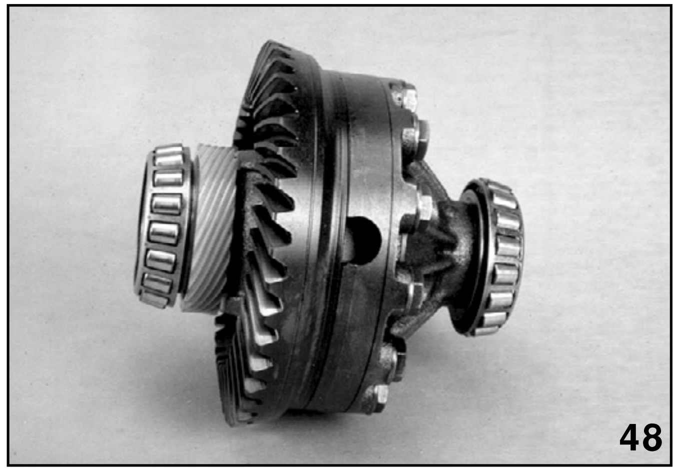
Pinion depth is set by shims, which are located between the bearing flange and the oil pump housing.

A double-lip oil seal separates transmission fluid from the hypoid gear oil. This greatly improves the fluid system reliability.

Differential Carrier Features

The ring gear is mounted on the right side of the carrier. This design adds to its compactness and makes it easier to service. The backlash is easily adjustable through the carrier bearing retainers.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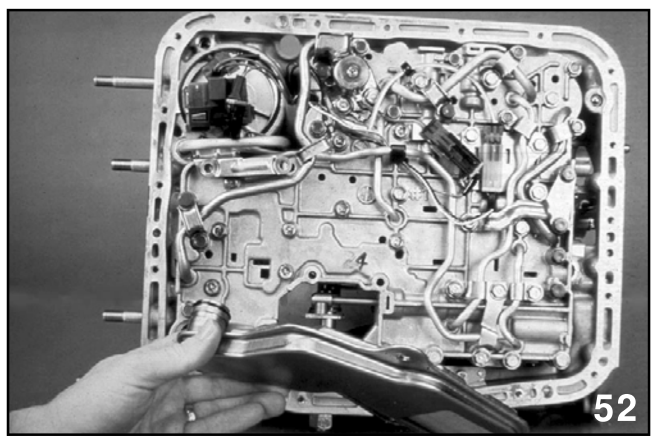
Hydraulic Control System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Valve Body

The valves and solenoids control the lubrication circuits, the lock-up torque converter, shifting, etc.

The valve body is divided into two major sections: upper and lower.

The valve body works in conjunction with the TCU. It is designed to provide smooth shift control and component longevity. It also reduces unnecessary high pressure in certain instances. As an example, line pressure is lowered between shifts.

The valve body features shift step control. This means that gear members are momentarily applied between shifts it allows them to be brought up to speed, which reduces shock.

Accumulators

There are four accumulators mounted in the transmission case:

- 4-Apply (4A)
- 2-Apply (2A)
- 3-Release (3R)
- Neutral/Drive (ND)

They are designed to lessen shift shock by absorbing the sudden pressure change generated when a circuit is activated. This ensures smooth component application. The accumulator resistance will vary in direct proportion to the line pressure.

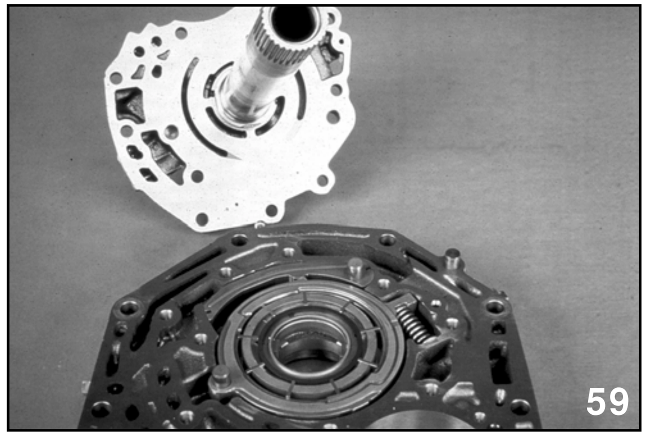
Accumulator Operation

Accumulators normally operate at a fixed rate in other automatic transmissions. Therefore, as the transmission pressure rise, the accumulator cannot further compensate due to the constant value of the spring. Pressure shocks are thus transferred to the components.

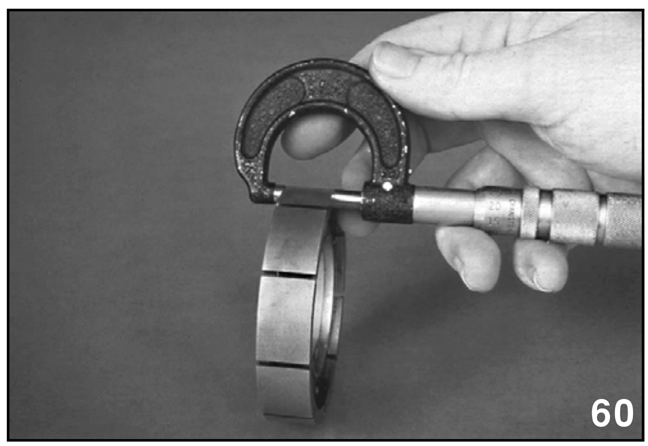
In the 4EAT Accumulators, however, the line pressure is applied to the back of the accumulator piston. Therefore, the resistance to pressure is proportionally increased hydraulically. This keeps the pressure shock under control, allowing smoother component application.

An additional accumulator is located in the lower section of the valve body, next to the manual valve. It absorbs line pressure pulses created by the sudden changes in the pressure.

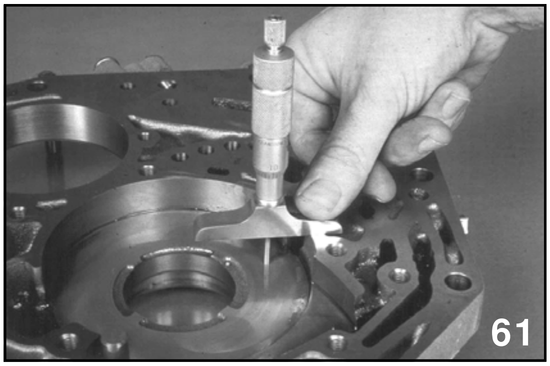
Component Disassembly / Inspection



In order to inspect the oil pump assembly, remove the pump cover and then lift out the pump components. Examine the piston and cam ring seal. Check the rotor, piston, vanes, and cam ring for cuts, gouges, etc. Replace any components that show evidence of excessive wear or damage.



Measure the pump components in at least four positions in order to maintain correct component to housing clearance.

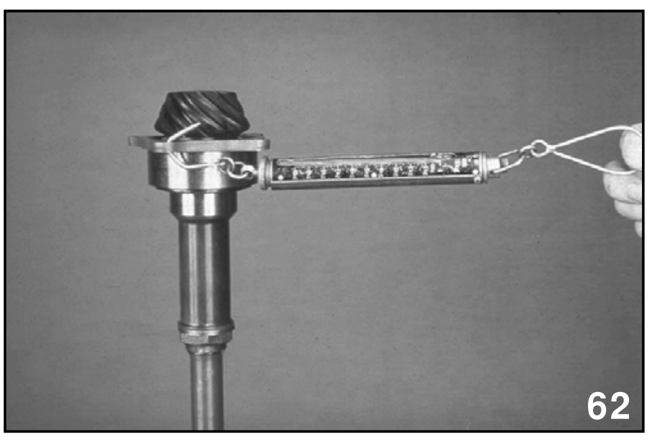


Measure the oil pump housing depth in several places. Then subtract the readings from the previous measurements. Finally, check the wear limits in order to determine the proper clearance when installing new components. Select vanes, which are the same height as the rotor.

NOTE: SHOULD THE ROTOR OR VANES REQUIRE REPLACEMENT, BE SURE THEY ARE BOTH THE SAME HEIGHT.

NOTE: REINSTALL LIBERALLY LUBRICATED COMPONENTS. THE DOUBLE LIP SEAL AND RETAINER WILL BE INSTALLED LATER.

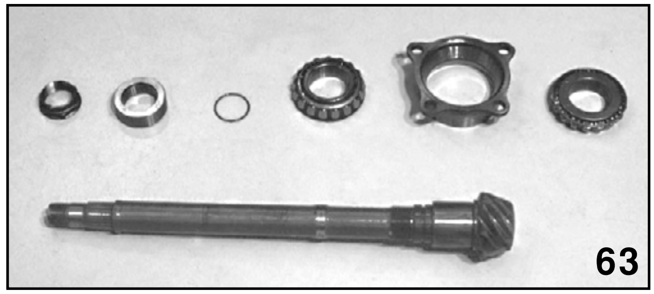
Drive Pinion



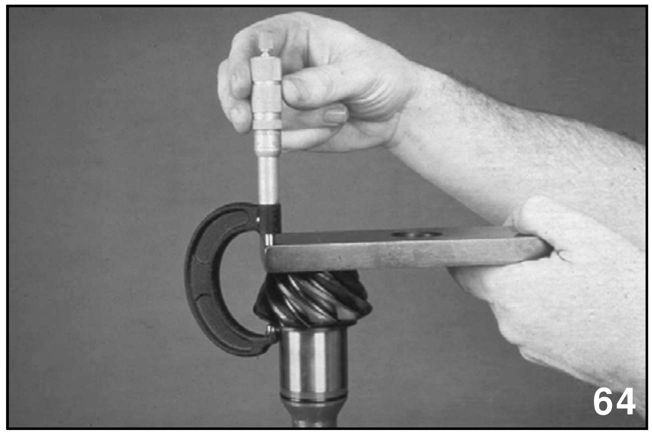
Prior to disassembling the pinion shaft, verify proper starting torque of the bearings.

IF THE REPAIR IS FOR OTHER THAN A RING AND PINION LUBRICATION FAILURE THIS SHOULD BE DONE FIRST. SO A NEW BEARING CAN BE ORDERED PRIOR TO REASSEMBLY IF OUT OF SPECIFICATIONS. IF THERE IS A RING AND PINION LUBRICATION FAILURE, YOU WILL MORE THAN LIKELY NEED A NEW BEARING.

IF THE BEARING IS OUT OF SPECIFICATIONS, NEW ROLLER BEARINGS ARE REQUIRED. DO NOT OVERTIGHTEN THE LOCK NOT TO COMPENSATE.



Disassemble the drive pinion shaft and examine the components for gouges, cuts, damage, etc.

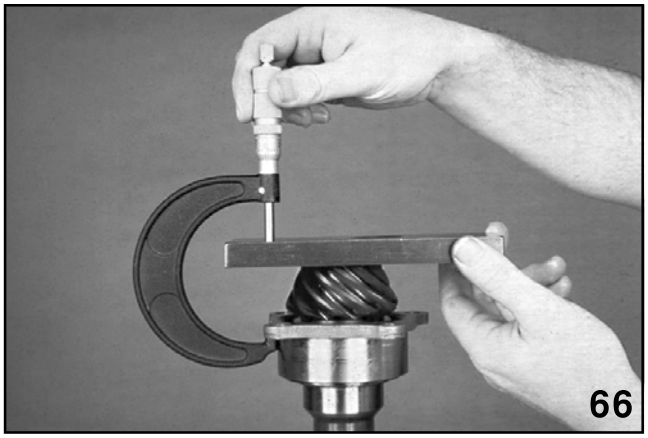


Next, determine the pinion depth. A two step process is used to determine the number of shims and the thickness of the shims.

First, measure the thickness of the pinion gear and record this as measurement "A".

NOTE: DIMENSION "A" INCLUDES THE THICKNESS OF THE TOOL.

Then install the flange assembly with bearings using a new O-ring and carefully install the collar and washer with a new nut. Make sure the bearings are lubricated and then torque the nut to specifications. Use special tools **#499787100** Wrench and **#498937100** Holder. Be sure to stake the new lock nut in place.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For the second step of the pinion depth measurement, the combined thickness of the flange and pinion must be determined. Record this as measurement “B”.

Perform the following calculation in order to determine the shim thickness (t) in millimeters.

FORMULA: $t = 6.50 \pm 0.0125 - (B - A)$

- t = Thickness of drive pinion shim(s)
- 6.50 ± 0.0125 = Ideal distance of pinion protrusion from oil pump housing
- B = Thickness of pinion and flange
- A = Thickness of pinion

Finally, mount the pinion to the housing using the selected shim(s).

NOTE: NO MORE THAN 3 SHIMS MAY BE USED. REFER TO SECTION 3-2, [W8C8], SUBARU SERVICE MANUAL TO DETERMINE THE PROPER SHIM SELECTION.

Reassembly

Inspect the clutches for damage caused by normal wear, heat, contamination, or component failure.

Also examine the sealing ring and the lip seals for damage, and see that the check balls aren’t sticking.

Clutch Reassembly Precautions

- Orient the dish plates correctly.
- Lubricate the components liberally with ATF and allow time to soak.
- Measure the clutch pack clearance between the retaining plate and the snap ring.
- All retaining plates are selective. See the service manual sec. 3-2, pg. 83.
- Verify their operation with air pressure.

Examine the band friction surface for wear or damage and carefully check the servo and accumulator sealing rings. Note that many different sizes are used. Do not confuse the locations of the components or seals. Also check the bores for scoring damage. Lubricate the components liberally with ATF during reassembly.

Inspect the differential carrier components for wear, cuts or damage. Then reassemble the ring gear to the carrier.

Differential Pinion Backlash

In order to verify the carrier backlash, temporarily, install the stub axle backwards and set up a dial indicator against the side gear. Then lock the pinions with a screwdriver and rotate the axle shaft. Verify the backlash reading. Correct the backlash if it is not within specifications. To change the backlash, disassemble the carrier and change the selective thrust washer(s) located behind each side gear.

Transfer Clutch Valve Assembly

In the transfer case, inspect and clean the valve body assembly. This includes the transfer clutch valve and the pilot valve. Also examine the strainer located in the case. Clean as necessary.

Transmission Reassembly

NOTE: EACH AND EVERY REASSEMBLY STEP IS NOT BEING COVERED IN THIS BOOKLET. THEY ARE COVERED IN THE SERVICE MANUAL. ONLY THE KEY REASSEMBLY STEPS/MEASUREMENTS WILL BE COVERED IN THIS PORTION OF THE BOOKLET.

Torque Converter Case

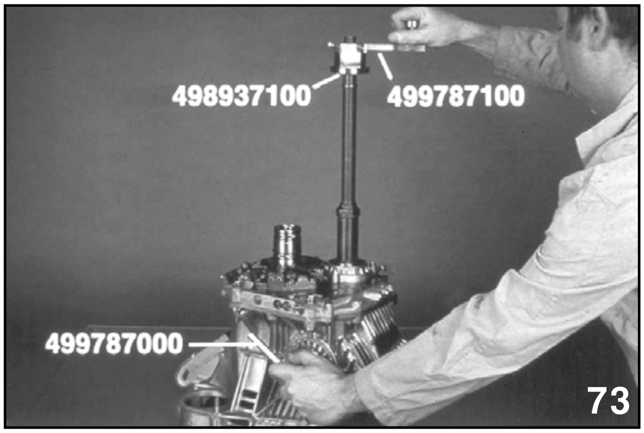
Install the differential carrier into the case being careful of the nylon speedo gears. Then insert the stub axle shafts using new snap rings and check the axle shaft thrust play.

Next, wrap the stub axles with vinyl tape and install the carrier bearing retainers. Screw in the right retainer further than the left retainer. This prevents potential damage to the ring and pinion.

Final Drive Pre-load & Backlash

Install the oil pump housing using four bolts. Take extra precaution to protect the sealing surface from bolt damage by temporarily installing gasket material under the bolt heads.

NOTE: THE LIP SEAL RETAINER CAN BE INSTALLED BEFORE OR AFTER PREFORMING THE BACKLASH ADJUSTMENT. CHECK THE ORIENTATION OF THE LIP SEALS AND USE THE SPECIAL TOOL #4992457300 TO INSTALL IT AT THE CORRECT DEPTH.



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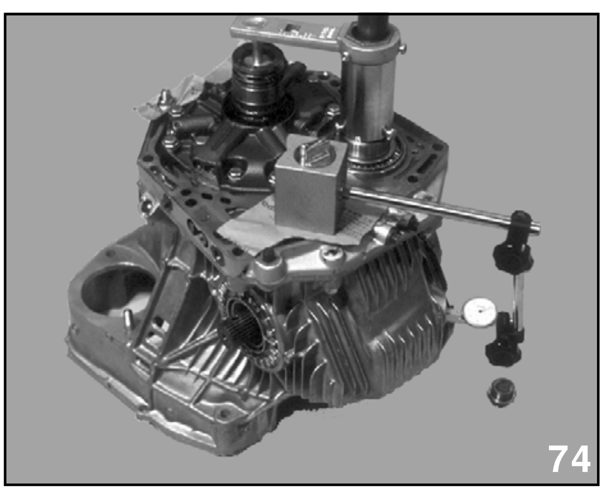
Next, rotate the pinion several times using the following special tools:

- **#499787100** Wrench
- **#498937100** Holder

In order to set the pre-load, the "zero" state must be established first. Tighten the LH retainer and loosen the RH retainer until contact is felt while rotating the shaft. Repeat this process several times to confirm the point at which the contact is felt. This is the "zero" state.

After the "zero" state is established, back off the LH retainer 3 notches and secure it with the locking tab. Then back off the RH retainer and retighten until it stops. Repeat this procedure several times. Tighten the RH retainer 1 3/4 notches further. This sets the pre-load. Finally, secure the retainer with its locking tab.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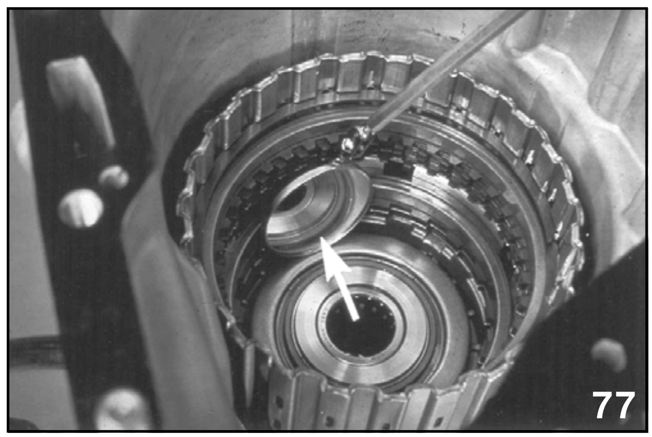
In order to check the backlash; mount a dial indicator securely so that it extends through the drain hole. Then lock the pinion shaft using the special tool #499787100 (Wrench), and check the backlash.

In order to change the backlash; rotate the retainers an equal amount in opposite directions. This maintains the proper pre-load. In order to increase backlash, loosen the LH retainer and tighten the RH retainer. In order to decrease backlash, tighten the LH retainer and loosen the RH retainer. One notch of the retainer equals 0.002 in. or (0.05mm).

Finally, mark the position of the retainers, and remove them so they can be reinstalled with their O-rings. Also reinstall and secure the lock-plates.

Forward Clutch Installation

NOTE: THE LOW/REV BRAKE HAS ALREADY BEEN INSTALLED.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Install the forward clutch drum into the low/rev brake. Rotate the drum carefully during installation. It can only rotate clockwise due to the O.W.C. 1-2.

In order to verify a proper installation; check the relationship between the drum and the O.W.C. 1-2 inner race. The race should protrude slightly.

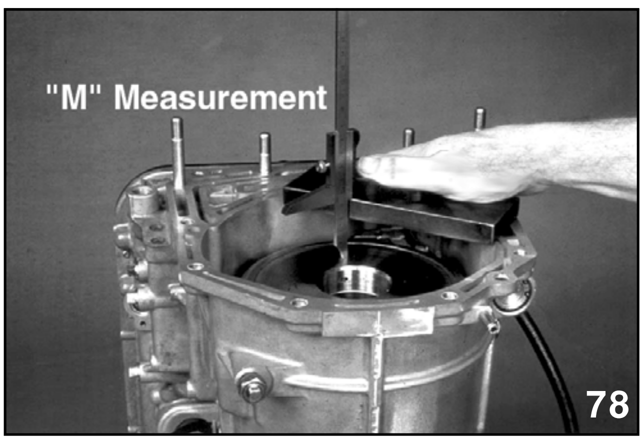
Reverse Clutch Drum End-Play

NOTE: THE BALANCE OF THE GEAR TRAIN COMPONENTS HAS ALREADY BEEN INSTALLED.

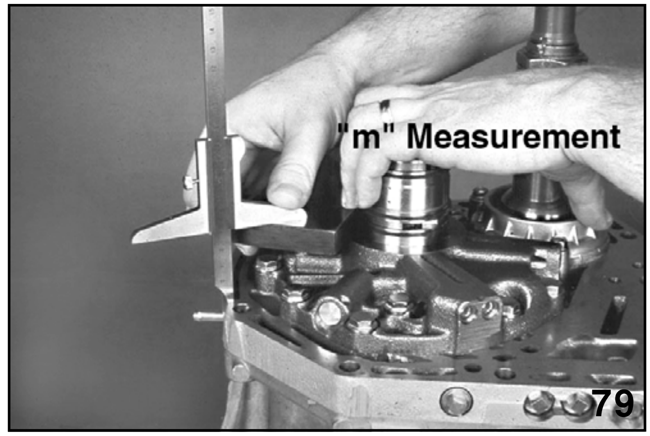
Select a washer for proper end-play adjustment using the following formula.

FORMULA (mm):

- t = (M + 0.40) - m - (0.55 to 0.90)
- t = thickness of thrust washer (to be determined)
- M = Distance from top of case to reverse clutch drum
- 0.40 = Thickness of gasket
- m = Distance from reverse clutch thrust surface (on oil pump cover) to oil pump housing
- 0.55 to 0.90 = Ideal reverse clutch end-play



First measure “M” using a depth gauge noting that no gasket is used. Measure where the thrust washer contacts the drum and record the reading.



Then measure “m” using the same measuring block and depth gauge. Finally, perform the calculations to determine “t” (large washer). Choose the proper thrust washer as listed in the service manual, sec. 3-2, [W4B2]. Subaru Service Manual to determine the correct thrust washer.

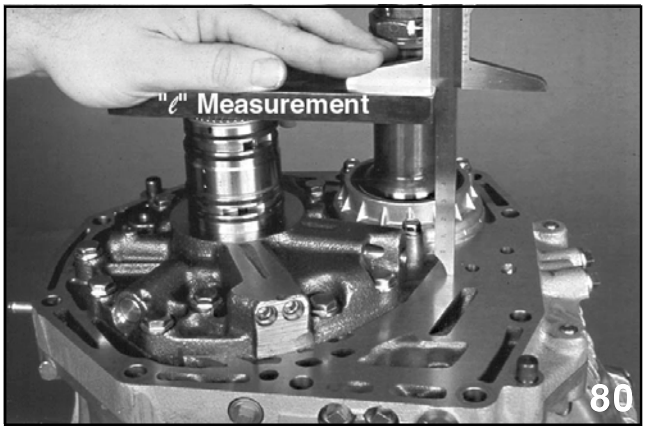
Total End-Play

Select a washer for total endplay using the following formula:

FORMULA (mm):

- T = (L + 0.40) - l - (0.25 to 0.55)
- T = Thickness of race
- L = Distance from case to reverse clutch drum race surface
- 0.40 = Thickness of gasket
- l = Distance from top of oil pump cover needle bearing to oil pump housing
- 0.25 to 0.55 = Ideal total end-play

First measure “L” using a depth gauge. Again, note that there is no gasket. Measure to the race surface and record the reading.



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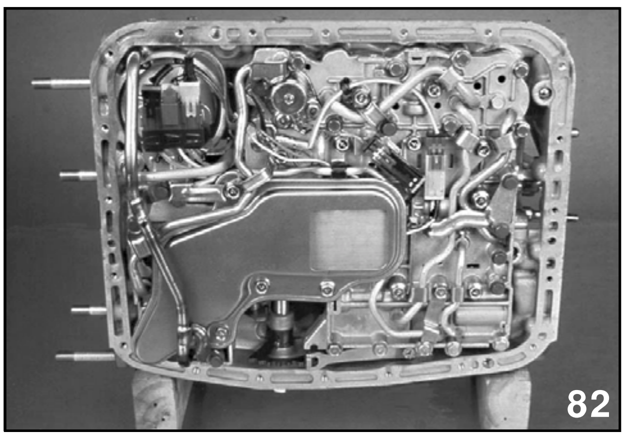
Next, measure “l” using the same measuring block. With the bearing in place, record the reading. Perform the calculations to select “T” (small 3 tanged washer). Refer to sec. 3-2, [W4B2] Subaru Service Manual to determine the correct thrust washer.

Valve Body Precautions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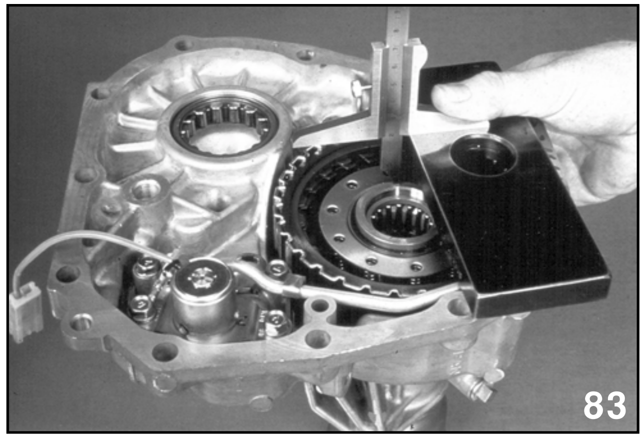
- Route the harness correctly.
- Torque the mounting bolts evenly.
- Use a new O-ring on the strainer.
- Install the oil cooler pipe.
- Make sure the magnet is properly positioned on the pan.
- Torque the pan bolts evenly.

Extension Case

In order to determine the endplay measurement (4WD), measure the distance from the extension case gasket surface to the transfer clutch thrust surface (4WD) using the formula below.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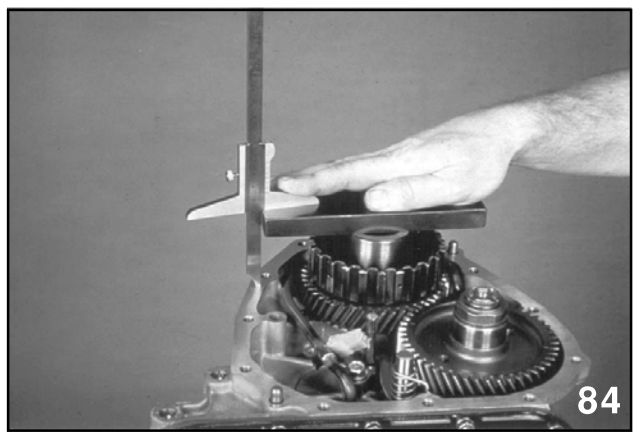
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NOTE: HEIGHT OF GAUGE TOOL #499577000 MUST BE SUBTRACTED FROM L.

FORMULA (mm):

- T = (L + 0.40) - ℓ - (0.05 to 0.25)
- T = Thickness of thrust bearing
- L = Distance from extension case gasket surface to transfer clutch thrust surface
- 0.40 = Gasket thickness
- ℓ = Distance from transmission case gasket surface to reduction drive gear thrust surface
- 0.05 to 0.25 = Ideal end-play

Select the proper bearing/washer from the chart in sec. 3-2, [W4B6] pg. 78 Vol. 2 of the 1995 service manual.

In order to determine the endplay measurement for FWD vehicles, use the same procedure as 4WD except:

- T = **Thickness of thrust washer**
- L = Distance from rear cover to reduction drive shaft bearing mounting surface
- ℓ = Distance from transmission case to bearing surface

Transmission Reinstallation

Reverse the order of removal except for the following procedures:

1. Torque the rear cross member bolts to specification.
2. Use new axle spring pins, making sure the chamfered DOJ and stub axle holes align.
3. Torque the transverse link bolts noting that the vehicle must be on the ground.
4. Install the gearshift cable and verify proper gearshift operation.
5. Install the pitching stopper by tightening the body side bolt first.
6. Add differential fluid and ATF.
7. Road test the vehicle.
8. Re-check the fluids for the proper level or leaks.

Whenever performing any service work on the 4EAT Transmission **ALWAYS** use the appropriate Subaru Service Manual.

Electronic Control System

Overview

The electronic control system consists of various inputs (sensors) and outputs (lights and solenoids) in addition to the Transmission Control Unit (TCU).

This is the second generation of Subaru automatic transmission. In addition to being smoother and quieter, it is designed to help maximize fuel economy while providing performance.

It monitors the engine and transmission performance conditions, the driver's demands and the vehicle speed.

Transmission Control Unit

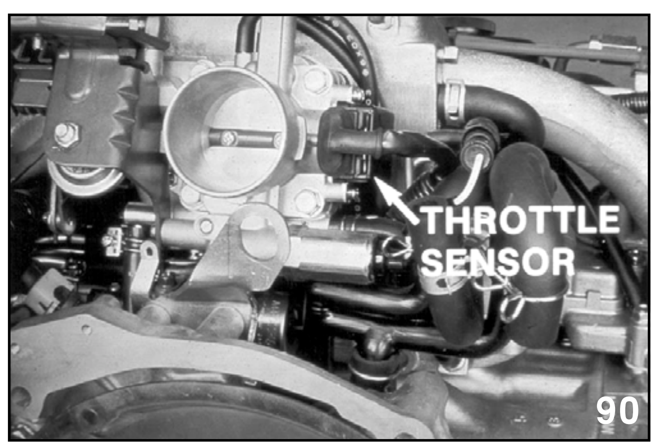
The TCU is a highly sophisticated microprocessor with a self-diagnostic long-term memory. It also has a fail-safe function, which maintains driveability in case of a major electrical component failure.

In a transmission equipped for 4WD the TCU utilizes a program which continually changes the degree of 4WD based upon vehicle operating condition(s).

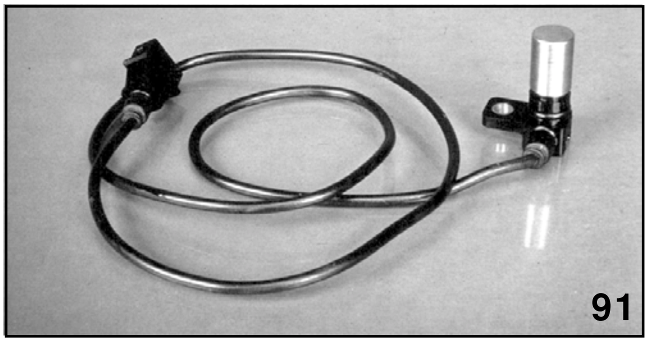
The TCU controls shifting and line pressure in addition to the lock-up torque converter and the MPT clutch.

TCU Inputs

- Throttle sensor/idle switch
- Vehicle speed sensor #1
- Vehicle speed sensor #2
- Tachometer signal
- Inhibitor switch
- Cruise control signal
- ATF temperature sensor
- Ignition/battery voltage
- 1-HOLD switch
- Forced FWD



The throttle sensor/idle switch is basically electrical throttle pressure. The load signal effects: shifting, line pressure and lock-up. The closed throttle input effects the lock-up release mode as well as smooth downshifting into 2nd gear. It also causes a reduction in the pressure.



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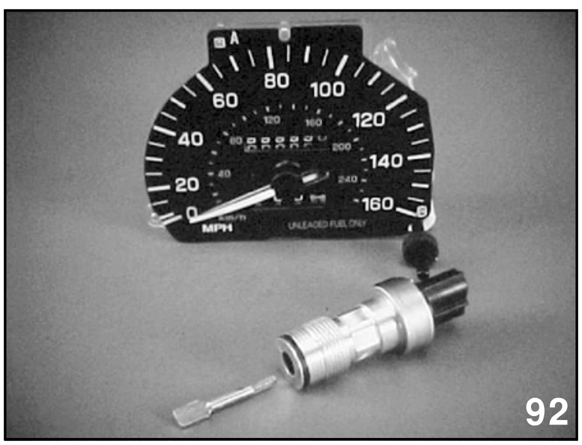
Vehicle speed sensor #1 is mounted to the transmission and is basically electrical governor pressure. It is used to detect vehicle speed and it effects shift points, lock-up, and line pressure.

In FWD transmissions, the speed sensor reads parking gear rotation at the front output shaft. In 4WD transmissions, it senses the transfer clutch drum rotation at the rear output shaft.

Vehicle speed sensor #2 is built into the combination meter. In FWD units, it is used as a back up for speed sensor #1. In 4WD units, it is used as the front output shaft speed sensor.



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Starting with SVX introduction in 1992, then added to 1995 Legacy, 1996 Impreza, 1998 Forester an electric speedometer system was introduced. The system uses a Magnetic Resistance Effect (MRE) type speed sensor driven by a conventional speedometer drive gear system. The speed sensor, which generates four pulses per revolution, is located on the front differential housing.

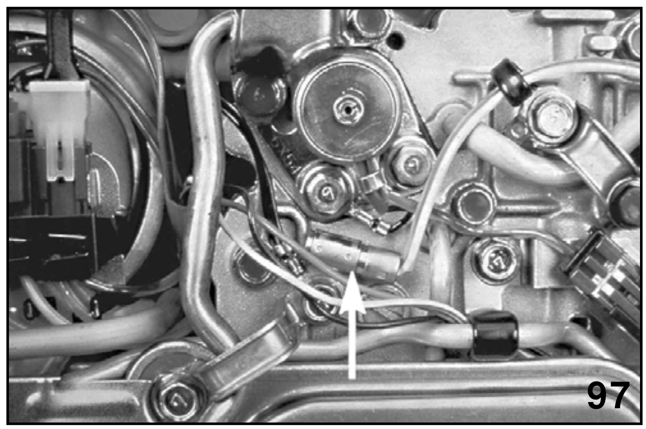
The Speedometer Driving Unit (SDU) receiving pulses from the MRE sensor processes the signal sending the information to the transmission control unit.

The TCU compares the speed signal from the front output shaft with the signal from the rear output shaft (sensor #1). The speed differential helps the TCU determine the degree of 4WD (along with other inputs).

The tachometer signal effects the shift points at kick-down. The TCU uses the signal to prevent the engine from over-revving.

NOTE: THE TCU WILL OVERRIDE THE INHIBITOR SWITCH, IF NECESSARY, IN ORDER TO PREVENT THE ENGINE FROM OVER-REVVING.

The cruise control signal tells the TCU of cruise control activation. This allows for a wider operating range in 4th gear unless a large speed differential exists from the set speed in which case the transmission may downshift. This improves fuel economy.



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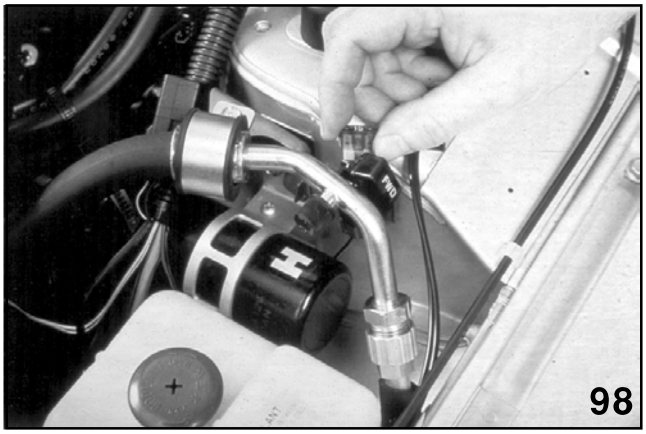
The ATF temperature sensor is located on the lower valve body next to duty solenoid “B”. When the ATF is cold, the TCU won’t allow an up-shift into 4th gear. The object is to warm the engine quickly for lower emissions. It is more sophisticated than the KDLH system and less objectionable for the consumer.

When the ATF is hot (4WD only), the TCU shifts the transmission as if in the POWER mode. This pushes the shift points higher which allows the engine to run faster. The oil pump then circulates ATF through the oil cooler more quickly so as not to overheat the engine coolant.

The TCU also monitors system voltage in order to correctly interpret the inputs and alter the control of the outputs. For example, the system is designed for 12-volt operation. When running, however, most vehicles have other than 12 volts available.

The 1-HOLD switch is located aft of the shift quadrant. When activated, it creates a forced 1st gear.

NOTE: THE TCU WILL SHIFT 2ND TO 3RD IF NECESSARY, IN ORDER TO PREVENT THE ENGINE FROM OVER-REVVING.



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The FWD switch changes the driving mode from 4WD to FWD. The FWD switch is located on the left front shock tower. It is activated by inserting the spare fuse into the under hood connector. The FWD light on the combination meter verifies that the vehicle is in FWD.

Legacy FWD switch is located on the right strut tower.

SVX and Forester switch is located in the main fuse box.

Legacy TCU Inputs

The Legacy fuel system ECM, beginning with MY 1990, sends new inputs to the TCU for line pressure control.

It networks the MPFI ECU RPM signal and altitude compensation inputs. This provides additional line pressure control for high altitude compensation to reduce shift shock. ABS system inputs turn “OFF” the over-running clutch when ABS is active and fixes the duty ratio of the MPT to mostly FWD.

Maintenance Precautions

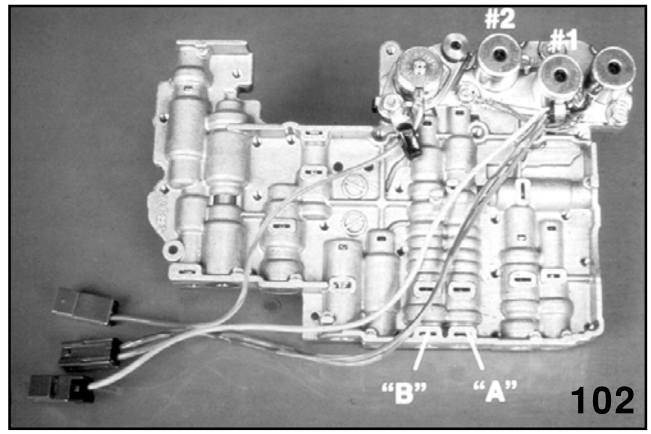
Before jacking up one or two wheels for maintenance with the engine running or before running the vehicle on a chassis dynamometer, the electronic 4WD engagement system MUST be disengaged by installing the spare fuse (15A) of the fuse box into the FWD connector located under the hood. Failure to do so could result in movement of vehicle. (Refer to owner’s manual)

TCU Outputs

There are two types of outputs, solenoid controls and light controls. The solenoids control shifting, line pressure, lock-up and 4WD.

The light controls indicate operating conditions to the driver. They indicate the POWER mode, manually selected 1st or 2nd gear, or hot ATF (4WD only).

On the 1990 M.Y. and later Legacy the light controls indicate hot ATF (FWD and 4WD), gears 3 - 2 - 1, MANUAL mode, and POWER mode.



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Shift solenoids #1 and #2 are located on the upper valve body. The TCU induces “ON/OFF” conditions, which regulate the shifting of the forward gears.

When a shift solenoid is “ON”, it passes pilot pressure to shift valve “A” and/or shift valve “B”. The valve(s) will then shift, feeding the appropriate controlling member circuits (high clutch, band, etc.).

NOTE: PILOT PRESSURE IS NOTHING MORE THAN A PRESSURE HELD AT A CONSTANT VALUE.

When a shift solenoid is “OFF”, the affected shift valve will move to its static position due to spring pressure. The appropriate controlling member circuit will than be fed (high clutch, band, etc.).

COMPONENT APPLICATION

		REV./C	B/B	HIGH/C	FWD.\C	OWC (3-4)	OVR/C	Lo/ REV./B	OWC (1-2)	Sol 1	Sol 2
P/N										X	X
R		●				○		●		X	X
D	1st				●	●			●	●	●
D	2nd		●		●	●				X	
D	3rd			●	●	●				X	X
D	4th		●	●	●						X

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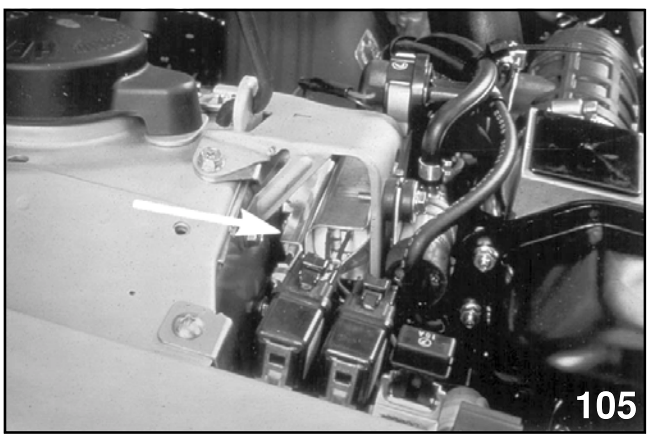
Shift Modes

Shift solenoid #3 is located on the upper valve body. It is used to control downshifts. It quickly releases the 3-Release pressure during low speed, heavy load situation in order to provide smooth 3-2 downshifts. It operates the overrunning clutch in order to provide engine braking during deceleration. It is also used to cancel the overrunning clutch momentarily during light throttle 3-2 downshifts, or closed throttle 2-1 downshifts. This reduces the shift shock.

Duty Solenoid "A" is located on the upper valve body. It regulates line pressure at 3 levels:

- Basic:
  - Altered with load, vehicle speed, and range signal.
- Shifting:
  - Lower line pressure in between shifts to minimize shift shock.
- Start up:
  - With low ATF temperature or a low tachometer signal [cranking speed], it sets line pressure to a minimum.



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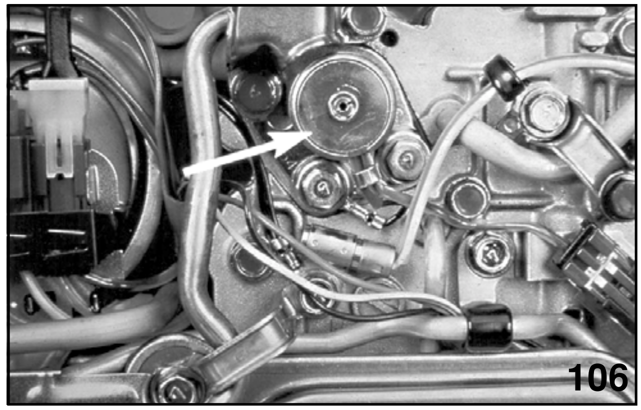
The dropping resistor is wired in parallel with duty solenoid "A", and is used to regulate line pressure. It is located on the right front shock tower behind the MPI fuel system-dropping resistor. It takes over line pressure control during the "OFF" portion of the duty cycle for the duty solenoid. In other words, the duty solenoid is never fully "OFF".



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Duty Solenoid "B" is located on the lower valve body next to the ATF temperature sensor. It operates the lock-up clutch in 3 modes: "ON", "OFF", and a gradual "ON/OFF" control of the lock-up clutch during gear shifting in order to reduce shift shock.

Duty Solenoid "C" is located in the extension housing. It is also controlled by the TCU. It varies the degree of 4WD.

Combination Meter Light Operation XT - 6 and L – Series

XT - 6 and L – Series 2nd gear indicator bar is located in the combination meter shift position indicator. Controlled by the TCU, other quadrant indicators are controlled by the inhibitor switch, both providing a path to ground. 2nd indicator bar is affected by the 1 – Hold switch input. With the 1 – Hold button switched "OFF" & the shift selector in the "2nd select" position, the TCU grounds the 2nd indicator light circuit illuminating the 2nd gear indicator.

The 1-HOLD indicator light ("L" and XT only) is located near the shift position indicator. It is activated by the TCU whenever the 1-HOLD button is depressed with the shift lever in "2". It changes the display and cancels the "2" indicator.

The vehicle stays in 1-HOLD unless the TCU determines a potential engine over-rev condition, at which point, the transmission will then up-shift.

NOTE: WHEN 1-HOLD IS ACTIVATED, ALL OTHER SHIFTING INPUTS ARE IGNORED.

ATF temperature warning light was used on AWD vehicles only indicates overheated ATF. See description of TCU inputs for control unit logic in response of hot ATF.

The Power indicator was a frame that illuminates around the word "POWER" on the combination meter. Activation logic of the power mode is the same as later models.

Late Model Combination Meter

Legacy, SVX, Impreza & Forester Lighting

Manual light was activated when the manual button is depressed. On 90 – 91 M.Y. the 3 – 2 – 1 Light box changed color from green to yellow. This feature was discontinued in the 1992 M.Y.

The Manual Light and Switch was discontinued in all models but the SVX in 1995.

The POWER light is activated momentarily whenever the vehicle is started. The computer, monitoring how quickly the gas pedal is depressed selects the POWER mode. This changes the performance characteristics of the transmission. I.E., it delays up-shifts and may downshift if necessary. When selected, the computer turns the POWER light "ON". The POWER light was eliminated on Legacy beginning with 1995 model year but TCU logic is the same.

NOTE: THERE ARE A NUMBER OF PREDETERMINED RATES BASED ON VEHICLE SPEED VS. THROTTLE ANGLE REALTIONSHIP. THESE DETERMINE EASE OF ACCESS TO THE POWER MODE. AS A GENERAL RULE, IT IS EASIER TO ACTIVATE POWER MODE AT LOWER SPEEDS FROM A LIGHT THROTTLE THAN IT IS AT HIGHER SPEEDS FROM A LIGHT THROTTLE.

Power Pattern Mode increases up and down shift points. It is deactivated by vehicle speed and throttle angle. For example, if speed is equal to or greater than (approximately) 40 MPH with a light throttle deactivation is immediate. Verses, if the speed is less than (approximately) 40 MPH a time lag up to 3 seconds will occur before resuming normal shift pattern.

ATF temperature warning light is provided on both FWD and AWD vehicles. It is activated by the TCU indicating overheated ATF. The TCU logic will shift the transaxle as if in the power mode, moving more ATF volume through the cooler.

In the 1993 Model year the indicator light was discontinued **but** the logic for controlling hot ATF remained.

Starting in the 1995 model year the "HOT ATF" indicator light was reintroduced. Performing the same as in the past. However it has an added function. When the vehicle is started it is light momentarily. If it is flashing when the vehicle is started this indicates the TCU has detected an electrical failure. When the TCU is programmed to do so, it will flash a trouble code to assist in diagnostics.

Fail Safe System

NOTE: THE 4EAT'S ARE A HIGHLY RELIABLE TRANSMISSION. SHOULD AN ELECTRICAL COMPONENT MALFUNCTION, IT WILL ENTER FAIL-SAFE MODE.

Fail Safe Components and Failure Results

If a speed sensor fails, the remaining sensor signal will be used.

In case of throttle sensor failure, the idle contacts will signal the throttle opening. Line pressure will go to maximum at open throttle and it will go to minimum at closed throttle.

Although the inhibitor switch may fail, the manual valve will still be in the correct position for all selected ranges. In "P" and "N" however, it may effect start-up, therefore, there is a potential for a no-start condition. In Reverse, the TCU is passive. Therefore, an inhibitor switch failure has no effect. If multiple signals are seen in the forward ranges the inhibitor switch is ignored and there is no fourth gear.

If the 1-HOLD switch is defective, the system operates in the same manner as an inhibitor switch failure in the forward ranges.

If the MANUAL switch is defective (Legacy only), the transmission will shift normally in D position. It will operate the same as an inhibitor switch failure when the selector position 3 - 2 - 1.

If shift solenoids #1 or #2 malfunction, the TCU deactivates the other. This results in either 3rd gear or Reverse (when selected).

If duty solenoid "A" fails, line pressure goes to maximum.

If duty solenoid "B" fails, the torque converter lock-up will not occur.

If shift solenoid #3 malfunctions, the overrunning clutch is always "ON" and there will be engine braking during deceleration.

If duty solenoid "C" should fail, the 4WD control will be set to maximum and the rear wheels will always be powered.

Self Diagnostic System

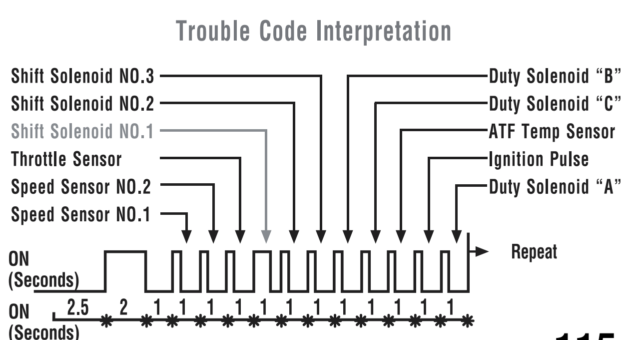
The 4EAT self-diagnostic system has three modes: a user mode and two dealer modes. In the first instance, the user is notified through the POWER light when a malfunction occurs. The failure is communicated after the next ignition "OFF/ON" cycle. For a more detailed description of the user mode, see the appropriate troubleshooting section of the service manual.

NOTE: THE SYSTEM WILL FAIL SAFE FOR "LIMP HOME". WHEN A COMPONENT FAILS, THE LIGHT WILL NOT ILLUMINATE UNTIL THE IGNITION IS SWITCHED "OFF" AND THEN SWITCHED TO "ON" AGAIN.

For specific information on the self-diagnostics dealer modes, see the appropriate trouble shooting section of the service manual.

XT and L-Series Diagnostics

To enter in to the dealer mode to retrieve trouble codes it is necessary to operate the inhibitor switch in a specific sequence as outlined in the service manual. Once this has been performed the Power light will flash a code sequence.



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The TCU checks 11 components and displays the codes different than other on board diagnostic functions. When activated, the Power light flashes "OFF" for 2.5 seconds, "ON" for 2.5 seconds then 11 flashes. This sequence will repeat after the 11th flash.

Each component is assigned a position in the sequence (i.e. ignition pulse is position #10 and each position has a duty cycle of one second. Normal functioning components Flash on at a 10% duty, light "ON" for 0.1 second, light "OFF" for 0.9 second. Malfunctioning components flash on at a 60% duty, light "ON" for 0.6 second, light "OFF" for 0.4 second.

EXAMPLE: TCU PROGRAMMED FOR SELF-DIAGNOSTICS, SHIFT SOLENOID #1 DEFECTIVE POSITION #4 IN SEQUENCE. POWER LIGHT "OFF" FOR 2.5 SECONDS LIGHT "ON" FOR 2 SECONDS 3 FLASHES AT 10% DUTY (0.1 SECOND) 4TH FLASH AT 60% DUTY (0.6 SECONDS) 7 FLASHES AT 10% DUTY CYCLE REPEATS.

1990 –1994 Legacy, 1992 – 1995 SVX, 1993 – 1995 Impreza Diagnostics

The procedure to retrieve trouble codes is similar previous years. The manual button replaces the 1 – hold button function. Three modes are available

Current trouble codes

Past trouble codes (Long-term memory)

Clear memory

The codes are communicated on the POWER light. There are 12 codes for the AWD and 11 codes for the FWD vehicles. They are displayed similar to fuel system codes, one long flash = 10 (1.2 seconds), one short flash = 1 (0.3 seconds). For example – one long, two short = code 12.

Select Monitor Analysis

The select monitor is a powerful tool for analysis of an electrical condition.

This form of analysis is the preferred troubleshooting/ self-diagnostic method. The select monitor identifies current problems, past problems (through long-term memory), and indicated actual circuit and component performance. Other functions that can be useful diagnostic aids are graphing; LED display of switched components, Max. & Min. readings, and save data and play back.

Also the select monitor Oscilloscope function serves to assist in finding intermittent electrical conditions using the trigger function.

Depending on the model and year vehicle the data list displayed can be extensive. As will be discussed later, OBD-II functions also have freeze frame data on 1995 and newer vehicles.

1995 – 1998 Legacy, 1996 – 1998 Impreza, 1996 – 1997 SVX, 1998 Forester, Diagnostics / OBD – II Vehicles

AT Oil Temperature light operation operates under the following conditions. Ignition switch on / engine off is the bulb check mode, light remains on. Normal - Ignition switch on / Engine on light remains on for 2 seconds from engine start.

NOTE: A FAILURE IS NEVER REPORTED VIA THE AT OIL TEMP LIGHT DURING CURRENT OPERATION. THE TCU WAITS UNTIL THE NEXT IGNITION CYCLE TO DISPLAY THE FOLLOWING AT OIL TEMP LIGHT CONDITION. THEREFORE THE DRIVER MAY DETECT AN ABNORMAL DIRVEABLITY CONDITION (FAIL SAFE OPERATION) WITH NO AT OIL TEMP LIGHT INDICATING A FAILURE.

Abnormal - Ignition switch on / engine on the light remains on for 2 seconds from engine start. Off for 0.25 seconds on for 0.25 seconds 4 times then off for 2 seconds. Cycle repeats 4 times for a total of 16 Blinks

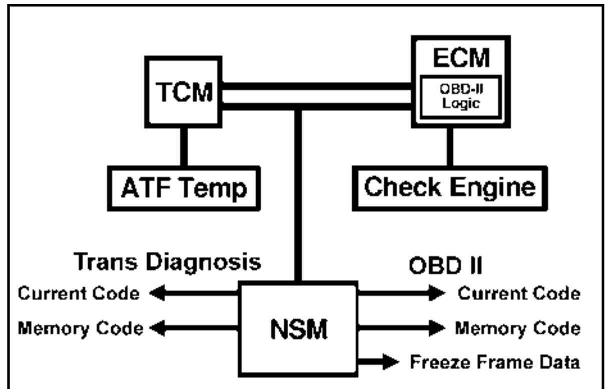
Abnormal ATF Temperature is too high. AT temp light comes on and stays on until ATF temperature returns to normal.

Trouble Codes

The procedure to retrieve trouble codes similar to previous models except, grounding terminal # 5 of connector B82 a 6 pole black, right side of steering column. Trouble codes will be displayed through AT Temp light with the following differences. There are 14 possible trouble codes communicated from the TCU. They are displayed in the same format as old fuel system trouble codes, long Flash = 10, short flash = 1. For example: 2 long and 4 short = code 24, Duty Solenoid “C”.

The clear memory procedure is simple and quick, just remove fuse No. 14 for at least one minute.

OBD - II



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OBD - II Operation Overview

The system monitors components and their operation, conducting continuity and performance checks. The check engine light or MIL illuminates when a code is set into ECU memory. Problems with the 4EAT are communicated from the TCU to the ECU.

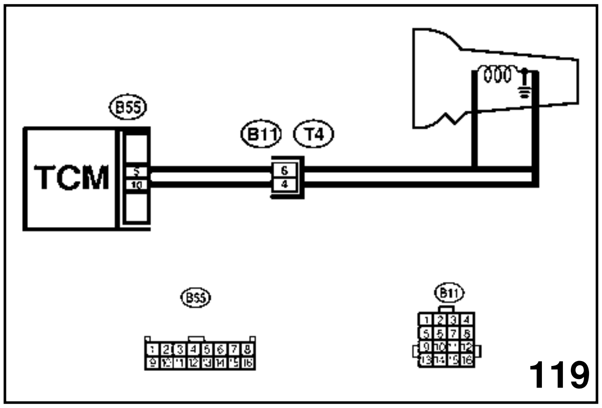
There are 2 trouble codes that are generated as soon as a problem occurs, turning on the MIL. With 22 others requiring a fault or error during two consecutive trips, before turning on the MIL. A trip is defined as a driving pattern in which test parameters are reached for a given time. A failed trip will be erased if the next trip is a good one.

Transmission codes generated in OBD-II have freeze frame information available on the select monitor in the fuel system section of data display.

OBD - II purpose

The Society of Automotive Engineers in cooperation with the EPA have in accordance with regulation J2012 of the1990 Clean Air Act, established DTC’s that are to be used by the automobile industry beginning with the 1995 model year. DTC’s that use a “PO” prefix are SAE assigned. DTC’s that use a “P1 “ prefix are categorized by SAE but are assigned by a vehicle manufacturer.

OBD-II checks a component and its operation similar to OBD-1, which is used on pre 1995 model vehicles. 0BD-I for example, checks the “Torque Converter Clutch System Electrical” by monitoring for minimum and maximum voltage signals. OBD-II also performs this function. For example examine DTC P0743



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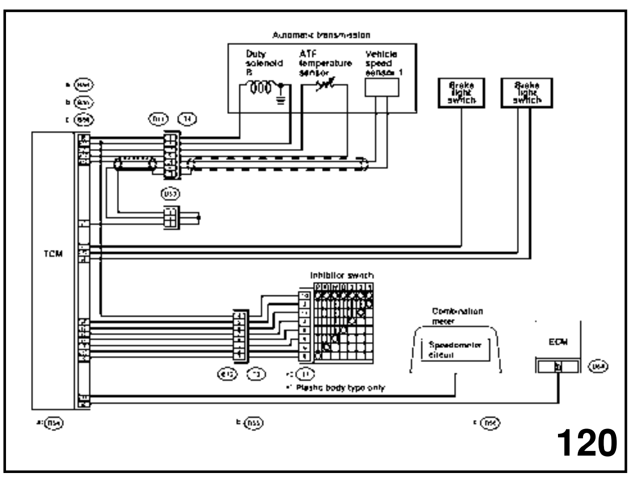
The TCM continuously monitors duty solenoid B Circuit. A fault will register if the following conditions are met:

1. When the TCM supplies an ON signal to the coil of the solenoid, the voltage from the coil is lower than preestablished parameters.
2. When the TCM supplies an OFF signal to the coil of the solenoid, the voltage from the coil is Higher than preestablished parameters.

Condition (a) or (b) will cause the DTC to register in the ECM memory on 0BD-I or OBD-II systems.

OBD-II in addition to the previous will monitor for performance of the " Torque Converter Clutch System ". For example examine DTC P0740.



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The detecting condition: Slipped wheel RPM (absolute value of difference from transmission input RPM computed from engine speed and vehicle speed) continues greater than [40 + vehicle speed / 2] for 10.2 seconds. When the lockup duty ratio is greater then 90% in lock up control mode detected by the TCM.

The TCM continuously monitors the torque converter clutch system. A fault will register if the following condition is present:

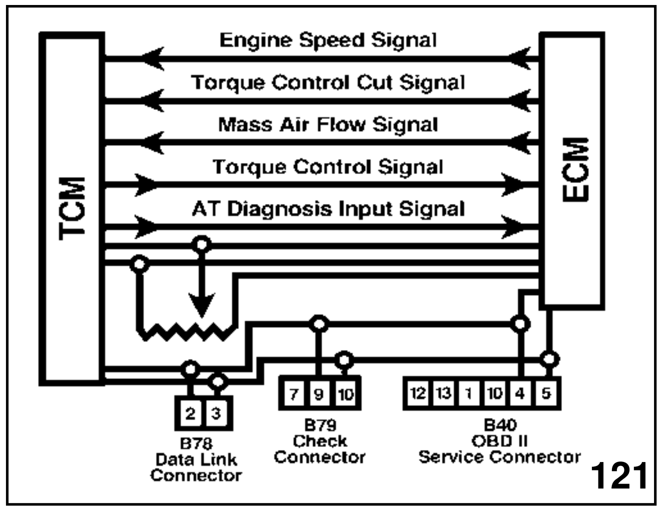
Engine speed is equal to or greater than output shaft speed (speed sensor 1) multiplied 4th gear ratio multiplied by 9/8.

The following conditions must be met before the test is performed.

1. The transmission is in 4th gear.
2. The duty ratio for lockup duty solenoid is equal to or greater than 90%

The DTC will set and the MIL will illuminate if a fault is registered during two consecutive trips.

Control Unit Networking



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Both the Fuel Injection control unit and the Transmission control unit share processed information and sensor in put by shared signals.

Engine speed signal is sent to the TCM form the ECM influencing Torque Converter lock-up.

Torque Control Cut signal is sent to the TCM from the ECM preventing fuel cut under certain conditions. Diagnostics are provided by the TCM as code 16, signal diagnostics are not provided in OBD – II.

Torque control signal (unique from the Torque Control Cut signal) is created in the TCM logic to communicate to the ECM that torque reduction (fuel cut) is required to reduce shift shock during a wide-open throttle up-shift. Diagnostics are provided by the TCM as code 25 and also in OBD – II logic as DTC P1103.

Mass Airflow signal is sent to the TCM from the ECM as a back up for influencing the shift points in the event of a throttle position signal loss. Line pressure is also affected by the Mass Airflow sensor input, lowering the line pressure during up shifts reducing shock. There are no corresponding onboard diagnostic codes for this signal in the TCM.

Automatic Transmission Diagnosis Input Signal represents an electrical check, for the circuit that networks the TCM and ECM communicating diagnostic information to the ECM. This signal has no corresponding 4-EAT code.

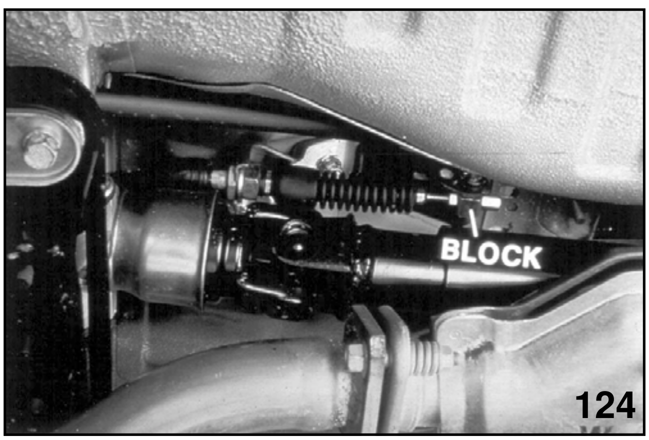
Troubleshooting and Adjustments

Preliminary Inspection

Check the following:

1. Fluid level
2. ATF leaks
3. Road Test:
   - Check proper shift points
   - Engine performance
4. Correctly adjusted throttle sensor
5. Gearshift cable adjustment
6. Correct stall test results
7. Inhibitor switch connections
8. Correct pressure test results

Gearshift Cable Adjustment



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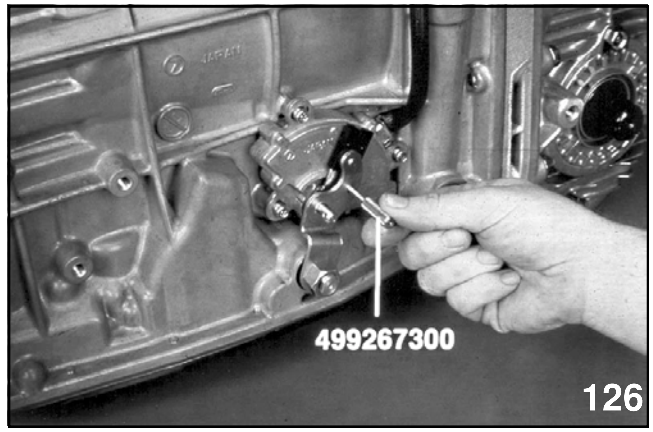
Place the transmission in neutral with the engine "OFF". Then loosen the locking nut and the adjusting nut. Push the shift lever arm rearward and tighten the adjusting nut until it contacts the connecting block. Finally, secure the cable with the locking nut and double check the operation.

After adjusting the gearshift cable, verify the correct inhibitor switch position. Remove the cable from the inhibitor switch in order to perform the adjustment. The switch must be in neutral.



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Then insert the special tool #499267300 Stopper Pin through the 2 levers of the switch into the depression in the switch body. Next, loosen the 3 retaining bolts and rotate the inhibitor to adjust. Finally, reinstall the cable and reconfirm the cable adjustment.

Stall Test

The stall test checks the operating condition of the AT clutches the torque converter, and the engine. Perform these checks in "D", "3", "2", and "Reverse".

Stall Test Results

Higher than normal RPM indicates one or more of the following:

- Slippage of the forward clutch
- O.W.C. not holding
- Low/Rev. brake slipping
- Overall low line pressure

Lower than normal RPM indicates one or more of the following:

- Incorrect throttle adjustment
- Poor engine operation
- Torque converter stator slippage

Time Lag Test

The time lag test checks the operation of the forward clutch, the reverse clutch, the low/reverse brake, O.W.C. 3-4, and O.W.C. 1-2.

Perform this test at operating temperature. Idle the engine with the A/C "OFF". Confirm the proper idle speed in "N" and correct if necessary. Then shift into "D" and measure the time (seconds) to full engagement. It should take less than 1.2 seconds. Then shift into "R" and measure the time. It should take less than 1.5 seconds.

Time Lag Results:

If the time takes longer from “N” to “D”, it may indicate one or more of the following:

- Low line pressure
- Worn forward clutch
- O.W.C. problem

If the time takes longer from “N” to “R”, it may indicate one or more of the following:

- Low line pressure
- Worn reverse clutch
- Worn low/rev brake

Pressure Test

Perform a pressure test when all the circuits show evidence of slippage or when the circuits show negative results from the time lag test.

This test should also be performed if there is excessive shift shock, delayed shifting, or if the vehicle is immobile.

Perform this test by connecting the pressure gauge to the “oil pump outlet” test port in order to determine the overall line pressure. Should a particular component be suspected, perform pressure tests at its unique test port.

Refer to the Service Manual, Sec. 3-2, [S1D0] for other ports. Check for minimum and maximum values at each port.

On Car Service/Adjustments

The following can be performed on the vehicle:

- Checking/changing fluids
- Band adjustment
- Valve body servicing
- Shift Linkage adjustment/replacement
- Inhibitor switch adjustment/replacement
- Harness repair/replacement
- Transfer clutch assembly (servicing/ replacement)
- Speed sensors replacement

Notes:

302 Module Lesson Plan Bulletins

The slide numbers are the same as the latest edited version

Bulletin #	Date	Description
16-36-90	2/26/90	Torque converter bleed down, check valve added
16-37-90	3/26/90	Drive line binding on sharp turns PDI
16-39-90	4/9/90	Broken differential dip stick
16-40-90	4/9/90	Correction to part numbers in TSB 16-36-90
16-42-90	8/20/90	Flushing the Transmission oil cooler
16-49-90	12/31/91	Provide copy as hand out (brake band adj.)
16-50-92	3/6/92	Checking O.W.C. 1-2 & 3-4 for proper installation
16-53-92	7/9/92	Cooler hose routing, cooler flushing
16-54-92	11/27/92	Gear reduction drive shaft replacement (Orifice plug separate)
16-55-93	5/3/93	More filter kit information
16-56-93	5/12/93	SVX filter kit installation
16-58-94	3/8/94	Oil pump gasket or case **not** modified could show up in a failed time lag test. Or stall test in extreme failure. High clutch failure, Bearing change and oil holes
16-59-94	4/20/94	Prevention of repeat planetary gear failures
16-60-94	5/16/94	Installation of Speedo cable adapter
16-61-94	6/1/94	Updated information for TSB 16-58-94
16-62-97	5/16/97	Transfer clutch binding and/or bucking on turns

302 Module Service Help-Line Updates

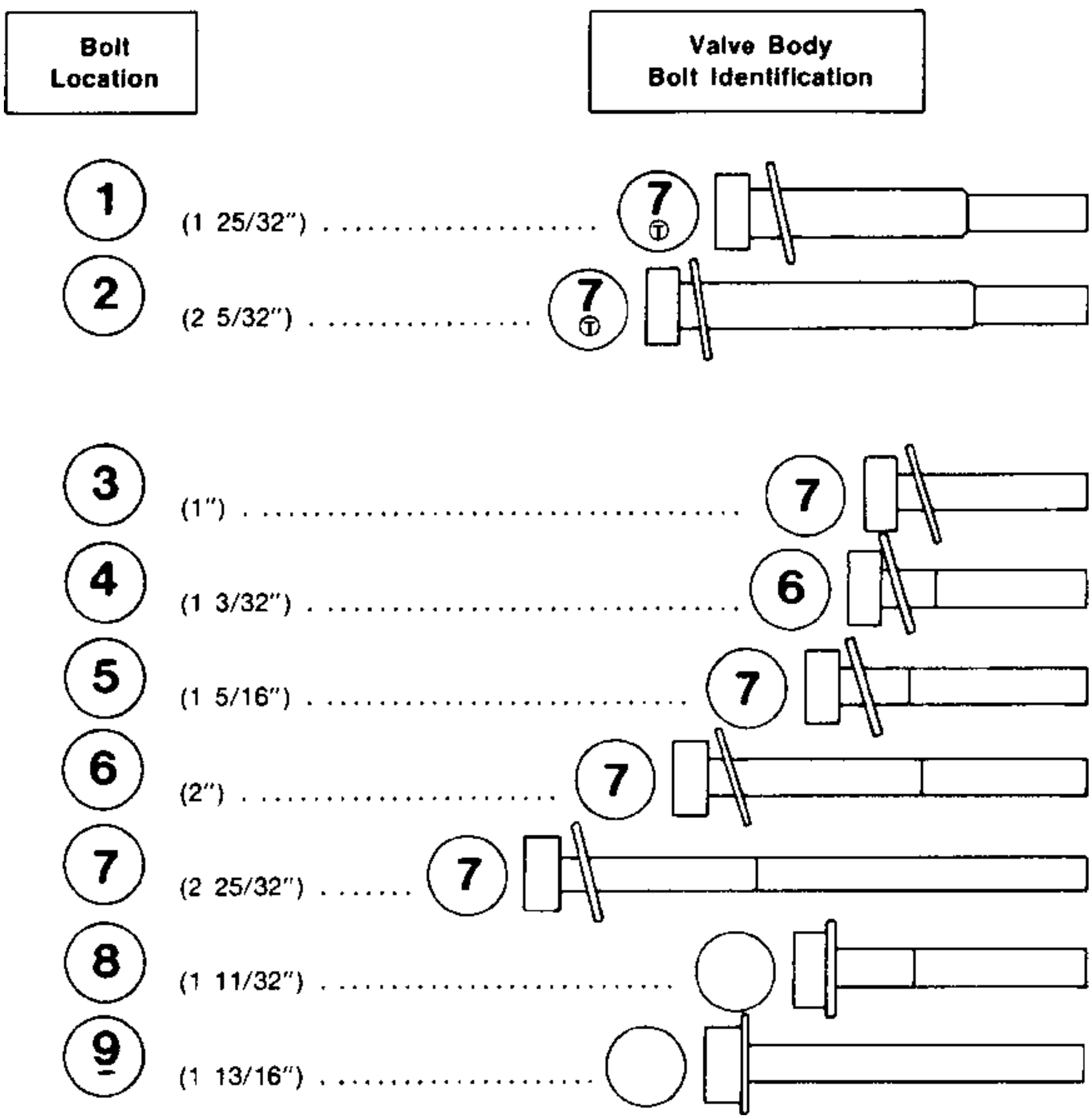
The slide numbers are the same as the latest edited version

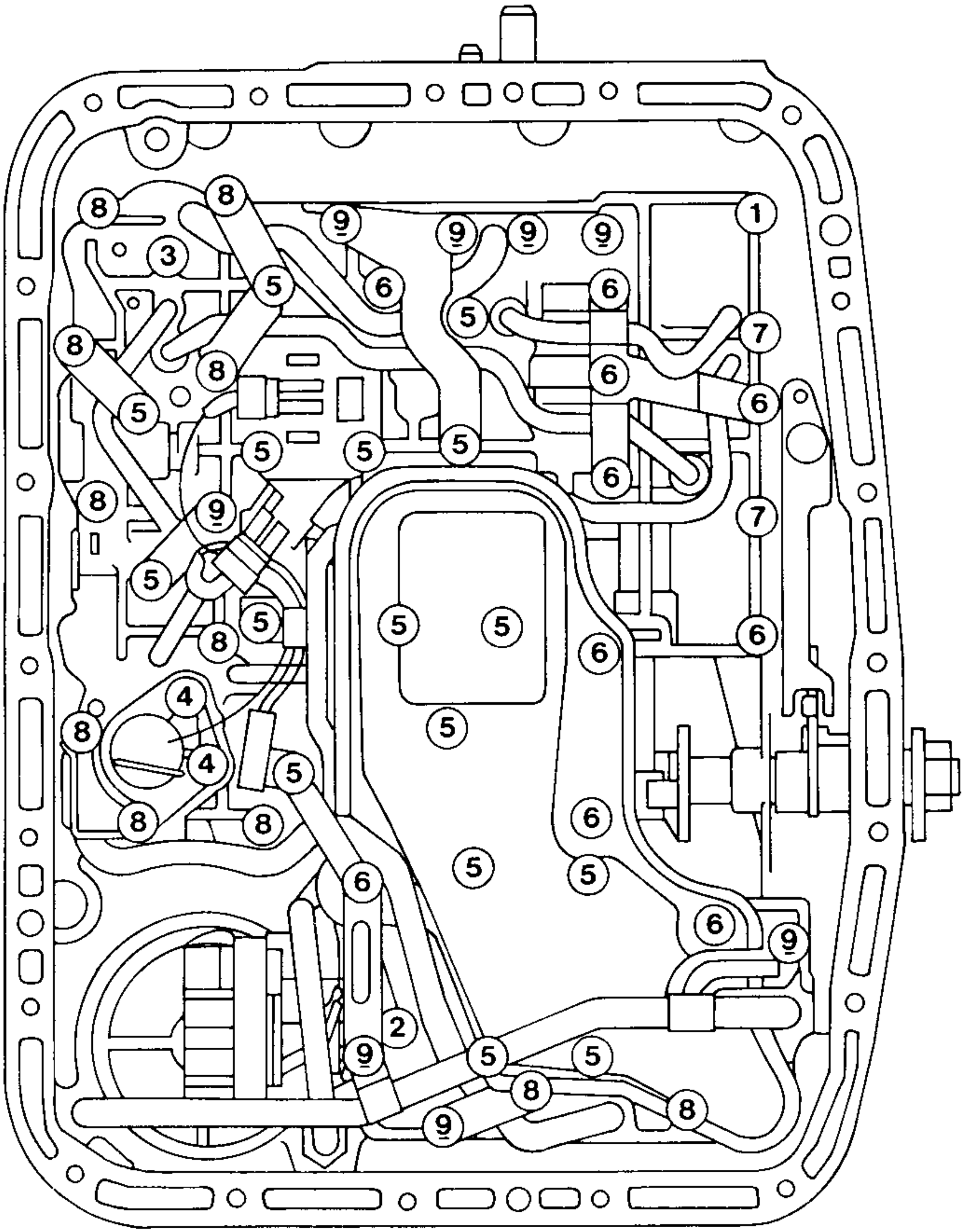
Date	Page	Subject
04/91	2	Metallic noise on light acceleration / Torque Converter installation
06/91	2	4EAT slow engagement / Torque Converter drain back
06/91	3	Transmission oil cooler flushing
06/91	3	Failure after replacement of reduction shaft
11/91	2	Oil pump cover bolt torque clarification
11/91	4	Loose ground affects / no power light and early up-shift
08/91	2	AWD binding on corners
01/92	2	Thrust bearing identification
06/92	3	Servicing and repairs General info
08/92	4	Auxiliary filter replacement
08/92	4	Auxiliary filter installation caution
10/92	4	Torque bind complaints
11/92	3	Batteries affecting auxiliary filter lines
11/92	3	Tires affecting AWD
12/92	2	Reassembly Cautions
02/93	2	Torque Converter lock up clutch causing engine stall
02/93	3	Auxiliary filter
04/93	2	Modified pump gasket
05/93	2	Low temperature operation
06/93	2	Squeaking noise from Torque Converter
10/93	5	Speedometer cable adapter
10/93	5	Towing cautions
12/93	3	Swapping Duty solenoid “C” for testing purposes
05/94	6	Torque Converter bolt removal
05/94	6	High clutch seizure / failure
06/94	6	Gasket and Seal kit
09/94	4	No movement in any gear
12/94	4 & 5	Shift problem diagnosis
05/95	5	Clicking noise from transmission
09/95	5	Low or erratic line pressure
02/96		ATF cooler hose re-routing
04/96		Change in pinion shaft
05/96		Delayed engagement into drive when warm
07/96		extension case roller bearing removal
07/96		4EAT systems diagnosis
08/96		Binding in turns
09/96		Transfer clutch chatter
04/97		Speed Sensors
08/97		Engine RPM goes to zero when coming to a stop
01/98		Rear axle binding on turns

4EAT Valve Body Bolts

Order of Bolt Assembly
Note: See chart on next page

1 bolt at location 1
1 bolt at location 2
1 bolt at location 3
2 bolts at location 4
16 bolts at location 5
6 bolts at location 6 (keep 4 screen bolts)
2 bolts at location 7
INSTALL VALVE BODY IN CASE
11 bolts at location 8
INSTALL SCREEN
4 bolts at location 6 (4 screen bolts)
INSTALL OIL COOLER PIPE
8 bolts at location

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SUBARU

CERTIFIED SUBARU TECHNICIAN

Technicians Reference Booklet

Basic Electrical Theory

Module 601

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of May 2001.

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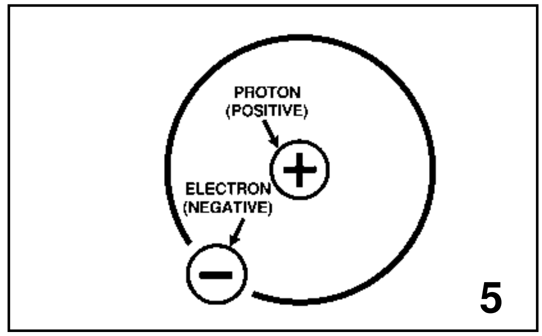
Introduction

This Technicians Reference Booklet contains information pertaining to basic automotive electricity, and the Subaru electrical system. It reviews electron theory, current flow, circuitry, and the types and causes of electrical shorts. Electrical terms are defined, Ohm's Law is explained, and the following major components of Subaru electrical systems are discussed: the battery, circuit protectors, switches, relays, and motors. Finally, the six-step method of troubleshooting is introduced. This method presents a logical step by step process of identifying and correcting typical electrical system problems.

The text and illustrations are derived from the classroom lecture and slide presentation material and are intended to reinforce previous classroom instruction and lab participation.

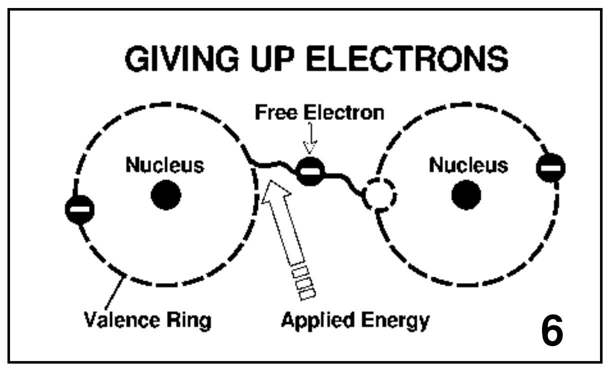
Technicians Worksheets provided by your instructor will be completed during the "hands-on" lab work segments of the Basic Electrical Theory & Diagnosis Module. Always refer to the appropriate model year Subaru Service Manual and the applicable Service Bulletins for all specifications and detailed service procedures.

Electrical System Theory



Electron theory

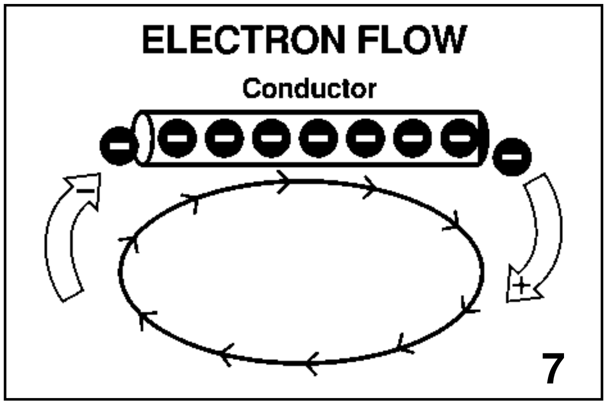
Atoms are composed of electrons and protons. Electrons have a negative charge and whirl around a nucleus composed of protons, which have a positive charge.



Electron flow

The electrons can move from the valence ring of one atom to the valence ring of another atom. This chain reaction effect type of movement of electrons constitutes electric current.

Atoms with fewer than four electrons are considered to be conductors because they give up electrons to other atoms easily.

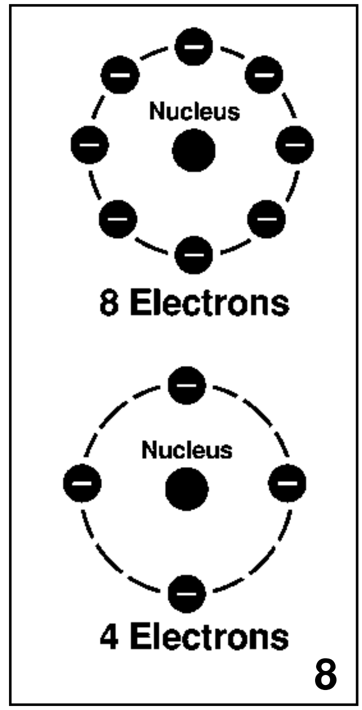


Conductors

All circuits must have conductors and insulators to operate properly. Electricity will always return to its source if a path (circuit) is available. Circuits provide a path for electrons to travel from a source to the load and back to the source.

Conductors such as copper, iron, and aluminum allow electrons to flow freely, or be released. There are several methods to produce electromotive force which causes electrons to be released:

- Magnetic (Alternator)
- Pressure (Knock sensor)
- Heat (Thermo-couple)
- Chemical (Storage battery)



Insulators/Semiconductors

Atoms with more than four electrons are insulators because they do not freely give up electrons. Examples are:

- Glass
- Rubber
- Vinyl

The best insulators have eight (8) electrons.

Atoms with exactly four electrons in the outer valence ring are called semiconductors. Examples are:

- Carbon
- Silicon
- Germanium

A semiconductor may be a conductor or an insulator, depending on the application and circuit conditions.

NOTE: SEMICONDUCTORS WILL BE ADDRESSED FURTHER IN THE ADVANCED ELECTRICAL THEORY & DIAGNOSIS MODULE.

Electrical Terms
- Amps—Current flow of electrons or intensity: Symbol = I
- Volts—Electromotive force or pressure: Symbol = V
- Ohms—Resistance to electron movement: Symbol = R

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Watts
- Measurement of electrical power: Symbol = W
- Watts = Volts x amps: W = V x I
- Example: 1) 12 V x 5.01 = 60 W
  2) 120 V x 0.51 = 60 W

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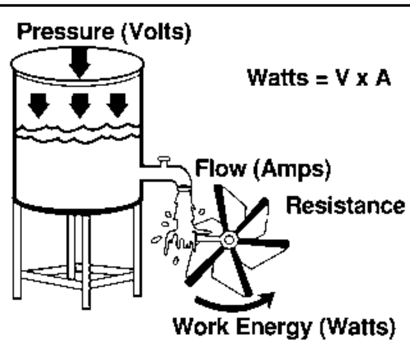
It is important that you understand the definitions of the electrical terms listed above.



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An electrical analogy

Think of an electrical system as a water system in which the water tank represents the power source (potential energy). The tank is similar to a battery. The water flowing from the water tank is measured in gph (gallons/hour) and represents electron flow. In a battery, chemical interaction produces this electron flow which is measured in amperes (amps).

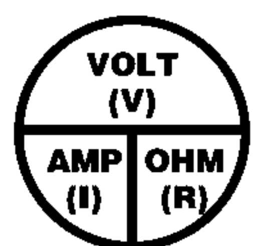
Pressure is created by the physical weight of the water which causes the water to move. Water pressure is measured on pounds/in^2 (psi). Similarly, the pressure that moves the electrons, which is called electromotive force, is measured on volts (V).

As the water strikes the water wheel, the weight of the water causes the wheel to turn. A continuous volume of water keeps the wheel turning. The weight of the wheel impedes (provides resistance to) the flow of the water. This resistance is measured as friction or drag. In an electrical system, the wire provides resistance through the covalent bonding of the electrons. This resistance is measured in ohms (R).

Work is equal to the pressure of the water times the flow of water which is equal to rotation of the wheel. An increase in the pressure or volume at the same resistance will equal an increase in the flow of water which in turn increases the speed or amount of wheel rotation. In an electrical system, the voltage (pressure - V) X amps (flow of electrons - I) will equal the watts (the wheel rotation) or work performed.

Ohm's Law

- **one volt applied to one ohm of resistance will result in one amp of current, therefore**
  - **I = V / R**
  - **V = I x R**
  - **R = V / I**



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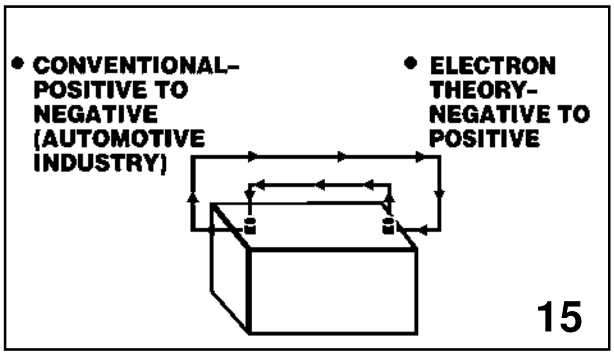
Using Ohm's Law, complete the following problems:

1. How many amps of current can flow through a 12-ohm resistor if 12,000 volts are available?

2. How many volts are required to move 10 amps of current through a 0.5-ohm wire?

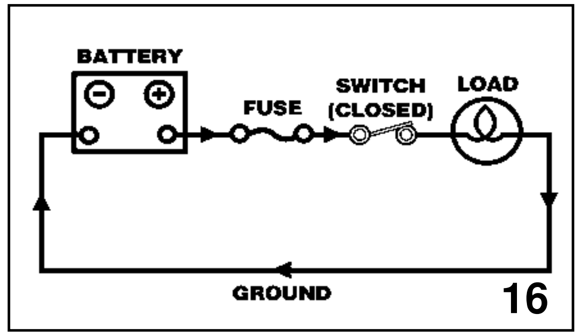
3. What resistance value will allow the flow of 15 amps of current if 12 volts are available?



Theory of electron flow

The conventional theory of electron flow states that the direction of current flow is from the positive (+) terminal of the voltage source, through the external circuit, and then back to the negative (-) terminal of the voltage source. The electron theory states that the direction of current flow is from the negative (-) terminal of the voltage source, through the external circuit, and then back to the positive (+) terminal of the voltage source.

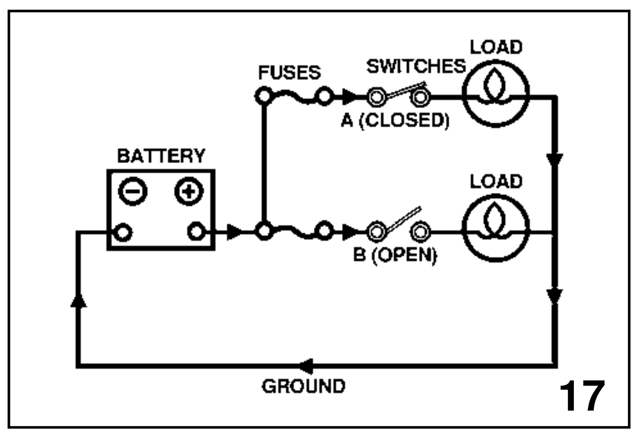
Circuits: Electron Flow



Basic electrical circuit

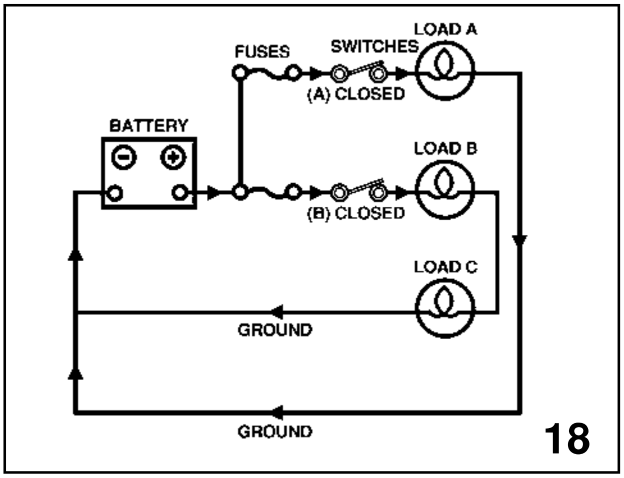
The basic circuit shown above has a battery as the power source. The wires carry the current from the battery (positive wire to the load (bulb) and back to the source (ground wire). A switch controls the flow of current, and a fuse protects the circuit from an overload or an unintentional ground.

The circuit shown above is a series circuit because it provides only one path for current flow. A break or short anywhere in the circuit will stop the current flow.



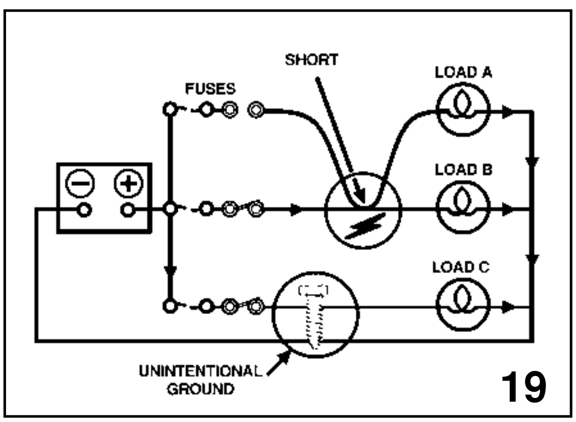
Parallel circuit

Current flows through parallel branches of the circuit only affects that branch and does not stop the flow of current to other components on the other branches of the circuit.



Series-parallel circuit

This type of circuit is a combination of the series and parallel forms of circuitry and has the advantages and disadvantages of both types. If the fuse blows in the main feed line, current cannot flow to Load A, Load B, or Load C. On the other hand, a break in the Load A wire will not affect the operation of the Load B or Load C circuit. This is the most common type of circuit used in automotive electrical systems.

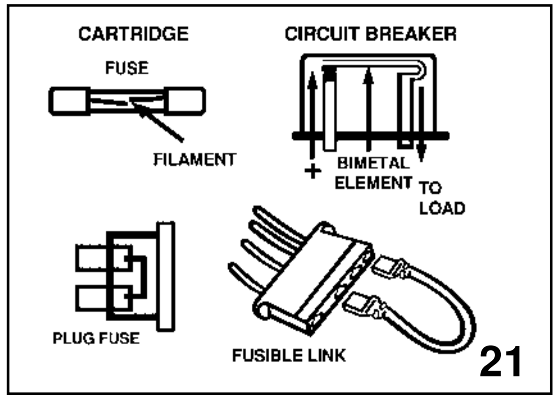


Shorts grounds and opens

The figure above shows two types of shorts that occur in automotive electrical systems. A short circuit can be a connection of two circuits caused by a break in the insulation of the circuits or an unintentional ground caused when a circuit comes in contact with a ground as shown above. An open is an interruption of the current flow in a circuit caused by the activation of a switching device or a break in a conductor.

Electrical Terminology

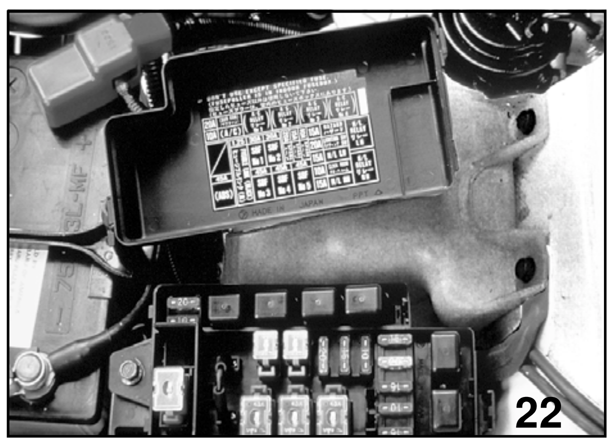
Circuit Protectors



Circuit Protectors

Circuit protectors provide a vital safeguard to an electrical system.

A blown circuit protector is an indication of a problem in the circuit. Replacing the circuit protector is not usually the solution to the problem.



Fusible link

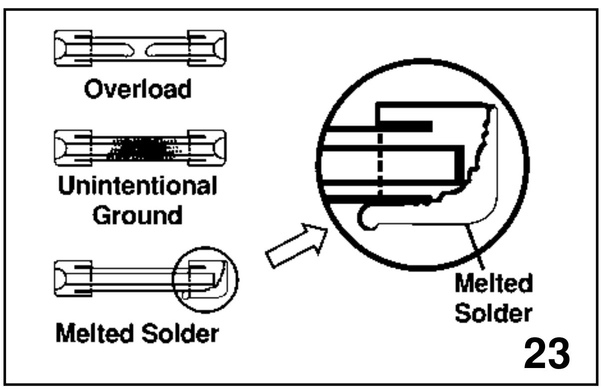
A fusible link is a short piece of insulated wire that is usually four gauges smaller in wire size than the circuit it protects. Subaru vehicles use up to five fusible links depending on model and year.

There are two types of fuses used in Subaru vehicles:

1. Cartridge type
   These fuses have a zinc strip attached to two metal end caps. The end caps are separated by a clear glass tube.
2. Plug type
   This fuse has a zinc strip attached to two metal terminals are imbedded a plastic holder.

Some Subaru vehicles use plug type fuses as main fuses instead of fusible links. Examples are certain circuits in the Legacy and Justy vehicles.

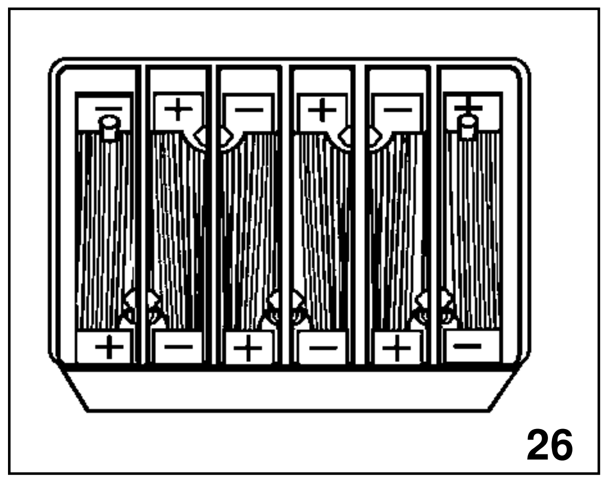
Circuit breakers are a thermal mechanical device that opens a circuit when its amperage rating is exceeded. The advantage of a circuit breaker is that it is reusable and automatically resets.



Fuse interpretation

When a fuse blows because of a circuit fault, it will exhibit one of three visual characteristics as described below. By examining the fuse closely, it can be determined what type of circuit fault caused the problem.

1. Overloaded circuit, occurs when 20 amps pass through a 15 amp fuse. The center of the fuse strip will get hot, droop then melt leaving the ends drooping down at the break point.
2. A short circuit or unintentional ground causes an extremely high current to pass through the fuse strip. The strip melts so quickly that it vaporizes. The strip particles splatter the glass tube or plastic body and the glass tube or plastic body will appear tinted (silvery/black).
3. A poor fuse connection is caused by a loose contact between the fuse cap and holder (cartridge type only). This creates a resistance, which can produce enough heat to melt the solder attaching the fuse strip to the end caps. In this case beads of solder or flux stains may be seen on the inside or on the outside of the glass tube, however the fuse strip will appear to be intact.



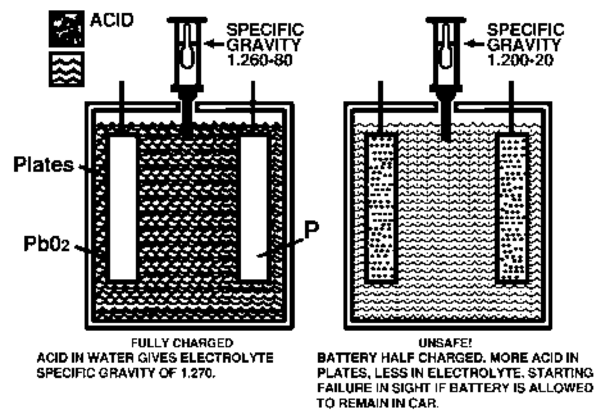
Battery

The automotive battery is an electrochemical device that stores and converts chemical energy into electrical energy. It is not a storage container for electricity. The battery provides the initial electrical energy for the ignition system and starting system. It also supplies additional current when the current demand of the system exceeds the output of the alternator.

Automotive batteries normally have six cells. Each cell produces 2.1 volts; thus a six-cell battery produces 12.6 volts. The voltage output of the battery is determined by the material used in the construction of the plates.

Automotive battery plates are made of two dissimilar materials, for example, lead peroxide (positive plate) and sponge lead (negative plate). A thin separator of rubber or plastic is between each negative and positive plate.

The cells are then connected in series, i.e., the positive plates of one cell are connected to the negative plates of the next cell, etc. Note that additional plates in a cell do not increase the voltage capability of the cell or battery, but they do increase the length of time that the battery can produce electricity (amperage rating).



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Electrolyte specific gravity

Electrolyte is the final ingredient required for an active battery. Without electrolyte, a battery is inactive and does not produce electricity. Electrolyte is a solution of water and purified sulfuric acid which allows the chemical reaction to occur between the plates. Generally, the percentage of sulfuric acid in a battery is 36 percent by weight and 25 percent by volume.

To determine the amount of charge of a battery, the specific gravity of the electrolyte is measured. A full charged battery theoretically should have an electrolyte specific gravity of 1.299. However, a normally charged battery will most likely indicate specific gravity readings ranging from 1.260 to 1.280 at 80° F.

Specific gravity is the ratio of the weight (or mass) of the water to the weight (or mass) of the sulfuric acid. Thus, a specific gravity of 1.000 is equal to water. Specific gravity will change with changes in temperature of the electrolyte, For each 10° above 80° F., add .004 to the electrolyte reading. For each 10° below 80° F., subtract .004 from the electrolyte reading. Or you may use an electrolyte temperature correction chart or a temperature equipped hydrometer.

NOTE: THE SPECIFIC GRAVITY READINGS MUST NOT VARY MORE THAN 50 POINTS BETWEEN CELLS. A VARIATION OF MORE THAN 50 POINTS INDICATES CELL DETERIORATION, AND A NEED FOR BATTERY REPLACEMENT.

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Voltmeter usage

There are two basic types of voltmeters:

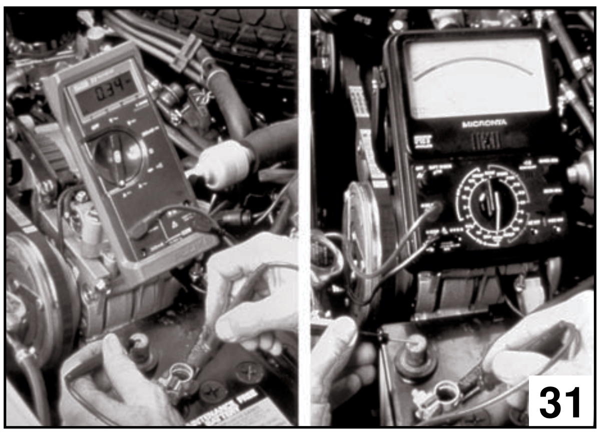
- Digital type which is best for low or fractional voltages.
- Analog type which is best for measuring rapid or large voltage changes.

A high input resistance of usually 10 megohms (W) per volt input resistance prevents overloading of low current circuits by the voltmeter. An overloaded circuit will produce inaccurate voltmeter readings.

Always connect a voltmeter in parallel, i.e., positive (+) lead to the positive (+) side of the circuit/component and the negative (-) lead to the negative (-) side of the circuit/component.

Voltmeter Cautions

- Never connect in series
- Use the proper scale for the circuit voltage
- Always zero the meter
- Voltmeters are precision instruments, handle with care.



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Ammeter usage

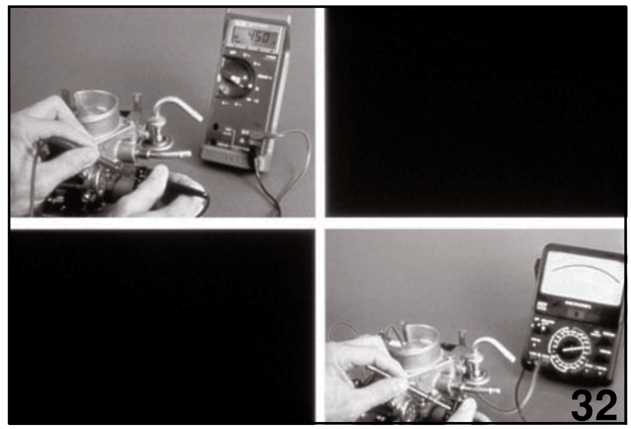
There are two types of ammeters:

- Digital type which is best for low or fractional current readings.
- Analog type which is best for varying current readings.

Always use an ammeter with a low input resistance. There is not a standard input resistance specification available, however higher quality meters offer this feature. Proper connection will protect your ammeter from damage. **Always** connect in series with a circuit. Connect the leads to either end of an opened/separated part of the circuit; the positive (+) lead connector toward the positive (+) side of the circuit/component and the negative (-) lead connector toward the negative (-) side of the circuit/component.

Ammeter Cautions

- **Never connect in parallel with power source** (Will cause immediate meter damage)
- Use a meter with a high enough capacity for the potential current in the circuit being measured
- Use a higher scale first and work down
- Handle the meter carefully
- Always zero the meter



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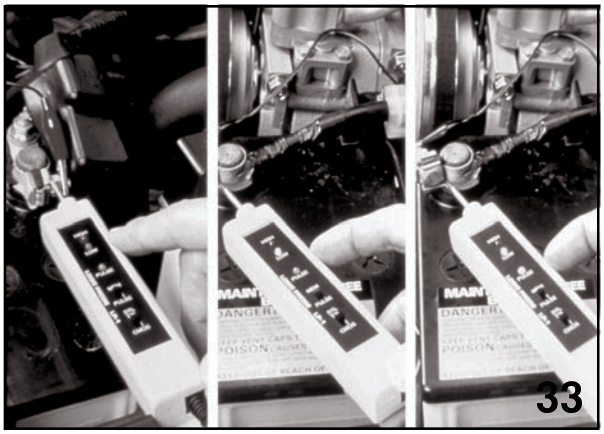
Ohmmeter usage

There are three types of ohmmeters:

- Digital types are best for reading low and fractional resistance values. Some digital meters are also self-ranging.
- Analog types are difficult to read fractional resistance values. The analog type is not the preferred meter for measuring resistance.
- The field effect transistor type (F.E.T.). A very low voltage is provided at the tips which prevents damage to computer circuits. This feature can be found on either analog or digital type meters, and is used in conjunction with the diode testing scale for checking diodes.

Ohmmeter Cautions

- **Never connect to a powered circuit/ component**
- Use proper scale
- Handle meter carefully
- Always zero the meter



Digital logic probe (DLP)

The digital logic probe can be used to quickly test the power supply or ground circuit. It is used in lieu of the test light which can damage computerized circuitry. It is best to have a DLP with a pulse/memory feature, which is used to check for pulsing signals or intermittent opens. Also, it is best to have an input overload protection to a minimum of 250 volts at the probe.

Connect the positive (+) lead to the B+ power source and the negative (-) lead to any viable ground. (A cigarette lighter adaptor can be used for working inside of the vehicle.) Touch the center probe to any power source or ground in the electrical system.

The DLP is used to determine high or low voltage in a circuit.

- Above 10 volts the "HIGH" LED illuminates.
- Below 4 volts the "LOW" LED illuminates.
- Between 4.1 and 9.9 volts, neither LED illuminates, but the "PULSE" LED flashes: "ON" and "OFF" once. This indicates the voltage availability in this range.
- The "PULSE" LED will flash "ON" and "OFF" to indicate any change in voltage, i.e., the crank angle sensor, cam angle sensor, speed sensor, ignitor, or any circuit where varying voltage is present.

The pulse memory is used to detect an intermittent open or short in the circuit. Connect the probe to the circuit. Then wiggle the connections, wires, etc., the "MEM" LED illuminates when an intermittent or poor connection is disturbed.

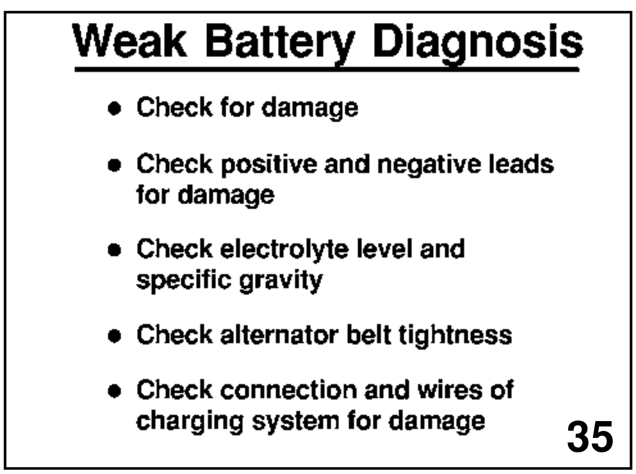
DLP Cautions

- Do not use on high voltage sources, i.e., ignition secondary.
- Only use on automotive 12 volt power sources.

Battery Testing Procedures

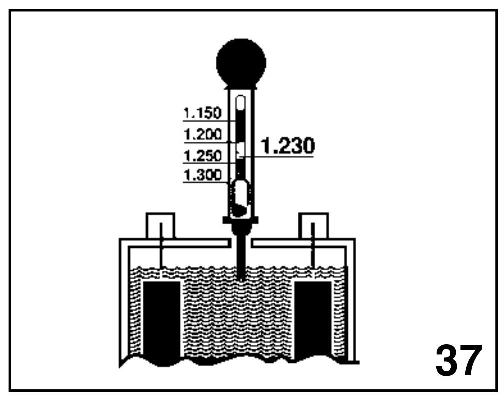
The first step is to check the operation of the electrical components. Then complete the following checks:

1. Check the battery for damage
2. Check the positive and negative leads for corrosion and proper installation.
3. Check that the electrolyte is at the full level indicator(s). Check the color of the electrolyte.
   — Clear means there is no damage.
   — Red means there is positive plate deterioration.
   — Gray means there is negative plate deterioration.
4. Check the specific gravity, it must be a minimum of 1.230 to test the battery. There should be no more than a maximum of a 50 point differential between the cells.
5. On sealed maintenance free batteries, check the open circuit voltage and compare its value with the manufacturer's specifications.
6. If the specific gravity is below 1.230 or the open circuit voltage is below the recommended value, charge the battery and recheck the specific gravity/open circuit voltage.



Battery performance test

A battery performance test is required when the engine cranks slowly or does not start. If the battery specific gravity is greater than 1.230, conduct a battery performance test. If the specific gravity is less than 1.230, charge the battery in accordance with the manufacturer's recommended procedures. Then proceed with a battery performance test.



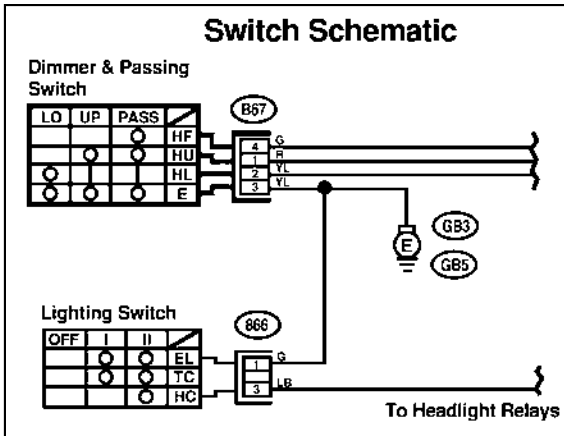
NOTE: WHEN CONDUCTING A BATTERY PERFORMANCE TEST ALWAYS FOLLOW THE EQUIPMENT MANUFACTURER'S RECOMMENDED PROCEDURES. APPLY A LOAD EQUAL TO 1/2 THE COLD CRANKING AMP RATING OF THE BATTERY FOR 15 SECONDS. OBSERVE THE BATTERY VOLTAGE WHILE THE LOAD IS BEING APPLIED AND COMPARE IT WITH THE MANUFACTURERS' SPECIFICATIONS.

Switches, Relays and Motors

System Components

A switch is a device used to open, close, or redirect the flow of current in an electrical circuit. Switches are available in various shapes, sizes, and capabilities to meet circuit control requirements. A single-position switch, such as a stop light switch, controls the stop light by closing/opening the circuit to allow/stop the flow of current to the stop light.

A multiple-position switch, such as a lighting switch, controls the flow of current to several components. Finally, a switch may work in conjunction with other switches, such as the four courtesy light switches in a four-door vehicle.



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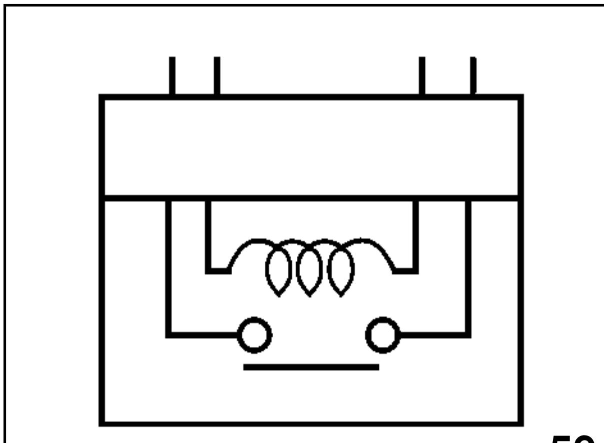
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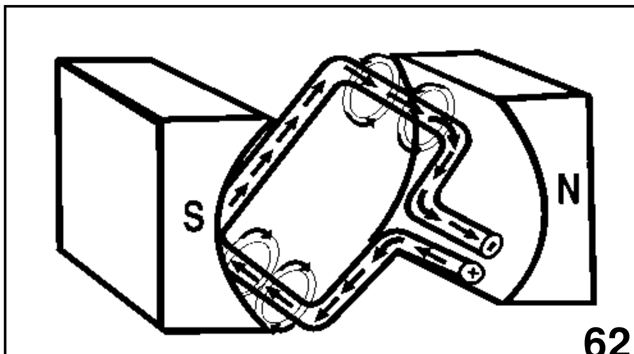
Relays

A relay is an electromagnetic switching device that uses low current to open or close a high-current switching device. There are two basic types of relays used on Subaru vehicles: normally open (NO) and normally closed (NC). A third type of relay is used in special automotive applications. This relay transfers current flow from one circuit to another.



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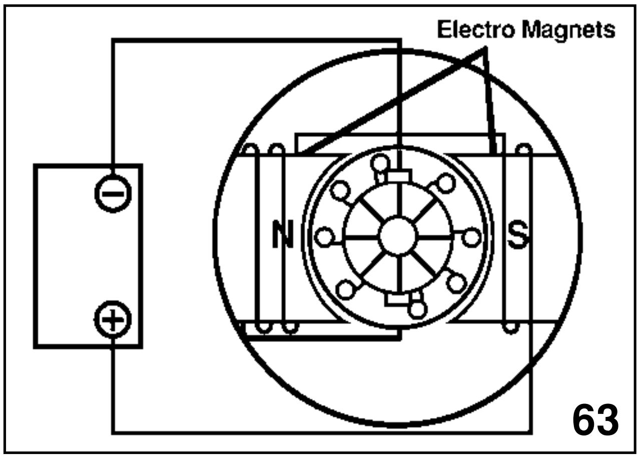
Motors

A motor is an electromagnetic device that converts electrical energy into mechanical energy. Motor operation is accomplished by placing a loop-shaped conductor in a magnetic field and then passing current through the conductor. The flow of the current through the conductor loop causes an unbalanced field condition, which causes the loop to rotate to a position where the field is once again in balance. Then the loop will stop rotating.

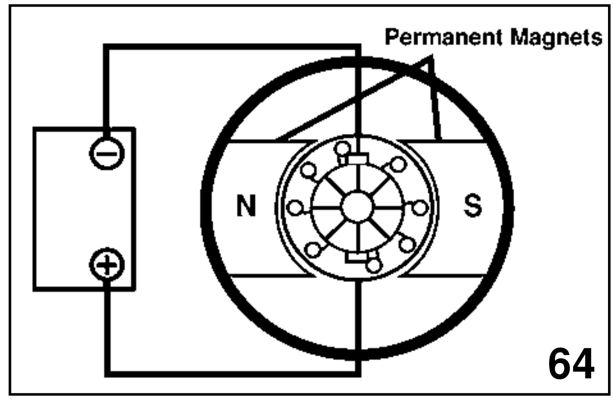


Motor operation

To obtain continuous rotation, a motor must contain numerous conductor loops, and the direction of the current must be reversed at the halfway point of rotation for each of the loops. This is accomplished through a split ring called a commutator. The rotating loops and commutator make up the armature of the motor.

Rotation of the motor creates a generating action called back voltage or counter electromotive force.

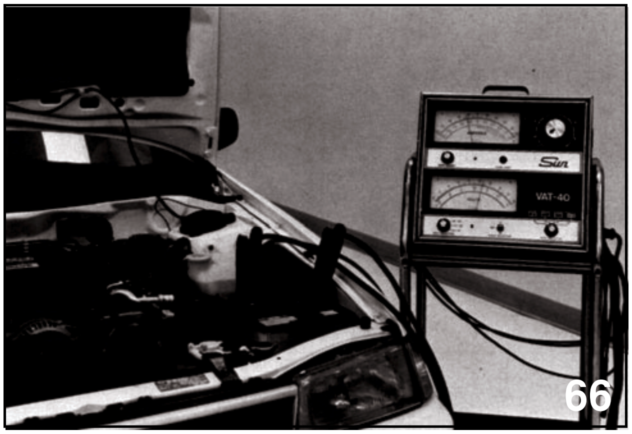
This force limits the current draw of the motor (armature) so that the motor only draws the amount of current to perform the job required. If the force required to perform the job exceeds the current capacity of the armature, the armature will stop rotating, the current will overheat the wires in the armature, and the motor will be damaged.



Permanent magnet motor operation

Permanent magnet motors do not use field coil construction. Because the field magnetism is constantly available from highly efficient permanent magnets, the current is sent directly to the brushes. The operating principle is similar to a field coil type motor. The advantage of this motor design is a significant reduction in the size and weight of the motor with no loss of operating capacity.

Starting and Charging Systems Tests



Starting system test

A performance test is required if any of the following conditions are present:

1. Difficult starting is experienced.
2. Cranking speed is slow.
3. Consecutive starting of the engine results in a slower cranking speed.
4. The starter does not engage.
5. All other components of the starting system have been eliminated as the possible fault.

Cautions and preliminary steps to conducting a performance test:

1. A performance test should only be made with a serviceable battery.
2. Turn off all lights and accessories and close all doors.
3. Adjust test equipment according to the operator's instructions.
4. Prevent the engine from starting during the cranking test.
   - Ground the negative coil primary wire or the tach terminal on gasoline engines with an externally mounted ignition coil, or disconnect the distributor primary connector. On distributorless ignition vehicles, disconnect the crank angle sensor.
   - On gasoline engines with an integral mounted ignition coil, disconnect the ignition switch lead from the ignition system assembly. Do not allow the lead to touch a ground.
5. Conduct the performance test according to the directions contained in the operator's instructions.

NOTE: REFER TO SEC. 6-1 OF APPROPRIATE MY SUBARU SERVICE MANUAL FOR SPECIFICATIONS.

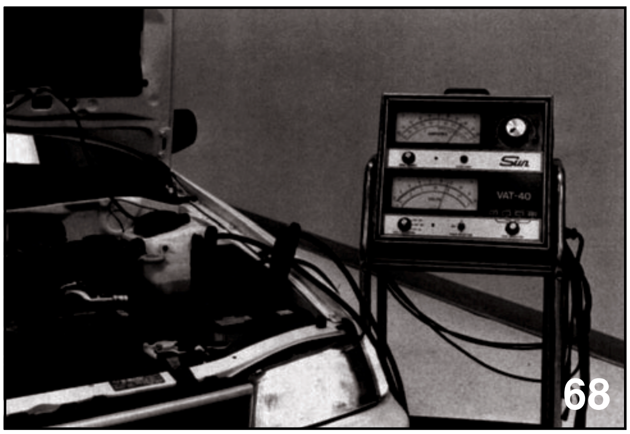
6. Restore the engine and component connections to the normal starting condition.

Alternator performance tests

An alternator performance test is required if any of the following conditions are present:

1. The battery is dead (discharged), but holds a charge when charged. Also, the battery performance test indicates a good battery.
2. The vehicle voltmeter indicates a discharging condition or the charge warning light is illuminated during normal vehicle operation.
3. The system is overcharging.
4. All other components of the charging system have been eliminated as the fault.

Conduct the alternator performance test in accordance with the operator's instructions for the test equipment you are using. Conduct an alternator charging test, a voltage regulator test, and a diode stator test. Compare the results of the tests to the specifications listed in the appropriate MY Subaru Service Manual and repair and or replace components as required. Then retest the system.



Charging system requirements test

Conduct a charging system requirements test in accordance with the operator's instructions for the test equipment you are using. Be sure to connect the D-Check connectors so that the fuel pump and other fuel system components operate.

Note the total accessory load reading and compare the reading to the total alternator output reading obtained in the alternator performance test. The total alternator output reading should exceed the total accessory load reading by at least 5 amps.

If the readings are below specifications, conduct a voltage drop test between the alternator and the battery, (between the alternator B+ terminal and the battery positive terminal).

Troubleshooting

Slides 71 through 78

The Six Step Troubleshooting Method

1. Verify the problem.
2. Determine related symptoms.
3. Isolate the problem.
4. Identify the cause.
5. Repair and/or replace.
6. Verify operation.

This method of troubleshooting will save time and effort in the diagnosis and analysis of electrical problems. It provides a logical approach to solving the problem—not just treating the symptoms. The steps are defined as follows:

1. Verify the problem (operational check). Identify the symptoms of the problem. Are components inoperable or malfunctioning? When, how often, and where does the problem occur?

2. Determine related symptoms (operational check). Identify other symptoms that exist. Are other circuits and components affected? Do the related symptoms always occur with the primary symptom?

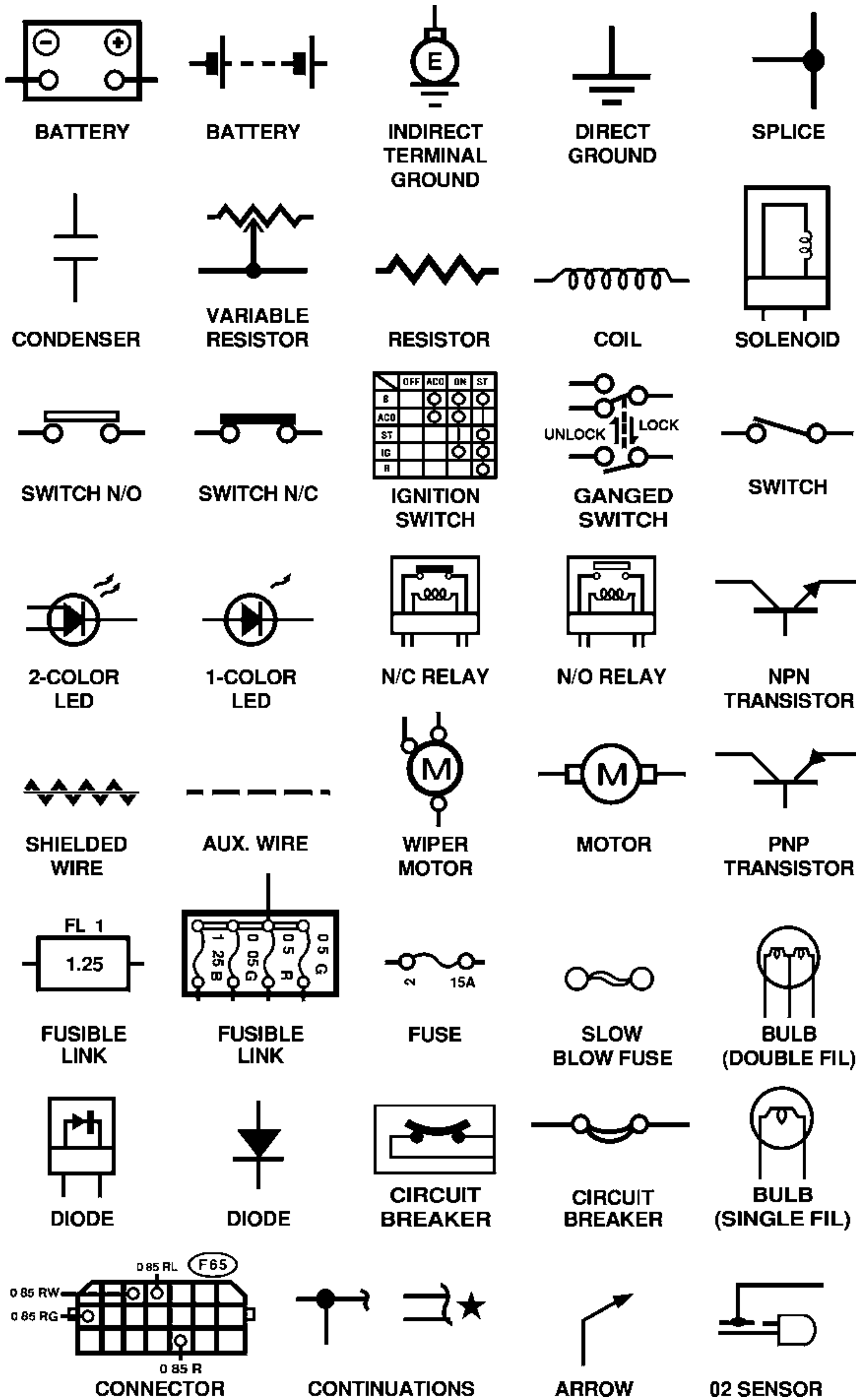
3. Isolate the problem. Use the split half technique*, the wiring diagram, and the wiring harness diagram to locate a short in a grounded circuit.

   *The split-half technique is used as follows:
   - Obtain the proper wiring diagrams.
   - Divide the circuit in half at an accessible connector.
   - Check half of the circuit.
   - Repeat the process if the first half of the circuit is good, check the second half of the circuit, etc.,
   - The problem always exists between a positive and a negative result.

4. Identify the cause of the problem. Is the circuit grounded, shorted, feeding through another circuit, or is a component defective?

5. Repair and/or replace defective wiring and components as required.

6. Verify operation. Check the circuit to verify that the problem has been solved. Ensure that all circuit components operate properly under standard operating conditions according to technical specifications. Also check related circuits for proper operation.


BATTERY
BATTERY
E
INDIRECT TERMINAL GROUND
DIRECT GROUND
SPLICE
CONDENSER
VARIABLE RESISTOR
RESISTOR
COIL
SOLENOID
SWITCH N/O
SWITCH N/C
OFF ACC ON ST
B
ACC
ST
IG
R
IGNITION SWITCH
UNLOCK
LOCK
GANGED SWITCH
SWITCH
2-COLOR LED
1-COLOR LED
N/C RELAY
N/O RELAY
NPN TRANSISTOR
SHIELDED WIRE
AUX. WIRE
M
WIPER MOTOR
M
MOTOR
PNP TRANSISTOR
FL 1
1.25
FUSIBLE LINK
1 25 B
0 05 G
0 5 R
0 5 G
FUSIBLE LINK
2
15A
FUSE
SLOW BLOW FUSE
BULB (DOUBLE FIL)
DIODE
DIODE
CIRCUIT BREAKER
CIRCUIT BREAKER
BULB (SINGLE FIL)
0 85 RL
F65
0 85 RW
0 85 RG
0 85 R
CONNECTOR
CONTINUATIONS
ARROW
02 SENSOR

Electrical Terms Glossary

Resistance
Property of an electrical circuit that tends to prevent or reduce the flow of current.

Dynamic resistance
Effect of a resistor or resistance in a circuit.

Voltage Drop
The difference in voltage between one point in a circuit and another, or the difference in measured voltage from one side of a component to the other side.

Resistor
Device that permits a predetermined current to flow at a given voltage. Examples are a SPFI ballast resistor and a 4EAT dropping resistor.

Rheostat
See variable resistor.

Variable Resistor/Rheostat
A device that adjusts the amount of resistance required. An example is a sliding contact resistor. The position of the contact determines the amount of resistance. The fuel sending units of a vehicle equipped with an analog dash use a variable resistor.

Potentiometer
A resistive element with a sliding wiper contact that is used in applications in which a division of resistance is required (such as a three-terminal adjustable resistive divider). Example: The throttle sensor on SPFI and MPFI fuel systems.

Splice
Joining of two or more conductors at a single point.

Terminal
Device attached to the end of a wire or cable to make an electrical connection.

Ground/Chassis ground
Negative side of a complete circuit. In automotive applications the negative side of the battery or any wire connected to the engine, frame, or body sheet metal.

Relay
Electromagnetic switching device using low current to open or close a high-current device.

Solenoid
An electromagnetic device consisting of a tubular soil of wire containing a core that moves when the coil is energized. Movement of the core can open/close a circuit. A solenoid converts electrical energy to mechanical energy.

Filament
A fine high resistance wire or thread which glows and produces light when current is forced through it.

Diode
Solid-state device that permits current to flow in one direction only; performs like a one-way check valve.

Transistor
Solid-state semiconductor that is a combination current amplifier and switch (similar to a solenoid in the starter circuit or a relay in function). It uses low control current to channel high current.

Capacitor (Condenser)
Device used to store an electrical charge.

Notes:

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Module 405

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Technical Training

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Slide Sequence

Introduction

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Today's automobile is the refinement of research, which through the years has led to a computer controlled machine sensitive to both internal and external influences. It is able to provide optimum performance throughout a broad range of atmospheric conditions, fuel quality, engine condition and driver demand. The information covered in this course will get you started with the knowledge base you must have to effectively analyze conditions, situations and problems associated with vehicle emissions. The majority of the course will be conducted in a lab/lecture format.

You are required to be an active member of the class. Take notes and complete the lab structured work sheets. A completion test will be given at the end of the class based on information covered in lecture and hands on exercises.

Raw Materials For Combustion

To fully understand the emissions produced by a vehicle, a closer look at the raw materials used must be made. They include fuel and the atmosphere. The fuel or gasoline is a hydrocarbon made from a mixture of components which vary widely in their physical and chemical properties. Gasoline must cover a wide range of vehicle operating conditions, engine temperature, climates, altitudes and driving patterns.

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There are many driveability conditions that can be caused from gasoline problems. One such problem is incorrect fuel volatility. Volatility is a fuels ability to change from a liquid to a vapor. Gasoline refiners must chemically adjust their product seasonally, providing more volatile gasoline in the winter and less in the summer. There are many ways of measuring volatility however there is only one practical way you can check it in your shop. That is the vapor pressure test using the Reid Method.

Problems associated with incorrect Volatility:

Low Volatility -

Cold Start

Warm up performance

Cool weather performance

Cool weather drive ability

Increased deposits of the combustion chamber

High Volatility -

High evap emissions

Hot drive ability

Vapor lock

Poor fuel mileage

There are six volatility classes of gasoline. Record their values on the spaces below.

AA ______________________________

A ______________________________

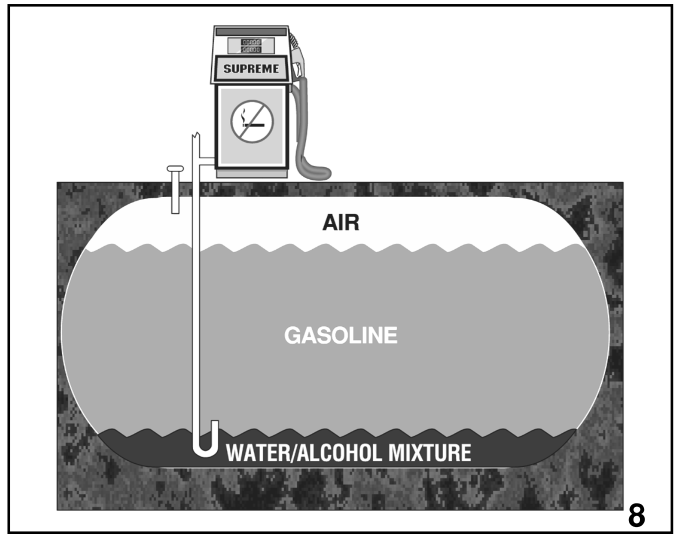
B ______________________________

C ______________________________

D ______________________________

E ______________________________

Higher volatile fuels will evaporate easier than lower volatile fuels so higher pressure readings will be achieved.



Storage Tank

Phase Separation

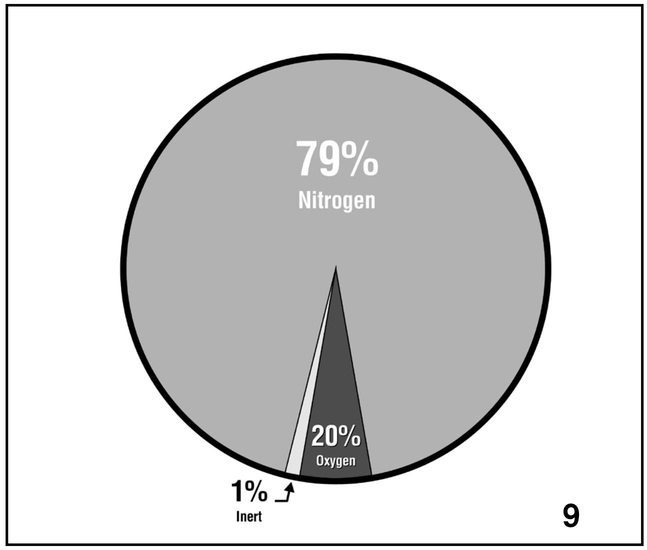
Another problem of today's' gasoline can be created if the fuel is stored in a water contaminated tank. Referred to as Phase separation, this condition results because of the use of alcohols as octane boosters and oxygenates. The alcohol in the gasoline will absorb the water in the tank and separate from the gasoline. This new heavier mixture will settle in the bottom of the storage tank. Sooner or later someone will get a tank full or enough of it pumped into their vehicle to cause a drive ability problem. Oxygenates or alcohols are used in fuels where lower emission output is required by state or federal regulations. These fuels are called "Reformulated" or "Oxygenated" fuel. The difference between the two is the amount of additional oxygen they supply to the combustion process.

Reformulated and Oxygenated Fuel
"Reformulated" fuel contains 2% oxygen by weight. "Oxygenated" fuel contains 3.5% oxygen by weight. There is a trade off with use of either of these fuels and that is a 2% fuel economy loss and less energy output per gallon. Gasoline normally creates 115,000 BTU's per gallon. Reformulated or Oxygenated fuel will produce only 76,000 BTU's per gallon. Ethanol and Methanol are the two alcohols used in oxygenated gasoline. Methanol is a wood alcohol and can be used up to 5% with most auto manufactures. However it is very corrosive and many cosolvents and rust inhibitors must be used with it to prevent damage to the fuel system. Ethanol or grain alcohol is not as corrosive and is allowed up to 10%.

Octane
Octane is defined as a fuels ability to resist knock. Also known as the Anti Knock Index. (AKI) is the average of the Motor and Research Octane Number (RON).

(R+M)/2 Laboratory tests determine MON and RON. There is no advantage in using a higher octane than it takes to prevent engine knock. Engine knock is created by using a lower octane than is required. Heat and pressure will ignite the air fuel mixture before the spark, creating an uneven burn across the combustion chamber. Subaru ignition timing learning control logic memorizes when the engine knock occurs, and retards the timing away from optimum to compensate.

Atmosphere

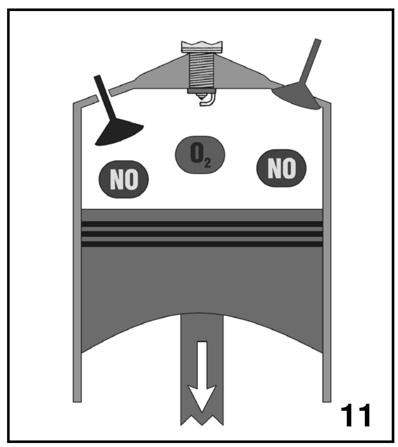


Atmosphere

The atmosphere is composed of 79% nitrogen, 20% oxygen and 1% inert gases.

Each intake stroke fills the cylinder with these gases. This action also produces vacuum.

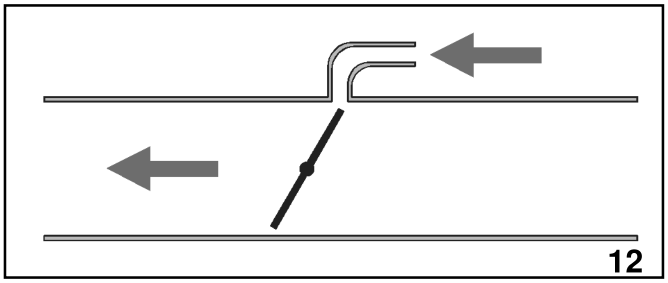
Vacuum



Manifold Vacuum

There are two types of vacuum or negative pressure produced by the engine. The first to be produced in a measurable amount is called Intake manifold vacuum. It is produced by the intake stroke of the engine.

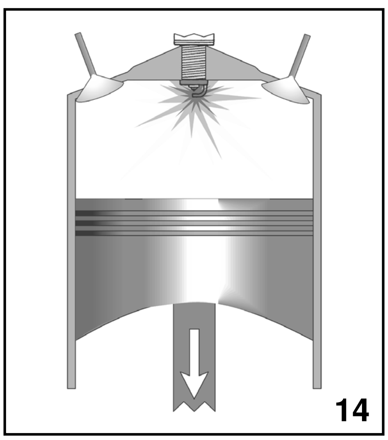
The second type is Ported vacuum. It is produced by the volume and speed of the air entering the engine. The positioning of the throttle plate determines the amount produced and at what spot in the throttle bore it is located. This effect enables the ported vacuum to be used as a working pressure and a controlling pressure.



Ported Vacuum

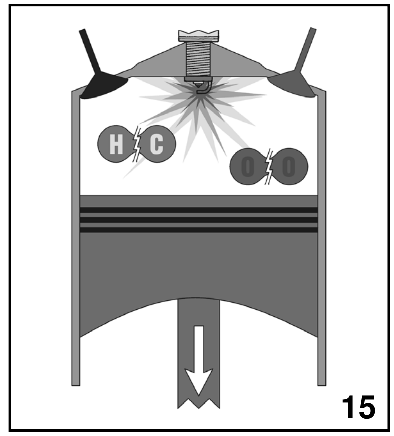
Combustion Process

Combining fuel and atmosphere in the combustion chamber under pressure and supplying a spark changes chemical energy to heat energy. The resulting gas expansion pushes the piston down.



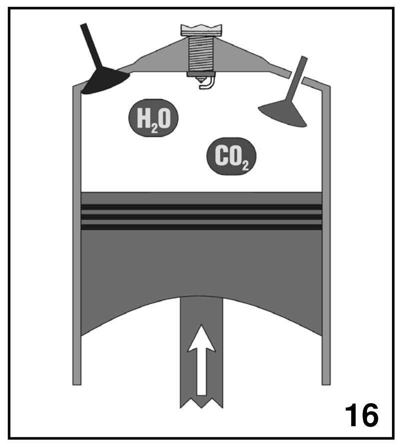
Power Stroke

Combustion splits gasoline or HC. Engine temperature, compression, fuel purity, ignition timing, and the mechanical condition of the engine determine the degree of complete combustion. This ultimately determines the amount and type of exhaust emissions produced. Near complete combustion will join oxygen with hydrogen and form water. The carbon will join with oxygen to form CO2, Carbon Dioxide.



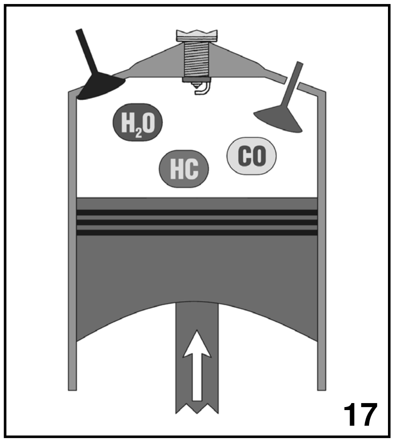
Combustion Process

Complete combustion is very hard to achieve because of uneven engine temperatures, random fuel impurities and many other situations, however in theory if complete combustion did take place one gallon of gasoline would produce one gallon of water.



Complete Combustion

Incomplete combustion occurs when the entire fuel charge is not burned in the combustion chamber. Unburned HC will be exhausted to the atmosphere if the exhaust remains untreated Carbon will still join with oxygen but with only one part so the result is the production of Carbon Monoxide, CO. This gas is very unstable. If inhaled .3 of 1% in a 30 minute time frame will create Carbon Monoxide Poisoning which can be fatal. HC and CO are both harmful to the atmosphere.



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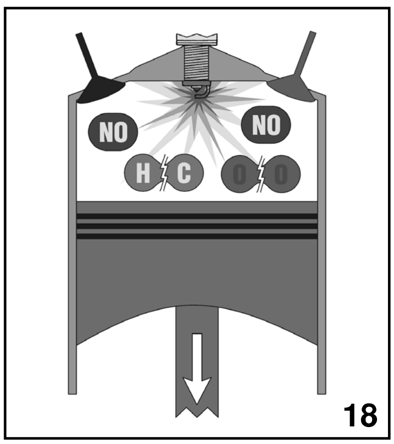
Incomplete Combustion

Another harmful gas is oxides of nitrogen, NOx. The x is an indicator that the number of oxygen molecules is unknown. NOx is produced from high pressure and heat in excess of 2500° F (1371.1 C) in the combustion chamber.



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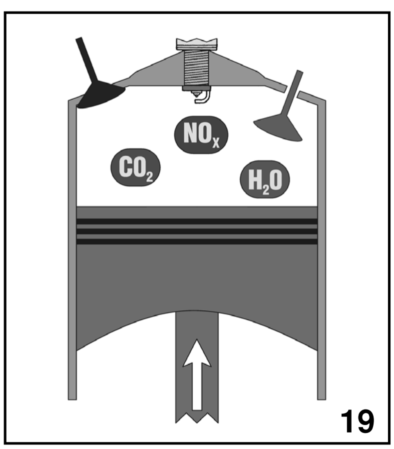
Nitrogen During Combustion



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NO_x Production

HYDROCARBONS (HC) *Measured in PPM* Result of incomplete combustion (raw fuel)	**75 PPM**
CARBON MONOXIDE (CO) *Measured in (%)* Result of fuel burnt without enough air.	**0.5%**
OXYGEN (O_2) *Measured in (%)* Result of a lean running engine.	**0.5%**
CARBON DIOXIDE (CO_2) *Measured in (%)* Result of an efficient running engine.	**13.5%**
OXIDES OF NITROGEN (NO_X) *Measured in PPM* Result of combustion chamber temperatures over 2500° F	**<400 PPM**

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Notes:

Review the analyzer readings below and choose the correct answer that best describes the condition. (Write the corresponding letter on the space provided below).

A) Normal Condition
B) Rich
C) Lean
D) Lean Misfire
E) Loose Knock Sensor
F) Open Coolant Temp Sensor
G) Clogged Injector
H) Open Plug Wire

CONDITION 1	HC (hydrocarbons)	75 PPM
	CO (carbon monoxide)	0.1%
	O_2 (oxygen)	9.0%
	CO_2 (carbon dioxide)	5.0%
	NO_x (oxides of nitrogen)	1000 PPM
CONDITION 2	HC (hydrocarbons)	20 PPM
	CO (carbon monoxide)	0.5%
	O_2 (oxygen)	13.0%
	CO_2 (carbon dioxide)	0.5%
	NO_x (oxides of nitrogen)	<400 PPM

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Condition 1: ____________

Condition 2: ____________

CONDITION 3	HC (hydrocarbons)	20 PPM
	CO (carbon monoxide)	0.0%
	O_2 (oxygen)	9.0%
	CO_2 (carbon dioxide)	5.0%
	NO_x (oxides of nitrogen)	800 PPM
CONDITION 4	HC (hydrocarbons)	350 PPM
	CO (carbon monoxide)	3.0%
	O_2 (oxygen)	9.0%
	CO_2 (carbon dioxide)	0.1%
	NO_x (oxides of nitrogen)	11 PPM

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Condition 3: ____________

Condition 4: ____________

CONDITION 5	HC (hydrocarbons)	850 PPM
	CO (carbon monoxide)	0.3%
	O_2 (oxygen)	8.0%
	CO_2 (carbon dioxide)	5.0%
	NO_x (oxides of nitrogen)	800 PPM
CONDITION 6	HC (hydrocarbons)	1200 PPM
	CO (carbon monoxide)	0.3%
	O_2 (oxygen)	8.0%
	CO_2 (carbon dioxide)	8.0%
	NO_x (oxides of nitrogen)	800 PPM

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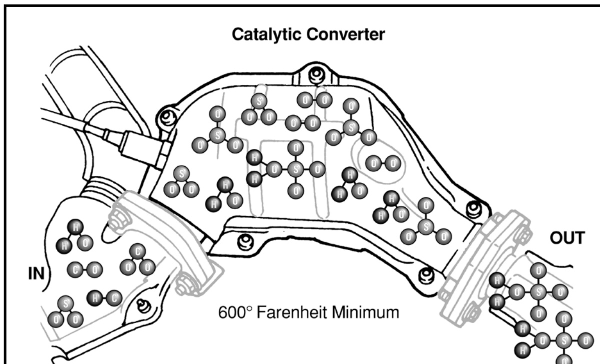
Condition 5: ____________

Condition 6: ____________

Catalytic Converter

Reducing HC, CO and NOx is the objective of the catalytic converter. The converter is made of a honey comb ceramic structure held in place with a Nickel support shell all contained in a metal housing. Rare nobel metals, Platinum, Palladium and Rhodium, are adhered to the ceramic structure. These two metals give the catalytic converter a 3 way operating characteristic. When in operation the converter will change CO, HC and N0x to CO2, Nitrogen also enables it to store oxygen during times of a lean mixture and bring it into the conversion process during times of ric mixtures. An operating temperature of at least 600° F (315.55 C) is required for the catalytic converter to operate.



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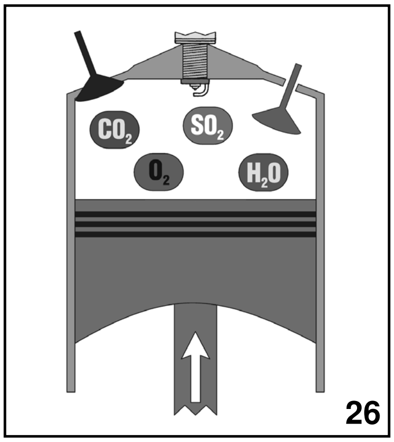
Normal Catalytic Operation

The Nickel content of Catalytic converts has been reduced in recent years because of its natural ability as a reducing agent.

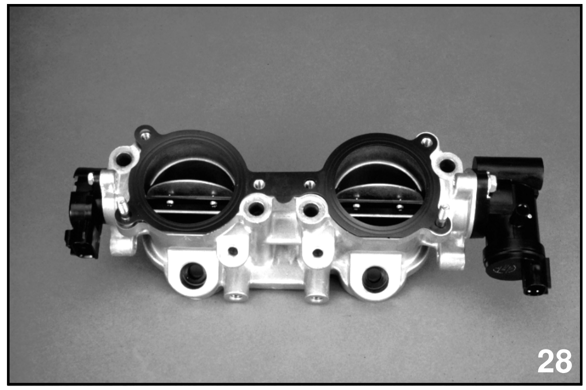


SO_2 Production

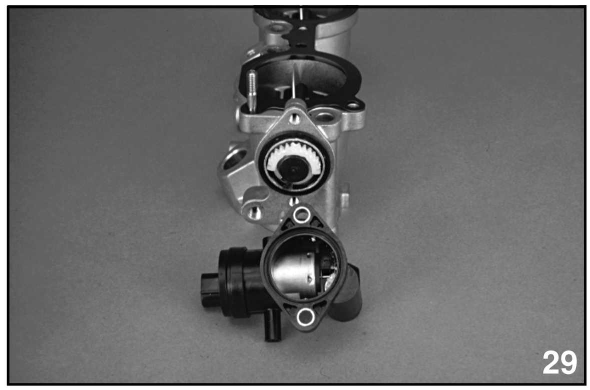
This characteristic normally is beneficial to the reduction of harmful emissions but if the fuel is sulfur contaminated the results is the production of Hydrogen Sulfide, H2S. Federal regulations state that there can only be 1/10 of 1% sulfur content in fuel. Removing sulfur from crude oil is an expensive and difficult procedure sometimes yielding poor results. Sulfur content higher than the Federal specification creates the sulfur contaminated fuel. Initial combustion of the contaminated fuel produces SO2. SO2 burned in the catalytic converter creates SO3. SO3 absorbs water very easy and produces H2SO4.

Some of the SO2 created at combustion will flow across the Nickel which strips or reduces an oxygen molecule from it and a Hydrogen molecule will replace it. Yielding H2S the aromatic that smells like rotten eggs.

Tumble Generator Valve

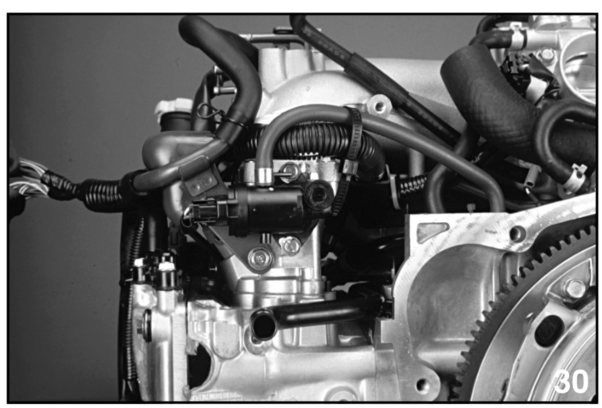


Runner Intake

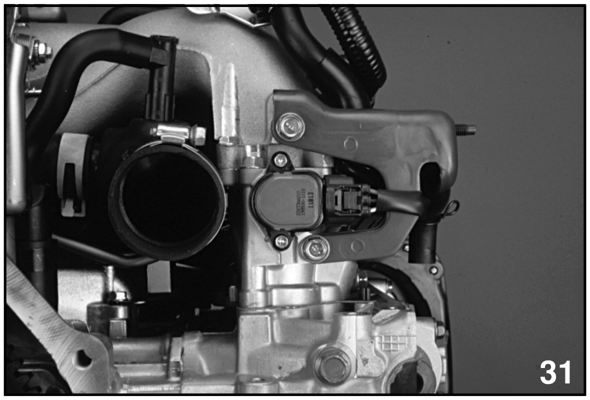


Stepper Motor

The EJ-2.0 is equipped with a tumble generator valve at each intake runner. This new system uses a shaft for each side of the engine that is driven by a stepper motor. The movement of the shaft is monitored by a sensor on the opposite end.



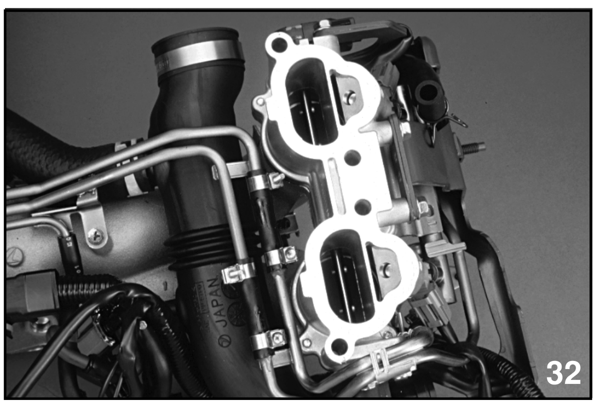
Vent Hose



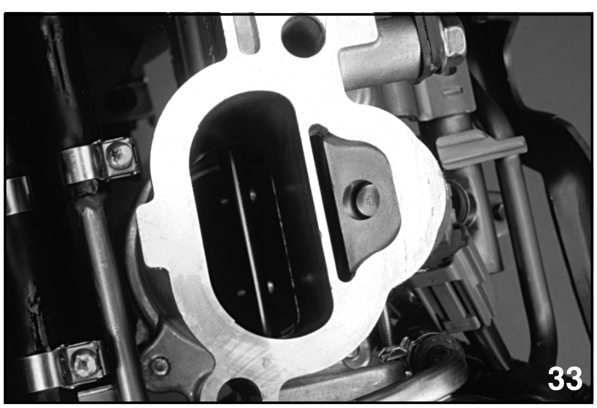
TGV Sensor

The shaft operates the tumble generator valve, which is a plate similar in design to the throttle plate. At idle the plate is closed (dependant on coolant temperature and time from engine start).

Off idle the plate is open.

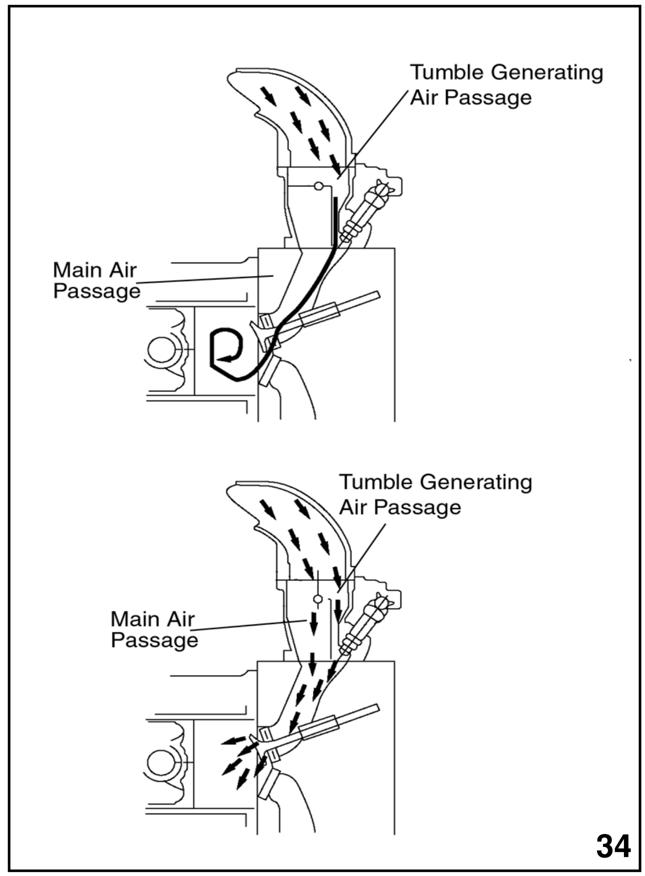


Manifold Bottom View



TGV Passage

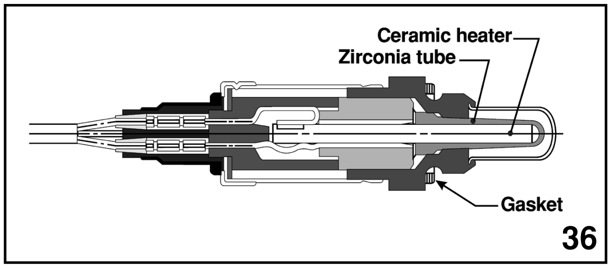
When the plate is closed the main air passage through the intake runner is blocked. This will force all air necessary for engine operation during idle to flow through the bypass channel. This action helps to mix the air fuel mixture by producing a tumbling effect to the incoming air, resulting in a cleaner operating engine while idling.



TGV Close / Open

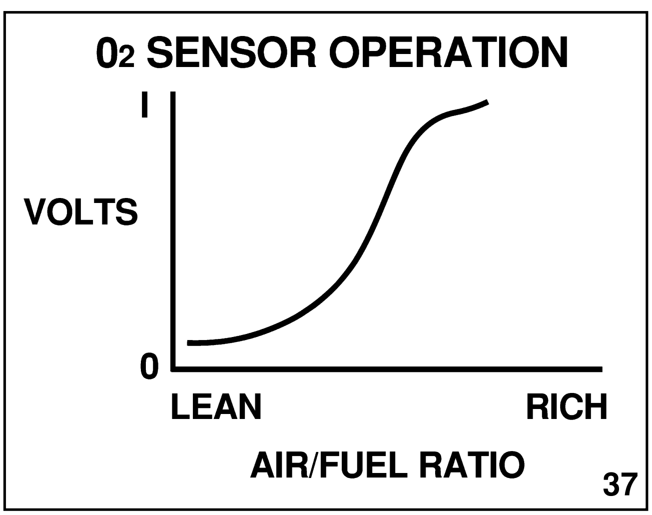
Oxygen Sensors

Oxygen sensors function to determine the amount of oxygen in the exhaust. The sensor is located upstream of the catalytic converter and monitors the exhaust as it leaves the engine. Rich air fuel mixtures will have very little oxygen in the exhaust while lean mixtures have much more by comparison.



O_2 Sensor

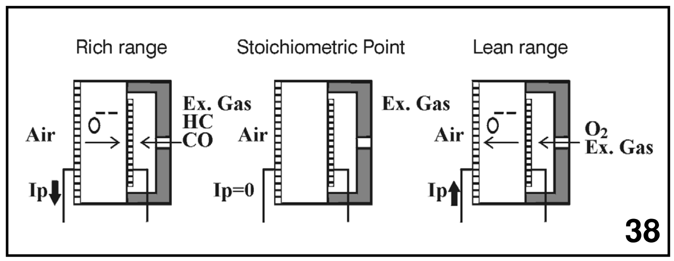
The oxygen sensor after reaching an operating temperature of 600° F (315.55 C) compares the oxygen content of the atmosphere to the oxygen content of the exhaust. Materials making up the oxygen sensor generate a small voltage that represents the air fuel mixture. This electrical signal is sent to the ECM so that adjustments can be made reducing harmful HC emissions. Rich air fuel mixtures generate higher voltages no higher than 1 volt and lean air fuel mixtures generate lower voltages closer to 300 millivolts.



Voltage Chart
(Oxygen Sensor Operation)

The normal color of the oxygen sensor tip is gray. White indicates the sensor has been operating in a constant lean air fuel mixture. Black indicates a constant rich air fuel mixture. Diagnose the fuel and engine management system if the color of the sensor is other than grey, as the response time or sensitivity of the sensor has been affected.

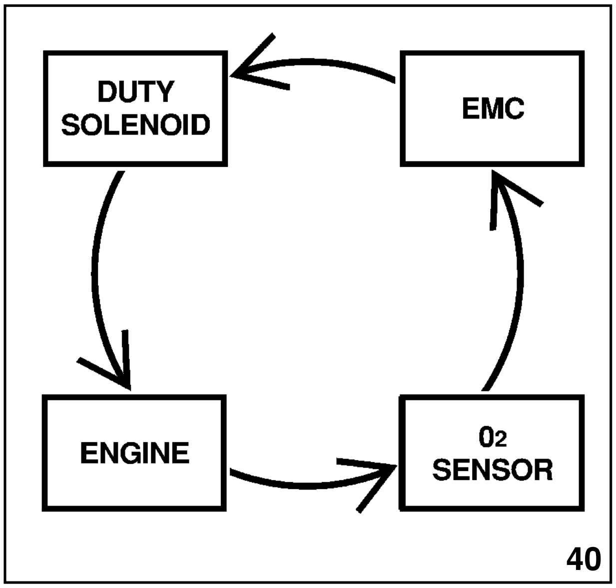
The Air Fuel Ratio Sensor is used on 1999 California Models. Located in place of the front Oxygen Sensor, the AFR begins to operate and effect the Air Fuel Ratio faster than conventional Oxygen Sensors. Zirconia remains the key material in AFR construction. It's ability to absorb oxygen and new ECM circuitry work together to provide fast accurate data.



A contact plate is located on the top and bottom of a layer of Zirconia. These plates are connected to wires that lead to the ECM. The exhaust side of the AFR is covered by a porous chamber that allows the exhaust gas access to the Zirconia center while the outside of the AFR sensor is exposed to the atmosphere.

Oxygen ions pass from the exhaust side to the atmospheric side during lean engine operation and from the atmospheric side to the exhaust side during rich engine operation. Stoichiometric engine operation will result in no ion exchange.

Closed Loop

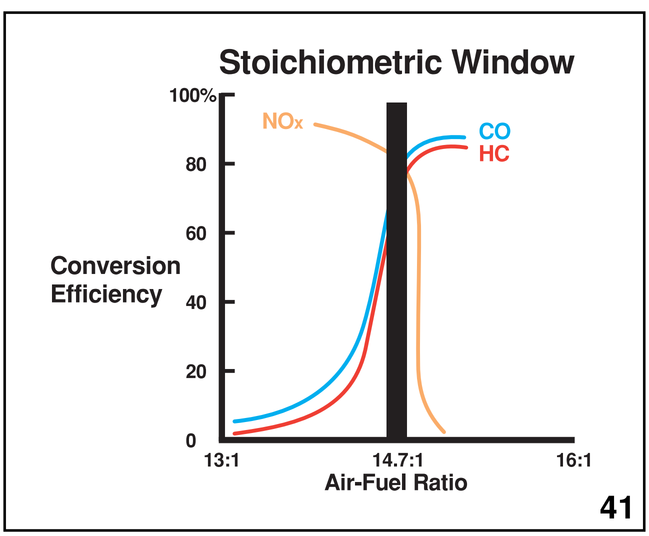


Closed Loop

Closed loop is a description of fuel injection and engine management operation where both systems are monitored and adjusted.

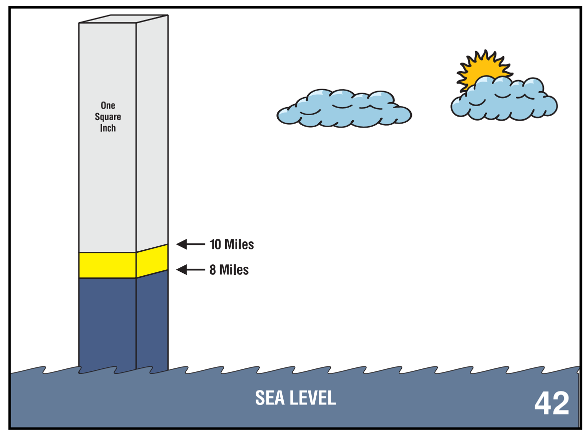
Closed loop relies on input from sensors that monitor engine operation. Providing precise control to increase power and reduce emissions.

Open loop is a description of the fuel injection and engine management systems that provide the best operating conditions during: Cold engine operation, near full throttle, and fail-safe.



Stoichiometric Window

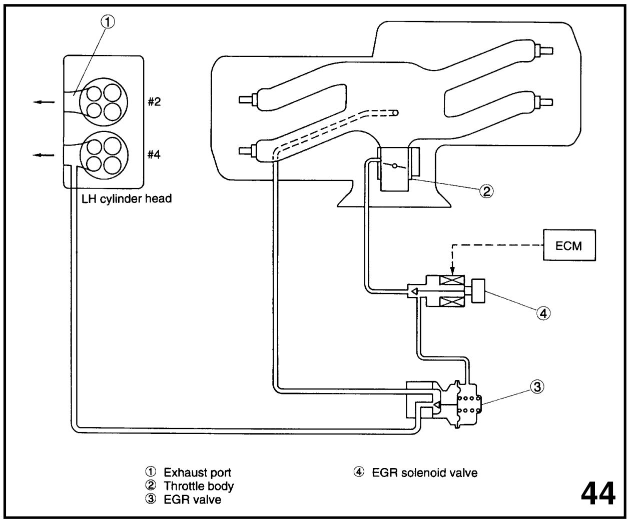
Maintaining the ideal air fuel mixture that creates the most power and lowest emissions is referred to as Stoichiometric. At sea level the weight of the atmosphere is 14.7 pounds per square inch. This column of air extends from the ground to approx. 110 miles straight up. This 14.7 psi burned with 1 pound of fuel is stoichiometric. Higher altitudes have less dense air, it weighs less because its closer to the beginning of the 110 mile high column.



Sea Level
(Atmospheric Pressure)

Maintaining stoichiometric air fuel mixture in this condition becomes more difficult. The atmospheric pressure can be increased in the engine with turbo chargers and super chargers. The introduction of additional air to the air fuel mixture will compensate for the less dense air.

Exhaust Gas Recirculation



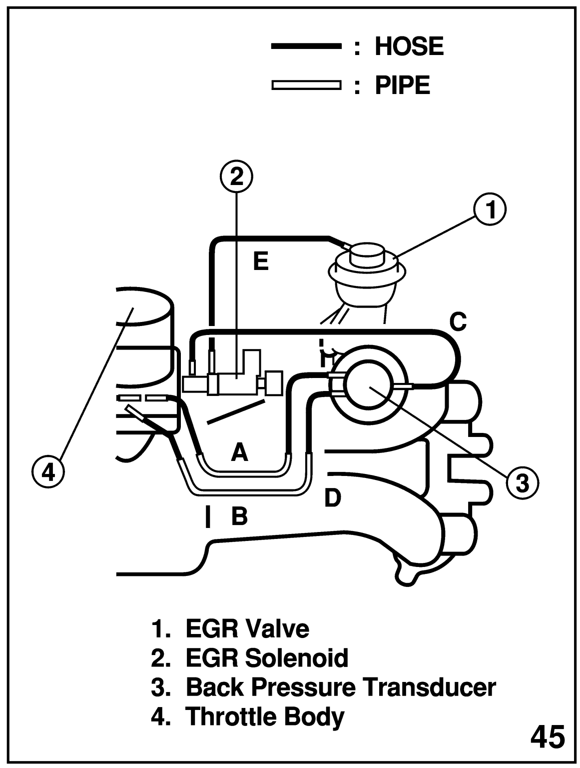
Exhaust Gas Recirculation

Preventing the production of harmful emissions is the best way to keep them from the atmosphere. NOx emissions control is performed by the Exhaust Gas Recirculation (EGR) system. The EGR system when activated displaces 6 to 13 % of the normal air in the intake manifold. Part of the exhaust is routed through the EGR valve to the intake manifold. This EGR gas has already burned, containing little oxygen and fuel. Mixed in the combustion chamber with normal air and fuel, the EGR gas reduces the heat because the EGR gas will not effectively burn. The heat generated with normal air surrounding the EGR gas is absorbed by the EGR gas and exits the engine as exhaust. This action lowers the overall combustion chamber temperature controlling the production of NOx emissions.

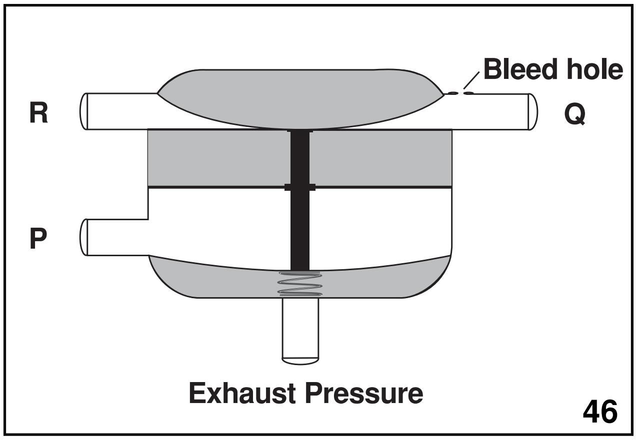
The EGR valve is operated with a ported vacuum signal that is controlled by the EGR solenoid. Solenoid activation is dependent on ECM logic.

EGR systems used on later model Subaru vehicles are controlled with a solenoid and a Back Pressure Transducer (BPT). Ported vacuum enters the BPT at line R, this will be used as working pressure. Ported vacuum enters the BPT at line P, this will be used as control pressure, throttling vacuum in line R to line Q. Exhaust enters the bottom of the BPT pushing the diaphragm assisting the pressure at line P.

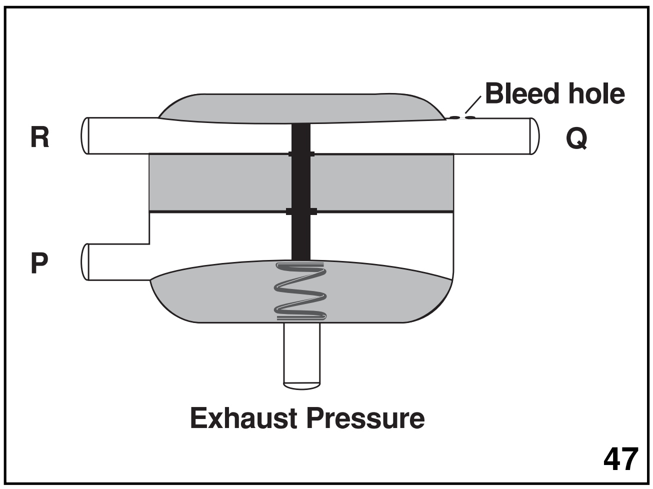
This action continues during all engine operation, however the EGR valve will not operate until the ECM grounds the EGR solenoid.



Vacuum Diagram
Most 95 and Newer EGR



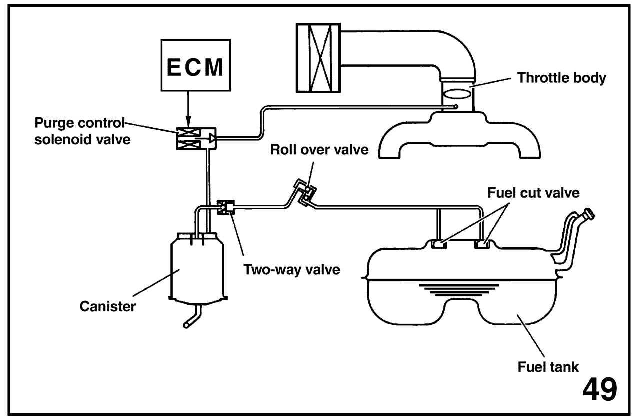
BPT Operation
EGR Off



BPT Operation
EGR On

Evaporative Emissions Control

Subaru vehicles are equipped with either a Conventional or Enhanced Evaporative Emissions Control System. Both systems function to prevent unburned Hydrocarbons from escaping to the atmosphere.



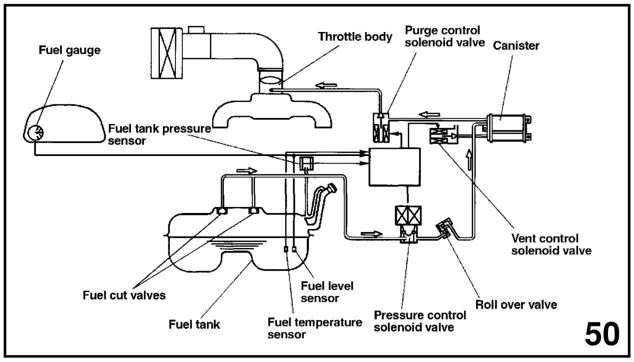
Conventional Evaporative System

Conventional Evaporative components include the following:

1. Fuel Cap - Construction incorporates a relief valve that allows air to enter the tank in the event a vacuum develops.
2. Canister - Temporarily stores evaporative gas from the fuel tank.
3. Purge control Solenoid valve - Controls the flow of stored evaporative gas from the canister to the intake manifold.
4. Two way valve - Controls air flow to the fuel tank. High tank pressure opens the valve allowing the pressure and evaporative gas to the canister. Low tank pressure closes the valve allowing atmosphere to the fuel tank through a pinhole in the valve.
5. Fuel cut valve - Used on AWD models. Prevents liquid fuel from entering the evaporative line.

Fuel separator allows fuel vapor to condense and return to the tank as liquid. Some models use a plastic tank mounted in the trunk or cargo areas. Other models use an air space designed into the fuel tank to condense fuel vapors.

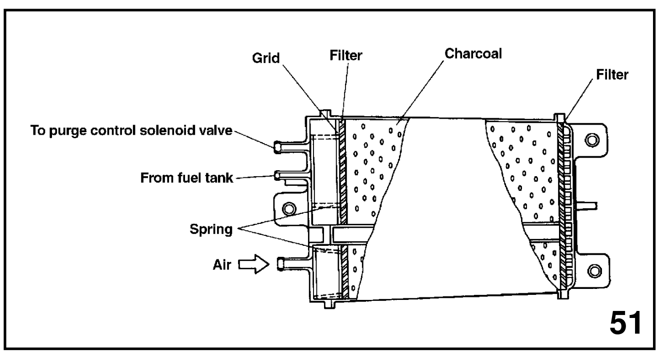
System operation - The ECM grounds the purge control solenoid turning it on. Ported vacuum then removes the stored evaporative gas from the canister. System activation is controlled using coolant temperature engine load and vehicle speed input.



Enhanced Evaporative System

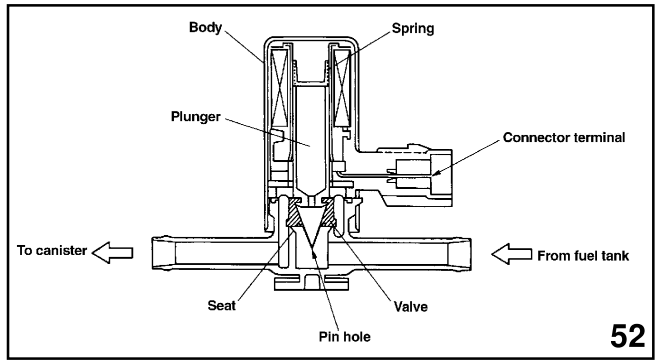
Enhanced Evaporative components include:

1. Canister - Function is unchanged, however the shape is more boxy and is located under the right rear of the vehicle.



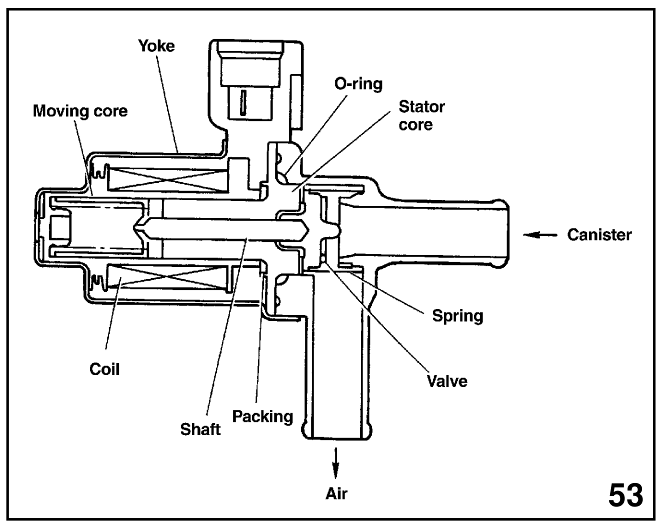
Canister

2. Pressure control duty solenoid - Adjusts the pressure inside the fuel tank from a signal from the ECM. It also controls the flow of evaporative gas from the fuel tank to the canister.



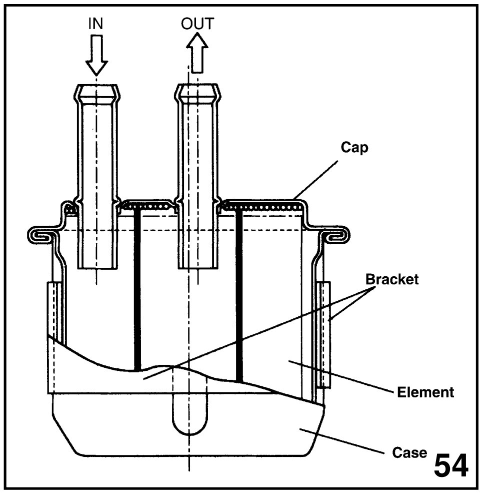
Pressure Control Duty Solenoid

3. Vent Control Solenoid Valve - Controls the flow of atmospheric pressure to the canister. During normal operation the valve is open allowing atmospheric pressure to the canister. During the time the ECM is checking the integrity of the evaporative system the valve is closed to isolate the system from atmosphere.



Vent Control Solenoid Valve

4. Air Filter - Filters air as it enters the vent control solenoid valve.



Air Filter

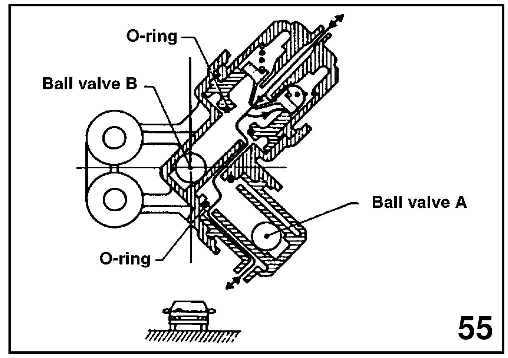
5. Fuel Tank Pressure Sensor - Monitors fuel tank pressure and sends an input signal to the ECM.

System operation - Optimum purge control is programmed in the ECM and is influenced by engine load, coolant temperature and vehicle speed.

Low fuel tank pressure - Pressure control solenoid valve closed. Vent control solenoid open. Purge Control Duty Solenoid active.

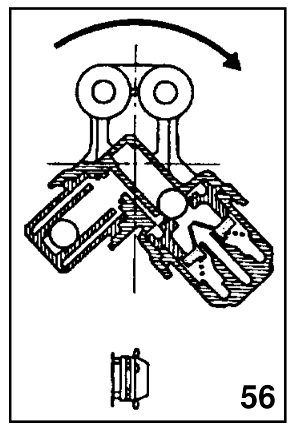
High fuel tank pressure - Pressure control solenoid valve open.

Fuel caps of both systems have a vacuum relief valve that allows atmospheric pressure to enter the fuel tank. This prevents vacuum from forming as the fuel is used, and acts as a back up for the two way valve.

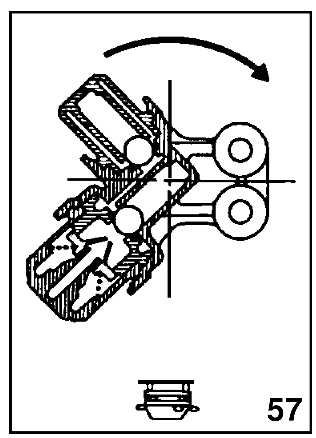


Roll Over Valve In Normal Vehicle Position

Both systems use a rollover valve located under the center rear of the vehicle. Rollover valve operation prevents fuel from flowing through the evaporative line in event of vehicle rollover. Valve operation is performed by gravity and the position of two "Ball Valves".



Roll Over Valve With Vehicle On Its Side



Roll Over Valve With Vehicle On Its Roof

On Board Refueling Vapor Recovery
This system will be used on all 2.2 liter Legacy and Impreza vehicles. Forester will be equipped with ORVR beginning approximately with October production.

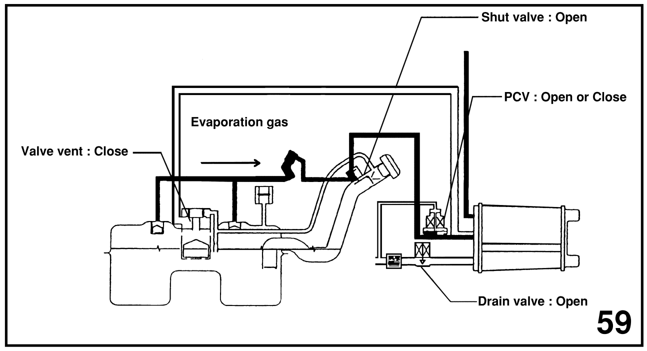
ORVR controls the pressure inside the fuel tank and collects fuels vapors during all vehicle operating conditions and during the time the vehicle is being refueled.

Components include:

- Fuel cut valve (FCV) - Prevents liquid fuel from entering into the evaporative line.
- Valve vent - Controls the flow of fuel vapors during the time the vehicle is being refueled.
- Pressure difference detecting line-Directs atmospheric pressure
- to the back side of the valve vent diaphragm.
- Orifice chamber - Drains fuel from the pressure difference detecting line into the tank.
- Shut valve - Closes the evaporation line when a filler gun is inserted into the filler neck. Prevents fuel vapors from escaping to atmosphere while refueling.
- Tank pressure sensor - Monitors fuel tank pressure for diagnosis.
- Vent line - Directs fuel vapors from the valve vent to the cannister during the time the vehicle is being refueled.
- PCV (Pressure Control Valve)-Controls the flow of fuel vapors from the tank to the cannister except during the time the vehicle is being refueled. And controls the flow of atmospheric pressure to the tank when a negative pressure develops.
- Drain Valve - Provides a pathway to atmosphere for air after the fuel vapors have been removed by the charcoal element of the cannister. (Only during the time the vehicle is being refueled.)

System Operation

While driving



ORVR System

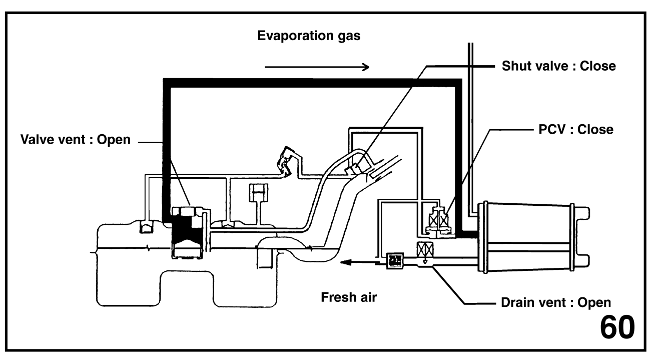
The fuel tank pressure is applied to one side of diaphragm inside the Pressure Control Valve.

When the pressure is greater than atmospheric a port inside the PCV opens allowing fuel vapors to the cannister.

If negative pressure exists the PCV opens allowing atmospheric pressure to the fuel tank.

While refueling
As fuel fills the tank the air inside the tank is displaced caring fuel vapors with it. This large increase in pressure opens the valve vent allowing the fuel vapors to the cannister.

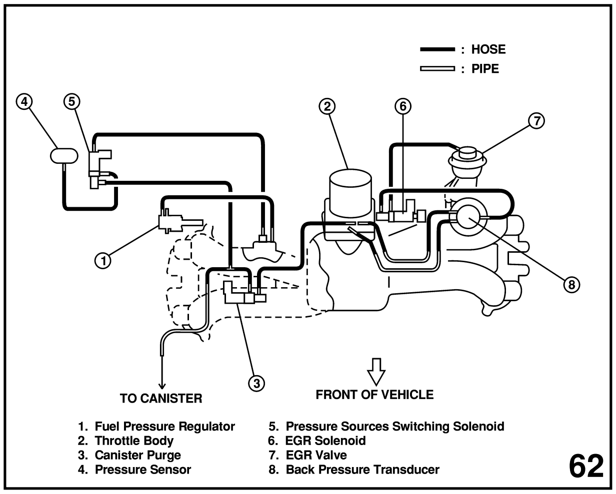
The continued filling of the tank pushes the remaining air and fuel vapors through the cannister. The charcoal element of the cannister absorbs the fuel vapors an directs fuel vapor free air to the atmosphere though the Drain valve and air filter.



While Refueling

The PCV is checked for circuit malfunction. Drain valve checks include circuit and performance checks.

Pressure Sources Switching Operation



1995 and Newer Manifold

Pressure sources switching solenoid (PSSS) Used on 1995 and newer vehicles equipped with OBDII. Functions from an ECM ground signal and Switches to allow atmospheric pressure to the pressure sensor during engine start and every 30 minutes, or 3.1 miles (5 kilometers). Switches to allow manifold pressure sensor when not switched to atmosphere.

The passage way to atmosphere on Conventional evaporative systems access atmosphere through the evaporative canister. Enhanced evaporative systems access atmosphere through an extension of the PSSS.

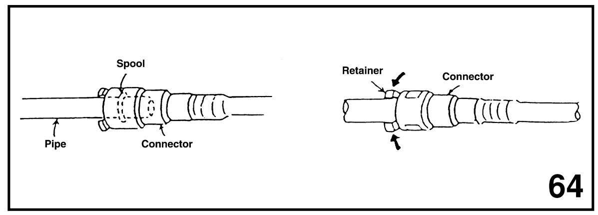
The Pressure sensor Functions to monitor manifold and atmospheric pressure. PSSS position determines pressure source. Changes in pressure positive or negative produce a changing reference voltage signal. Reference voltage signal changes are used to influence ignition timing and injection duration.

Canister purge flow is also monitored with the Pressure Sensor. (PSSS switches to atmosphere while the purge control solenoid is on)

Fuel Delivery Quick Connector

The fuel system of the forester is very similar to past models with enhancements to tank capacity, clamps, and delivery line. The resin delivery line between the fuel pump and the 60 liter fuel tank are connected by a one time use only "Quick Connector".

This "Quick Connector" must be released when removing the fuel pump or fuel tank. **C the directions in the appropriate service manual before removing any fuel lines.**



Quick Connector

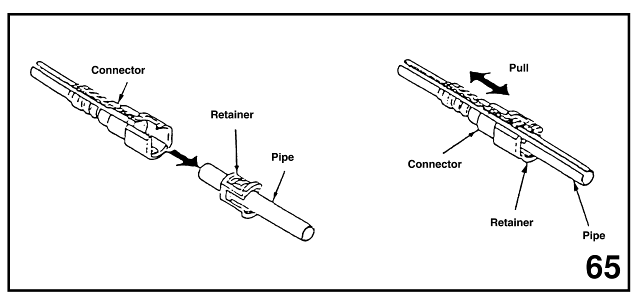
Quick connector service procedure.

1. Separation - Pushing the retainer with a finger in the arrow direction, pull the connector to separate it. After separation, the retainer will remain attached to the pipe.
2. Connecting- Check the connecting portion of the pipe visually. If a scratch or foreign particle exists on it wipe them off.

Align the pipe and the connector, insert the end of the pipe into the connector until an audible click is heard.

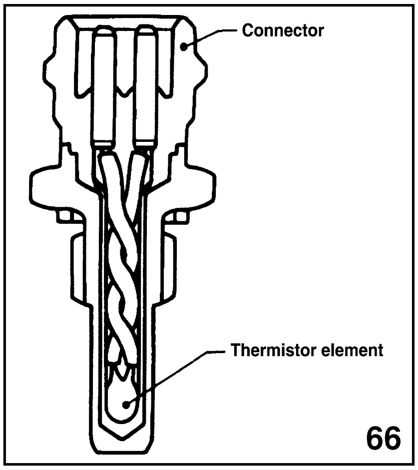
Confirm connection by pulling the connector backward. Also check that the two pawls of the retainer are engaged to the connector.

Replacement part is the retainer only.



Quick Connector Service

Engine Coolant Temperature Sensor

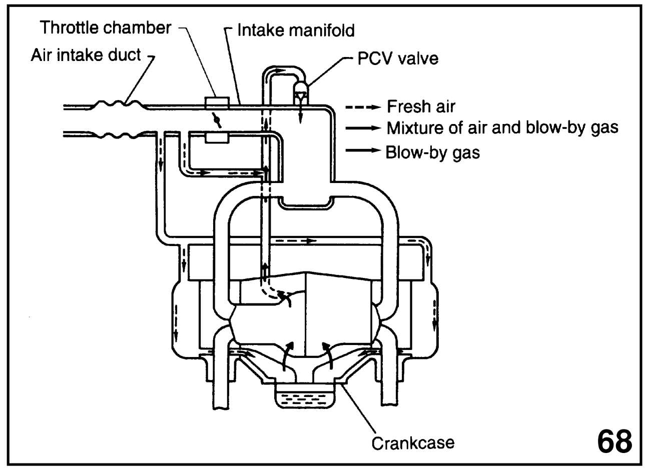


ECT

Engine Coolant Temperature Sensor (ECT) functions to monitor coolant temperature. Resistance of the sensor with cold coolant is high. Reference voltage from the sensor will be low Resistance of the sensor with warmer coolant is low. Reference voltage will be higher. Reference voltage signal changes are used to influence ignition timing, injection duration, and idle speed. Some models use ECT signal to control radiator fan motor relays. Fail-safe on these models will result in constant radiator fan operation.

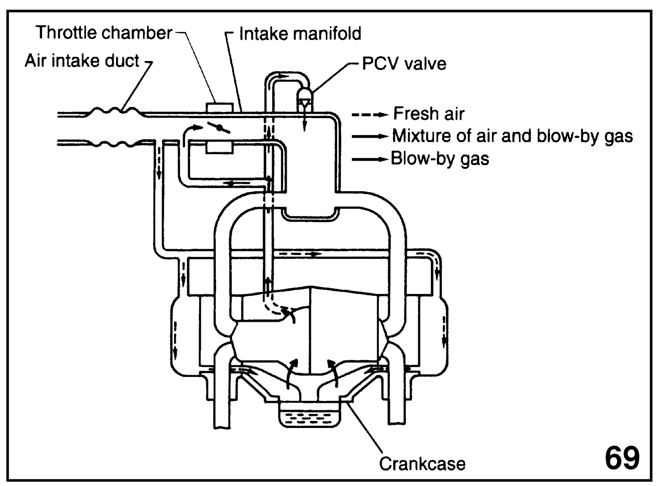
Crankcase Emission Control

Crankcase Emission Control System Functions to prevent blow-by gases from entering the atmosphere. Components include: Sealed rocker covers, hoses, PCV valve and Air intake duct.



Operation is performed in two modes:

Mode one - (Light engine load) Air flows in to the air duct, and part of the air is routed to the rocker covers. Vapors and air enter the PCV because of the negative pressure at the valve.



Mode two - (Heavy engine load) Air flows in to the air duct, and produces a negative pressure at the rocker covers. This action carries the vapors from the crankcase into the throttle body.

Notes:

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State I/M Program Advisories Bulletins and Service Bulletins

No.	Date	Title	Subject
11-50-97	12/05/97	All Subaru Full-Time AWD Models	State Emission Testing
11-51-97	12/05/97	All Subaru Full-Time AWD Models	Diagnostic Service Cautions
11-52-98	05/22/98	All 1999 Model Subaru AWD Models	State Emission Testing
11-49-97R	09/02/98	1996 MY Legacy, Impreza & SVX	OBD Check During State I/M Program
11-53-98	01/05/99	97-98 Legacy, Impreza and Forester Manual Transmission vehicles with 2.5L & 2.2L engines	Hesitation On Acceleration
11-54-99	03/01/99	All 1996-1999MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-55-99	03/17/99	All 1996-2000MY	On-Board Diagnostic System Check During State Emission Test
11-56-99	09/08/99	All 2000MY	State Emission Testing
11-57-99	09/29/99	All 2000 MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-59-00	02/25/00	1999 Legacy, Impreza, Forester	Air Intake Chamber Box Breakage
11-61-00	06/01/00	All Subaru Vehicles	State Emission Test / Fuel Filter or Gas Cap Test
11-62-00	05/08/00	All 2001 Models Subaru Vehicles	On-Board Diagnostic System Check During State Emission Test
11-63-00	11/01/00	1980-1989 MY Subaru Vehicles	Pressure Testing of Fuel Tank System During State Emission Test
11-64-01	02/01/01	All 1996-1999 Legacy Postal Vehicles	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location

405 Module Service Help-Line Updates

Date	Subject
03/95	Legacy and Impreza engines with no injection pulse #1 cylinder
03/95	Impreza air suction valve noise
06/95	1995 Subaru Legacy DTC P0505 - Idle control system malfunction
06/95	1995 Subaru Legacy DTC P0325 - Knock sensor circuit malfunction
06/95	1995 Subaru Legacy DTC P0130 - Front 02 sensor circuit malfunction
07/95	Rough idle on MPFI vehicles
07/95	94 Impreza ROM sockets
09/95	DTC P0505 idle control system when solenoid measures 5Ω or less
12/95	Extreme cold weather engine warm up and OBD ll
07/96	Loose fuel caps and trouble code P0440
09/96	1997 Legacy warranty claims for loose fuel caps
09/96	Legacy (Non Turbo), SVX, and Impreza ISC valves
11/96	P0440 and Legacy fuel caps
11/96	Blue vs. Gray connectors during diagnosis
11/96	Extreme cold weather engine warm-up and OBDll
03/97	DTC P1500 radiator fan relay one circuit
03/97	1997 Subaru Impreza Outback Sport
04/97	Understanding P0440
05/97	DTC P0507-Idle control system RPM higher than expected
07/97	Code P0500
07/97	Additional information regarding code P0440
08/97	OBD ll cylinder misfire codes
10/97	More P0440 information
01/98	Exhaust smell during cold start
01/98 & 05/98	Model Year 1998 changes in P0440 Evap operation
05/98	DTC P0440 Revisited
11/98	P0440 TIP
11/98	DTC P1507
05/99	DTC P0705 diagnostics
08/99	Freeze frame data
09/99	Evaporative system diagnosis
11/99	OBD readiness codes
11/99	P0440 1998/1999 Forester
11/00	WXV-79 engine control module service program

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Technicians Reference Booklet

Boxer Engine Series Module

Module 104

AUTOMOTIVE Youth Educational Systems®

March 2006

MSA5P0131C

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of March 2006.

This book is revised with material from New Model Updates 912 thru 915.

Table of Contents

Foreword

All Subaru of America, Inc. engines are of the four stroke, four cycle internal combustion design. The four strokes are the following: Intake, Compression, Power and Exhaust.

Subaru of America, Inc. vehicles are powered by boxer style opposed cylinder engines.

The engine horsepower has increased over the last several years at the same time as customer and governmental expectations for major component longevity and fuel mileage. This has meant better materials and engine design practices have been utilized. Higher quality piston and piston ring design as well as material construction have been used to obtain closer cylinder wall to piston clearance over more operating temperatures and longer mileage intervals. This has resulted in decreased "leak-down" for production engines. This "leak-down" percentage has decreased significantly over the last several years to where everyday street engines have cylinder sealing that once was the standard for racing applications.

Higher compression ratios have also been obtained. The compression ratio for all currently used Subaru engines that are naturally aspirated (non-turbocharged) are all over 10.1. This compression ratio was only previously seen in high performance and racing applications. Compression ratio is calculated by dividing the area in the cylinder head valve area for each cylinder by the distance in the combustion chamber at the bottom of the cylinder stroke. In the aforementioned 10.1 example, the cylinder head combustion area is 1/10 the size of the cylinder when the piston is in its lowest position in the cylinder.

New advances in computer design, fuel injection, ignition timing regulation, and air fuel swirl technology usage in the combustion chamber have greatly contributed to increased power output.

It is the desire of Subaru of America, Inc. that you derive the maximum possible knowledge from this engine course in order to do a complete diagnosis and repair of Subaru engines in order to achieve the utmost in customer satisfaction.

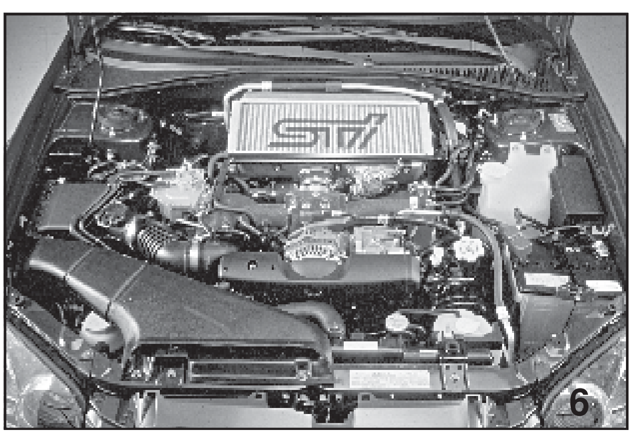
Introduction

This Technicians Reference Booklet is intended to introduce the 2.5 liter naturally aspirated (N/A), (Phase 1) and (Phase 2) engines, the 2.5 liter (DOHC) (Phase 1) and (Phase 2) engines, the 2.0 liter turbo engine and the 3.0 six cylinder engines.

This reference book reviews the mechanical features of these engines and the differences between existing engines. It also covers the procedures used in diagnosing and overhauling these engines. The text and slides also cover the new technologies and differences associated with variable valve lift and variable valve timing as well as active valve lift. The reference book text and illustrations are derived from and follow the classroom lectures and slide presentations. They are intended to supplement and reinforce classroom instruction and serve as an additional technical reference source. A list of applicable Service Bulletins, TechTips, Special Service Tools, pages for notes and cautions are included in this booklet.

Technician worksheets are to be completed during the hands on lab work segments of the engine series module.

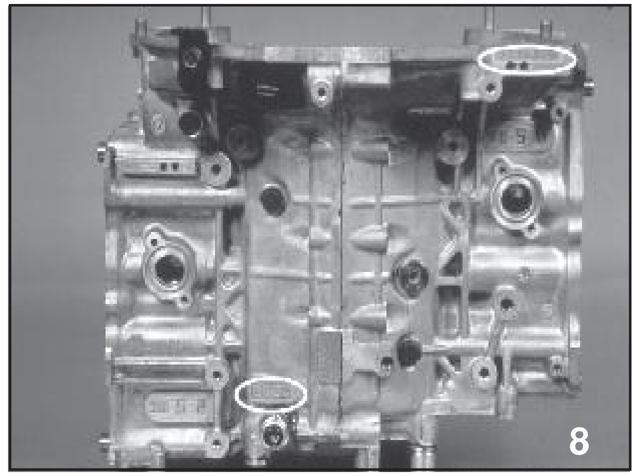
Always refer to the appropriate model year Subaru Service Manual and the applicable Subaru Service Bulletins on the STIS web site, for all specifications and detailed service procedures.



Engine

General Overview

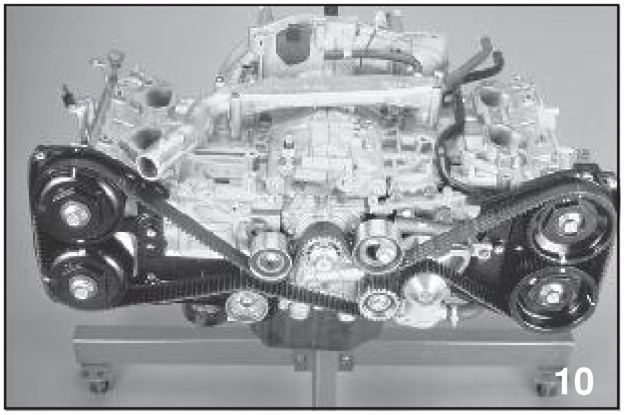
2.5 Engine Identification



Engine Serial and Designation Number

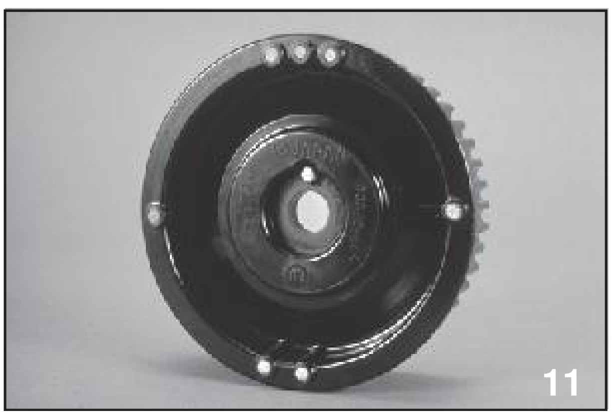
The engine serial number is located on the machined boss on the left side of the clutch housing. The 2.5 liter engine designation is EJ25.

2.5 Liter Engine Features Phase 1

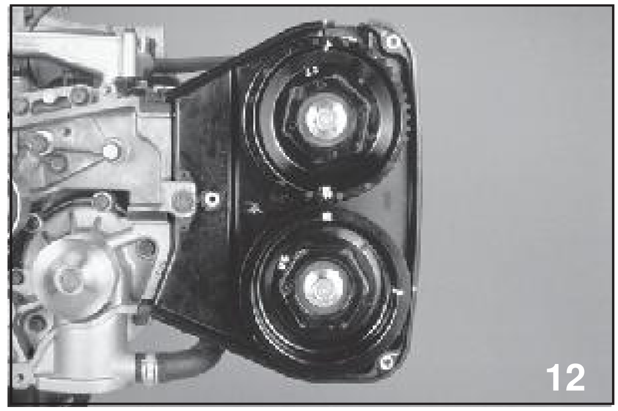


2.5 Liter Engine

The 2.5 liter engine uses double overhead camshafts that are belt driven. Belt tension is maintained through the use of the hydraulic tensioner.



Camshaft Sprocket (Left Bank) (Rear)



Camshaft Sprocket Timing Marks (Left Bank)

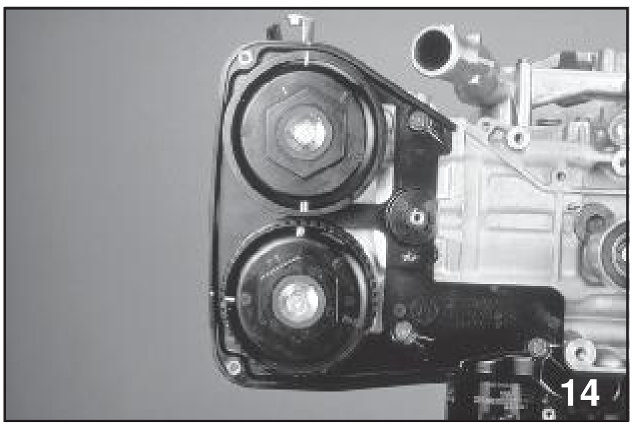
Camshaft sprockets are constructed from a resin type material with a metal key pressed into the sprocket for maintaining proper sprocket to shaft orientation.

The timing marks on the left bank intake camshaft sprocket are positioned at 12:00 o'clock and 6:00 o'clock. The 12:00 o'clock mark, which aligns with a timing mark on the timing belt housing, is used for camshaft to engine timing. The 6:00 o'clock mark is used for timing the intake camshaft to the exhaust camshaft, which has a timing mark at the 12:00 o'clock positions. The remaining timing mark on the exhaust camshaft sprocket, positioned at the 3:00 o'clock, ensures the exhaust camshaft sprocket is timed correctly to the engine. With all timing marks aligned, the intake and exhaust camshaft are in a loaded state. If the timing belt were removed, the camshafts would suddenly revolve from the force of the valve springs. To prevent this from occurring maintain the intake camshaft position and carefully unload the camshaft by allowing it to slowly rotate counterclockwise, (exhaust clockwise) while removing the belt.

NOTE: USE SPECIAL TOOL J-42908 FOR HOLDING CAMSHAFT SPROCKETS DURING BELT INSTALLATION. IT MAY ALSO BE USED FOR LOADING AS WELL AS UNLOADING THE CAMSHAFTS.

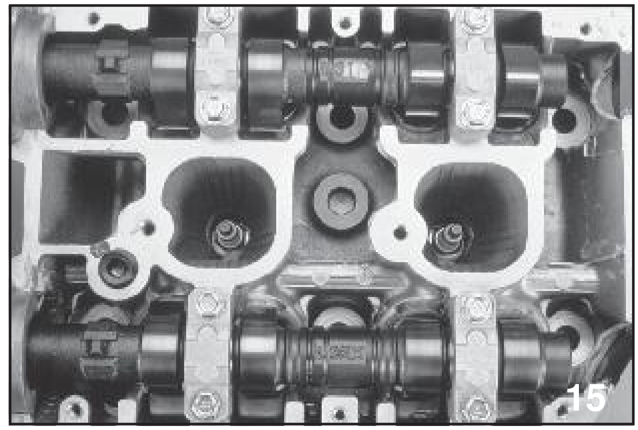
CAUTION: VALVE DAMAGE WILL OCCUR IF BOTH CAMSHAFTS ARE TURNED INCORRECTLY AFTER THE TIMING BELT HAS BEEN REMOVED.

Valve Interference



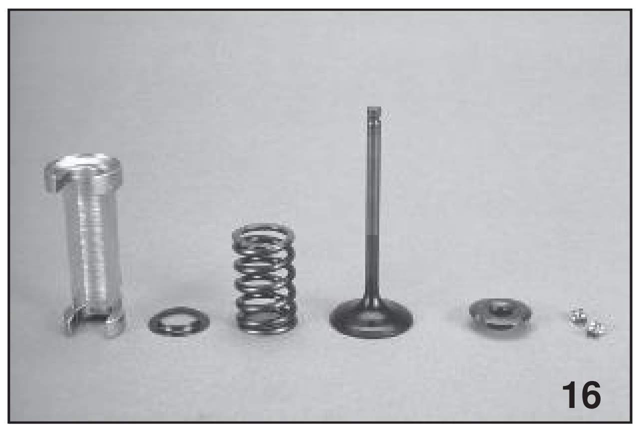
Camshaft Sprocket Timing Marks (Right Bank)

The right bank intake sprockets timing marks are similar in location and purpose as the left bank, however, the exhaust camshaft sprocket on the right bank uses a timing mark at the 9:00 o'clock position to ensure proper camshaft to engine timing.



Camshafts

To access the cylinder head bolts, the camshafts must be removed. Follow the procedure outlined in the on the STIS web site for performing this task. The camshafts are held to the cylinder head with bearing caps that are marked (right side) I1TD, I3TD, E1TD, E3TD.



Valve Spring Assembly

Valve servicing is accomplished by utilizing special tool **499718000** and a universal valve spring compressor. The single valve spring is color coded red and rests on a metal spring seat which is used to prevent cylinder head wear. A special tool (**498267700**) will be required to adjust valve guide height, if replacement is necessary. A valve guide reamer (**499767400**) and a valve guide remover (**499767200**) will also have to be used. The hydraulic lash adjuster is of the same type as the 3.3 and requires no servicing.

Spark plugs for the 2.5 liter engine will be platinum tipped, NGK PFR5B-11.

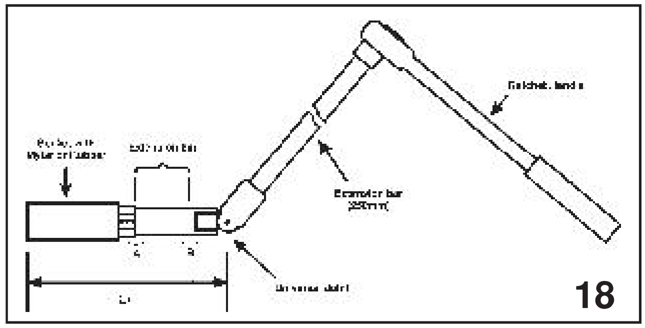
Direct Type HLA

Spark Plug Replacement Procedure for 2.5 Liter Engine

1. Remove battery, washer tank and air cleaner.
2. Remove high tension cords.
3. Cover ATF pipes and ABS pipes with cloth to prevent them from damage during replacement of spark plugs.
4. Remove spark plugs by using a general service tool with the special instruction described below.

Installation

1. Set the spark plug into the socket.
2. Tighten the spark plug in the cylinder head with the socket. It is necessary to support the end of the socket by a finger.
3. When the spark plug can be felt to be tightened with 2 or 3 rotations, remove the socket from the spark plug.



Spark Plug Removal

4. Confirm if the spark plug is screwed into the hole properly by touching it with a finger. If it is difficult to touch it by finger, confirm its condition by using mirror and so on.
5. Reset the socket on the plug then tighten it with the proper torque.
6. Install high tension cords.
7. Install battery, washer tank, and air cleaner.

Note:

1. Length L1 (100mm, 3.94") is most important for ease of removal and installation.
2. Wrap points A & B with tape to prevent them from separating during work.
3. An approximate 250mm long extension bar is recommended to be used between the ratchet and the universal joint.

1997 2.5 Engine DOHC (Phase 1) Changes

The double overhead camshaft engines have had internal and external changes that yield an approximately 10 % increase in power and 3% increase in fuel economy. Accomplishing this involves many factors, one of which is engine friction reduction.

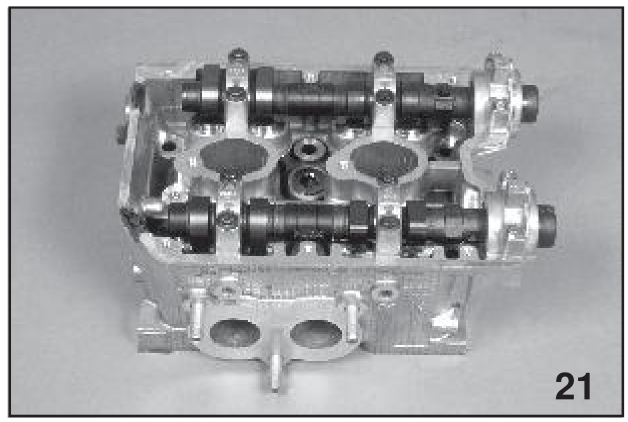
The piston, a major source of engine friction has been coated with a friction reducing agent called Molybendium. This thin coating not only allows a smoother travel through the cylinder but also reduces cylinder wall scuffing.

The skirt of the piston has been reshaped and the overall weight has reduced by approximately 100 grams. Compression ratio has been increased to 9.7 to 1 by reshaping the crown of the piston. This eliminates the clearance that was available between the piston at TDC and a fully opened valve. Piston pin offset has been changed to 0.5 mm. Piston to cylinder wall clearance has been reduced by increasing the piston diameter.

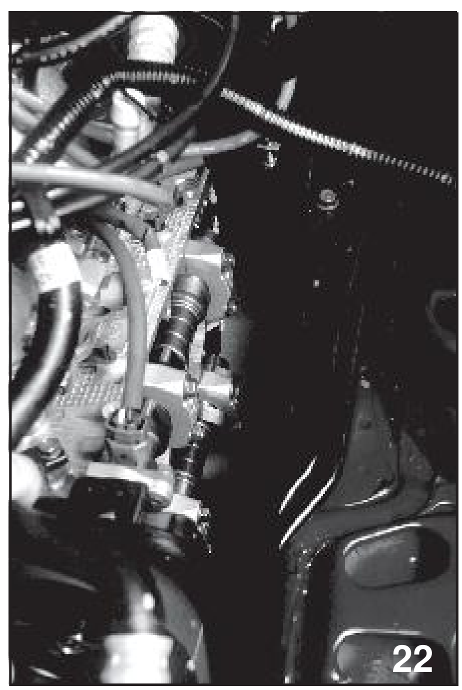
Redesigned 2.5 Liter Piston

Another source of high engine friction is the valve train. Hydraulic lash adjusters are always in contact with the camshaft or valve rockers. The hydraulic pressure of the lash adjuster must be overcome during operation and the most critical time of engine start. To overcome this situation and to contribute to the total reduction of friction loss the DOHC engines will have solid valve adjusters.

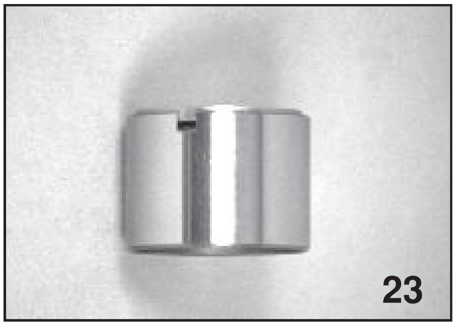
The scheduled service of these valve trains is set at 100,000 miles and is not required during the PDI. The DOHC engine uses an adjustment shim. There are 94 shim sizes.



2.5 Liter Valve Assembly



2.5 Liter Head on the car



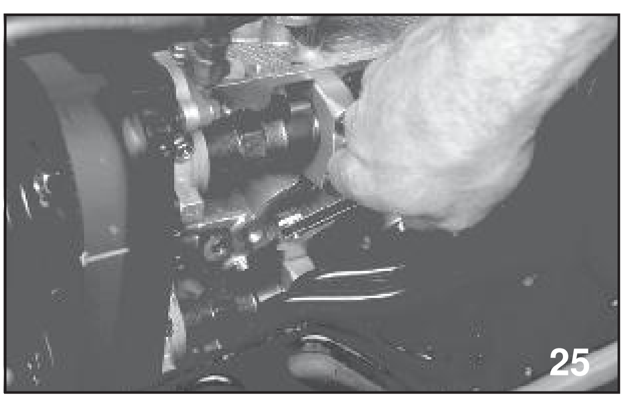
Bucket and Shim Assembly

NOTE: USE A THIN NONMAGNETIC TOOL PLACED IN THE NOTCH OF THE LASH ADJUSTER TO REMOVE SHIM. (SPECIAL TOOL J-43979)

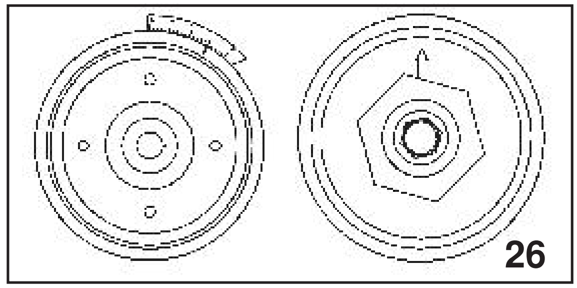
Identifying Shim Size

NOTE: THE PRINTED SIZE OF THE SHIM SHOULD BE INSTALLED AWAY FROM THE CAMSHAFT LOBE.

As you can see the space between the valve train and the frame rail of a DOHC is some what limited, however valve adjustment is possible by performing the following: Refer to the 1997 Legacy Subaru Service Manual on the STIS web site. Supplement.



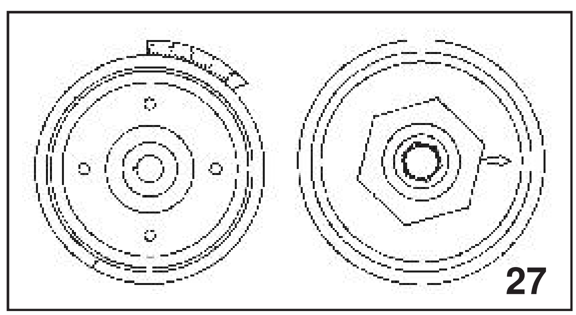
Checking Valve Clearance on the Car



Exhaust Valve Clearance on Cylinders 1 and 3

Step 1

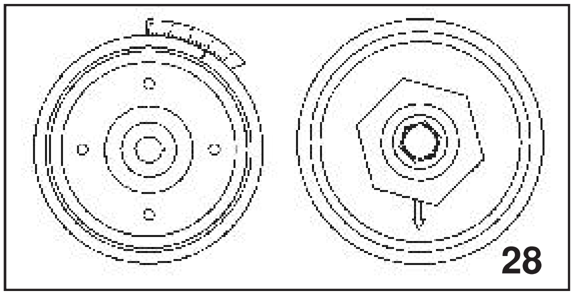
- Set the crankshaft sprocket at 0 degrees. (use crankshaft wrench)
- Set the left intake camshaft sprocket arrow at 12 o'clock (Please remember that the camshaft sprocket has an arrow and a mark used for belt timing. Make certain to use the arrow and not the mark for valve clearance check.)
- The engine is now set for allowing the clearance check of the exhaust valves on cylinders 1 and 3 only. (Please remember that the profile of a camshaft with solid lifters has a ramp that is used to gradually take up the clearance between the lift of the lobe and the lash adjuster.)
- Measure the clearance ensuring the thickness gauge is placed as shown on previous page.
- Record the measurement



Intake Valve Clearance on Cylinders 1 and 3

Step 2

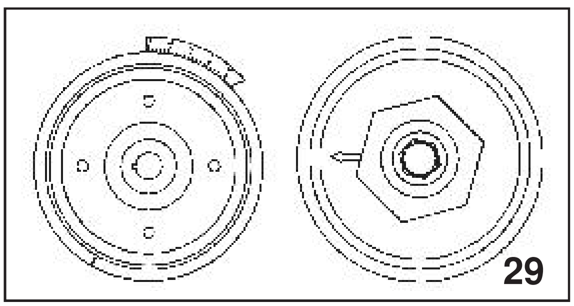
- Rotate the crankshaft 180 degrees
- The left intake camshaft arrow should now be at 3 o'clock (Figure 7).
- Check the clearance of the intake valves on cylinders 1 and 3 only.
- Record the measurement



Exhaust Valve Clearance on Cylinders 2 and 4

Step 3

- Rotate the crankshaft 180 degrees.
- The left intake camshaft arrow should now be at 6 o'clock.
- Check the clearance of the exhaust valves on cylinders 2 and 4 only.
- Record the measurement



Intake Valve Clearance on Cylinders 2 and 4

Step 4

- Rotate the crankshaft 180 degrees.
- The left intake camshaft sprocket arrow should now be at 9 o'clock.
- Check the clearance of the **intake valves on cylinders 2 and 4 only**.
- Record the measurement.

Step 5

- Use the formula below to choose the new shim:

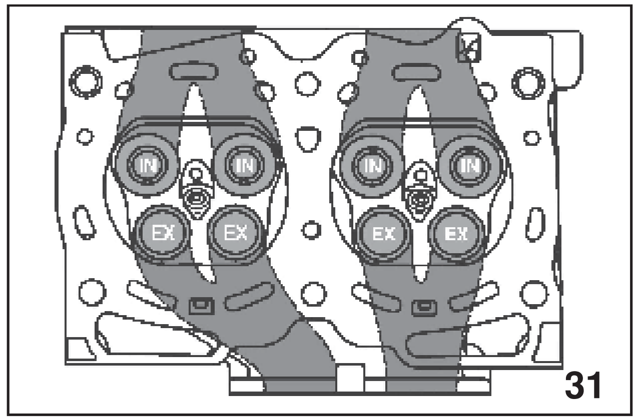
Intake valve S = V + T-.20
Exhaust valve S = V + T-.25
S = Shim thickness to be used
V = Measured valve clearance
T = Shim thickness in use

Standard valve clearance

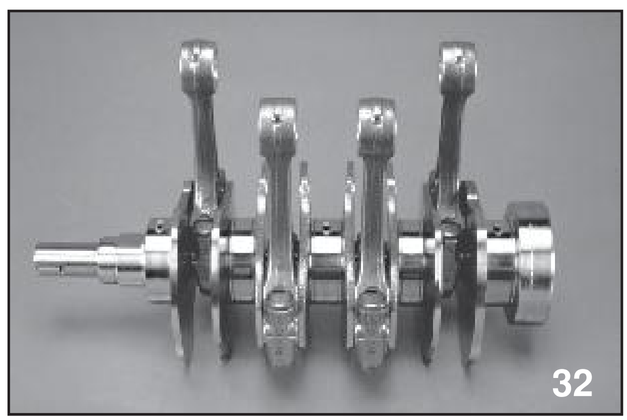
(Intake valves 0.20 +/- 0.02 mm)
(Exhaust valves 0.25 +/- 0.02 mm)

1997 2.5 Liter Engine DOHC (Phase 1) Features

The 2.5 liter DOHC four valves per cylinder engine is an addition to the existing Subaru "Boxer" design. The horizontally opposed, 4 stroke, 4 cylinder, liquid cooled, gasoline engine has aluminum alloy block and heads. It uses a normally aspirated MPI system. The cylinder liners are of a cast iron dry type design.



Cylinder Head Design

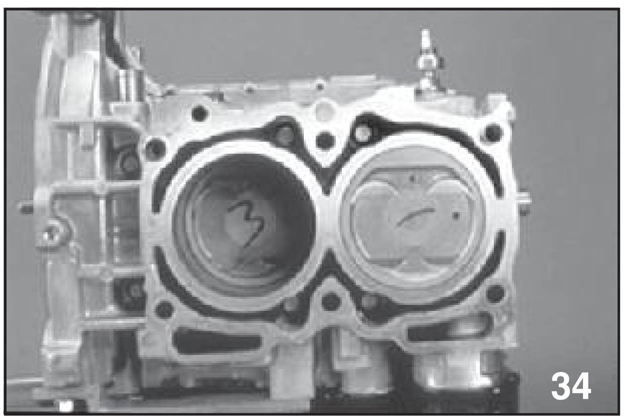


Crankshaft Assembly

The balanced forged crankshaft has fillet rolled micro-polished journals for increased strength and reduced friction. Due to the "Boxer" design, a counterbalance shaft is not required.

Connecting Rods

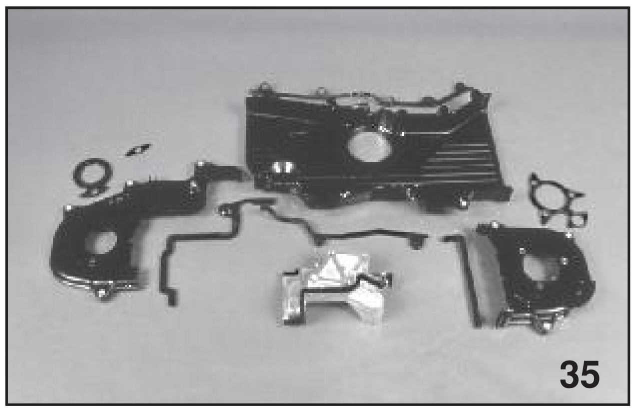
Due to increased material used to strengthen the large end of the rod, the rod bolts are pressed into the rod. An oiling notch is located on the large end of the rod below the FUJI symbol. This provides oil flow to the piston pin and the cylinder walls. The rods are not drilled.



N/A Pistons

The 2.5 liter pistons are cast aluminum alloy and feature a 2 mm offset piston pin. The pistons are directional for the left and the right side of the engine and are stamped with an "L" or "R". In addition, each piston is stamped with an arrow which must point to front of the engine. The valve reliefs for the intake and exhaust valves are different sizes to prevent valve contact with the piston should the cam belt break. The pistons use three rings, two compression and one oil.

A single belt is used to drive the camshafts and the water pump. This provides more precise valve timing. The cam belt width is 30 mm (1.18 inches) to increase cam belt life. The belt is constructed of wear resistant double canvas and heat resistant rubber materials with a wire core. A round tooth profile is used for quieter operation. The belt has an automatic cam belt tensioner which allows for thermal expansion and contraction. The cam belt path is from the crankshaft sprocket to the tensioner, to the left camshaft sprocket, to the water pump pulley, to the lower left idler to the lower right idler, to the right camshaft sprocket, to the upper right idler and back to the crankshaft sprocket. This has increased the belt life to 105,000 miles.



Cam Belt Covers

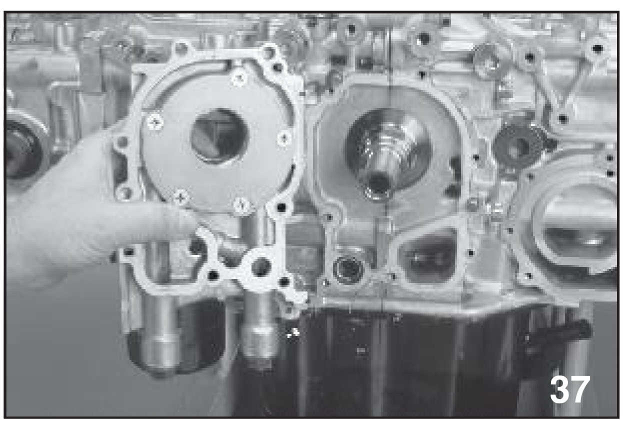
The cam belt covers and dust seals are resin molded and protect the timing belt from dust and water. There are additional dust seals on the left and right inner covers. These seals increase protection of the cam belt from dust and water and also improve cam belt noise isolation.

Water Pump Assembly-Cooling System

The water pump pulley is driven by the back side of the timing belt. The pump is mounted to the lower front of the engine. The thermostat is located in the lower part of the pump housing. This location provides even engine warm-up by improved metering of the coolant temperature. The thermostat senses the temperature of the crankcase and radiator coolant as it is mixed.

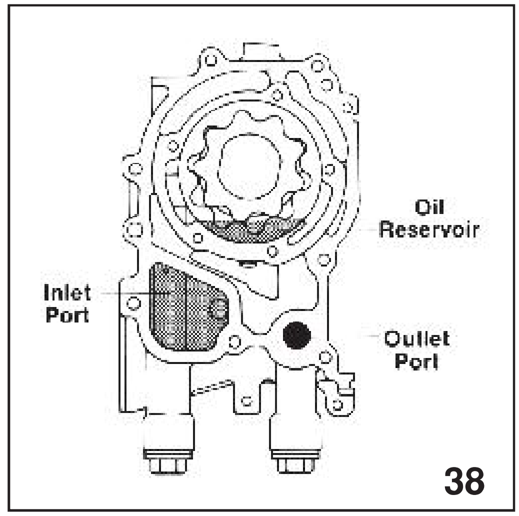
Because the thermostat housing is located on the lower front of the engine, all of the coolant must be drained to change the thermostat.

The heater core also serves as the bypass system.



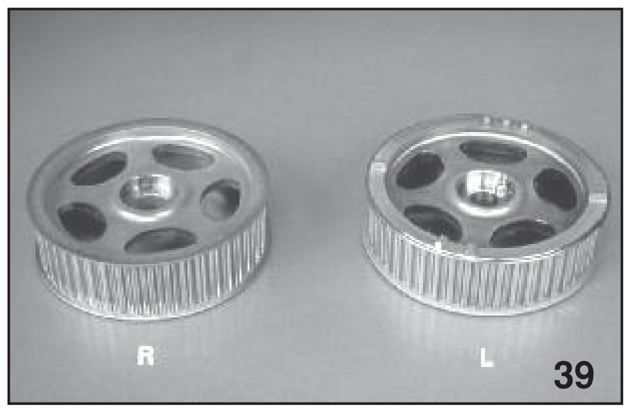
Oil Pump

The trichoid gear type oil pump is driven directly by the crankshaft. The pump is bolted to the front of the engine for serviceability. The relief valve located in the pump regulates oil pressure to 71 psi (5 kg-cm2). The filter bypass valve is located in the oil filter.



Oil Pump Cross Section

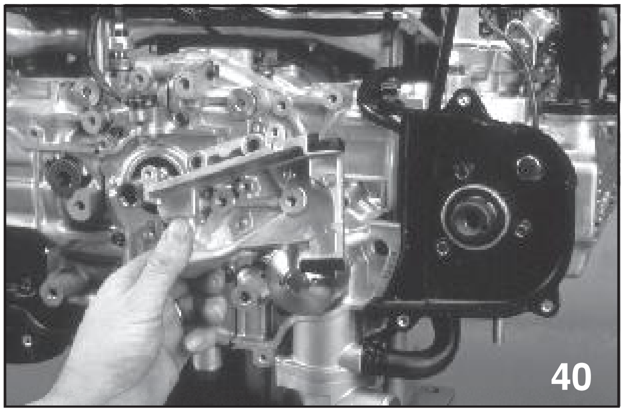
The oil pump has a reservoir which maintains oil for rotor lubrication. This is especially helpful when the engine has not been operated for extended periods of time. The reservoir also provides emergency oiling for the pump if there is temporary loss of oil supply.



Camshaft Sprockets

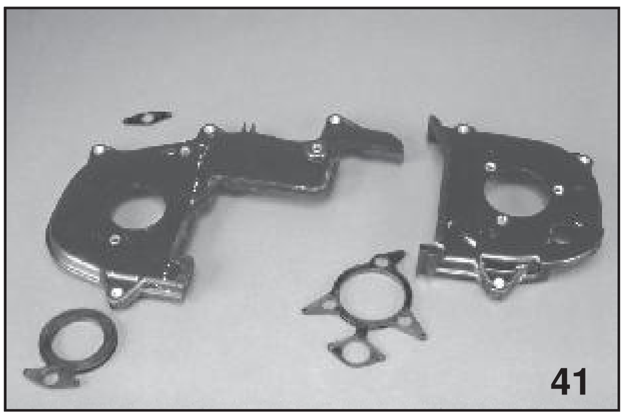
Notice the locating pin on back of the sprockets for reinstallation. Also locate the reluctors on the back of the left camshaft sprocket. These are the cam angle sensor reference triggers. Inspect the locating pin and reluctors for damage.

NOTE: THE LEFT CAMSHAFT SPROCKET MUST NOT BE INSTALLED ON THE RIGHT CAM SHAFT, AS DAMAGE TO THE INNER RIGHT CAM BELT COVER MAY OCCUR. A NO START CONDITION ALSO WILL RESULT.



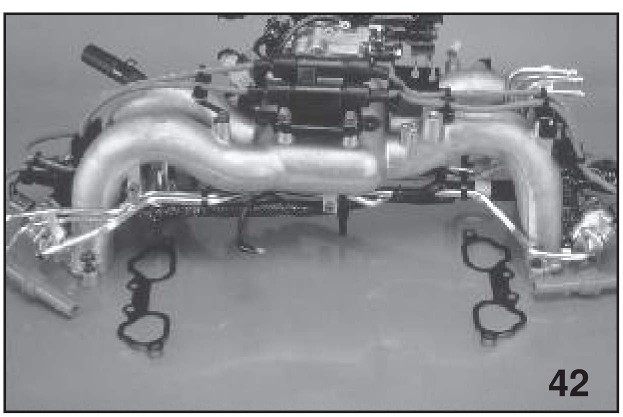
Tensioner Bracket Removal

Remove the mounting bolts and carefully remove the tensioner bracket to avoid damage to the friction-fit dust seals.



Inner Cam Belt Cover Removal

Remove the left and right inner cam belt covers. Note the location of the friction-fit dust seals.



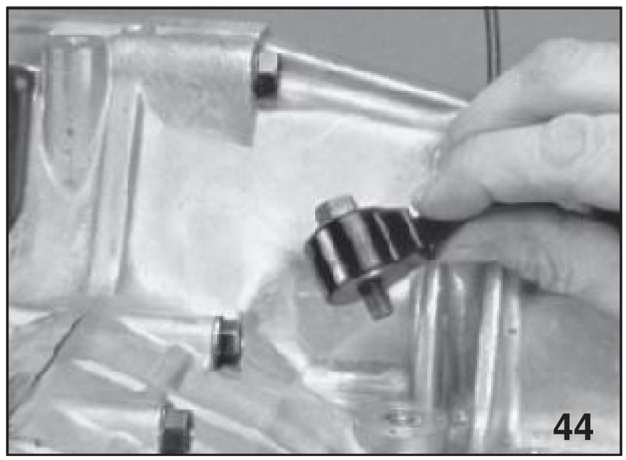
Engine Accessory Removal

Remove the hoses, electrical connections, sensors, switches, intake manifold, and intake manifold gaskets.

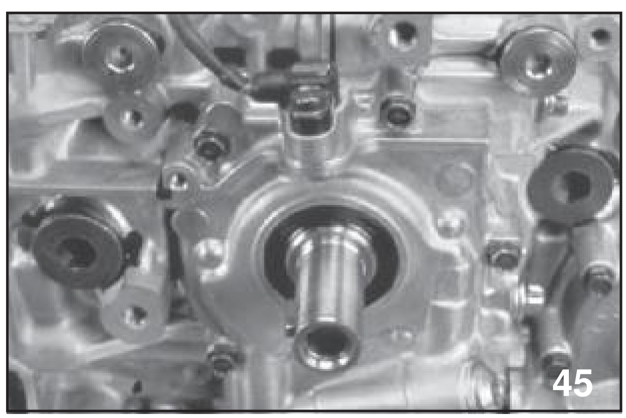
NOTE: THE RUBBER COATED METAL GASKETS ARE ONE TIME USE ONLY.

Remove the Water Transfer Pipe

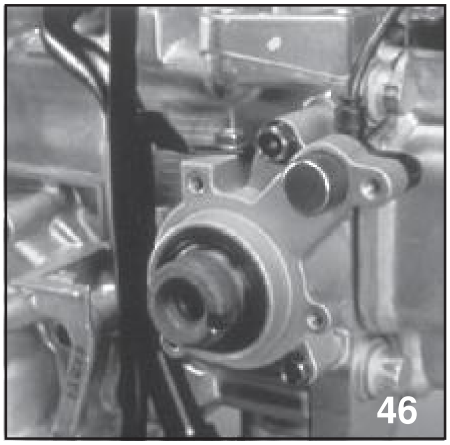
Remove the water transfer pipe and O-rings. New O-rings must be used at reinstallation.



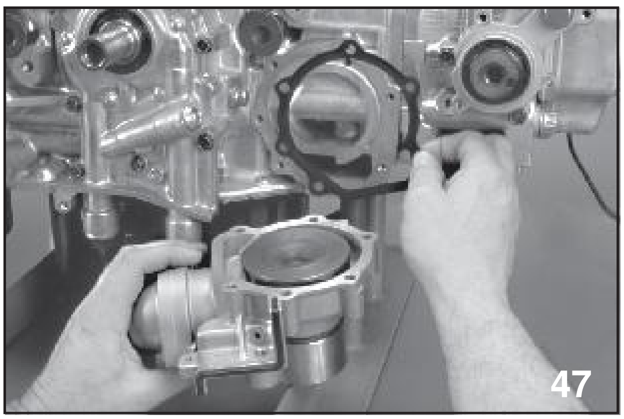
Remove Knock Sensor



Remove Crank Angle Sensor

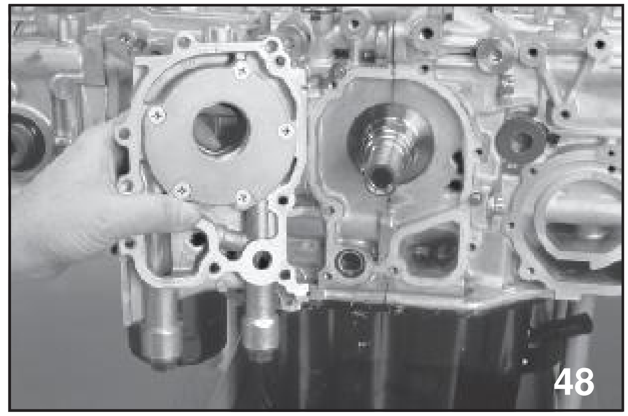


Remove Cam Angle Sensor



Remove Water Pump

Remove dip stick tube and then remove the water pump and rubber coated metal gasket. The gasket is onetime use only. Retain the dust seals for later reassembly.

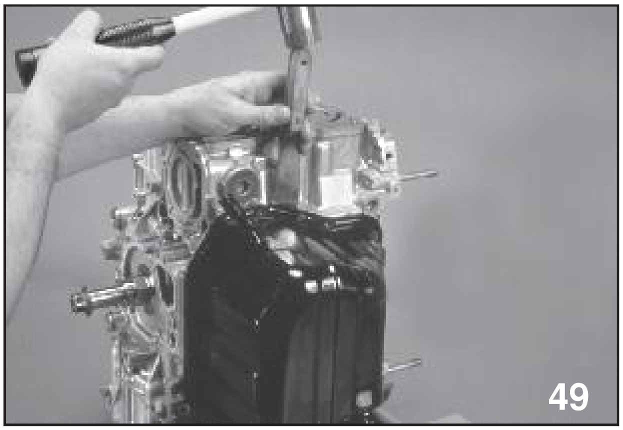


Remove Oil Pump

Remove the oil pump. Observe the condition and location of the O-ring seal and the dust seals. Retain the dust seals for later reassembly.

Loosen all head bolts in the reverse order of the tightening sequence, and then remove all of the cylinder head bolts except #1. Lightly tap the cylinder head with a rubber mallet to loosen the head from the gasket. Then remove #1 bolt and the cylinder head with the head gasket. Repeat the above steps for the other cylinder head.

NOTE: THE HEAD GASKETS ARE CARBON COMPOSITION WITH INTEGRATED O-RINGS. ALWAYS USE NEW GASKETS. CHECK FOR PROPER ORIENTATION.



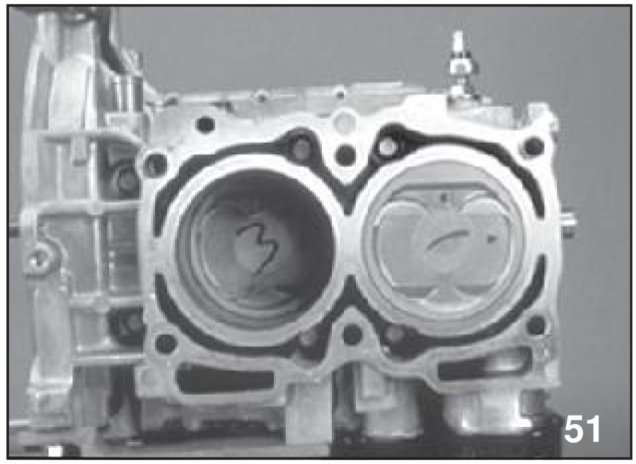
Remove Oil Pan

Remove the oil pan bolts. Use a thin gasket scraper/putty knife and a rubber mallet to loosen the oil pan. Remove the oil pan. Notice the location of the oil seal for the drain tube. Remove the oil pickup tube and also note the O-ring. Remove the oil pan baffle plate (windage tray).

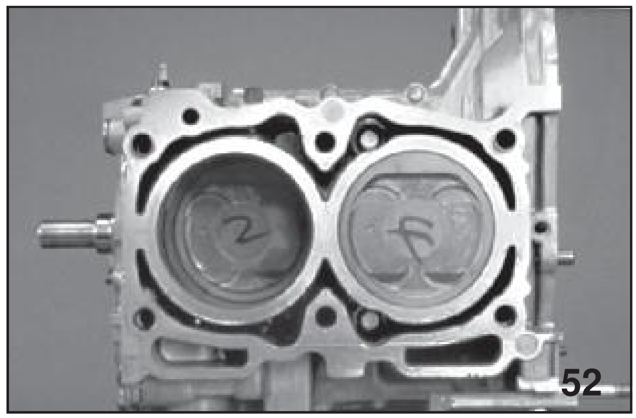
Piston Pin Removal

Use piston pin remover **499097300** or **499097500** to remove the piston pin. Insert the tool 3/4 of the way into the pin and pull the tool with the pin through the access hole. Repeat for the remaining pistons. Finally, rotate the crankshaft to position the pistons at the top of the cylinders. Repeat the procedure for the other cylinders.

NOTE: USE CAUTION WHILE ROTATING THE CRANKSHAFT TO PREVENT THE CONNECTING ROD LARGE ENDS FROM DAMAGING THE LOWER CYLINDER BORES.



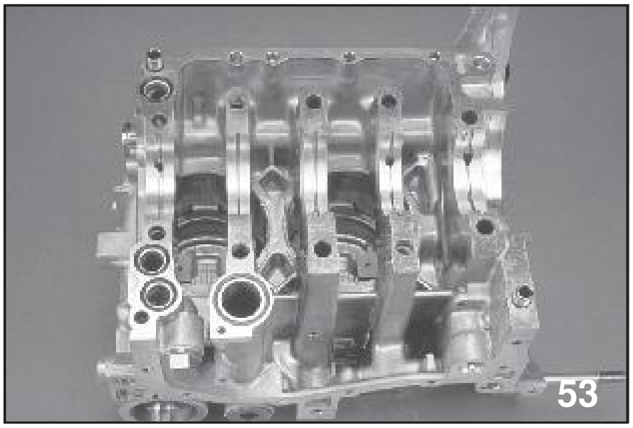
Crankcase Hidden Bolts (Right Bank)



Crankcase Hidden Bolts (Left Bank)

To split the crankcase remove **ALL 16** of the crankcase bolts. Six (6) of the bolts are hidden in the water passages, four in the RH case (1-3 side) and two in the LH case (2-4 side).

NOTE: ALL SIX (6) OF THE HIDDEN SHOULDERED CRANKCASE BOLTS HAVE SEALING WASHERS. THESE BOLTS ARE NOT INTERCHANGEABLE WITH THE OTHER CRANKCASE BOLTS. THE SEALING WASHERS ARE ONE TIME USE ONLY.

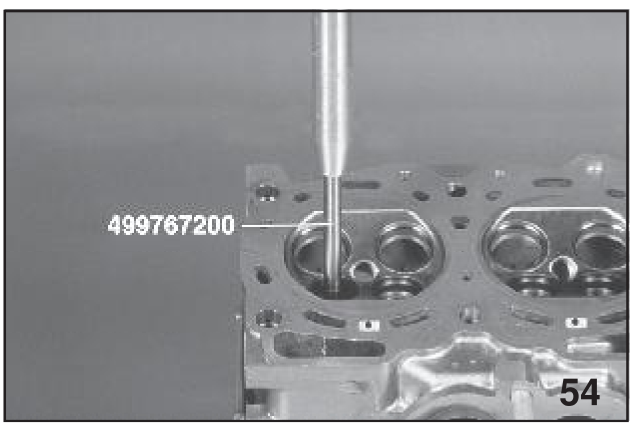


Crankcase Half with O-Rings

Carefully separate the crankcase halves.

NOTE: IDENTIFY THE LOCATION OF THE FOUR O-RINGS (THREE SMALL, ONE LARGE), IN THE MATING SURFACE OF THE RIGHT (1-3 SIDE) CRANKCASE. THE BLACK O-RINGS ARE FOR OIL PASSAGES, THE ORANGE O-RING IS FOR A COOLANT PASSAGE.

Finally, inspect the rocker arm cam contact surface. Replace the rocker arm(s) when they are scored or gouged.



Valve Guide Removal

Use a press, cylinder head table, **498267200**, and valve guide removal tool **499767200** to remove the valve guides.

Precautions

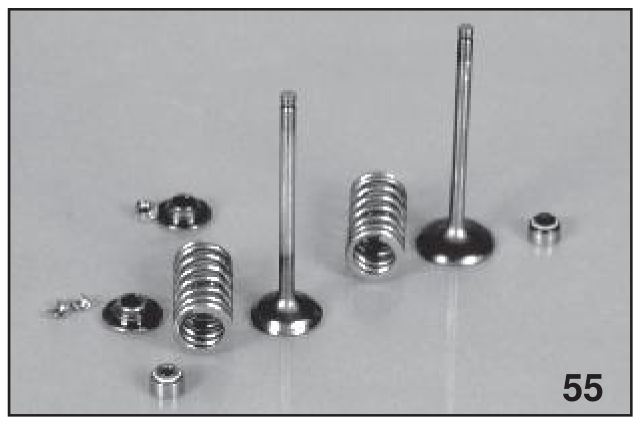
Follow the precautions listed below when inspecting and servicing engine components.

a. Clean all parts thoroughly.
b. Remove all gaskets and sealing material.

CAUTION: DO NOT DAMAGE ALUMINUM MATING SURFACES

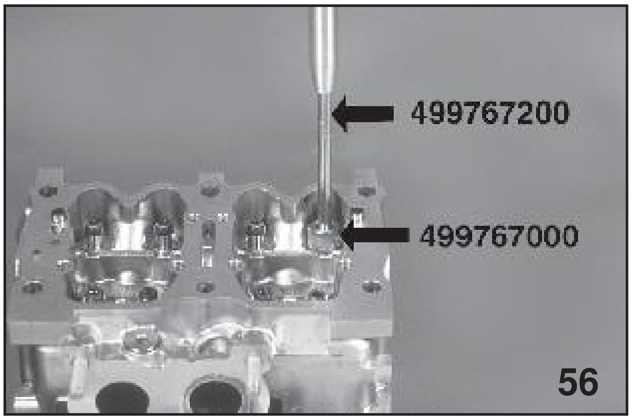
c. Use compressed air to insure clear oil and coolant passages.
d. Do not damage components when removing carbon.
e. Keep parts in order to ease reassembly.
f. Service all valves as a set.

Refer to the Subaru Service Manual on the STIS web site for the detailed step-by-step inspection and servicing steps. The following information addresses only the special steps which are distinctive to the 2.2L engine.



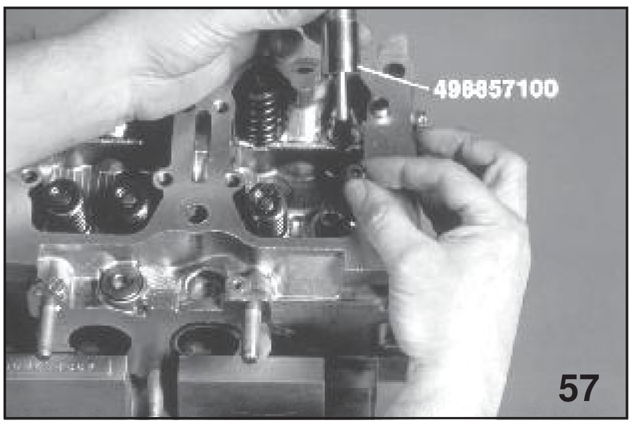
Valve Components

Use valve spring remover **499718000** to remove the valve springs. Then remove the valves and seals. The intake seals are black and the exhaust seals are brown.



Installing Valve Guides

Install the valve guides using a press, cylinder head table **498267200**, valve guide remover **499767200**, and valve guide adjuster **499767000**.

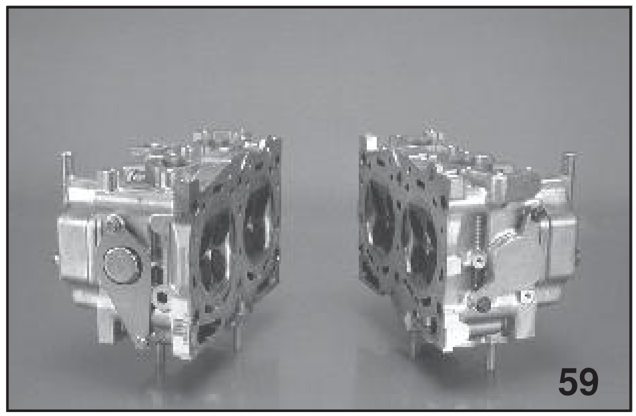


Installing Valve Guide Oil Seal

Use valve seal installer **498857100**, to install the valve guide seals (black for intake, brown for exhaust). Then use cylinder head table **498267200** and valve spring remover **499718000** to install the valve spring and retainer. Install the camshaft into the cylinder head bearing journals. Be careful to not damage or score the camshaft journals.

Installing the Oil Seal

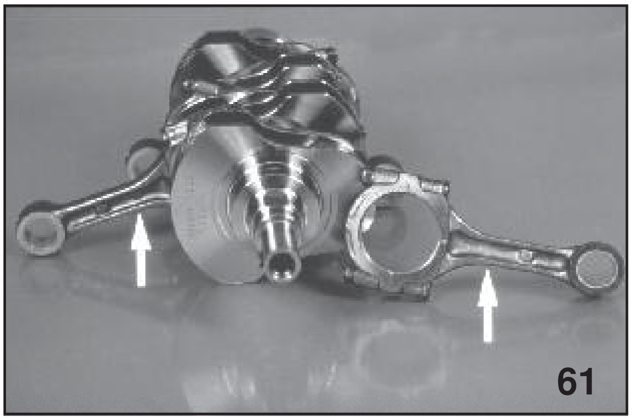
Install the left rear camshaft plug (oil seal). Then install the oil seal using oil seal installer **499587100**.



Storing Cylinder Heads

Temporarily store the cylinder head by standing it on the exhaust manifold studs. Repeat these steps for the other cylinder head.

Engine Reassembly



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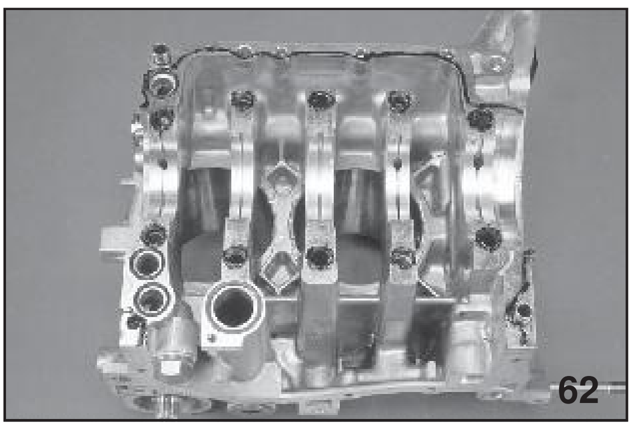
Assemble Crankshaft

Always refer to the applicable Subaru Service Manual on the STIS web site for the bearing size, oil clearance, and torque specifications. The "FUJI" symbol on the connecting rods must face the front of the engine.



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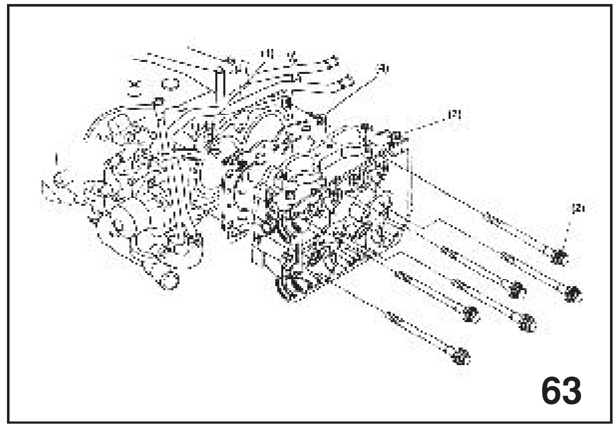
Crankcase Sealer and O-Rings

Apply sealant to the crankcase mating surface on the o-ring side of the crankcase. Do not allow the sealant to enter the O-ring grooves, oil passages, or bearing grooves. Install the crankshaft assembly. Align the connecting rods, and assemble the crankcase halves.

CAUTION: REMOVE ALL FLUIDS FROM THE THREADED PORTIONS OF THE CASE HALVES. THIS PREVENTS HYDROSTATIC LOCK AND POTENTIAL CRACKING OF THE CRANKCASE.

FOLLOW CORRECT SEQUENCE FROM THE SUBARU SERVICE MANUAL ON THE STIS WEB SITE.



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Cylinder Head

(1) Bolt
(2) Cylinder head bolt
(3) Cylinder head
(4) Cylinder head gasket

1) Install cylinder head and gaskets on cylinder block.

CAUTION: USE NEW CYLINDER HEAD GASKETS.

2) Tighten cylinder head bolts per Subaru Service Manual specifications on STIS web site.

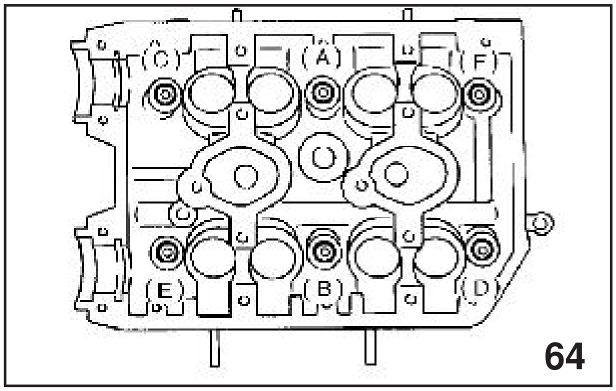
(1) Apply a coat of engine oil to washers and bolt threads.

(2) Tighten all bolts to 29 N•m (3.0 kg-m, 22 ft.-lb.) in alphabetical sequence.

Then tighten all bolts to 69 N•m (7.0 kg-m, 51 ft.-lb.) in alphabetical sequence.

(3) Back off all bolts by 180 first; back them off by 180 again.

(4) Tighten bolts (A) and (B) to 34 N•m (3.5 kg-m, 25 ft-lb).



Bolts

(5) Tighten bolts (C), (D), (E) and (F) to 15 N•m (1.5 kg-m, 11 ft-lb).

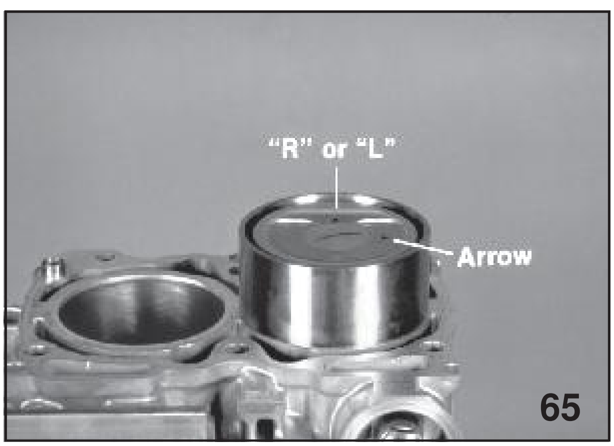
(6) Tighten all bolts by 80 to 90 in alphabetical sequence.

CAUTION: DO NOT TIGHTEN BOLTS MORE THAN 90.

(7) Further tighten all bolts by 80 to 90 in alphabetical sequence.

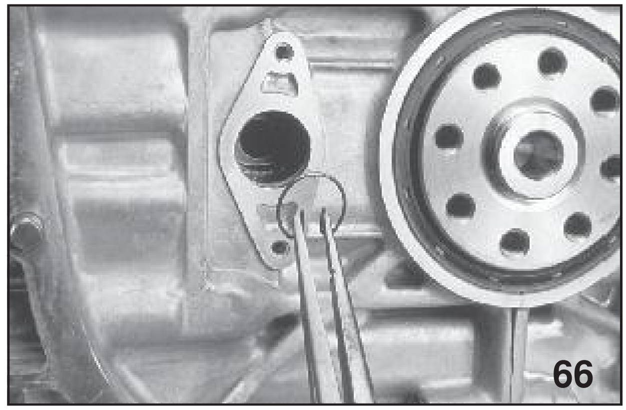
CAUTION: ENSURE THAT THE TOTAL "RE-TIGHTENING ANGLE" [IN THE TWO PREVIOUS STEPS] DO NOT EXCEED 180.

3) Install oil level gauge guide attaching bolt (LH side only).



Piston Installation

The pistons are directional and must be returned to the original cylinder locations. Use correct size piston guide to install the pistons. The pistons are marked with an "L" for the left side and an "R" for the right side. The arrow on the head of each piston must point to the front of the engine.

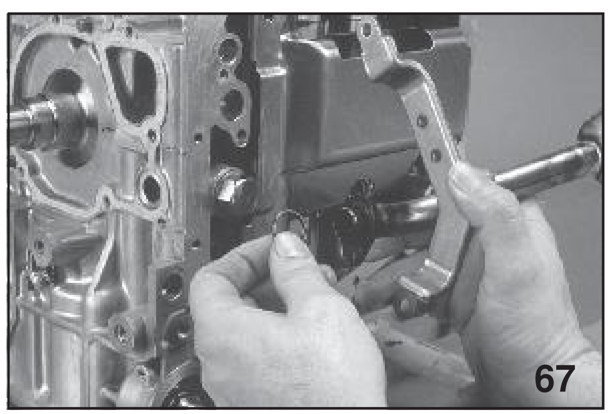


Circlip Removal

Rotate the crankshaft to position the connecting rod with the piston. Use piston pin guide **499017100** to align the piston and connecting rod. Then install the piston pin. Install the circlip. Note the proper direction of the circlip on early production models. The tangs must be tilted out. Repeat for the remaining pistons. Slowly rotate the crankshaft two (2) revolutions. This confirms the proper installation of the pins. Install the front piston pin access plugs. Use new aluminum sealing rings and sealer.

NOTE: DO NOT OVER TIGHTEN. CONSULT SUBARU SERVICE MANUAL ON THE STIS WEB SITE FOR SPECIFICATIONS.

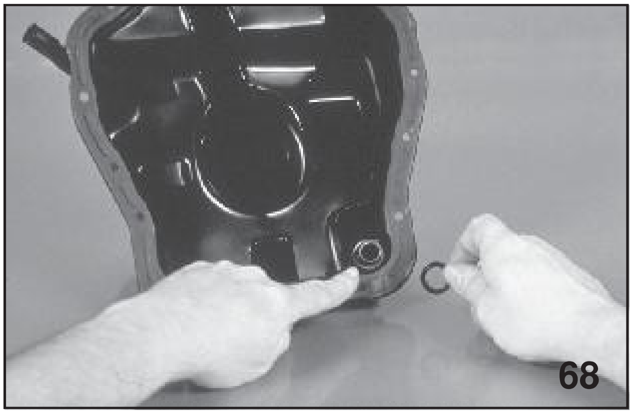
Install the left side access cover and new o-ring, PCV baffle plate, and piston pin plug using a new sealing ring and sealer.



Installing Oil Pick-Up Tube

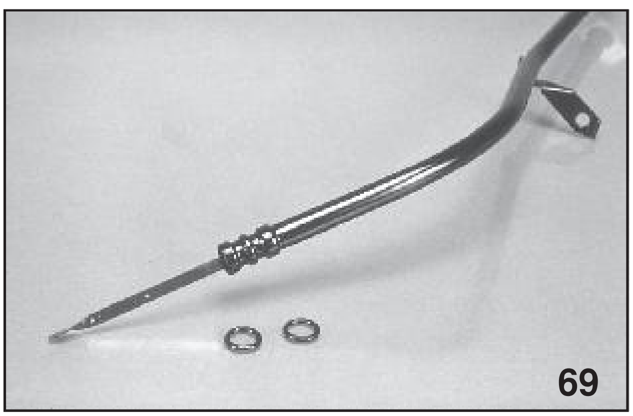
Install the oil pan baffle plate and oil pickup tube. Be sure to install a new O-ring to the oil pickup tube.

NOTE: DO NOT OVER TIGHTEN OR BOLT DAMAGE WILL OCCUR.



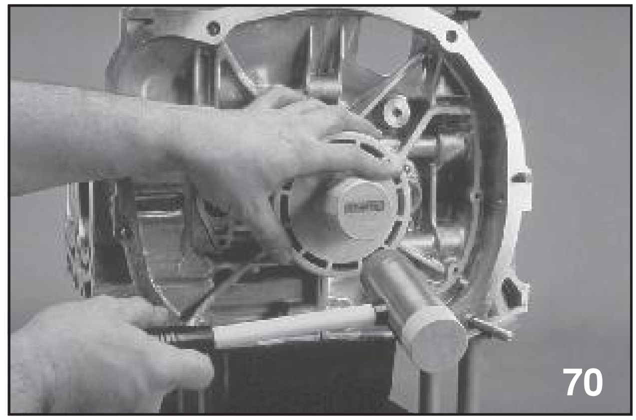
Oil Pan Drain Tube Seal

Install a new oil seal on the oil return tube. Apply liquid gasket sealer FUJI Bond 1207C or equivalent to the oil pan mating surface. Install the oil pan and oil pan retaining bolts. Diagonally torque the oil pan bolts on one pass to 0.5 Kg-m (3.6 ft lbs).



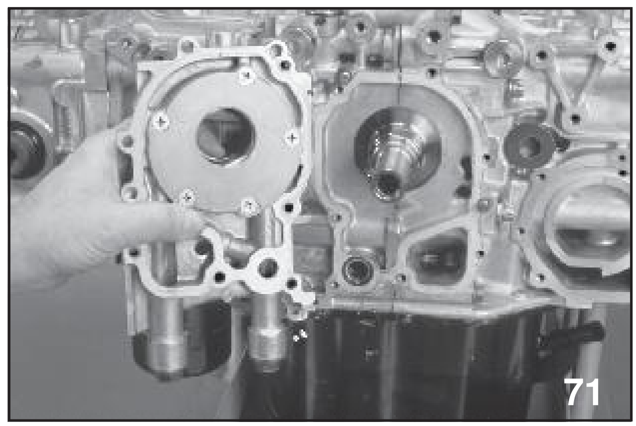
Dipstick Tube and Seals

Install the dipstick tube. Be sure to use two (2) new o-ring seals.



Installing Rear Crankshaft Oil Seal

Install the rear main oil seal using seal installer (**499587200**), oil seal guide (**499597100**) and a plastic hammer. Lubricate the seal with engine oil prior to installation.



Installing Oil Pump

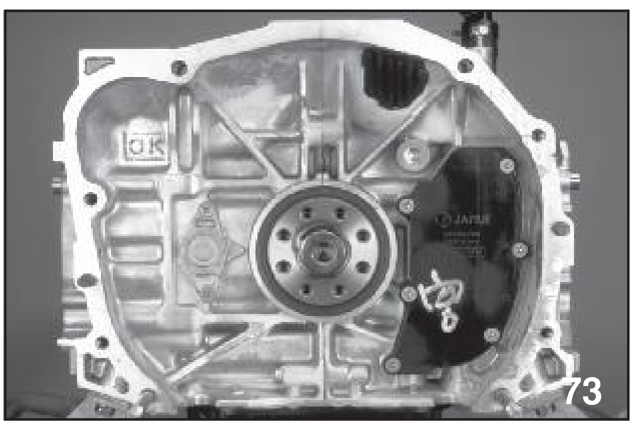
Install the oil pump. Refer to the 1995 Subaru Service Manual on the STIS web site section 2-4 [W1E0] for proper location of the sealer and O-ring. Apply FUJI Bond 1215 sealer or equivalent to the mating surface of the oil pump. Align the flats (2) on the oil pump with the flats (2) on the crankshaft and the mounting holes in the oil pump flange with the two (2) dowel pins. Install the mounting bolts and torque to specifications.

2.2 and 2.5 Engines 1999 Enhancements DOHC (Phase 1) and SOHC (Phase 2)

The engines for the 1999 Subaru line will be designated phase 1 and phase 2. 2.5 liter engines equipped on the Legacy will be phase 1 design while the Impreza and Forester will utilize phase 2 design 2.5 liter engines.

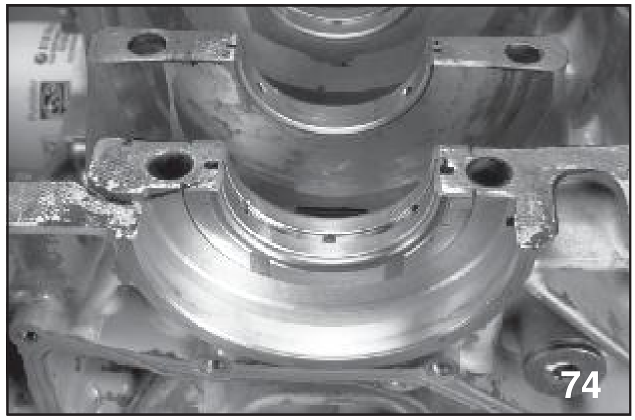
The 2.5 liter phase 2 engines are SOHC engine with a newly designed cylinder head. The (phase 1) 2.5 liter engine uses the same cylinder head configuration that it has used on prior year models with the crankcase and bell housing sharing the same characteristics of the new phase 2 engines.

Common Changes in the 2.5 liter (phase 1 and 2 engines.)



Engine to Transmission Mounting

The engine and the transmission are fastened with 6 bolts and 2 studs.



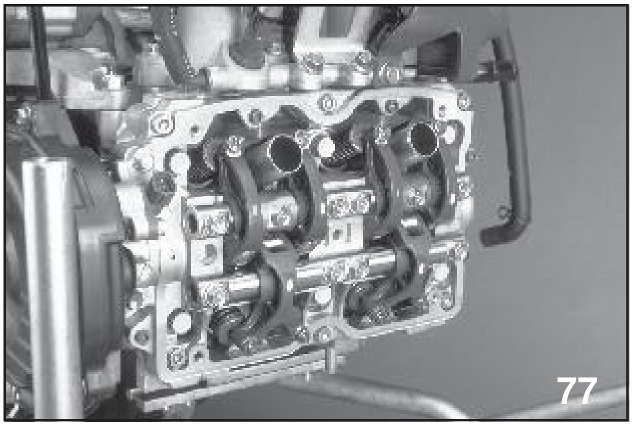
Thrust Bearing Location

The thrust bearing has been moved to the number 5 position.

Main Bearing Oil Grooves

Oil groove in the number 1 and 3 have been changed to supply additional lubrication to the crank journal.

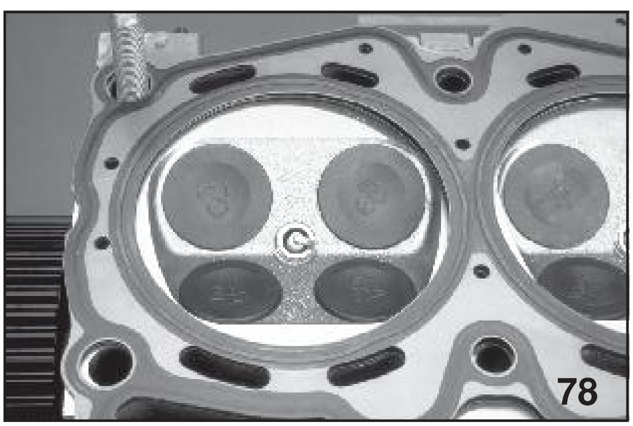
New Features of the 2.2 and 2.5 Liter (Phase 2) SOHC Engine



2 Rocker Shaft Assembly

The cylinder head will be a 2-rocker shaft valve system.

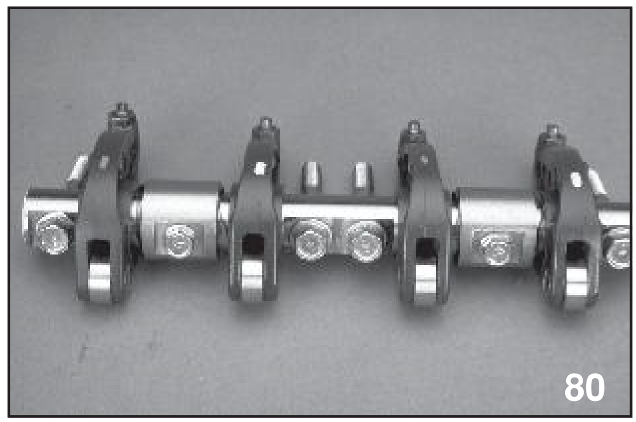
The valves are positioned at a larger angle than previous model years. The intake valves are positioned 23 degrees off center with the exhaust valves positioned 20 degrees off center. Prior model year engines utilized a 15-degree positioning angle.



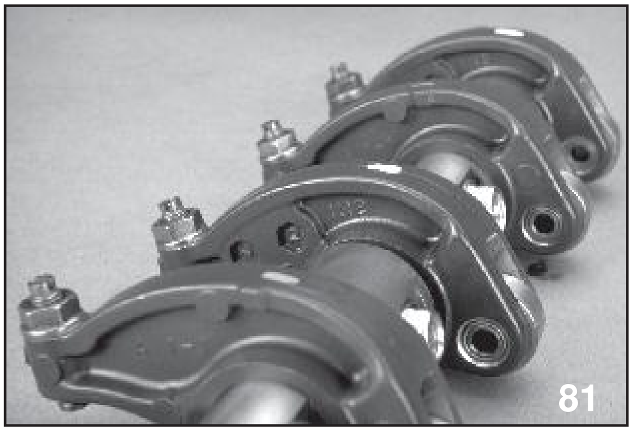
New Head Gasket Design

Head gasket thickness is 0.7 mm.

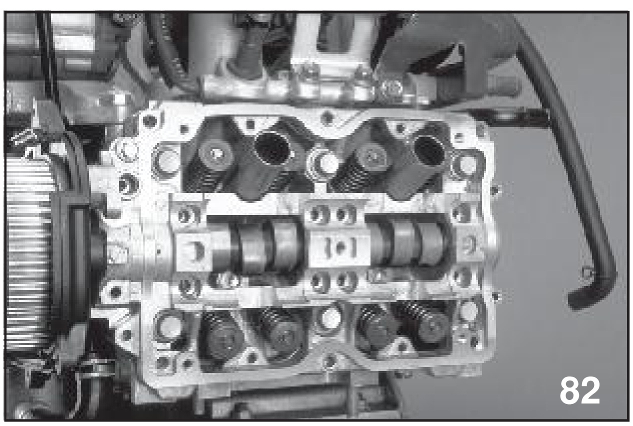
Rocker Arm Identification

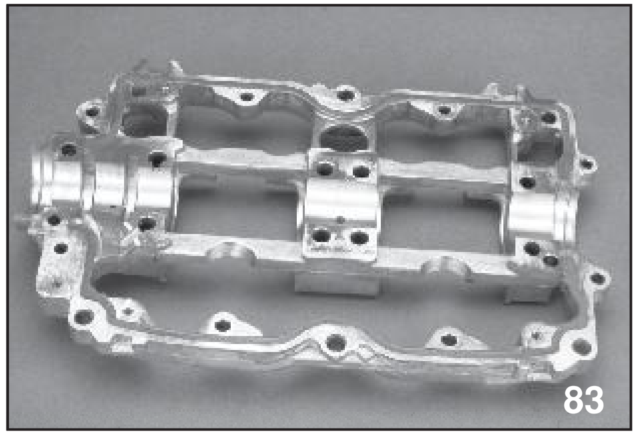


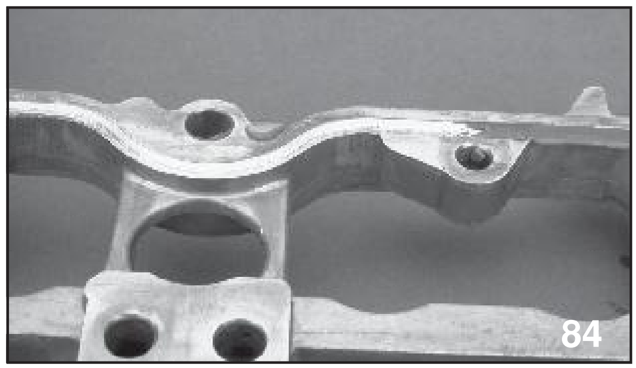
Roller Rockers and Wave Washers


Adjustment Screw and Nut

The intake rocker arms are marked so they are correctly placed on the rocker shaft when servicing. An IN1 or IN2 will be embossed on each rocker arm. As viewed from the front of the engine the Number 1 intake valve of each cylinder and the number 2 intake valve have an IN1 marked and IN2 marked rocker arm that mates with it. New IN1 rocker arms can also be identified by a Green painted mark on the top of the rocker arm. The IN2 rocker arms have a white mark. Proper positioning is maintained through the use of a wave washer located between the rocker shaft arm and rocker arm shaft support.


Camshaft Secured by Camcase

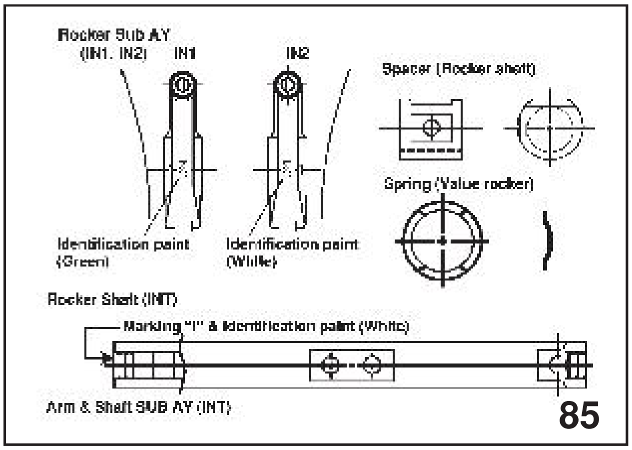

Camcase Sealing Points


Sealing Groove

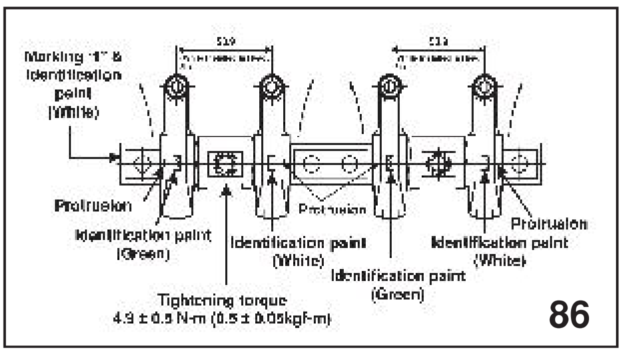
The camshaft is secured to the cylinder head with the camcase. An oil passage in the cylinder head provides the passageway in the camcase with oil that leads to the intake rocker shaft. Oil from the camshaft is collected on the opposite side of the passageway leading to the intake rocker shaft to provide oil to the exhaust rocker shaft.

Sealing of the camcase is accomplished by using a thin layer of three bond applied in the channel around the camcase edge. After the three bond (1280B) is applied, the camcase must be installed to the cylinder head and onto the engine before the three bond has time to cure. Failure to do this will result in oil leaks.

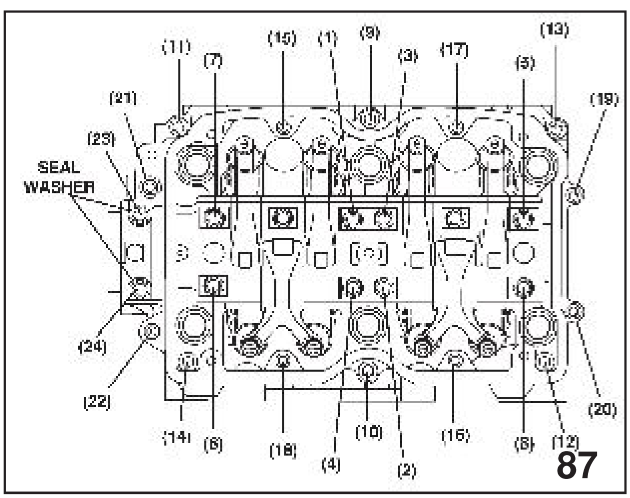
NOTE: CYLINDER HEAD AND CAMCASE MUST BE REPLACED TOGETHER. (LINE BORED)



Rocker Identification

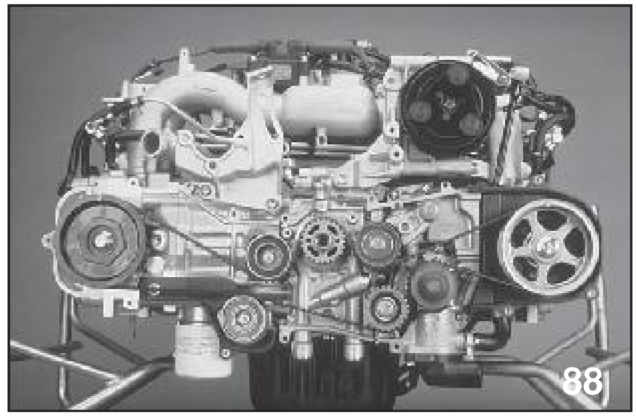


Rocker Arm Measurements



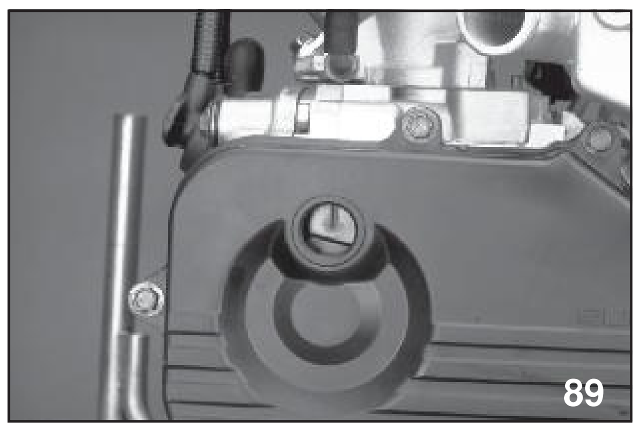
Camcase Tightening Sequence

The sparkplug pipe is pressed into the cylinder head and is not serviceable. If it becomes damaged the cylinder head must be replaced. The seals installed onto the ends of the sparkplug pipes seal against the valve covers and should be replaced when the valve cover is removed.



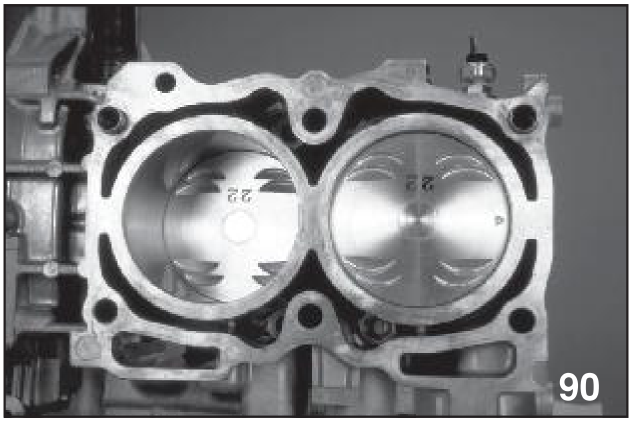
Timing Belt Marks

Timing belt marks on the left bank will be made onto the inner timing belt cover and the edge of the camshaft sprocket. The crank shaft timing mark remains on the reluctor with engine block mark just below the crank angle sensor. The right bank camshaft sprocket has a mark at the edge that is matched with the seam line formed by the meeting of the camcase and cylinder head. (12:00 o'clock position)



Right Bank Timing Mark Window

The right bank timing mark can be checked with outer cover in place using the provided window.

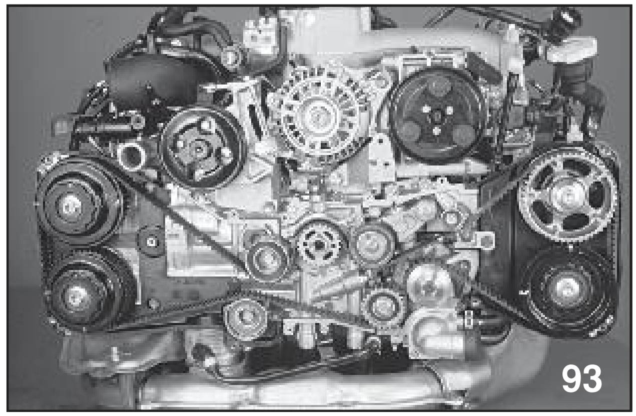


Open Deck Design

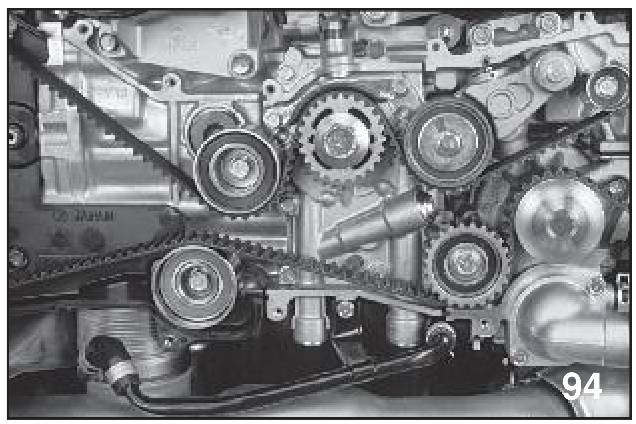
Piston With Valve Reliefs

Piston design on the 2.5 liter engine. The compression ratio is 10 to 1.

2.0 Liter Engine Features - WRX From 2002~2005



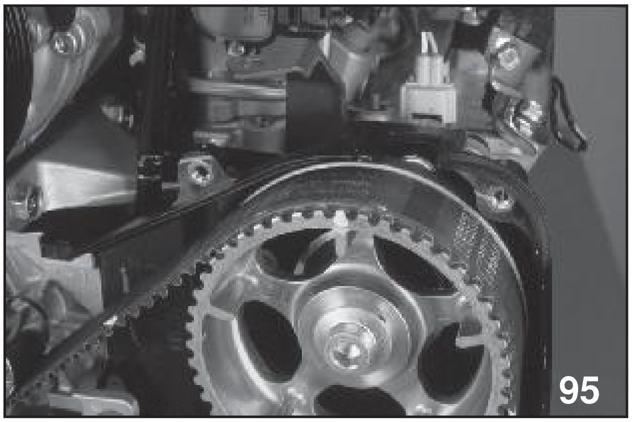
2.0 Liter Engine



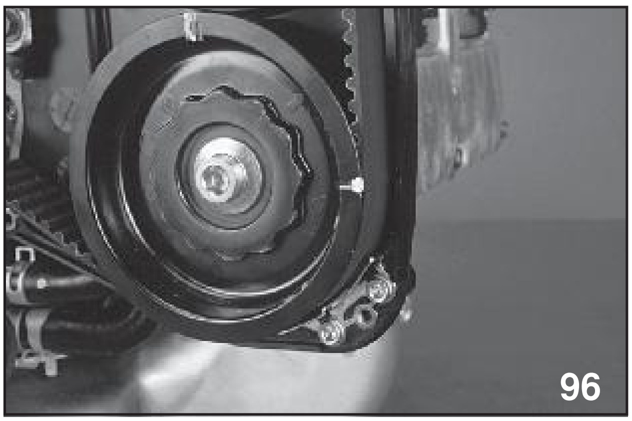
Cam Belt and Idler Pulleys

The EJ-2.0 engine is a double over head camshaft, turbo charged engine. The timing belt procedure and routing is very similar to other Subaru DOHC, engines, however, the increased power output of the engine requires the use of an additional timing belt idler pulley. Manual transmission vehicles are equipped with additional belt guides that function during deceleration or fuel cut from high rpm running conditions.

NOTE: WHEN SERVICING THE TIMING BELT RETURN ALL IDLER PULLEYS AND BELT GUIDES TO THEIR ORIGINAL POSITIONS.



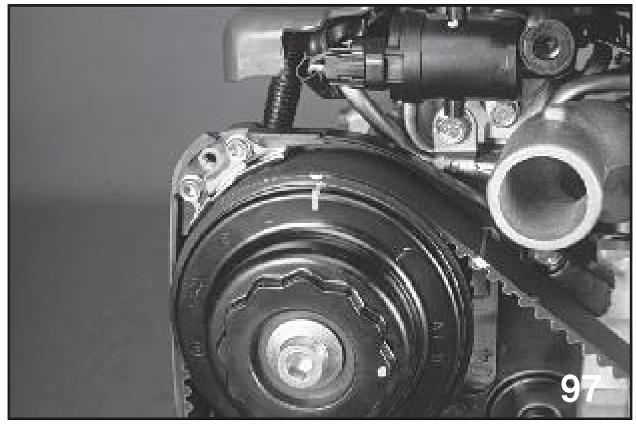
Intake Camshaft Sprocket Timing Marks (Left Bank)



Exhaust Camshaft Sprocket Timing Marks (Left Bank)

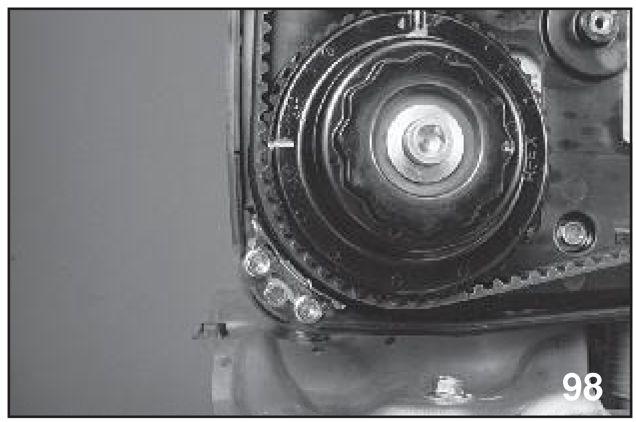
The left bank intake camshaft sprocket is metallic and the camshaft reluctor is made onto the backside. The timing marks for belt installation are at 12:00 (I) and 6:00 (II).

The left exhaust sprocket is made of a resin material with its timing marks during belt installation at 12:00 (II) and 3:00 (I). The exhaust 12:00 (II) mark lines up with 6:00 (II) of the intake sprocket. (A timing belt guide is located at the lower left side of the sprocket of manual transmission models.)



Intake Camshaft Sprocket Timing Marks (Right Bank)

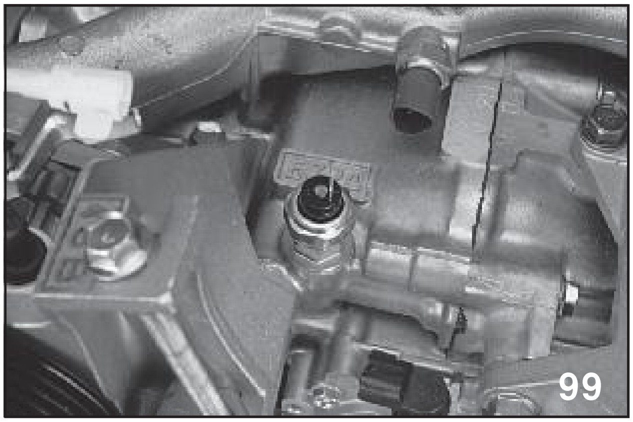
The right intake sprocket is also made of a resin material with its timing marks during belt installation at 12:00 (I) and 6:00 (II). (A timing belt guide is located at the upper left side of the sprocket of manual transmission models.)



Exhaust Camshaft Sprocket Timing Marks (Right Bank)

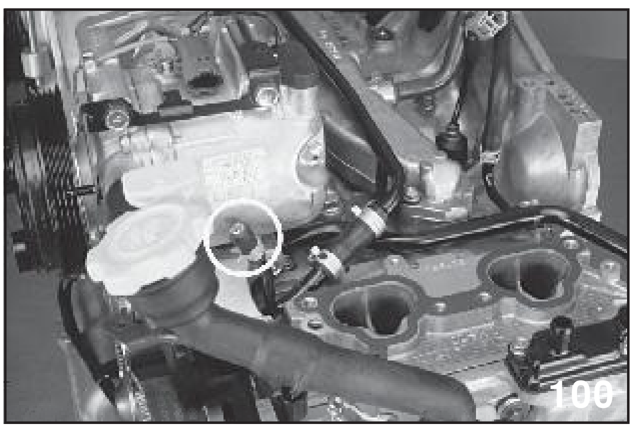
Finally, the right exhaust sprocket is made of a resin material with its timing marks during belt installation at 9:00 (I) and 12:00 (II). The exhaust 12:00 (II) mark lines up with 6:00 (II) of the intake sprocket. (A timing belt guide is located at the lower left of the sprocket of manual transmission models.)

NOTE: IT IS CRITICAL THAT ALL TIMING MARKS BE CONFIRMED TO THE CORRECT POSITION. INCORRECT POSITIONS WILL RESULT IN VALVE AND PISTON DAMAGE.



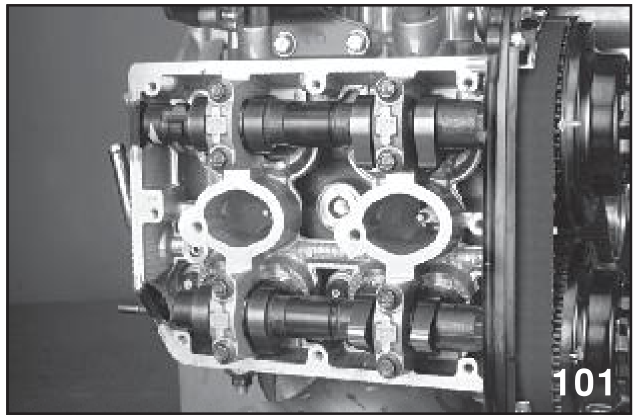
Engine Designation Number

The engine class number (Engine designation number) is located near the front of the engine behind the oil-sending unit and in front of the engine coolant temperature sensor.

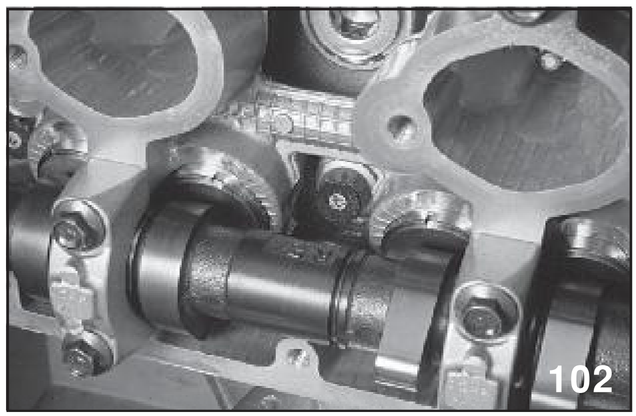


Factory Coolant Pipe Plug

A coolant pipe located on the left hand bank is sealed with a rubber plug at the factory. **Do not** remove the plug to service any part of the cooling system. When performing coolant pressure tests check plug for leaks.

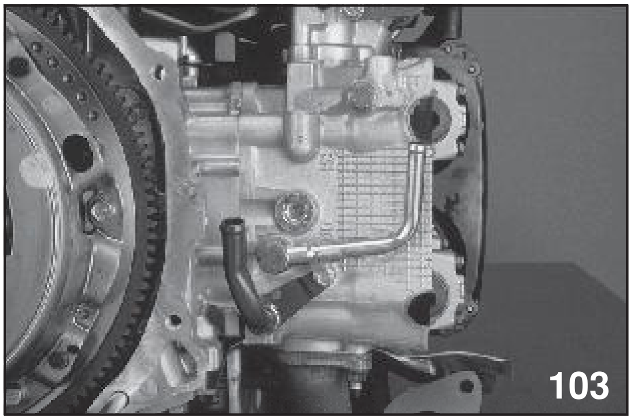


2.0 Liter Valve Train Assembly



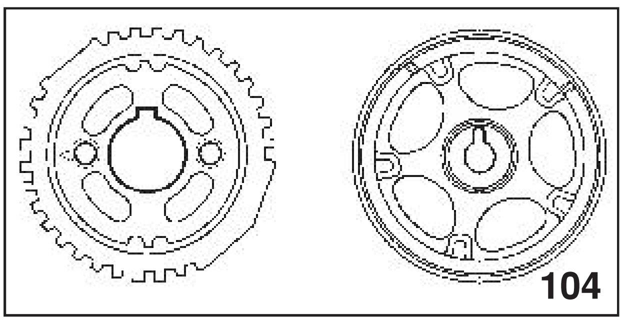
2.0 Liter Head Bolt Access

The valve train for the EJ 2.0 is the same design used on other DOHC engines. A new shim tool (2002 only) has been developed to allow valve adjustment without removing the camshafts. The camshaft inner cover, camshaft sprockets and camshafts must be removed to access the cylinder head bolts. 2003 and newer use select fit lifters to obtain correct valve clearance.



Turbo Oil and Coolant Passages (Right Bank)

The rear of the right bank cylinder head serves as the mounting for the oil and coolant passages for the Turbo Charger.

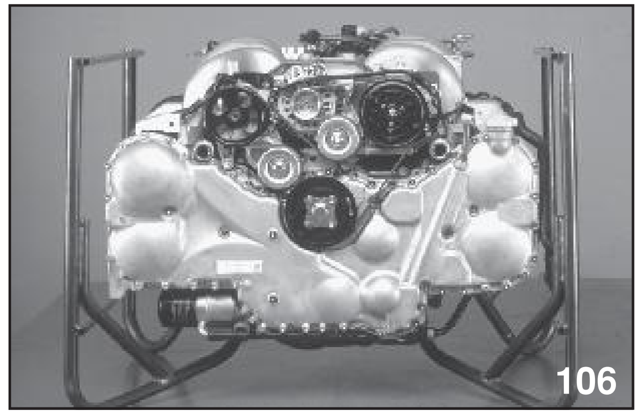


Crankshaft and Camshaft Sprockets for the 2.0 Turbo Engine

Piston pin design is strengthened with a near solid, non hollow design. Pin removal from pistons during disassembly requires a small diameter long thin punch of pliers to remove the pin.

Additional material is installed in the center of the piston pins in the 2.0 engine for strengthening.

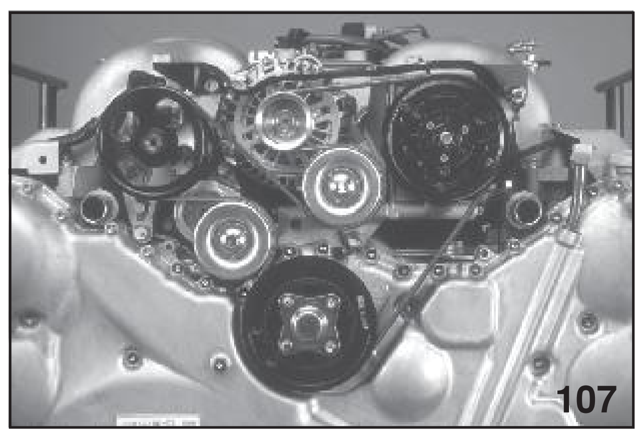
3.0 Liter Engine



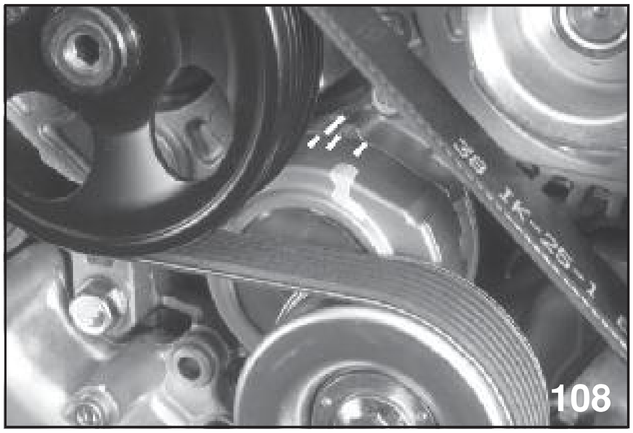
3.0 Liter Engine with Stands

General Information

The EZ-3.0 is the model name (Engine Designation) for the new 6-cylinder engine introduced for the 2001 model year Legacy. The design idea for this engine was to create a power plant that could utilize the current body style, provide more power and decreased exhaust emissions. Many of the features refined for the current 4 cylinder engine are employed on the EZ-3.0 however, new features such as Variable Intake Control and timing chain driven camshafts give the new engine a look and operation all of its own.



Single Serpentine Belt



Belt Wear Indicator

3.0 Liter Engine Features

The front of the engine displays the large front timing chain cover. It is secured to the inner cover with 59 bolts. There are 4 different lengths used and is sealed to the inner cover with Three Bond (1280B). Special care must be used when servicing the timing chain covers to ensure the proper length bolt and sealing procedures are used. A single serpentine belt provides the power to turn all engine accessories.

Tension to the belt is controlled with an automatic tensioner.

Replace the serpentine belt when the indicator is at or beyond this line.

3.0 Specifications

Bore and stroke 89.2 x 80 millimeters (3.51 x 3.14 inches)

Length 465 millimeters (18.3 inches)

Height 635 millimeters (24.99)

Displacement 3.0 liters (183 cubic inches)

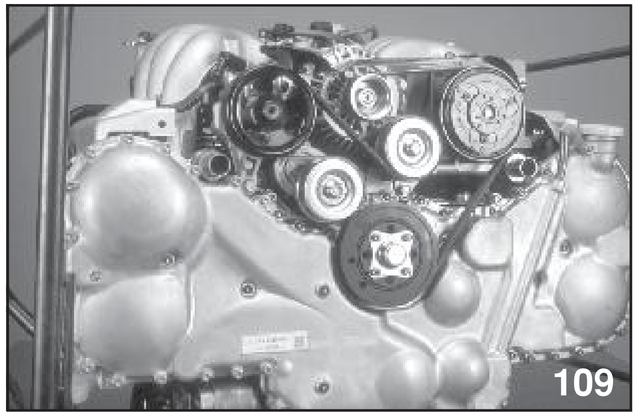
Compression Ratio 10.7 to 1

Gasoline for use Unleaded Premium

Fuel Injection Type DMPI

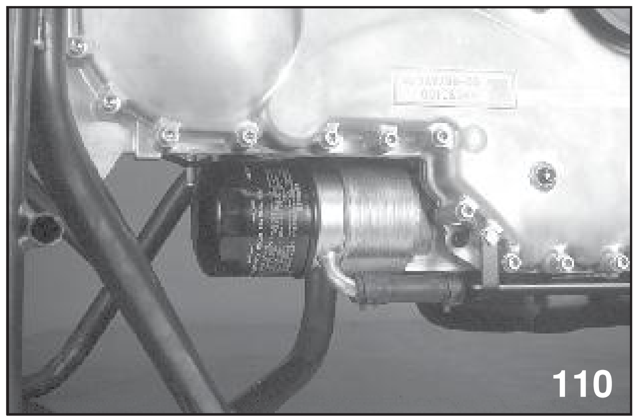
Maximum Horsepower 212 at 6,000 RPM

Maximum torque 210 at 4,400 RPM



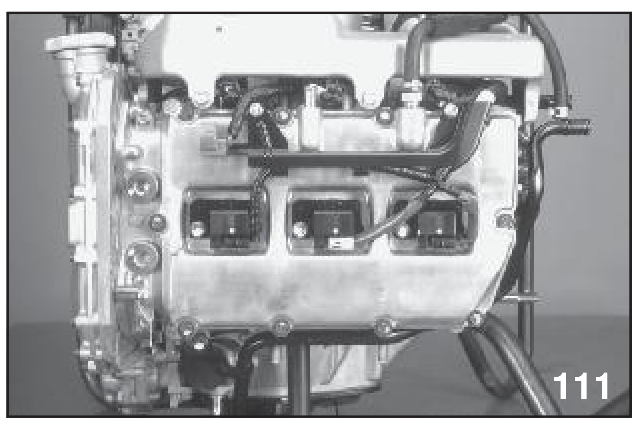
Upper Radiator Hose Connections

Two radiator hose connections are located at the top of the engine block connecting to each of the cylinder heads.

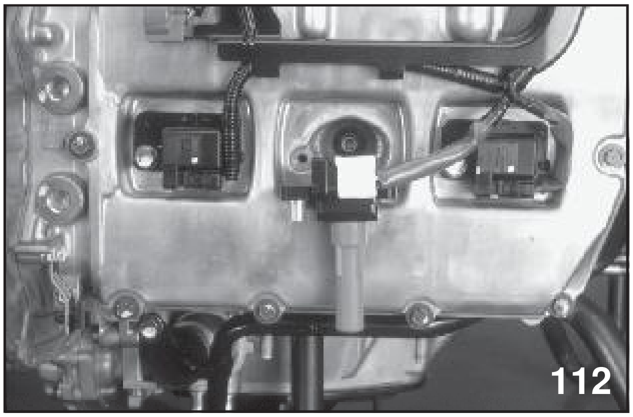


Oil Cooler

An oil cooler is used to assist with bringing the oil to operating temperature.

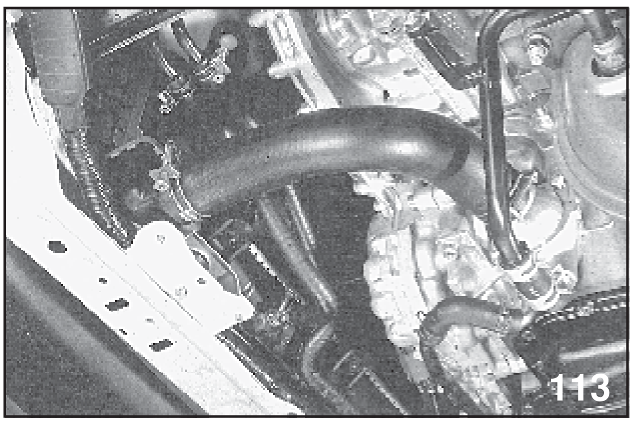


Individual Coils



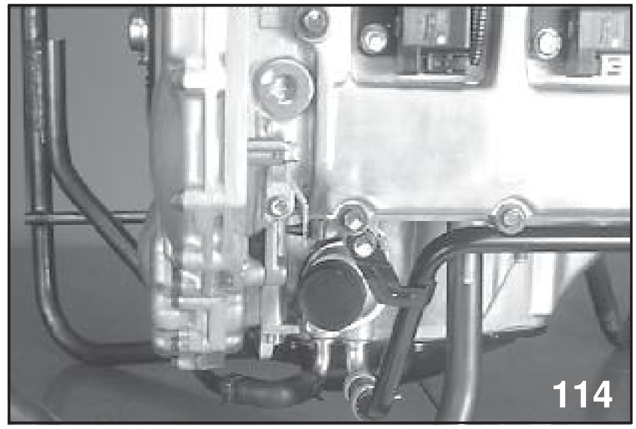
Coil and Igniter Assembly

The view of the left bank side shows the use of new direct ignition coils. The igniter and current control circuits are integrated.



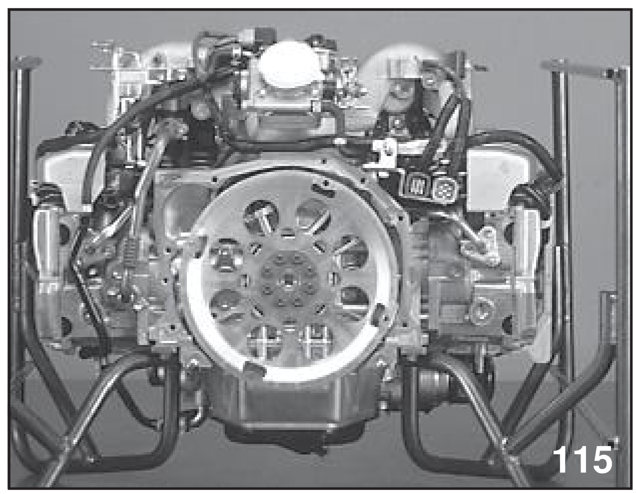
Lower Radiator Hose

The lower hose is located on the thermostat housing, connecting to the lower section of the radiator.



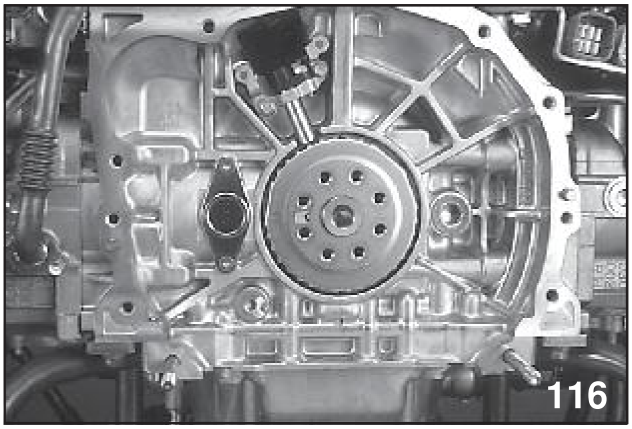
Oil Pan and Extension Case

The thermostat is housed in the oil pan extension case. The oil pan itself is much smaller than previous model engines and contains a small magnet to collect metallic debris.



Crankcase Ventilation System

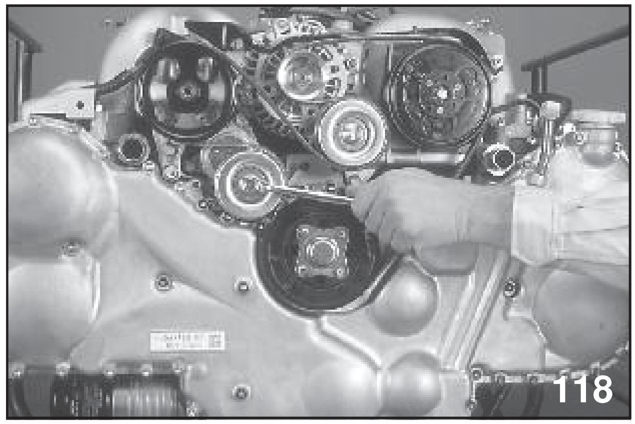
Connections for the crankcase ventilation system are located at the top of the valve cover. Pressure is equalized from the right bank with a cross over tube.



Crank Angle Sensor with Reluctor

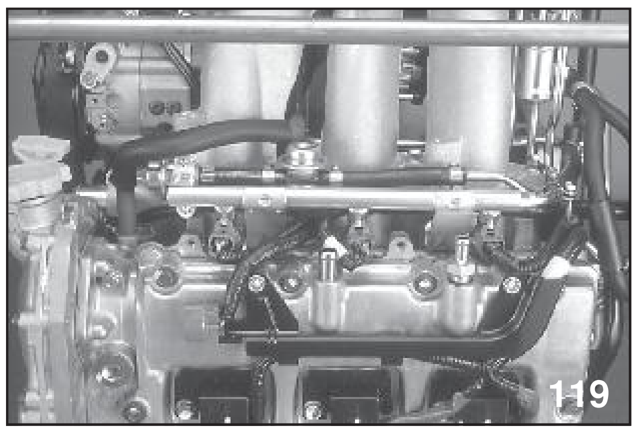
The new crank angle sensor, reluctor, and EGR pipe. The crank angle sensor and reluctor have been moved to the rear of the crankshaft. The EGR pipe has a new design and is mounted on the left bank of the engine.

3.0 Liter Engine Disassembly



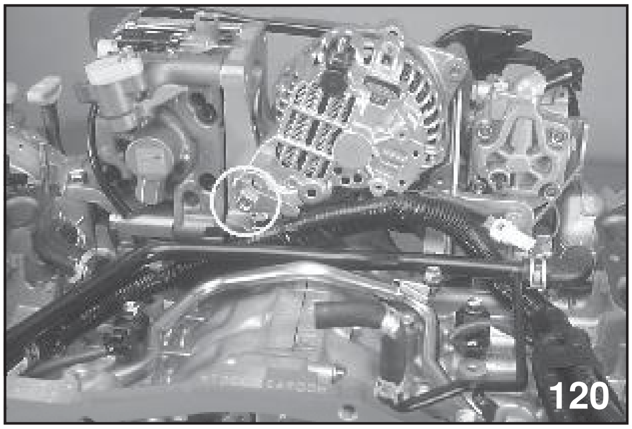
Unloading Tensioner

Begin disassembly by unloading and removing the serpentine belt.



Fuel Rail Assembly

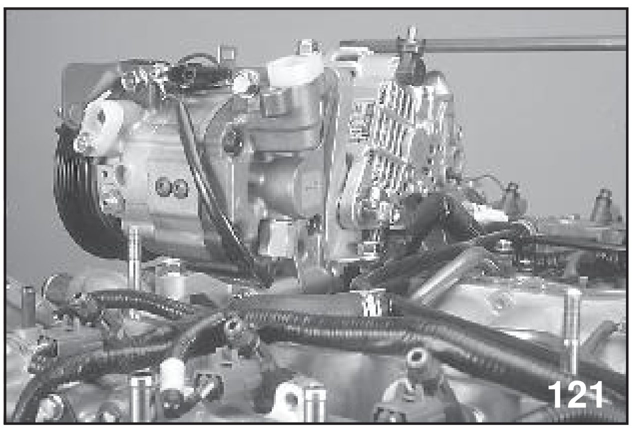
Remove the fuel rail protectors from both sides.



Lower Alternator Bolt

The lower alternator bolt must be backed out before the manifold can be removed.

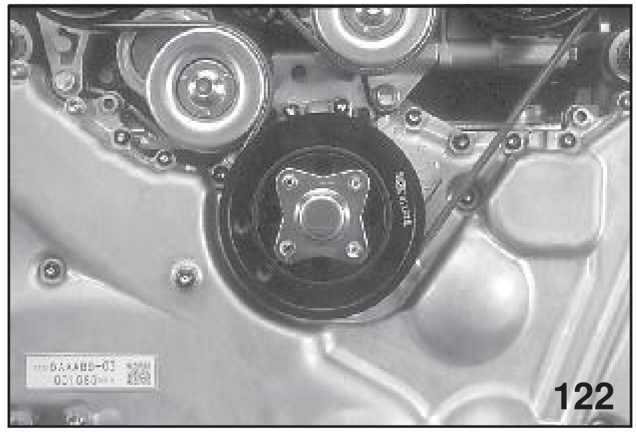
Remove the intake manifold.



Remove Accessories

Remove the alternator, compressor and power steering pump.

NOTE: THE COMPRESSOR IS EQUIPPED WITH A SPEED SENSOR THAT SENDS A SIGNAL TO THE ECM. IF THE COMPRESSOR SPEED DROPS MORE THAN 20% COMPARED TO THE ENGINE SPEED, THE ECM TURNS THE COMPRESSOR OFF THROUGH THE A/C RELAY. THE REFRIGERANT MUST BE EVACUATED BEFORE REMOVING THE SENSOR.

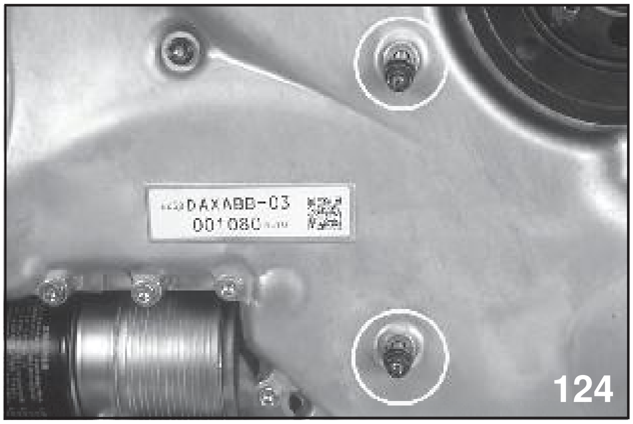


Crankshaft Bolt Cover

Crankshaft Bolt Seal

Remove the crankshaft bolt cover, bolt and harmonic balancer. Do not lose the O-Ring that seals the crank shaft bolt cover to the harmonic balancer.

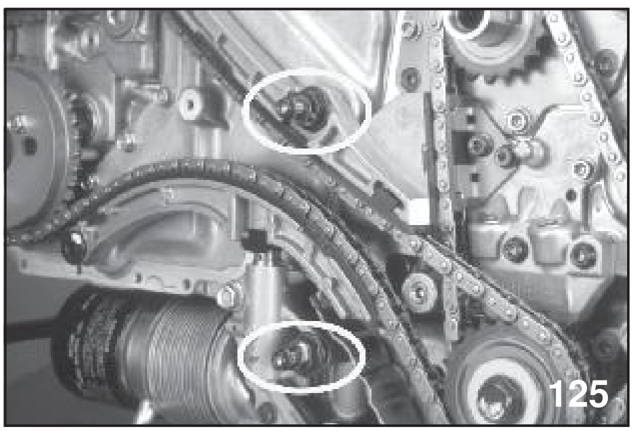
Begin removing the outer cover bolts. Keep them organized to ease reassembly. The bolts must be removed in the proper sequence to avoid warping the outer case.



Outer Cover Seals

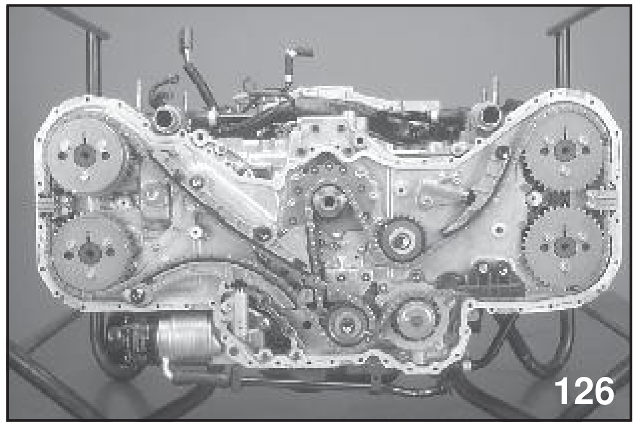
These two bolts use sealing washers to prevent engine oil from leaking to the outside.

The seals are not reusable.



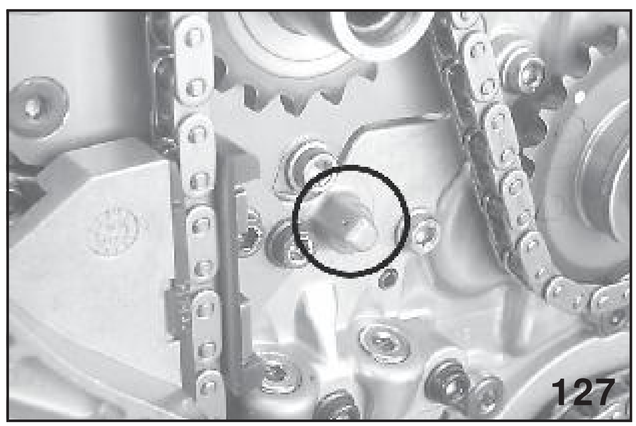
Outer Cover Bolts

The bolts circled in the above picture secure the outer cover to special bolts that have internal threads. These bolts assist with supporting the outer chain cover along the middle where there is no support from the inner case.



Timing Chain Routing

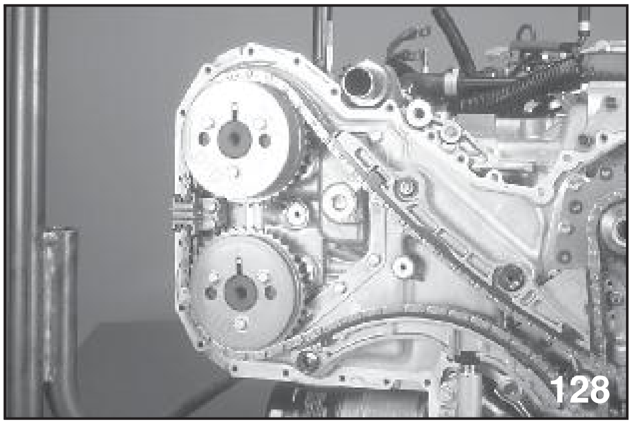
The timing chain on the EZ-3.0 is designed to last the life of the engine. Proper engine oil maintenance is necessary to ensure it lives up to its design. Two chains are used. Four (4) camshaft sprockets, one (1) crankshaft sprocket, two (2) idler sprockets and the water pump complete the timing chain routing.



Timing Chain Oil Jet

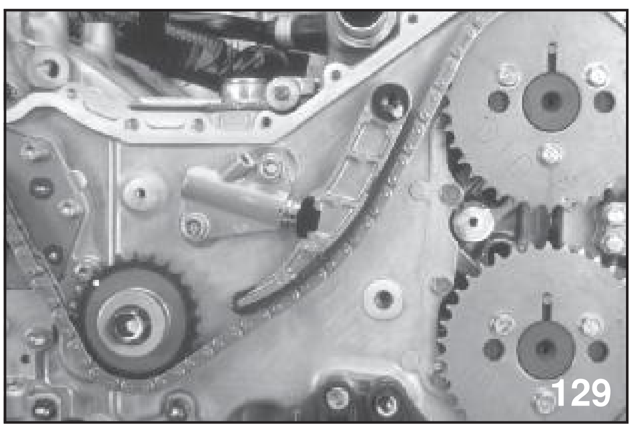
The timing chain is sprayed with oil from this jet located on the oil pump relief valve housing.

CAUTION: THE SPROCKET TEETH ARE SHARP SO USE EXTREME CARE WHEN WORKING NEAR OR AROUND THEM.



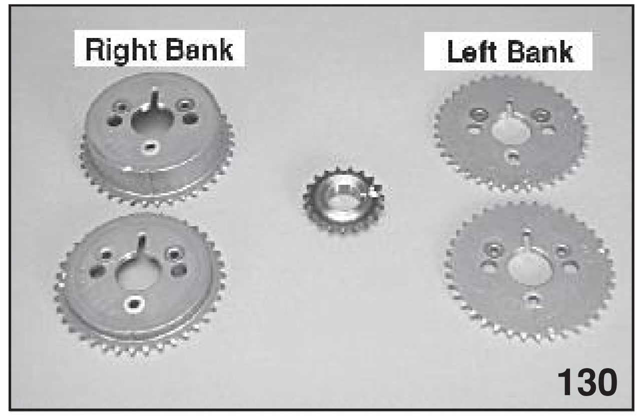
Right Bank Camshafts

The right bank camshafts are in a loaded state when the keyways are at 12:00. They must be unloaded in the proper way to prevent damage to the pistons and valves.



Left Bank Timing Marks

Timing marks are located on the camshaft sprockets and the crankshaft sprocket. Marks and letters on the idlers are manufactures markings and are used only to establish which side faces outward. *Do not use them to establish proper chain timing*.

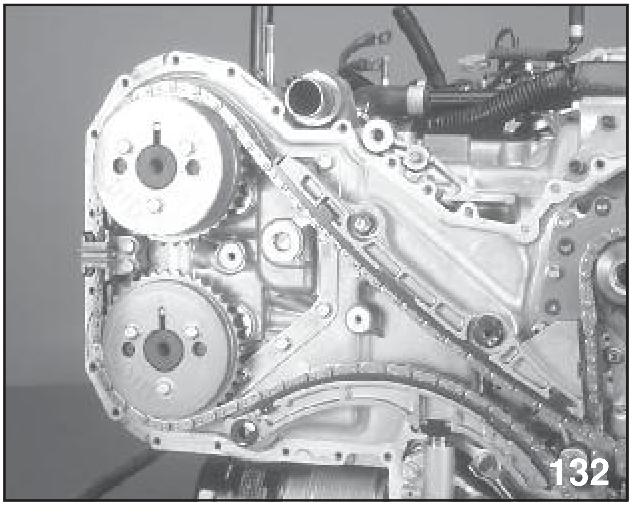


Camshaft Sprockets

The left bank camshaft sprockets are interchangeable when new. It is recommended they be returned to their original positions to maintain wear patterns after being used.

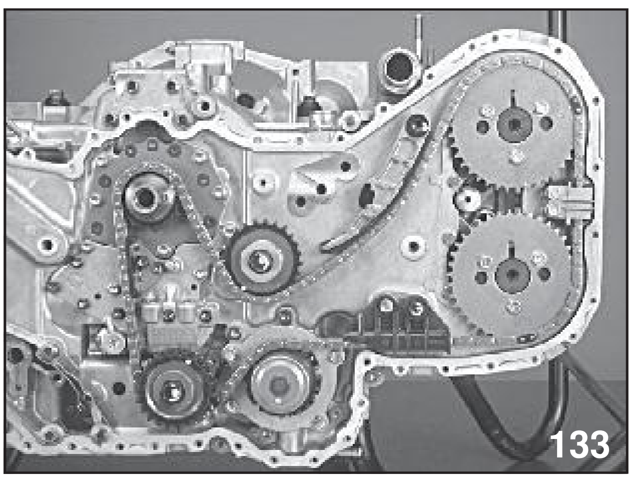
Timing Chains

The left timing chain is the longer of the two with 148 links. The right chain has 134 links.



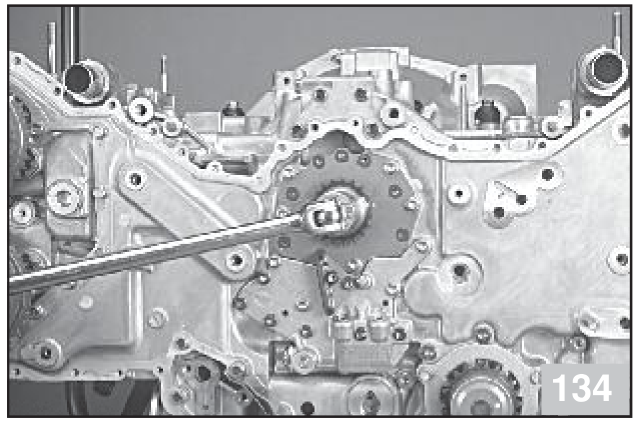
Removal of Right Bank Timing Chain Components

Turn engine clockwise to rotate it until the key ways of the cam sprockets are at the 12:00 position. Remove the right bank tensioner, chain and chain guides.



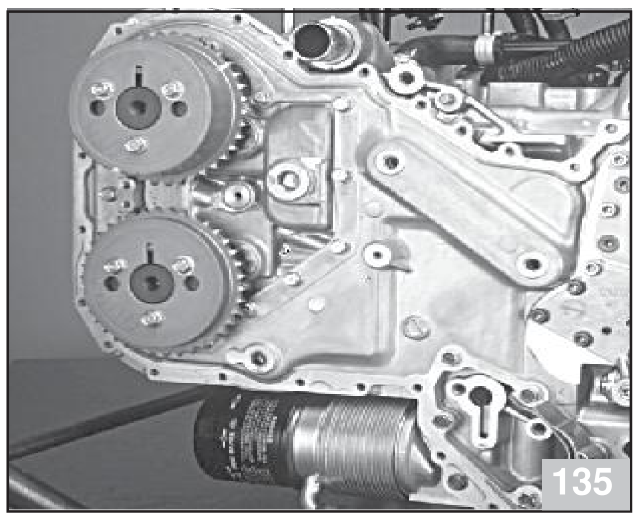
Removal of Left Bank Timing Chain Components

Remove the left bank tensioner, chain and chain guides.



Turn Crankshaft to Prevent Piston and Valve Damage

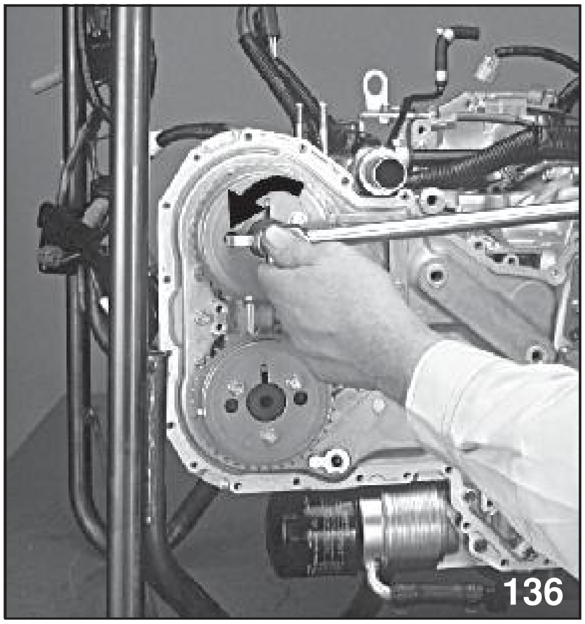
NOTE: TURN THE CRANKSHAFT 90 DEGREES COUNTER CLOCKWISE TO REDUCE THE CHANCE OF ACCIDENTAL DAMAGE TO THE PISTONS AND VALVES IN THE EVENT THE CAMSHAFTS SUDDENLY UNLOAD.



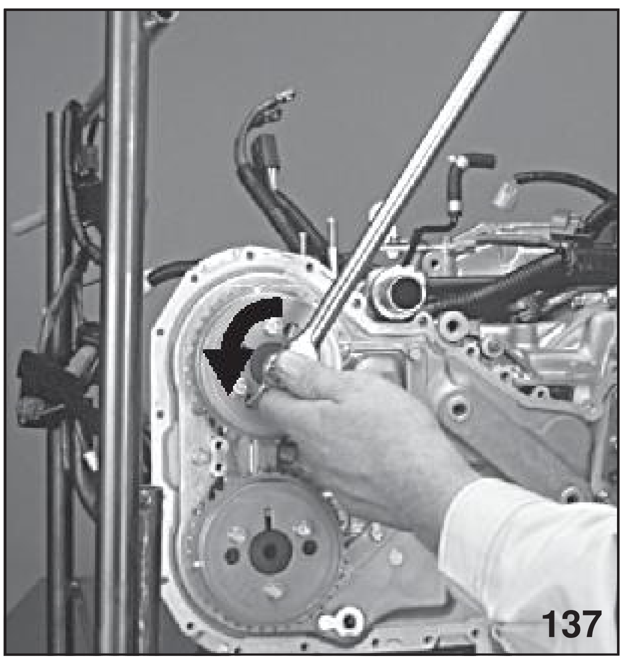
Right Bank Camshafts in Loaded Position

The left bank is currently unloaded. The right bank is loaded and must be unloaded using the procedure depicted on next page.

Unloading Cam Sprockets

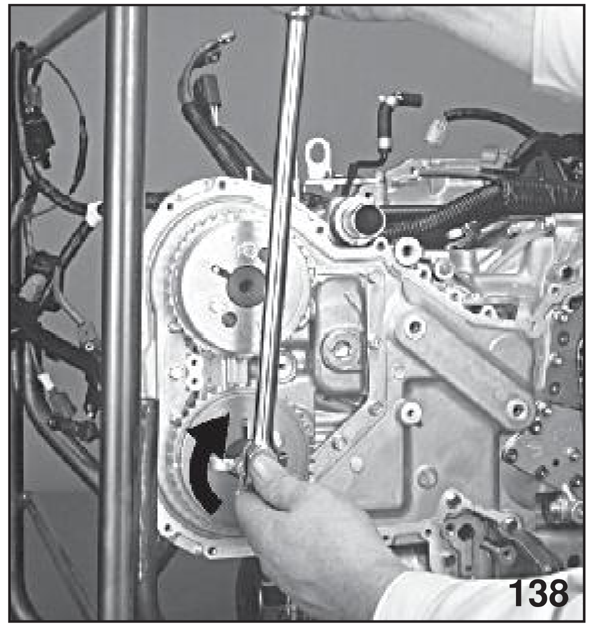


Unloading Intake Camshaft

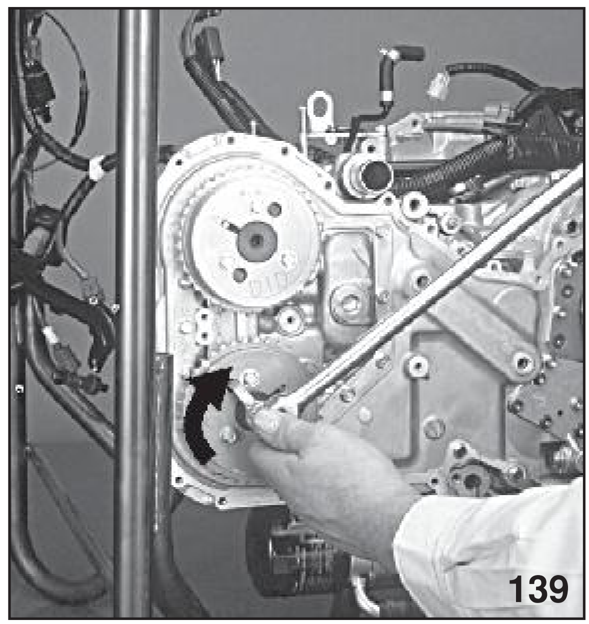


Unloading Intake Camshaft

Position the camshaft sprocket wrench on the **right bank intake** sprocket and turn 90 degrees **counter clockwise.**

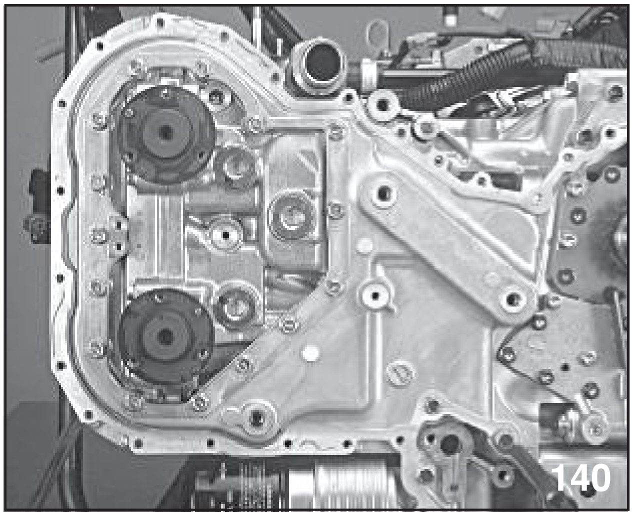


Unloading Exhaust Camshaft

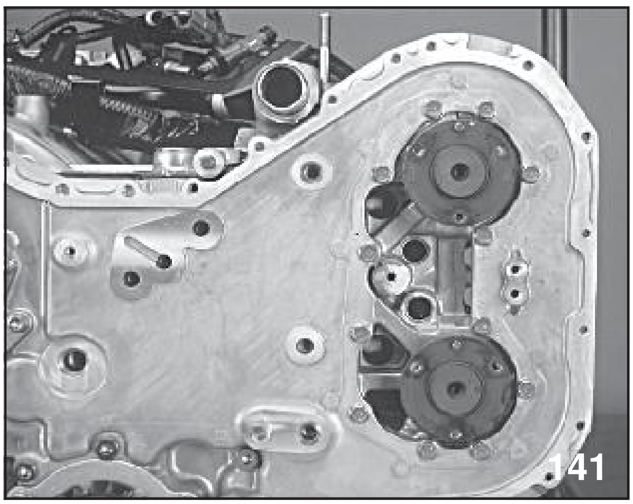


Unloading Exhaust Camshaft

Position the camshaft sprocket wrench on the **right bank exhaust** sprocket and turn 90 degrees **clockwise**. Both camshafts are now unloaded.

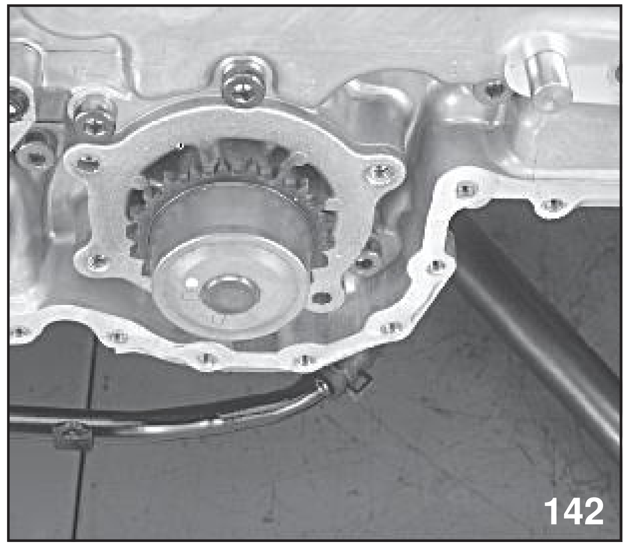


Remove Camshaft Sprockets (Right Bank)



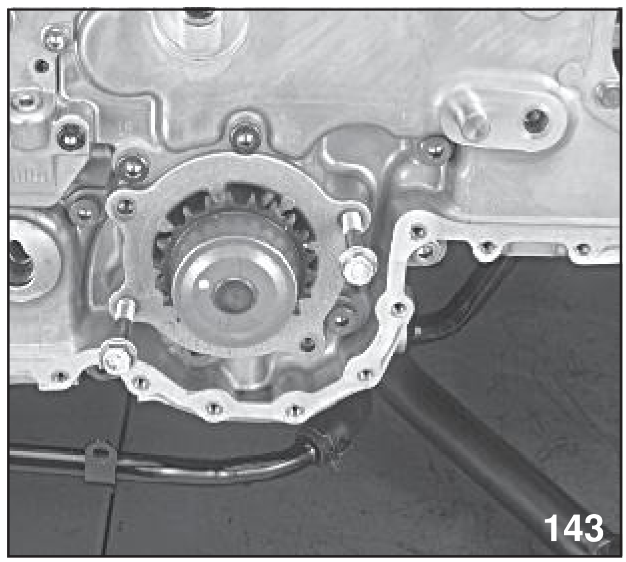
Remove Camshaft Sprockets (Left Bank)

Remove both the intake and exhaust camshaft sprockets on the left and right banks.



Water Pump Assembly

Remove the bolts from the water pump.

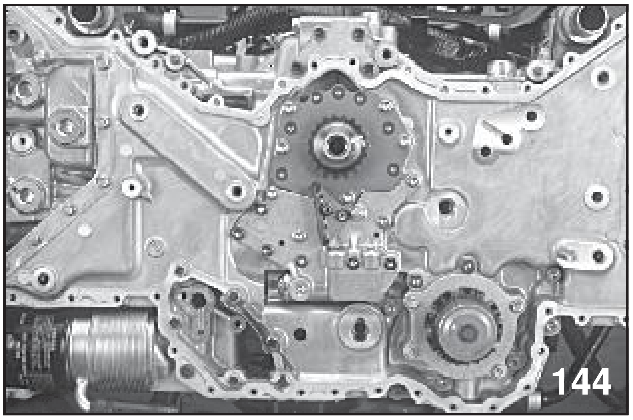


Insert Bolts for Pump Removal

Thread two eight millimeter bolts as shown and equally turn them in. This will assist with the removal of the pump.

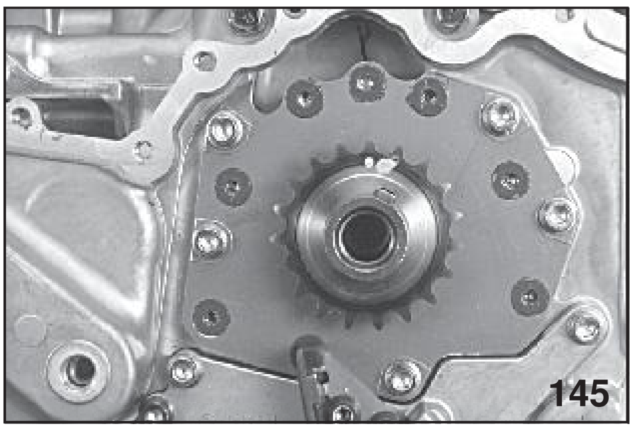
Remove the o-ring that seals the water pump to the inner cover.

Removal of Oil Pump



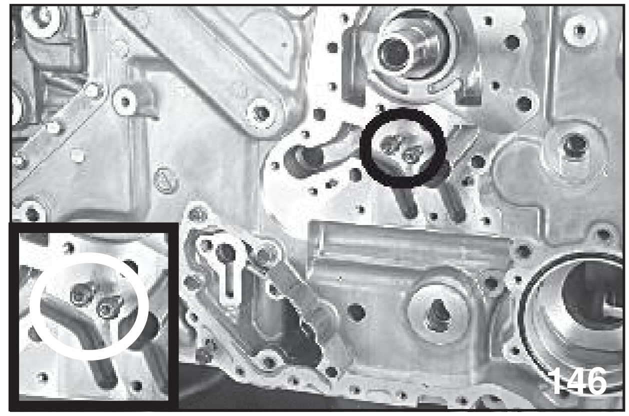
Oil Pump Cover

Remove the oil pump cover and oil pump gears.



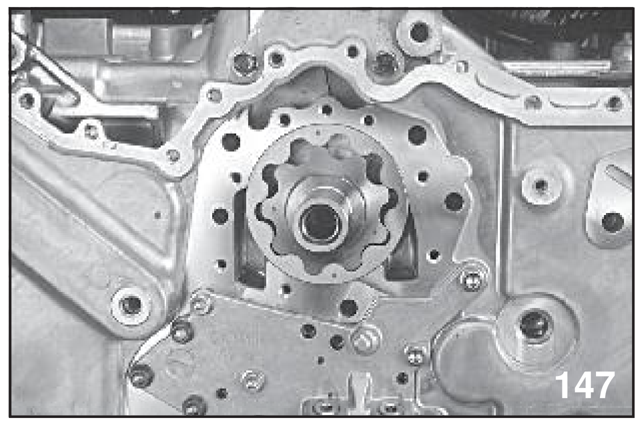
Chain Guide

NOTE: THE CHAIN GUIDE MUST BE REMOVED BEFORE REMOVING THE OIL PUMP COVER.



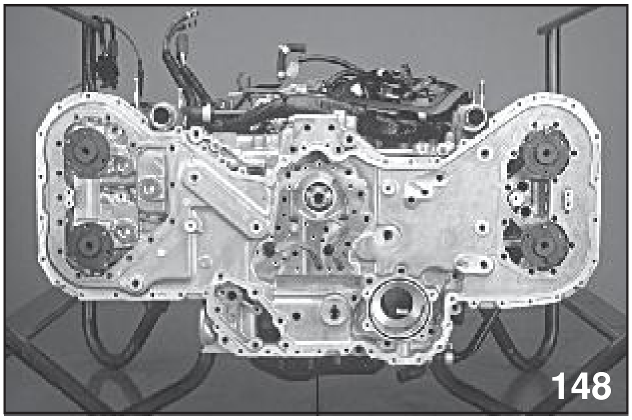
Chain Guide Bolts

The two bolts that secure the chain guide at the crankshaft pulley are pretreated with Locktite. (See insert)



Oil Relief Valve Housing

Remove the relief valve housing bolts and housing.

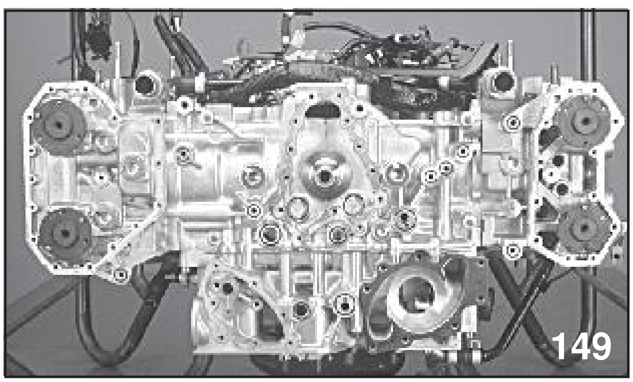


Inner Cover

NOTE: PLEASE FOLLOW PROPER SEQUENCE.

Remove the 46 bolts that secure the inner chain cover to the engine block. The numbers are embossed on the cover and must be removed in reverse order. (Start at bolt 46)

O-Ring Placement Inner Cover



O-Ring Locations

Remove the inner cover and observe the location of the o-rings. There are fifteen (15) in total.

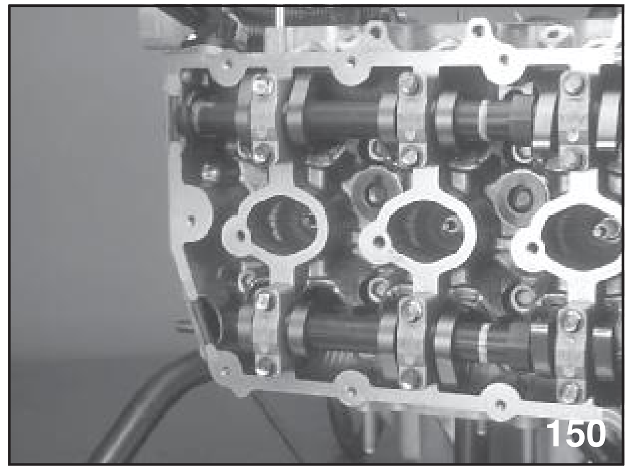
Care must be taken to ensure proper installation of all seals.

There are 6 different length bolts in this area so use care to keep them organized. Your 6 cylinder Service Manual Supplement illustrates correct order and size of the bolts.

NOTE: COLOR OF RINGS ARE DIFFERENT FROM PREVIOUS MODELS OBSERVE PROPER PLACEMENT.

NOTE: THE PAPER-TYPE WATER PUMP GASKET.

Removal of Cylinder Head



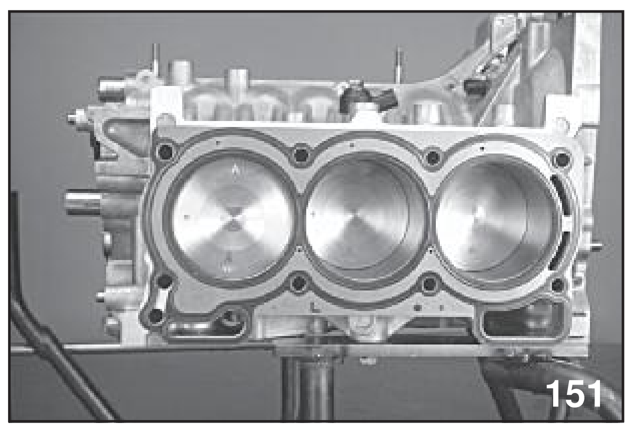
Valve Train Assembly

NOTE: PLEASE FOLLOW THE PROPER SEQUENCE. ALSO NOTE THEY ARE HEX DESIGN BOLTS.

Remove the cylinder head bolts. Use care to prevent rubbing the hex socket on the camshafts during removal.

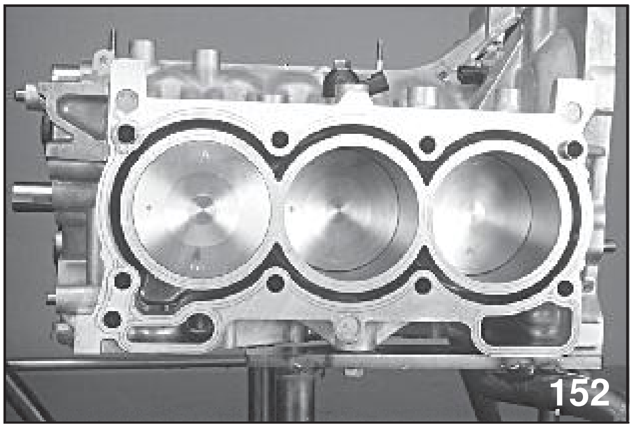
Remove the cylinder head and gasket.

Repeat this procedure on the opposite side.



Cylinder Block with Head Gasket

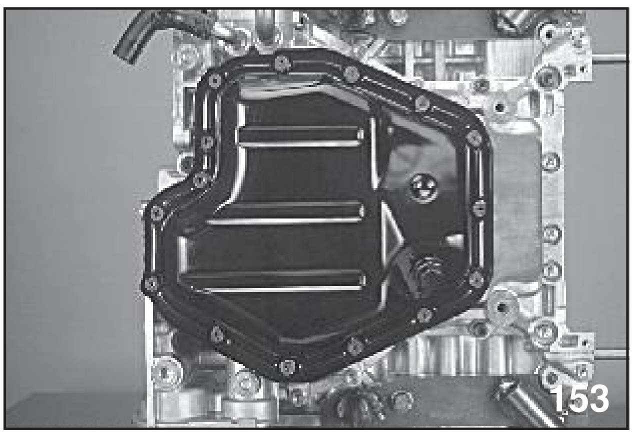
The cylinder block is made from aluminum die casting with monoblock casting cast iron cylinder liners. Water jackets are independent for the RH and LH block halves.



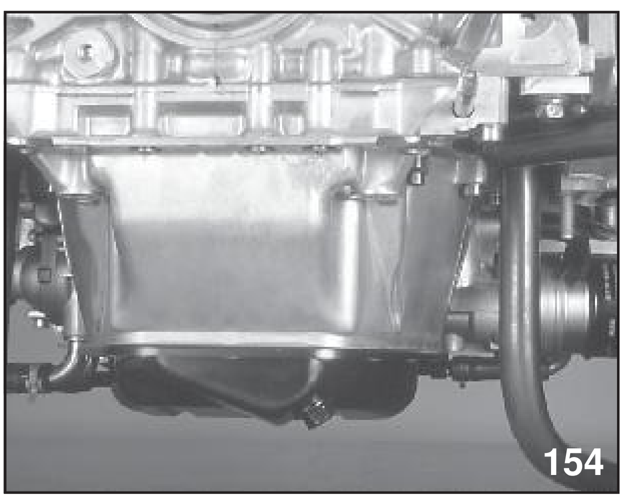
Open Deck Design

The block utilizes open deck design.

Removal of Oil Pan

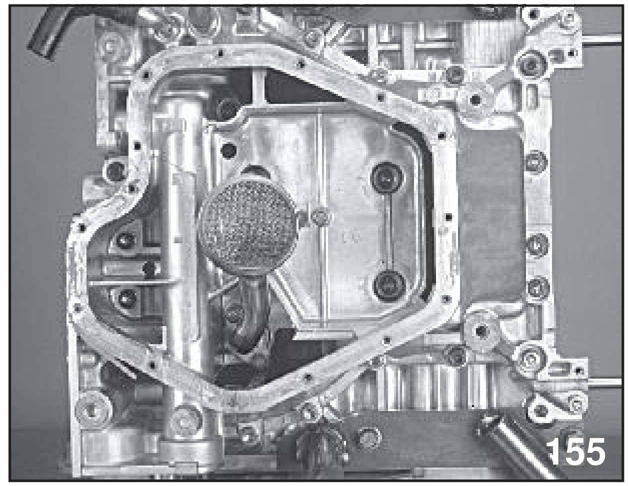


Oil Pan (Lower)



Oil Pan (Upper)

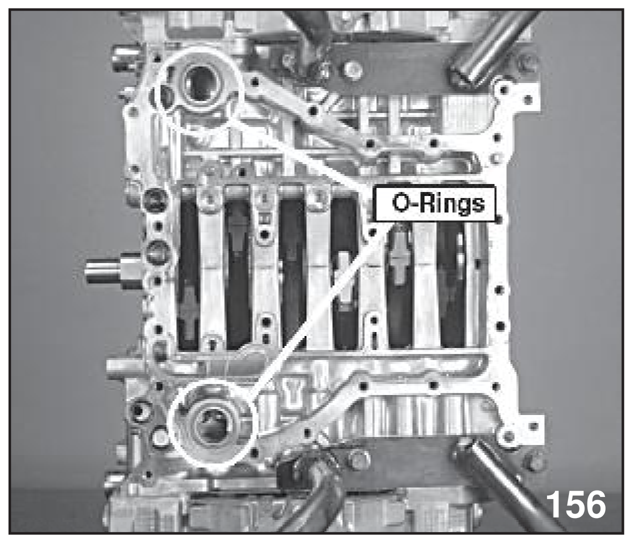
Remove the oil pan bolts and oil pan. Observe that the Oil Pan has a different design from 4 cylinder Subaru engines.



Oil Pan Bolt Locations

NOTE: PLACEMENT OF BOLTS.

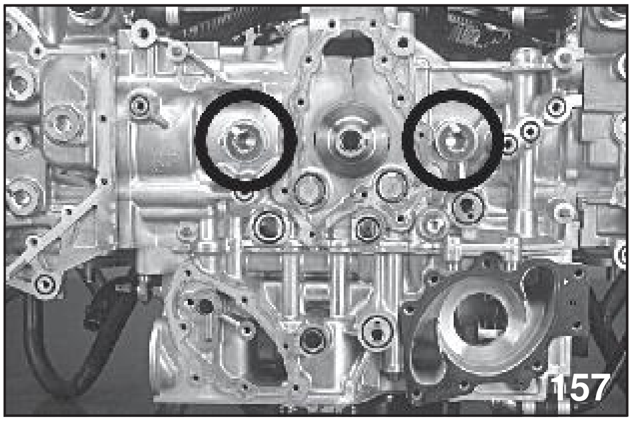
Remove the oil pan extension housing bolts. There are 28 bolts with five different lengths. Follow the proper sequence to prevent warping the case.



Block O-Ring Locations

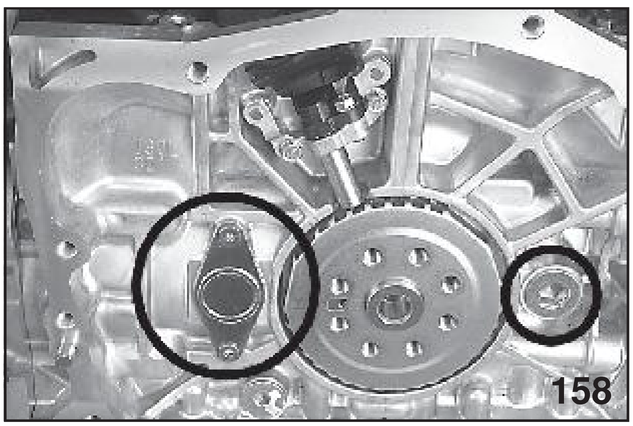
NOTE: CONFIRM PLACEMENT OF O-RINGS

Piston Pin Access



Piston Pin Access (Front View)

The piston pin access is gained from the front at these two positions.

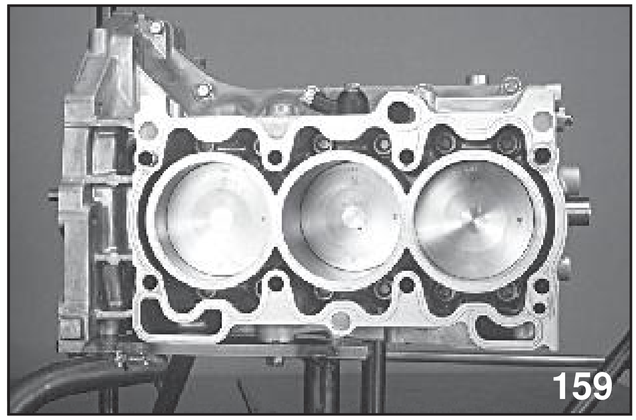


Piston Pin Access (Rear View)

Rear piston pin access is gained at these two points.

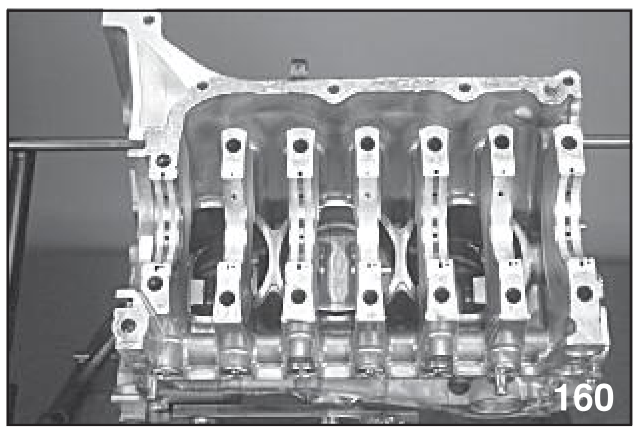
Remove the piston pins and organize them for assembly to their original positions.

Spliting Block Halves

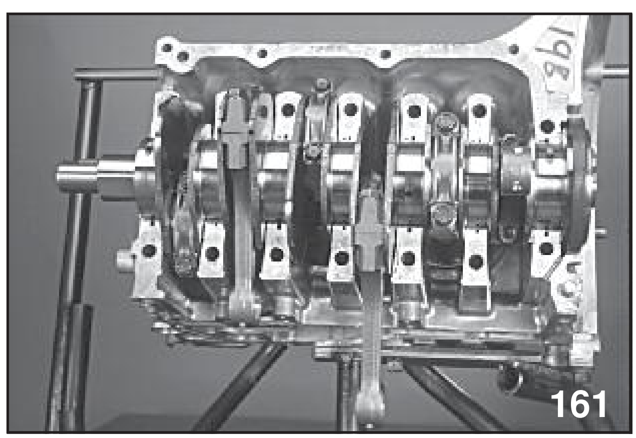


Engine Block Assembly Bolts (Right Bank)

The engine block halves are bolted together with 19 bolts. They are all located on the right bank of the engine. Remove the bolts in the proper sequence and split the engine block.

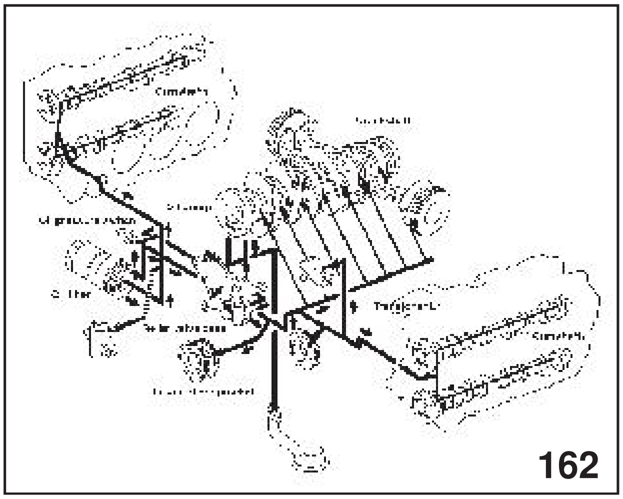


Main Bearings



Crankshaft and Connecting Rods

Lubrication System



Oil Flow

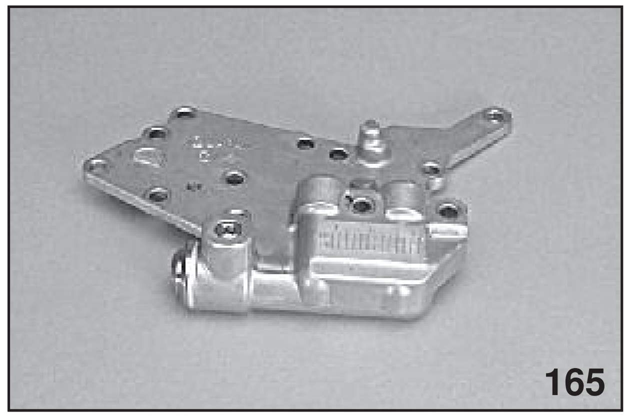
Oil is drawn from the oil pan to the trochoid oil pump and on to the following:

- Oil cooler and filter
- Relief valve case. (Oil pressure is regulated and oil is supplied to the oil jet that lubricates the timing chain)
- Right bank cylinder head
- Crank shaft
- Timing chain components
- Left bank cylinder head

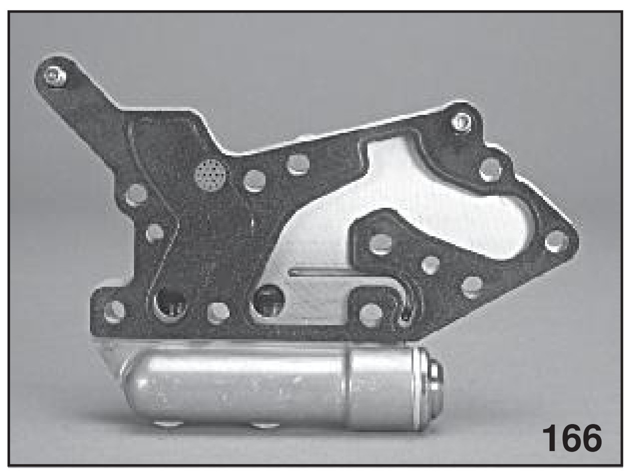
NOTE: FOR FURTHER INFORMATION CONSULT THE LUBRICATION (LU) SECTION OF THE 6 CYLINDER SUPPLEMENT.

Pump Gears (Front Side)

Pump Gears (Back Side)



Relief Valve Case (Front Side)

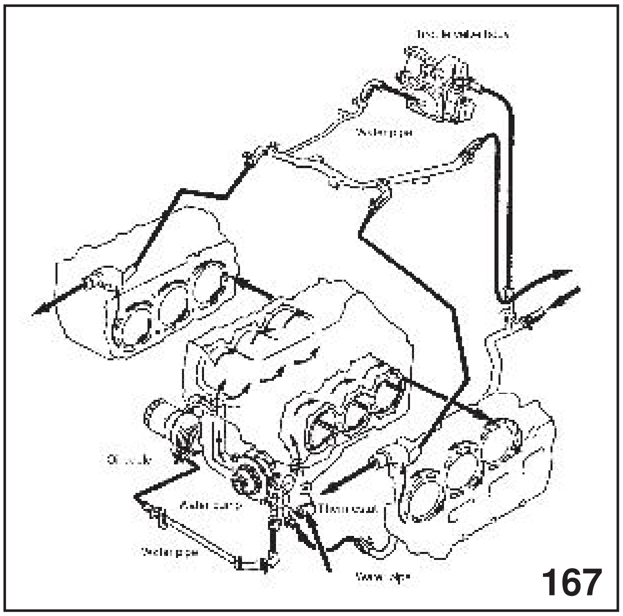


Relief Valve Case (Back Side)

A new gasket must be used upon installation.

NOTE: THE SCREEN OR FILTER IN GASKET. CONFIRM THAT IT IS NOT RESTRICTED.

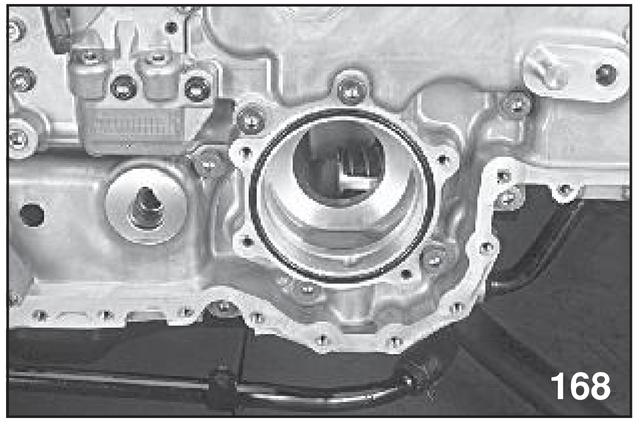
Coolant System


167

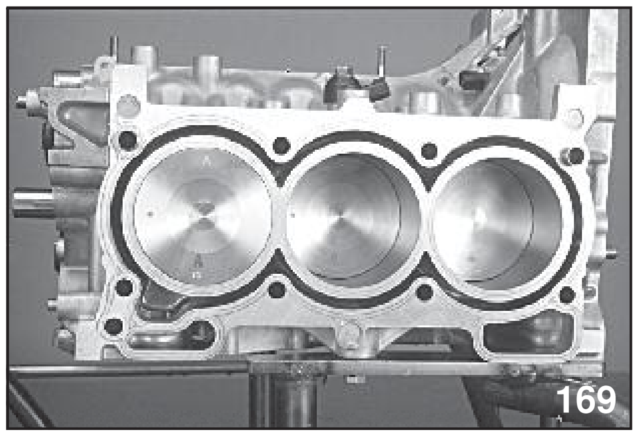
Coolant Flow

The coolant flow begins at the lower radiator hose and continues to the following:

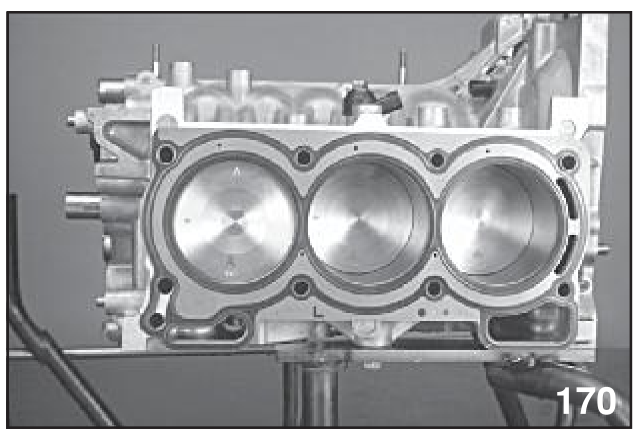
- Thermostat
- Water pump
- Internal block passages that carry coolant through the front of the block halves continuing on to the rear of the block halves.
- From around the rear cylinders of the block halves to the head gasket of the rear cylinders. A passage in the head gasket allows coolant to the cylinder heads.
- Around the cylinder heads to the upper radiator hose connections.


168

Water Pump Housing

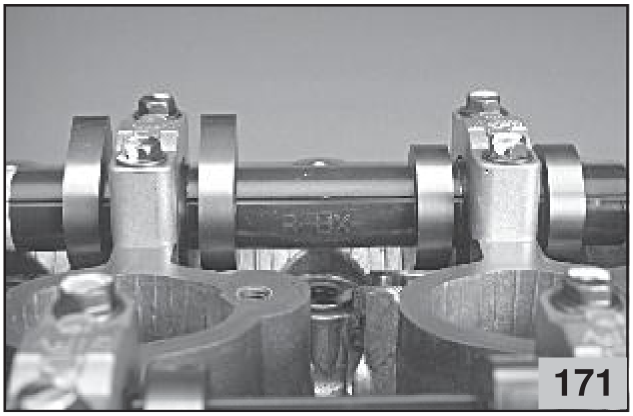

169

Water Jackets (Left Bank)


170

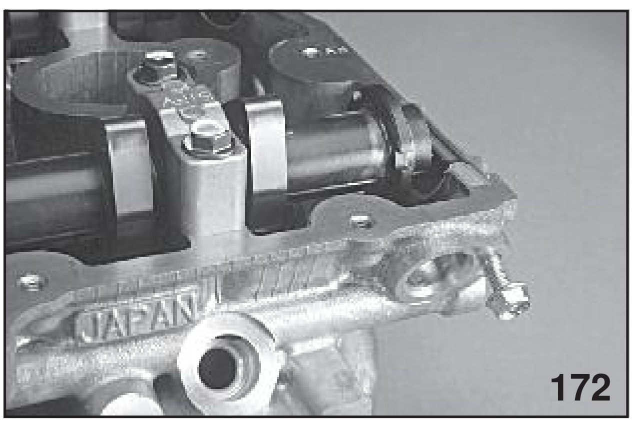
Head Gasket Coolant Passages

NOTE: FOR FURTHER INFORMATION, CONSULT THE COOLING SECTION (CO) OF THE 2001 LEGACY AND OUTBACK 6 CYLINDER SUPPLEMENT.



Sintered Camshaft Lobes

The camshafts are composed of carbon steel pipes with Sintered metal lobes. During construction, the lobes are positioned on the pipe using a sintered metal paste. The camshafts are then baked until the paste is hardened. The lobes of the camshafts are offset by 1 millimeter to rotate the camshaft bucket and shim which will reduce wear.



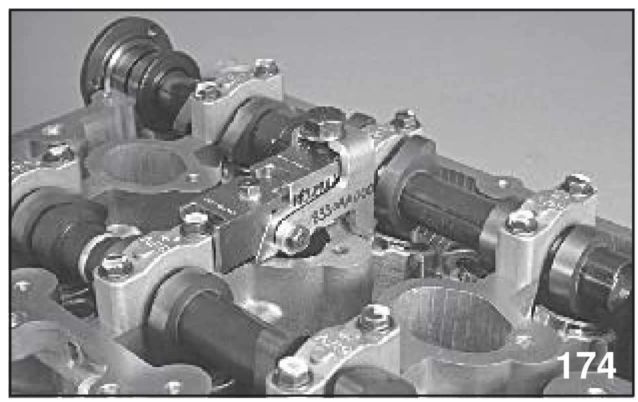
Camshaft Sensor Reluctor

The right bank intake camshaft has a reluctor built onto the end. The new camshaft sensor uses this reluctor to help determine injection and ignition timing.

Valve Adjustment

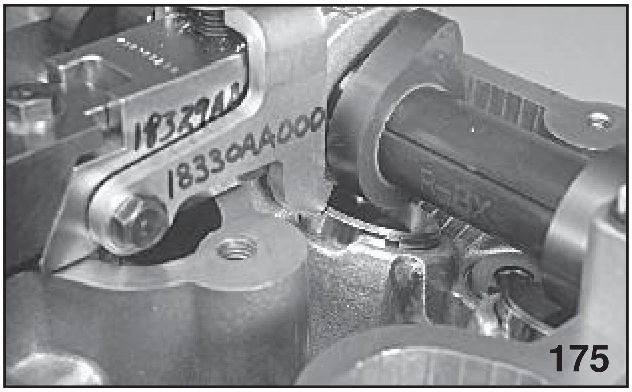
Valve Adjustment Tool

The valve adjustment procedure is the same as other DOHC Subaru engines however a new tool has been designed to work specifically on the EZ-3.0 Engine.



Valve Adjustment Tool Placement

The tool is wedge fitted into place over the two shims requiring removal.



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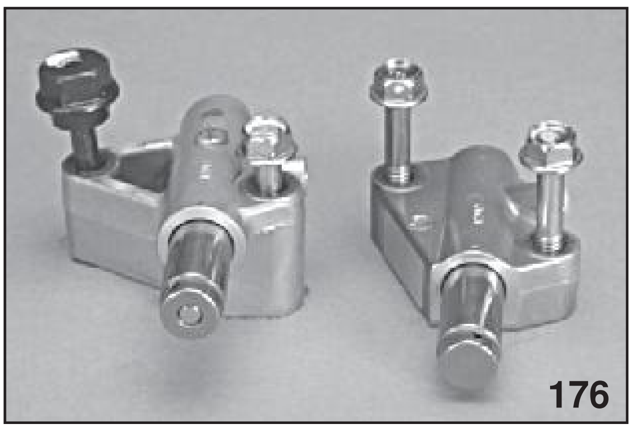
Adjusting Bucket Depression Finger

Some adjustment will be required to properly seat the bucket depression finger. Turning the top bolt pushes the fingers down allowing room for the shim to be removed.

Chain Tensioners



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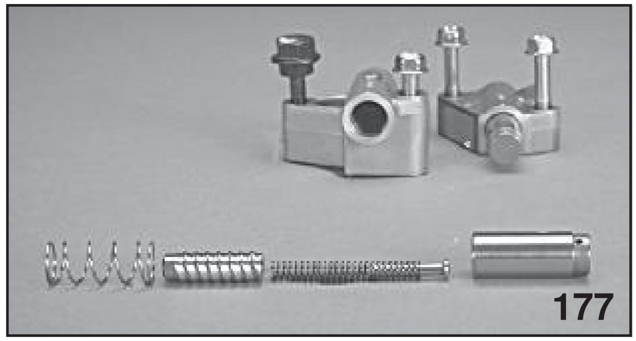
Chain Tensioners (Left and Right Bank)

The chain tensioners are fed oil pressure from the engine oiling system. The supplied pressure combined with spring tension keeps the timing chains operating at the correct tension.

NOTE: LEFT BANK AND RIGHT BANK TENSIONERS ARE NOT INTERCHANGEABLE.



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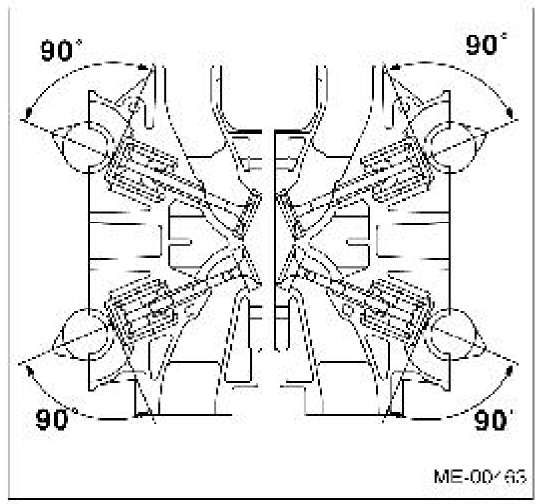
Worm Gear Assembly

The worm gear assemble and spring tension keep tension on the chains with the engine off, eliminating any tension problems that could occur during engine start up.

The tensioners are turned in by hand for reassembly. Observe the order of the worm gear assemble. Make sure your hands are dry when depressing the tensioners. A rivet or large paper clip will hold tensioner in place. Do not use a press to depress tensioner.

3.0 Liter Valve Clearance Adjustment- 2001~2004



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Valve Arrangement

1. Measure intake valve and exhaust valve clearances by using thickness gauge (A).

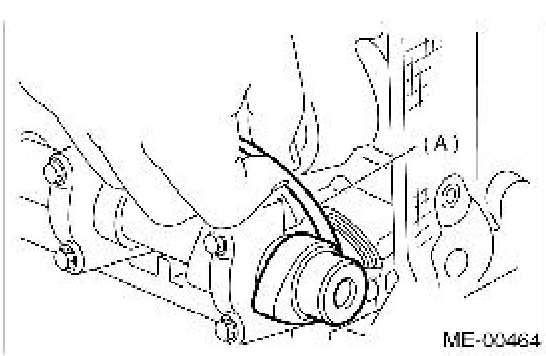
CAUTION: INSERT THE THICKNESS GAUGE IN AS HORIZONTAL A DIRECTION AS POSSIBLE WITH RESPECT TO THE SHIM.

VALVE CLEARANCE:

Intake: 0.20 $^{+0.04}/_{0.06}$ mm (0.0079 $^{+0.0016}/_{0.0024}$ in)

Exhaust: 0.25 0.05 mm (0.0098 0.0020 in)

NOTE: IF THE MEASURED VALUE IS NOT WITHIN SPECIFICATION, TAKE NOTES OF THE VALUE IN ORDER TO ADJUST THE VALVE CLEARANCE LATER ON.



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Measuring Valve Clearance

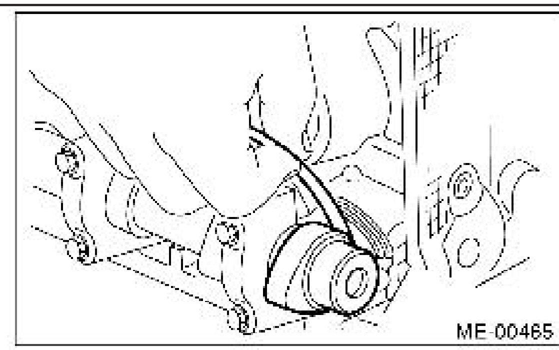
2. If necessary, adjust the valve clearance. <Ref. to ME(H6DO), ADJUSTMENT, Valve Clearance.>
3. Further turn crankshaft pulley clockwise. Using the same procedure described previously, then measure valve clearances again.
4. After inspection, install the related parts in the reverse order of removal.

Adjustment

CAUTION: ADJUSTMENT OF VALVE CLEARANCE SHOULD BE PERFORMED WHILE ENGINE IS COLD.

1. Measure all valve clearances. <Ref. to ME(H6D0), INSPECTION, Valve clearance.>

NOTE: RECORD EACH VALVE CLEARANCE AFTER IT HAS BEEN MEASURED.



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Measuring Valve Clearance

2. Remove shim from valve lifter.

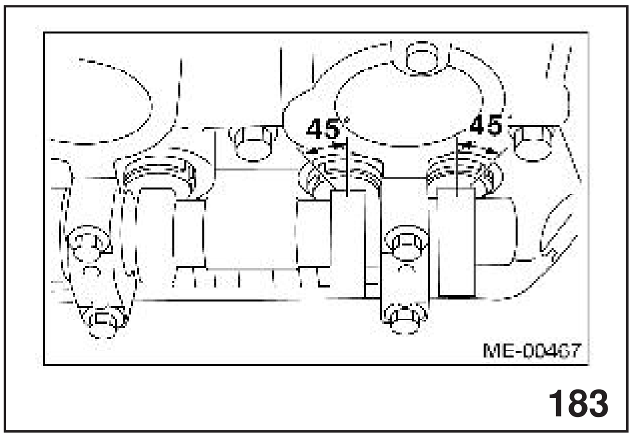
(1) Prepare the ST.

ST 18329AA000 SHIM REPLACER

<Ref. to ME(H6D0), PREPARATION TOOL, General Description.>

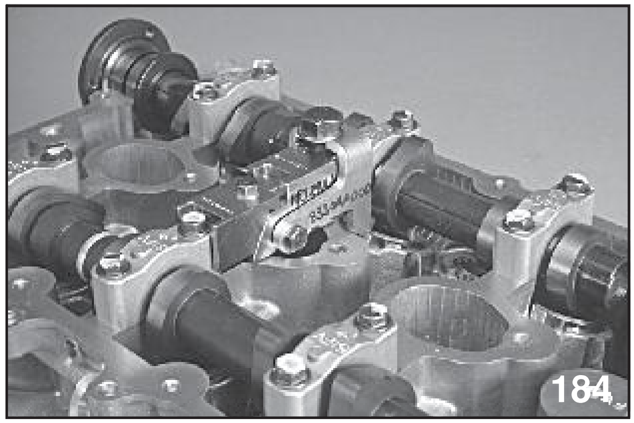
Valve Adjustment Tool

(2) Rotate the notch of the valve lifter outward by 45°.



Shim Replacer Notch

(3) Adjust SHIM REPLACER notch to valve lifter and set it.

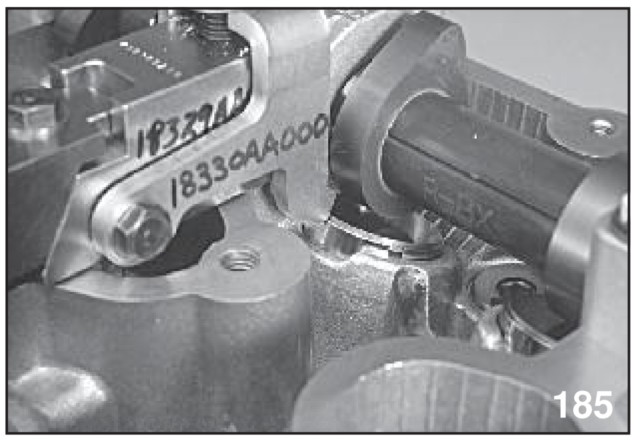


Valve Adjustment Tool Placement

NOTE: WHEN SETTING, BE CAREFUL SHIM REPLACER EDGE DOES NOT TOUCH SHIM.

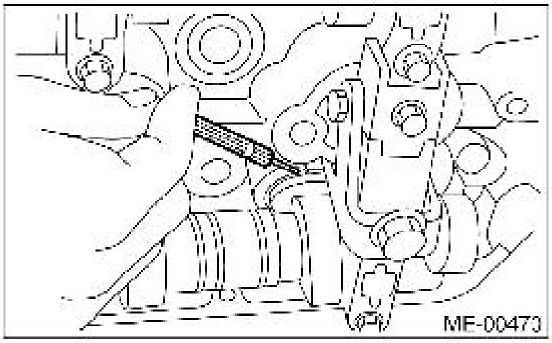
(4) Tighten bolt (A) and install it to the cylinder head.

(5) Tighten bolt (B) and insert the valve lifter.



Adjusting Bucket Depression Finger

(6) Insert tweezers into the notch of the valve lifter, and take the shim out.



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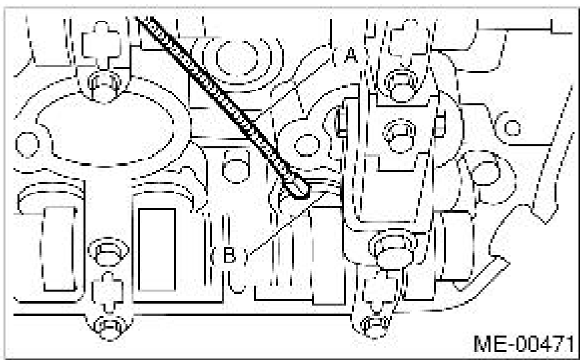
Use of Magnet

NOTE: BY USING A MAGNET (A), THE SHIM (B) CAN BE TAKEN OUT WITHOUT DROPPING IT.



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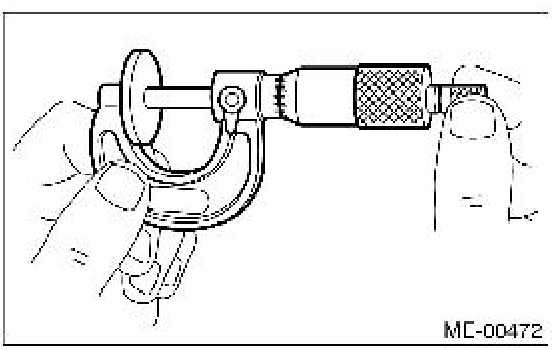
Shim Placement



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Micrometer

3. Measure thickness of shim with micrometer.

4. Select a shim of suitable thickness using measured valve clearance and shim thickness, by referring to the following table.

5. Set suitable shim selected in step 4 to valve lifter.

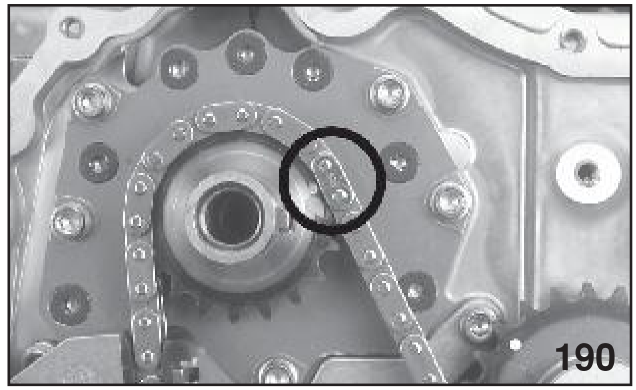
	Unit: mm
Intake valve: S = (V + T) - 0.20	
Exhaust valve: S = (V + T) - 0.25	
S: Shim thickness to be used	
V: Measured valve clearance	
T: Shim thickness required	

Part No.	Thickness mm (in)
13218 AK010	2.00 (0.0787)
13218 AK020	2.02 (0.0795)
13218 AK030	2.04 (0.0803
13218 AK040	2.06 (0.0811)
13218 AK050	2.08 (0.0819)
13218 AK060	2.10 (0.0827)
13218 AK070	2.12 (0.0835)
13218 AK080	2.14 (0.0843)
13218 AK090	2.16 (0.0850)
13218 AK100	2.18 (0.0858)
13218 AK110	2.20 (0.0866)
13218 AE710	2.22 (0.0874)
13218 AE720	2.23 (0.0878
13218 AE730	2.24 (0.0882)
13218 AE740	2.25 (0.0886)
13218 AE750	2.26 (0.0890)
13218 AE760	2.27 (0.0894)
13218 AE770	2.28 (0.0898)
13218 AE780	2.29 (0.0902)
13218 AE790	2.30 (0.0906)
13218 AE800	2.31 (0.0909)
13218 AE810	2.32 (0.0913)
13218 AE820	2.33 (0.0917)
13218 AE830	2.34 (0.0921)
13218 AE840	2.35 (0.0925)
13218 AE850	2.36 (0.0929)
13218 AE860	2.37 (0.0933)
13218 AE870	2.38 (0.0937)
13218 AE880	2.39 (0.0941)
13218 AE890	2.40 (0.0945)
13218 AE900	2.41 (0.0949)
13218 AE910	2.42 (0.0953)
13218 AE920	2.43 (0.0957)
13218 AE930	2.44 (0.0961)
13218 AE940	2.45 (0.0965)
13218 AE950	2.46 (0.0969)
13218 AE960	2.47 (0.0972)

Part No.	Thickness mm (in)
13218 AE970	2.48 (0.0976)
13218 AE980	2.49 (0.0980)
13218 AE990	2.50 (0.0984)
13218 AF000	2.51 (0.0988)
13218 AF010	2.52 (0.0992)
13218 AF020	2.53 (0.0996)
13218 AF030	2.54 (0.1000)
13218 AF040	2.55 (0.1004)
13218 AF050	2.56 (0.1008)
13218 AF060	2.57 (0.1012)
13218 AF070	2.58 (0.1016)
13218 AF090	2.60 (0.1024)
13218 AF100	2.61 (0.1028)
13218 AF110	2.62 (0.1031)
13218 AF120	2.63 (0.1035)
13218 AF130	2.64 (0.1039)
13218 AF140	2.65 (0.1043)
13218 AF150	2.66 (0.1047)
13218 AF160	2.67 (0.1051)
13218 AF170	2.68 (0.1055)
13218 AF180	2.69 (0.1059)
13218 AF190	2.70 (0.1063)
13218 AF200	2.71 (0.1067)
13218 AF210	2.72 (0.1071)
13218 AF220	2.73 (0.1075)
13218 AF230	2.74 (0.1079)
13218 AF240	2.75 (0.1083)
13218 AF250	2.76 (0.1087)
13218 AF260	2.77 (0.1091)
13218 AF270	2.78 (0.1094)
13218 AF280	2.79 (0.1098)
13218 AF290	2.80 (0.1102)
13218 AF300	2.81 (0.1106)

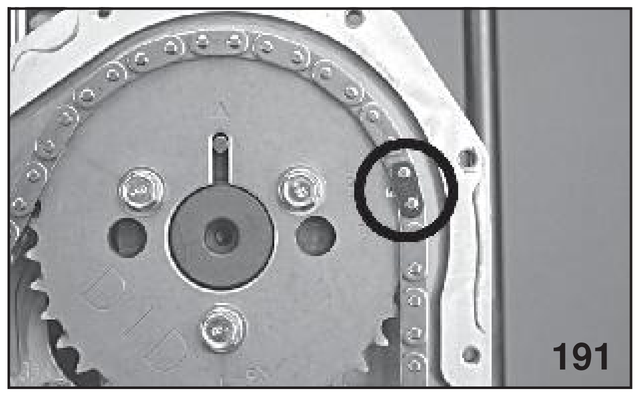
6. Inspect all valves for clearance again at this stage. If the valve clearance is not correct, repeat the procedure over again from the first step.
7. After inspection, install the related parts in the reverse order of removal.

3.0 Liter Engine Reassembly

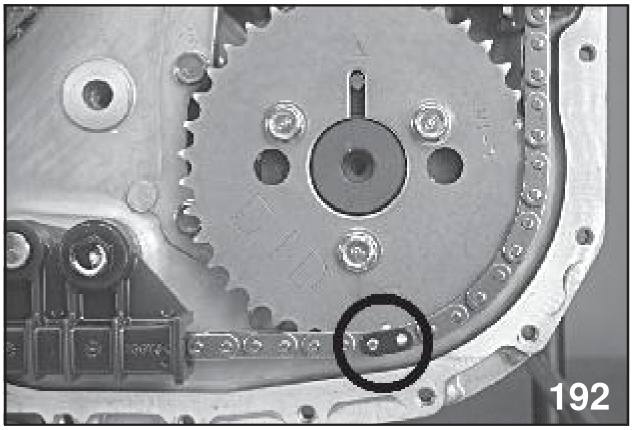


Crankshaft Timing Mark Location

Position the crankshaft sprocket to TDC. Indicated by the triangle mark. Place the chain over the water pump and lower idler sprocket.

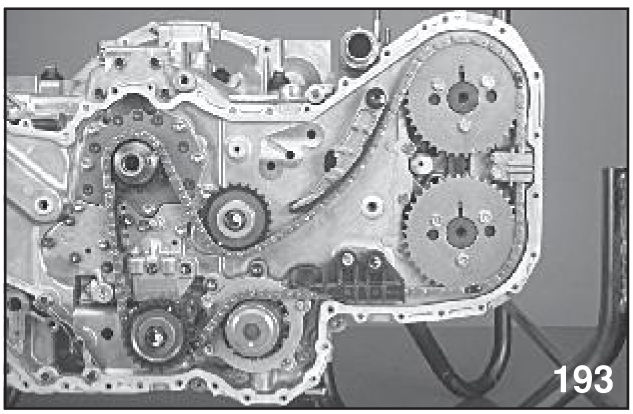


Left Bank Intake Camshaft Timing Mark

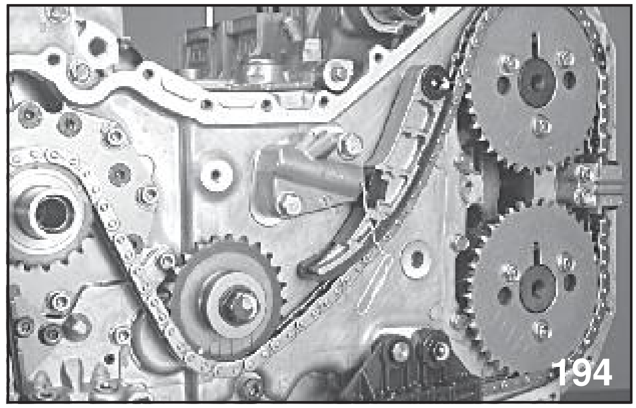


Left Bank Exhaust Camshaft Timing Mark

Place the gold link over the small circular timing mark of the crankshaft sprocket. Ensure the keyways for the left bank camshafts are at the 12:00 position.



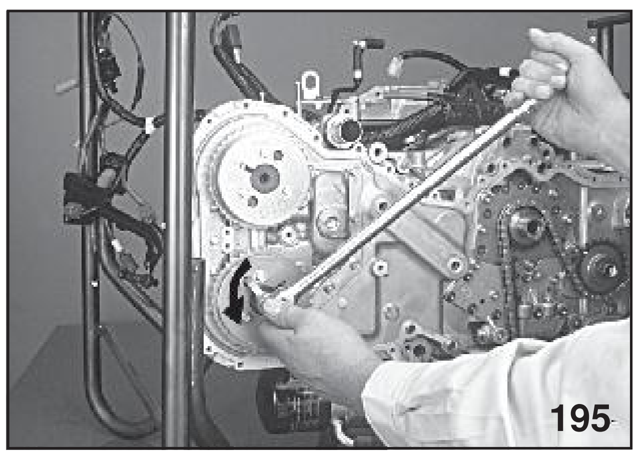
Matching Links to Timing Marks (Left Bank)



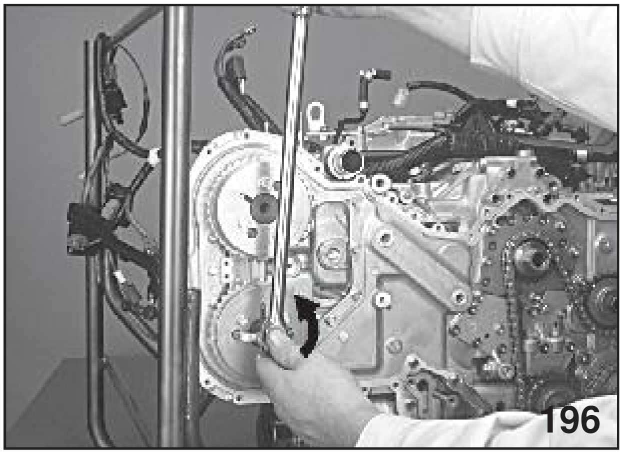
Installing Guides and Idlers (Left Bank)

Place the black link over the circular timing mark of the intake sprocket and the other black link over the circular timing mark of the exhaust sprocket. Install the upper idler and chain guides. Install the chain tensioner but **do not pull the pin.** Confirm the timing marks once again and pull the pin.

Turn the **crank shaft** 90 degrees **counter clockwise** to prepare for installing the **right bank** timing chain.

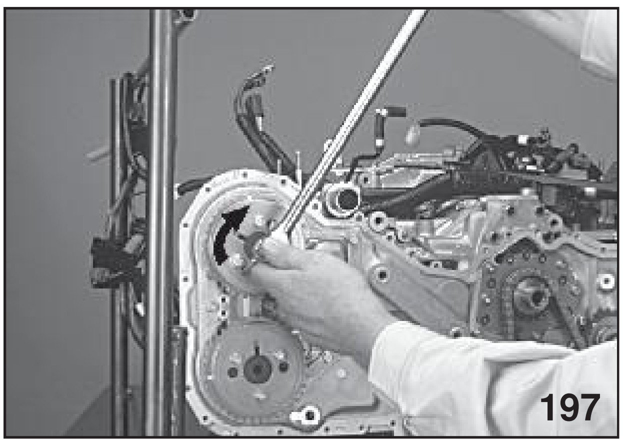


Loading Exhaust Camshaft (Right Bank)

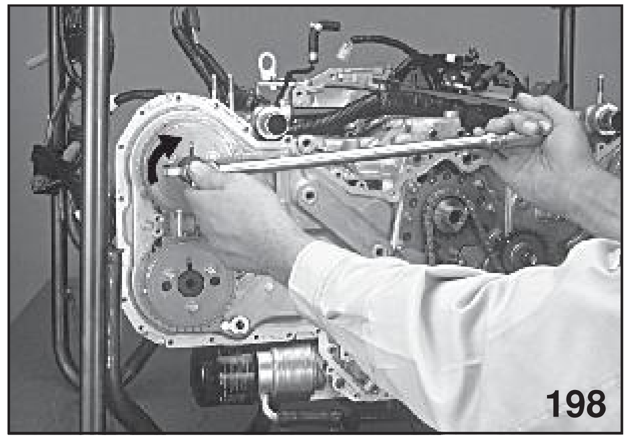


Loading Exhaust Camshaft (Right Bank)

Return the key way for the **right bank exhaust** camshaft to 12:00 by turning the sprocket **counter clockwise**.



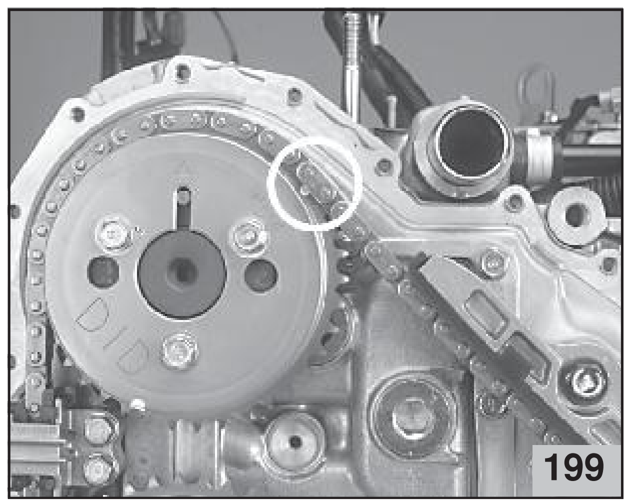
Loading Intake Camshaft (Right Bank)



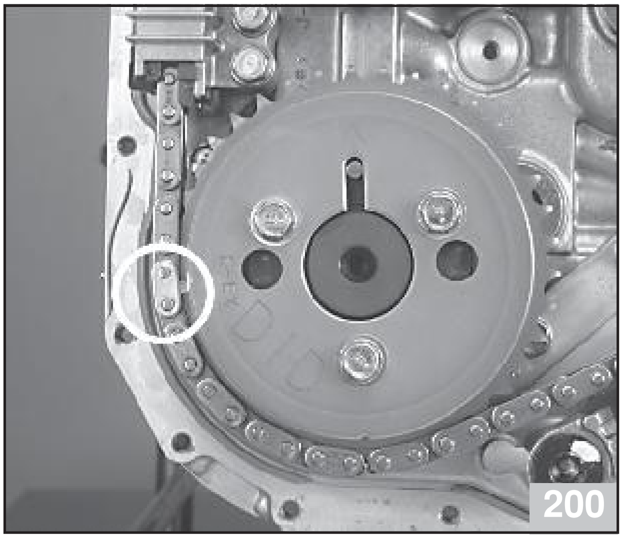
Loading Intake Camshaft (Right Bank)

Return the key way for the **right bank intake** camshaft to 12:00 by turning the sprocket **clockwise**.

Both right bank camshaft sprockets should now be in the correct position for timing chain installation. **Already done on image 191.**



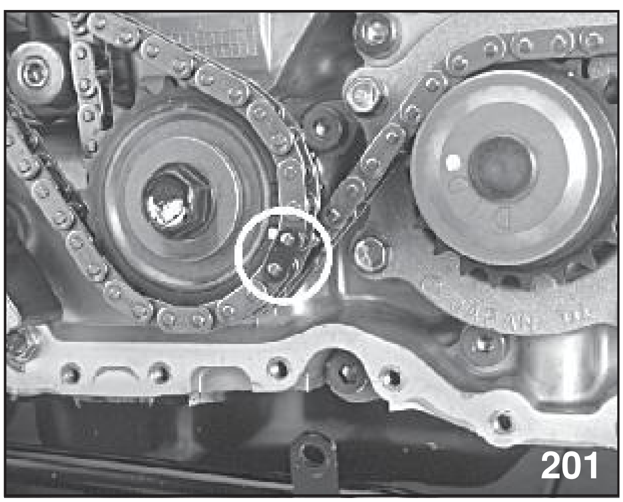
Intake Camshaft Timing Marks (Right Bank)



Exhaust Camshaft Timing Marks (Right Bank)

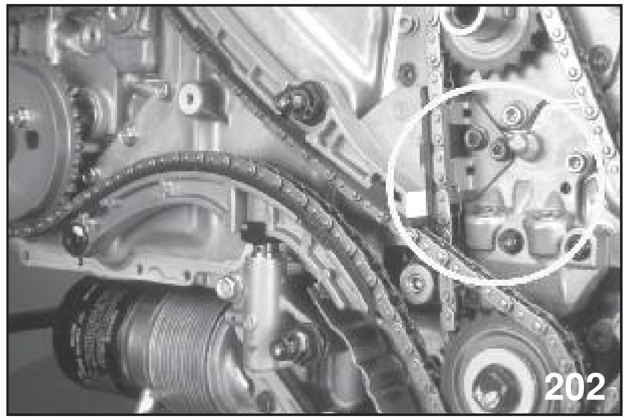
Place the lower gold link on the small circular mark of the exhaust cam sprocket and the upper gold link on the small circular timing mark of the intake camshaft sprocket.

NOTE: IT IS CRITICAL THAT TIMING MARKS ARE CONFIRMED TO BE CORRECT. IF THE MARKS ARE OFF MORE THAN 1 (ONE) TOOTH ON THE INTAKE OR 2 (TWO) TEETH ON THE EXHAUST, VALVE AND PISTON DAMAGE WILL OCCUR.



Lower Idler Timing Marks

Place the black link of the right bank timing chain over the lower idler so that it indexes with the black link of the left bank chain.



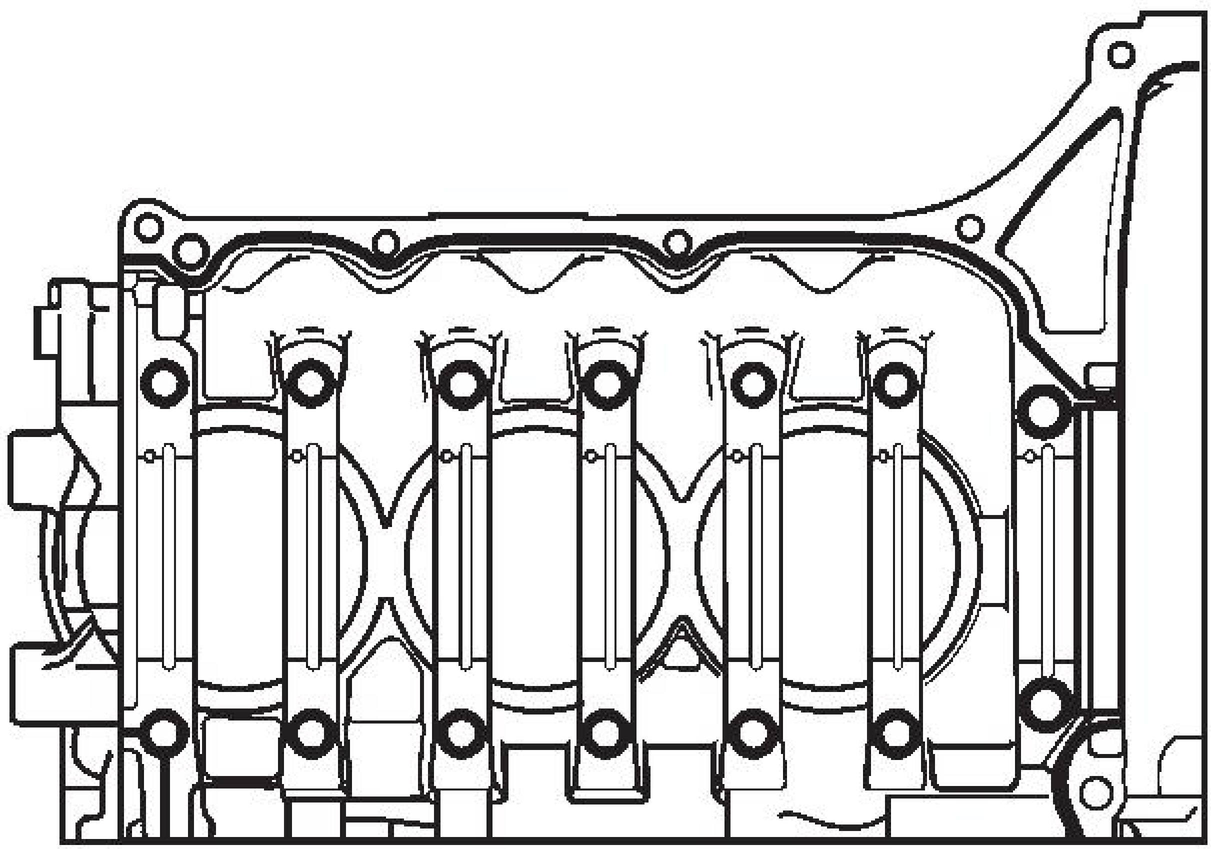
Chain Guides and Idlers (Right Bank)

Install the timing chain guides and tensioner. **Do not pull the pin.** Confirm the timing marks once again and if correct pull the pin.

NOTE: THE CHAIN GUIDE LOCATED ON THE OIL PRESSURE RELIEF HOUSING MUST BE ADJUSTED AS CIRCLED ABOVE.

Follow procedures in the appropriate Subaru Service Manual on the STIS web site, during reassembly and for checking chain guide clearances.

Fuji Bond Application Guide for Block Halves



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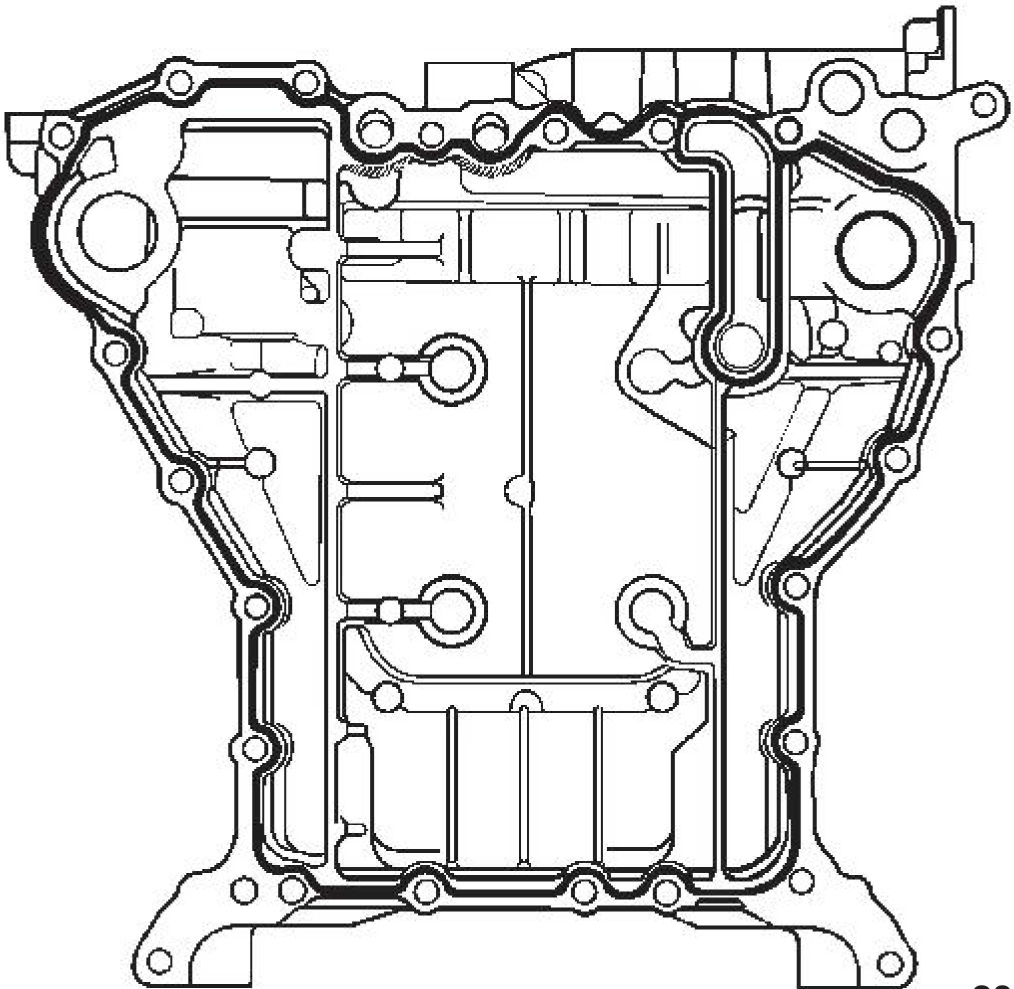
Refer to the Legacy and Outback 2001 Subaru Service Manual on the STIS web site *6 Cylinder Supplement.*

ME (H6) 65 to 69 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

Oil Pan Extension Housing
(Upper Oil Pan)

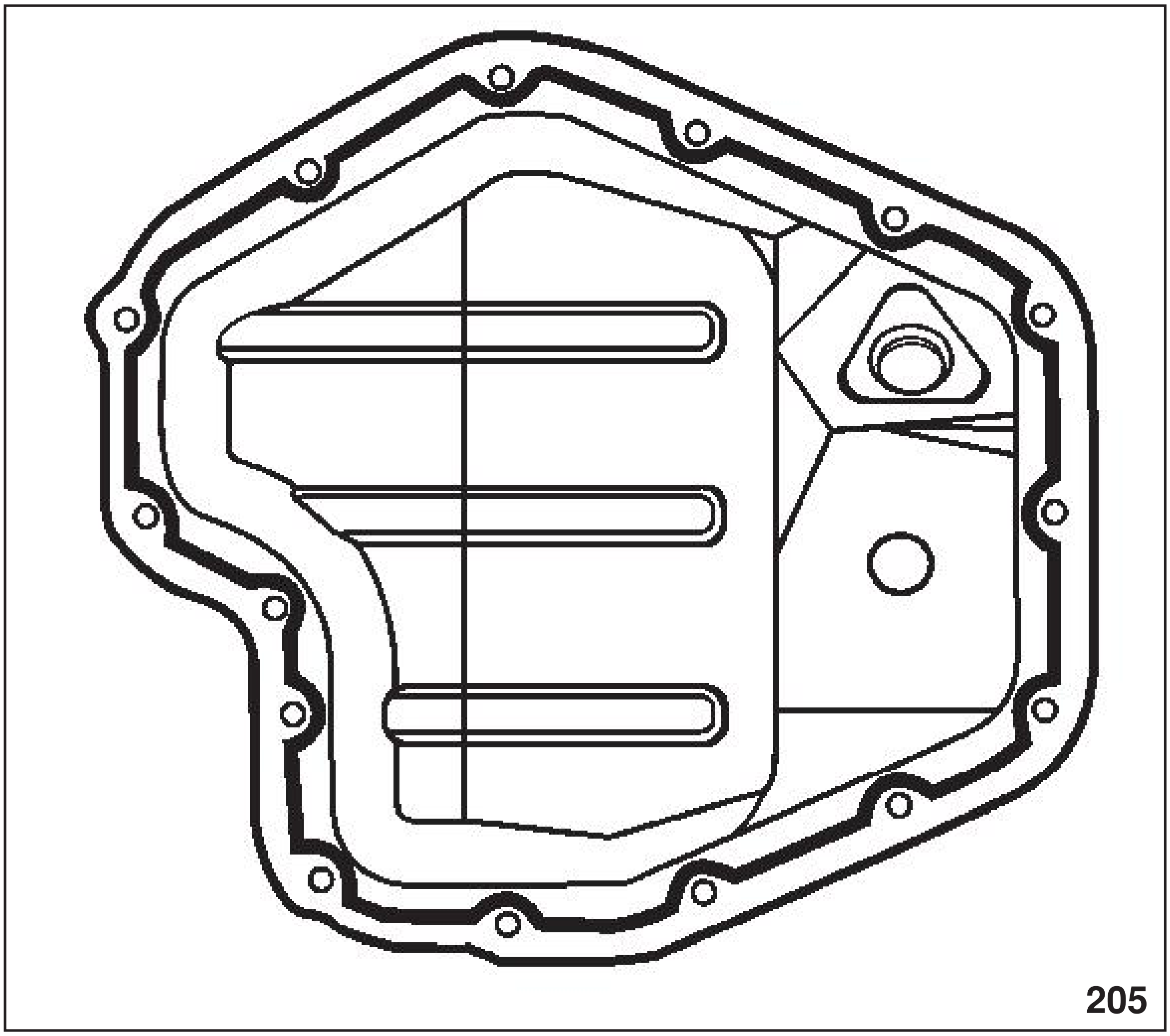


204

Refer to the Legacy and Outback 2001 Subaru Service Manual on the STIS web site *6 Cylinder Supplement.*

ME (H6) 65 to 69 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

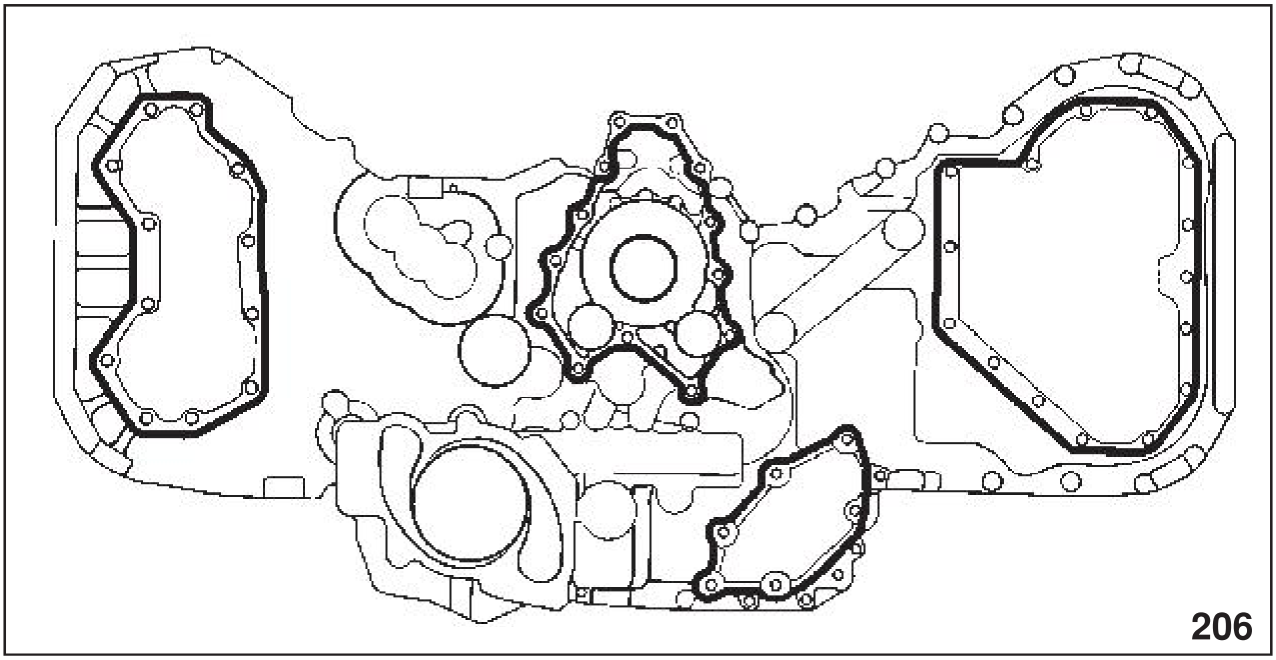
Fuji Bond Application Guide
for Oil Pan
(Lower)



Refer to the Legacy and Outback 2001 Subaru Service Manual on the STIS web site *6 Cylinder Supplement.*

ME (H6) 65 to 69 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

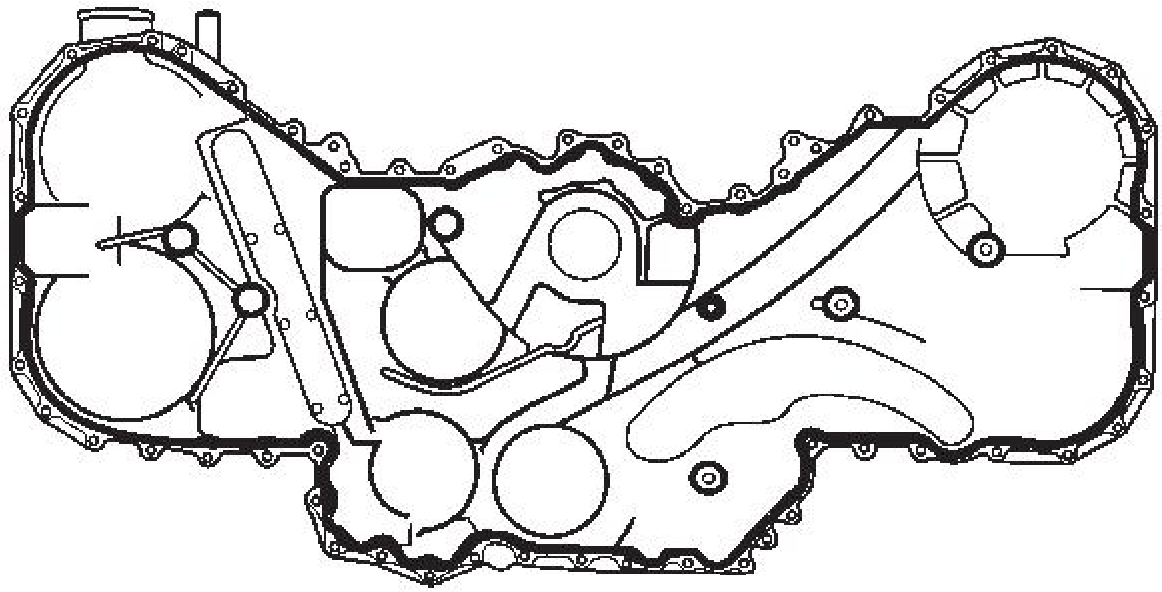
Fuji Bond Application Guide for Inner Cover



Refer to the Legacy and Outback 2001 Subaru Service Manual on the STIS web site *6 Cylinder Supplement.*

ME (H6) 52 for proper sealing, (including O-Ring placement) bolt sizes and sequence. Torque to proper specifications.

Fuji Bond Application Guide for Outer Cover (Front Chain Cover)

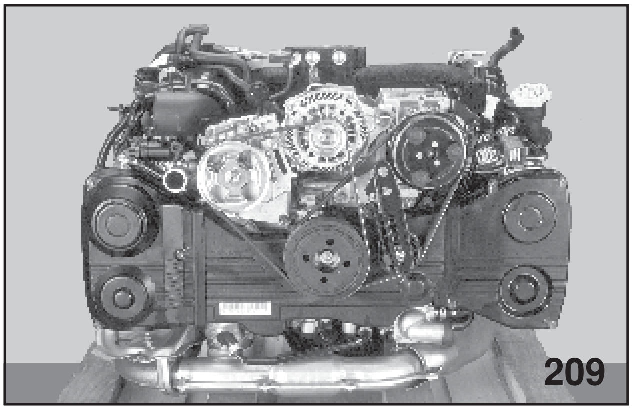


207

Refer to the Legacy and Outback 2001 Subaru Service Manual on the STIS web site *6 Cylinder Supplement.*

ME (H6) 43 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

2004 Variable Valve Timing System (2.5 Liter Engine)



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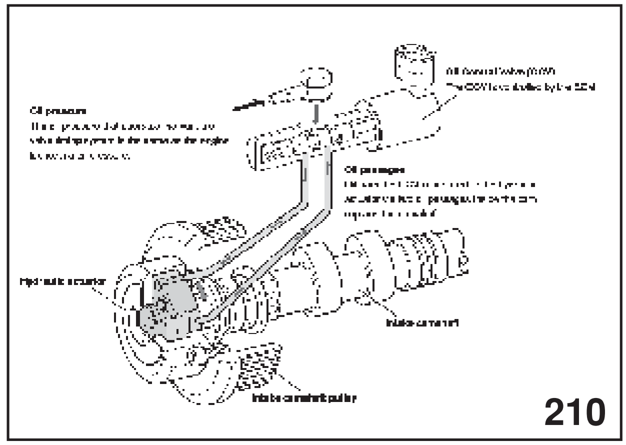
Engine

Variable valve timing functions to increase engine power output, improve fuel consumption and decrease exhaust emissions. These benefits are achieved by controlling the opening and closing time of the intake valves. The ECM monitors the engine operating condition and camshaft positions and controls the output duty ratio to oil control valves located on each cylinder head. The oil control valves in turn control the oil pressure to and from each intake camshaft sprocket. This allows the movement of the camshaft within the sprocket, controlling the opening and closing time of the intake valves.



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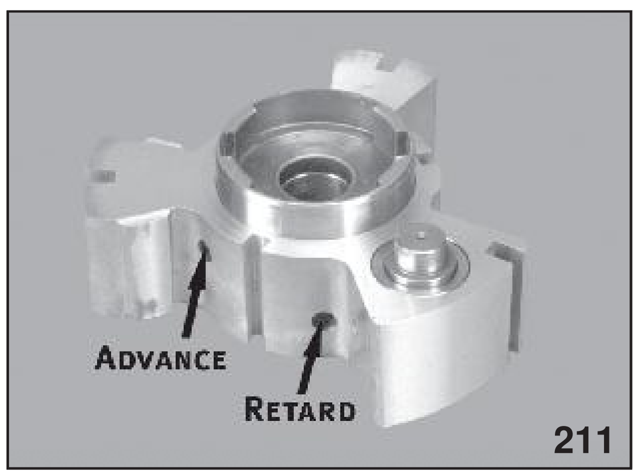
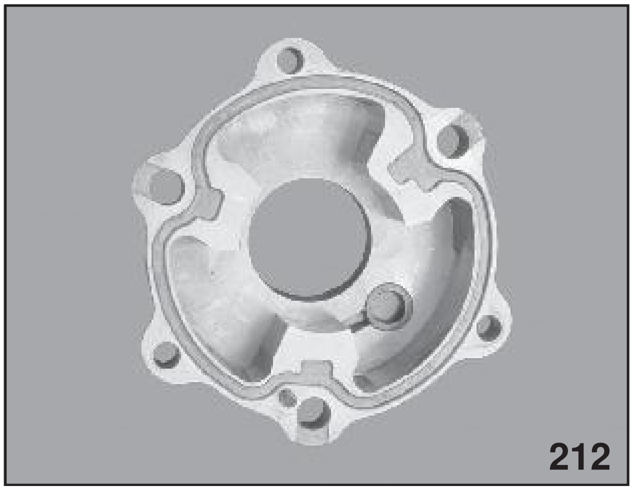
Camshaft (artwork)

The intake camshaft sprocket is a non serviceable hydraulic actuator consisting of a set of sealing vanes, rotor and a fail-safe lock valve. The camshaft is secured to the rotor with a bolt. The position of the rotor within the camshaft sprocket forms advance and retard chambers. Changing the balance of oil pressure to these chambers moves the rotor to advance or retard the intake camshaft.

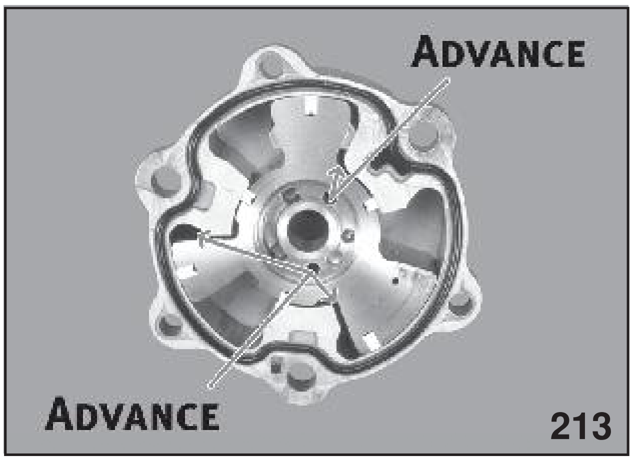


211

Camshaft Sprocket Rotor

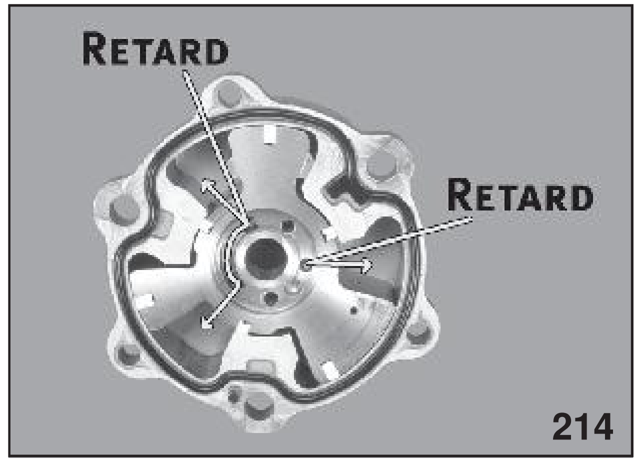


Sprocket Housing

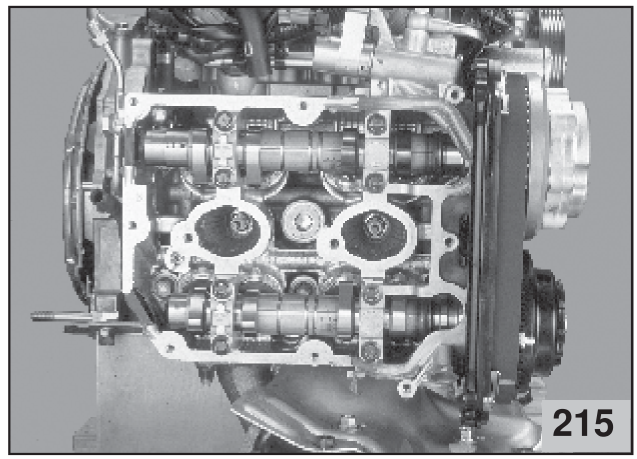


Advance Chambers

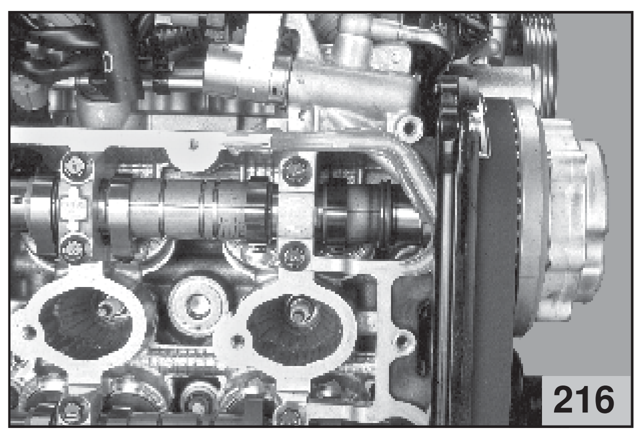
The fail-safe lock valve must operate to mechanically release the rotor from the sprocket before normal variable valve timing operation can begin. The fail-safe lock valve is unlocked by the oil pressure of the engine from the oil control valve when ever the camshaft is advanced and locked in place by the removal of pressure from the advance chamber and spring tension. The purpose of the valve is to allow the camshaft to operate in a preset fixed position in the event of a failure in the oil control valve or related hydraulic circuits. The camshaft position with the fail-safe lock valve seated is at full retard.



Retard Chambers



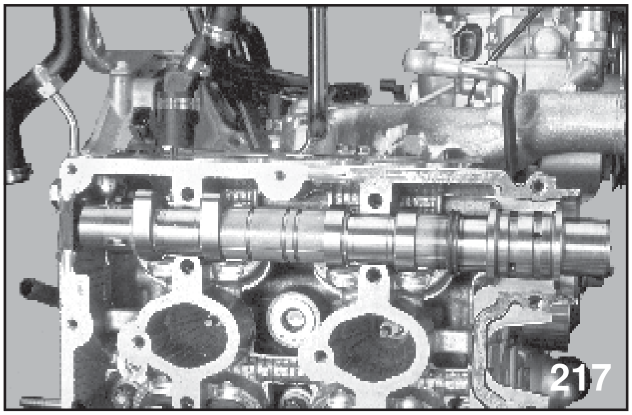
Cylinder Head



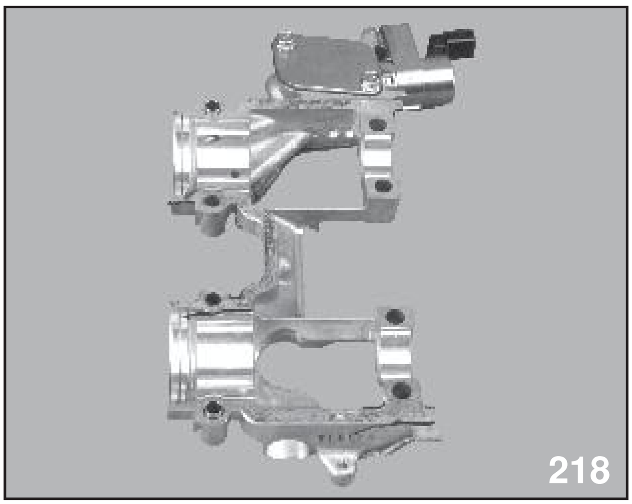
Saddle Cap

An oil control valve is located on each cylinder head, receiving a common duty ratio signal.

The oil control valve housing and the front camshaft saddle caps are incorporated into one unit.

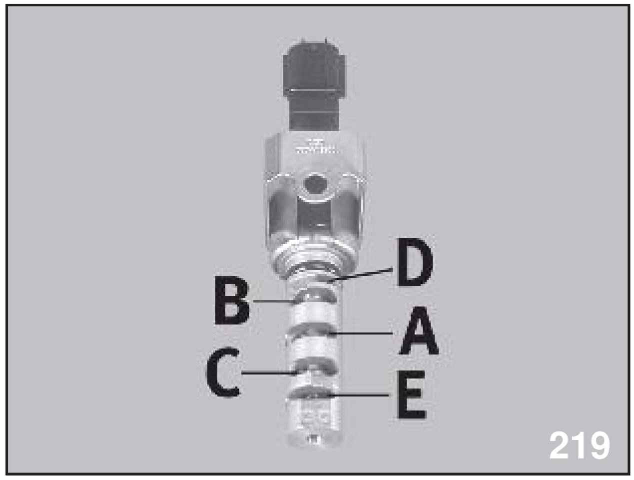


Camshaft

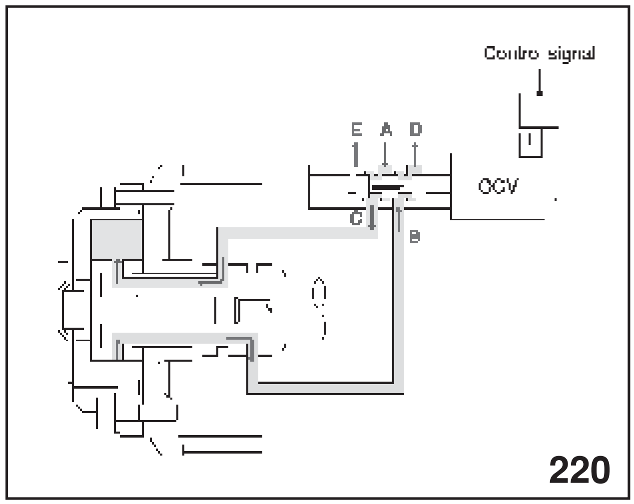


Oil Control Valve

Passageways in the oil control housing carry oil under pressure to and from the camshaft. The camshaft passageways then carry the oil to and from the camshaft sprocket. The forward passage way is for the advance chambers and the rear passage way is for the retard chambers.



OCV



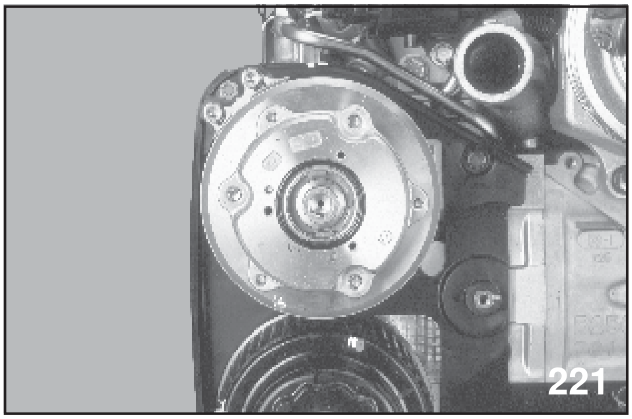
ABCD

The oil control valve chamber A is oil pressure into the valve. Chamber B provides a passage from the camshaft sprocket to drain D during advance.

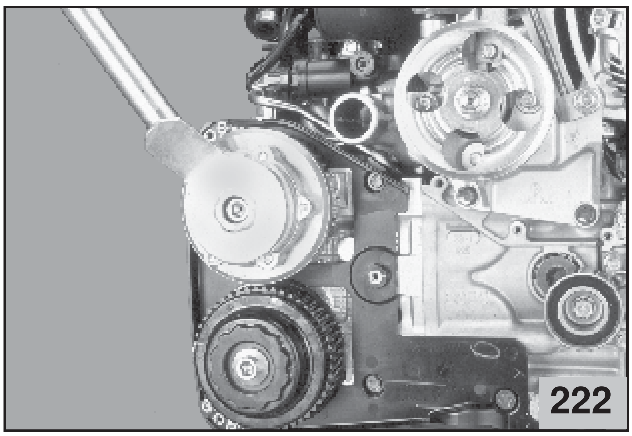
Chamber B also provides a passage way to the camshaft sprocket during retard.

Chamber C provides a passage way from the camshaft sprocket to drain E during retard.

Chamber C also provides a passage way to the camshaft sprocket during advance.



Intake Camshaft Sprocket

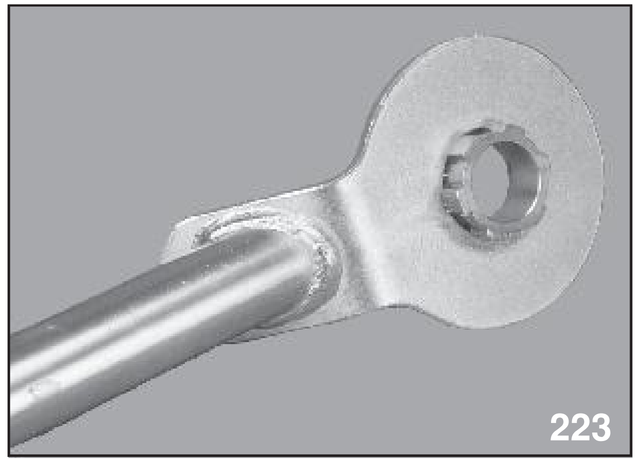


Special Tool Installed

Access to the intake camshaft bolt is obtained after removing the end cap. The bolt is hollow to allow oil to enter the front of the camshaft sprocket to lubricate the area where the rotor and the camshaft sprocket rotate against each other. Be certain to properly position the o-ring when reinstalling the end cap.

Make sure the special tool is positioned properly to avoid slippage as sprocket bolts are very tight.

Special tool 499977500 wrench is used to hold the camshaft sprocket while the bolt is being removed or installed.

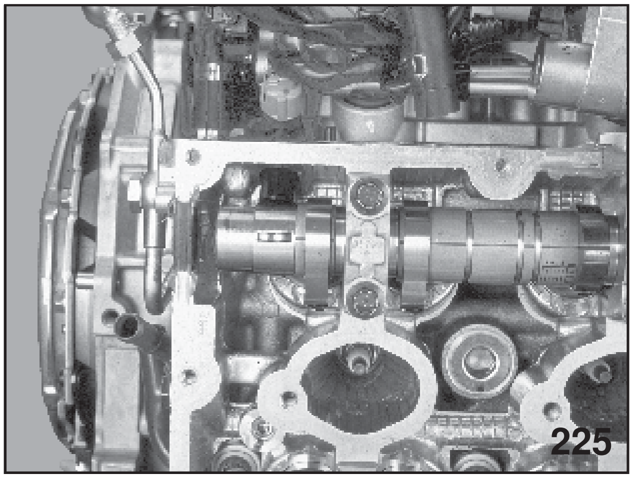


Wrench

Camshaft Sprocket Bolt

The shape of the wrench is made to match the shape made into the sprocket.

The intake camshaft bolt on each intake camshaft is hollow. Exhaust camshaft bolts are solid. Do not mix them up as the intake sprocket will be damaged from lack of lubrication.



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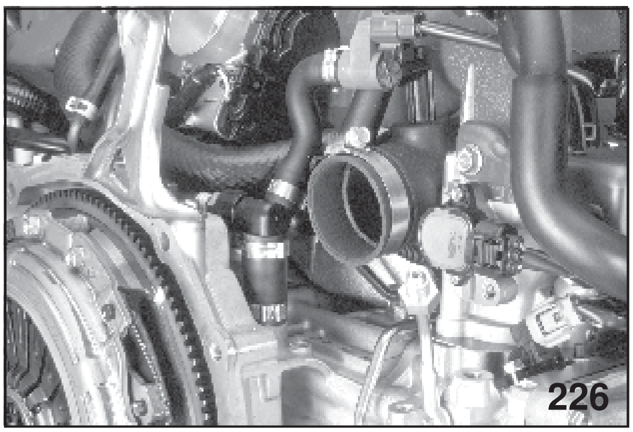
Hall Effect Sensor Over Camshaft



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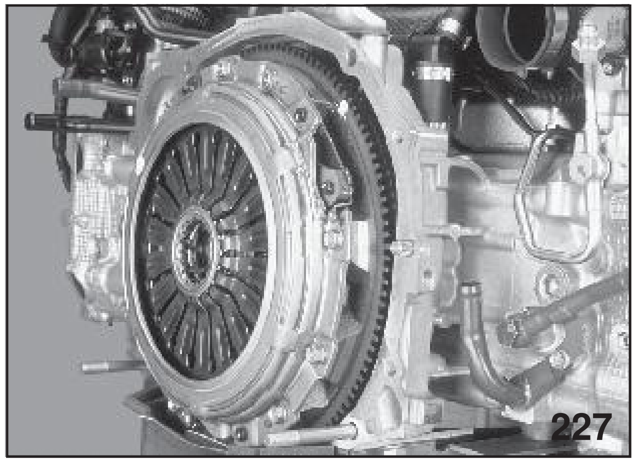
Sensor With Connector

A Hall effect camshaft sensor is used on the rear of each camshaft. These sensors are used to control the variable valve timing and to also provide camshaft information for ignition and fuel control.

NOTE: SENSOR FOR PCV PRESSURE FOR OBD II.



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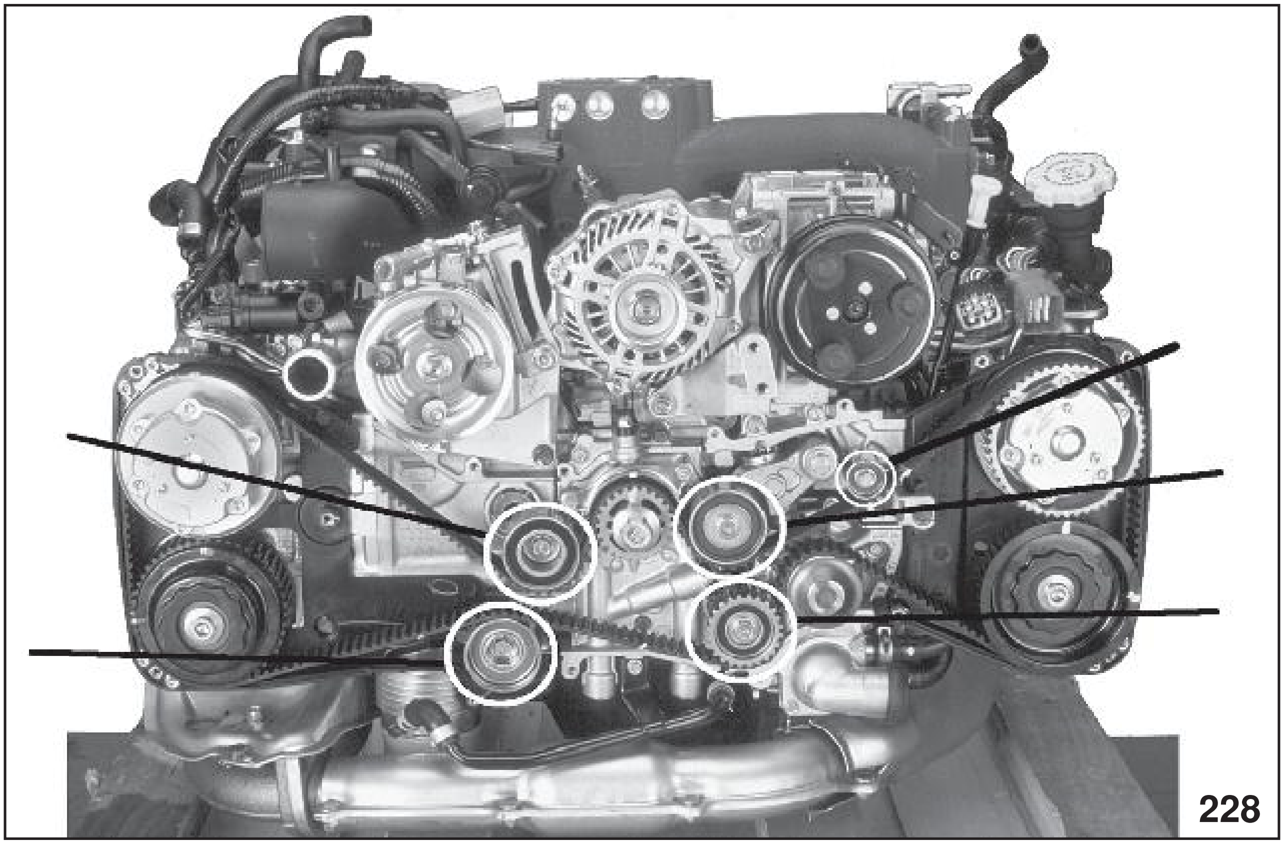
Oil Pipes

The oil supply for the passenger side oil control valve is shared with the turbo charger. The driver side oil control valve receives oil from a pipe from the front of the cylinder head.

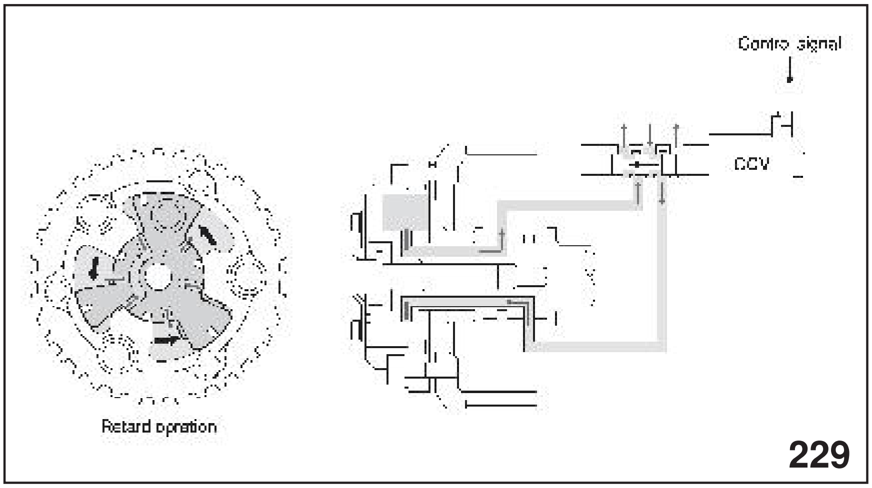


Engine Timing Belt Configuration And Bearing Identification

Proper timing belt configuration and pulley color identification.

Operation

Variable Valve Timing



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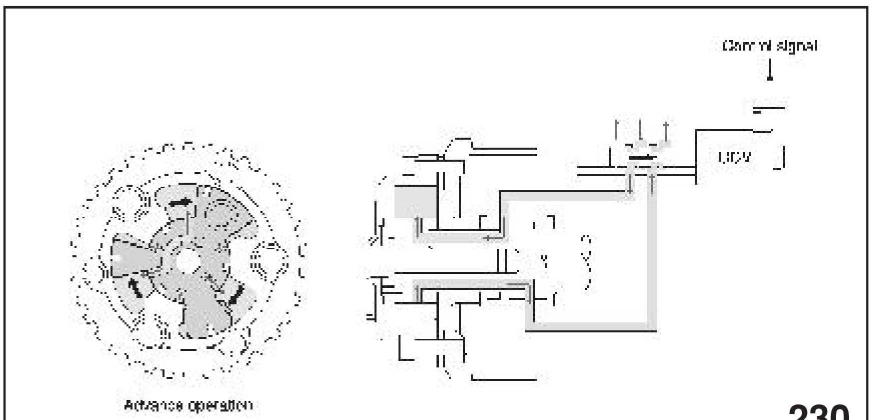
Retard Operation

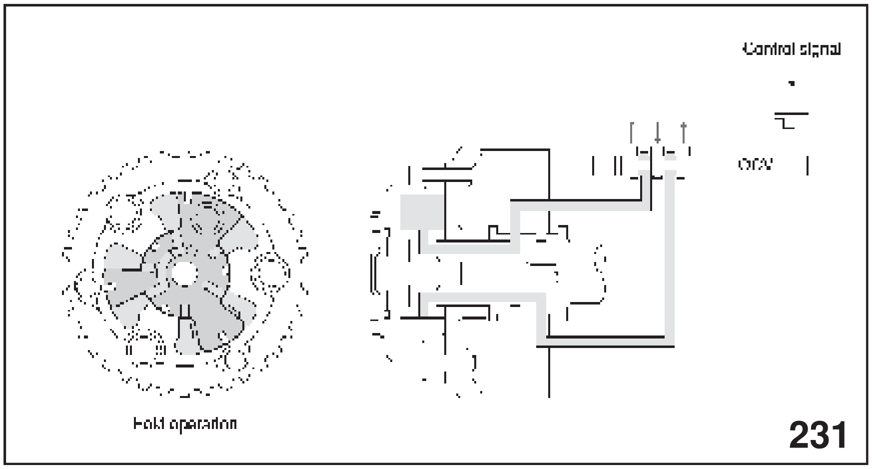
The oil control valve duty ratio during the time the camshaft is being retarded is low. This will affect the balance of pressure against the rotor to move the rotor in the opposite direction of engine rotation. This will retard the opening and closing of the intake valves as compared to the exhaust valves and crankshaft position.



230

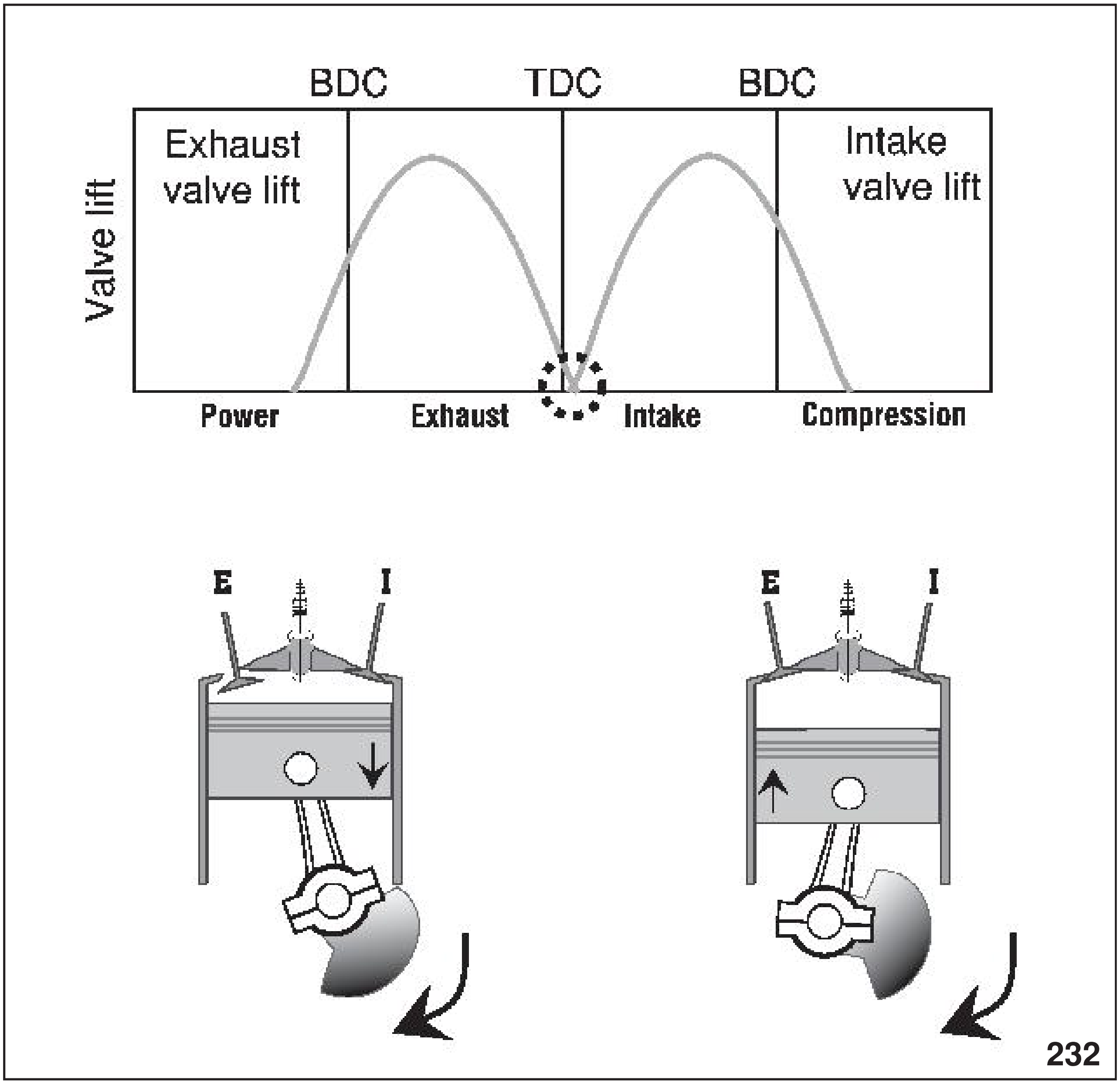
Advance Operation

The oil control valve duty ratio during the time the camshaft is being advanced is high. This will affect the balance of pressure against the rotor to rotate the rotor in the same direction of engine rotation. This will advance the opening and closing of the intake valves as compared to the exhaust valves and crankshaft position.



Hold Operation

The oil control valve duty ratio during the time the camshaft is being held is a certain valve. The two ports connected to the hydraulic actuator are closed by the valve, sealing the oil in the retard and advance chambers. This will maintain the balance of pressure against the rotor so that the camshaft is neither advanced or retarded as compared to the exhaust valves and crankshaft position.



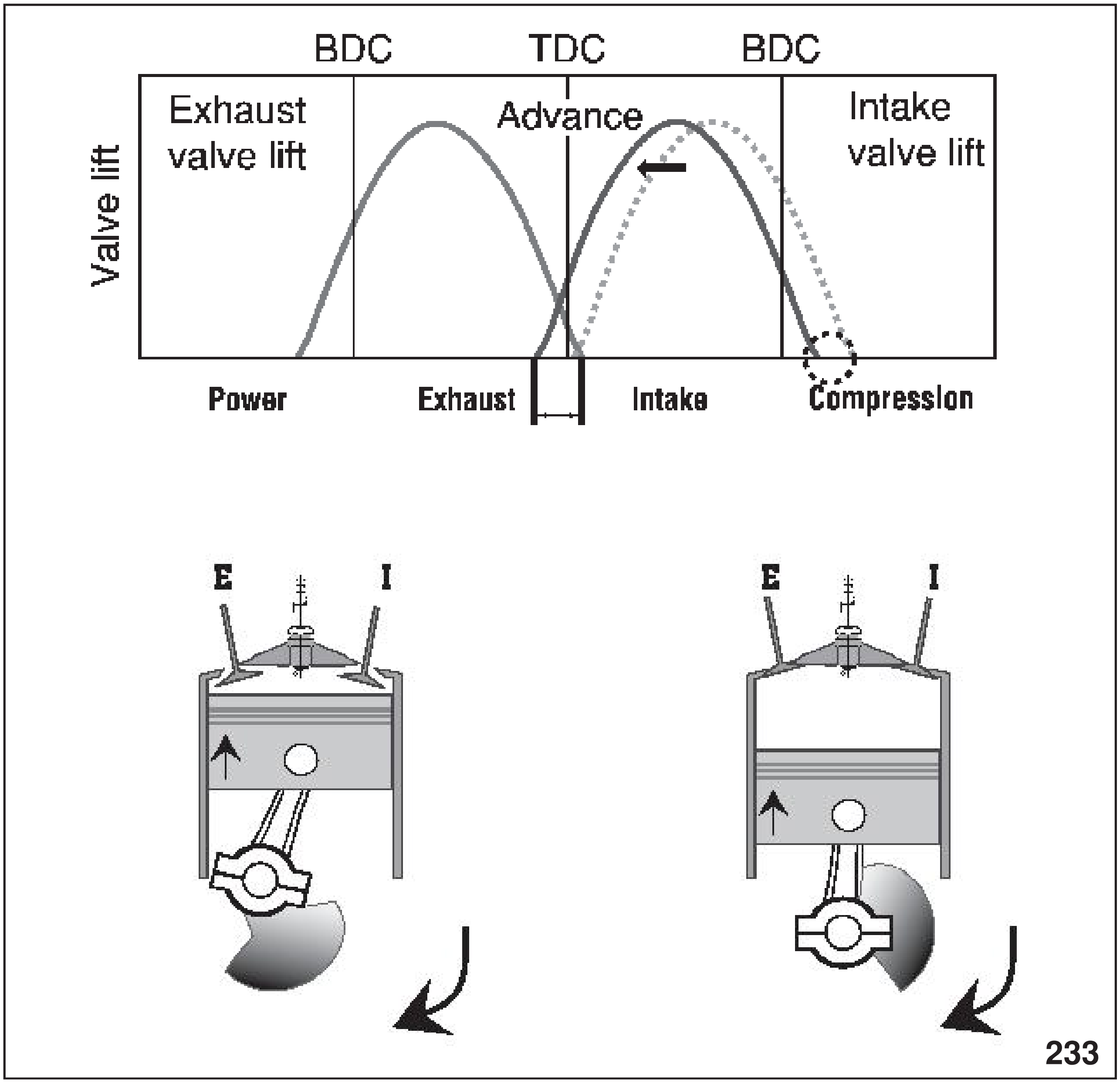
End of Exhaust Stroke
Beginning of Intake Stroke

Moving up on compression stroke

Light Engine Load

At idle the intake valves are timed to open a few degrees after TDC of the exhaust stroke. This takes advantage of the large volume of negative pressure created by the exhaust stroke and the positive pressure consisting of air/ fuel mixture now more efficiently fills the cylinder. The exhaust valves will remain open a few degrees down on the intake stroke.

Air/Fuel mixture will continue to fill the cylinder until a few degrees up on the compression stroke, Minimizing the air that goes back into the intake manifold.



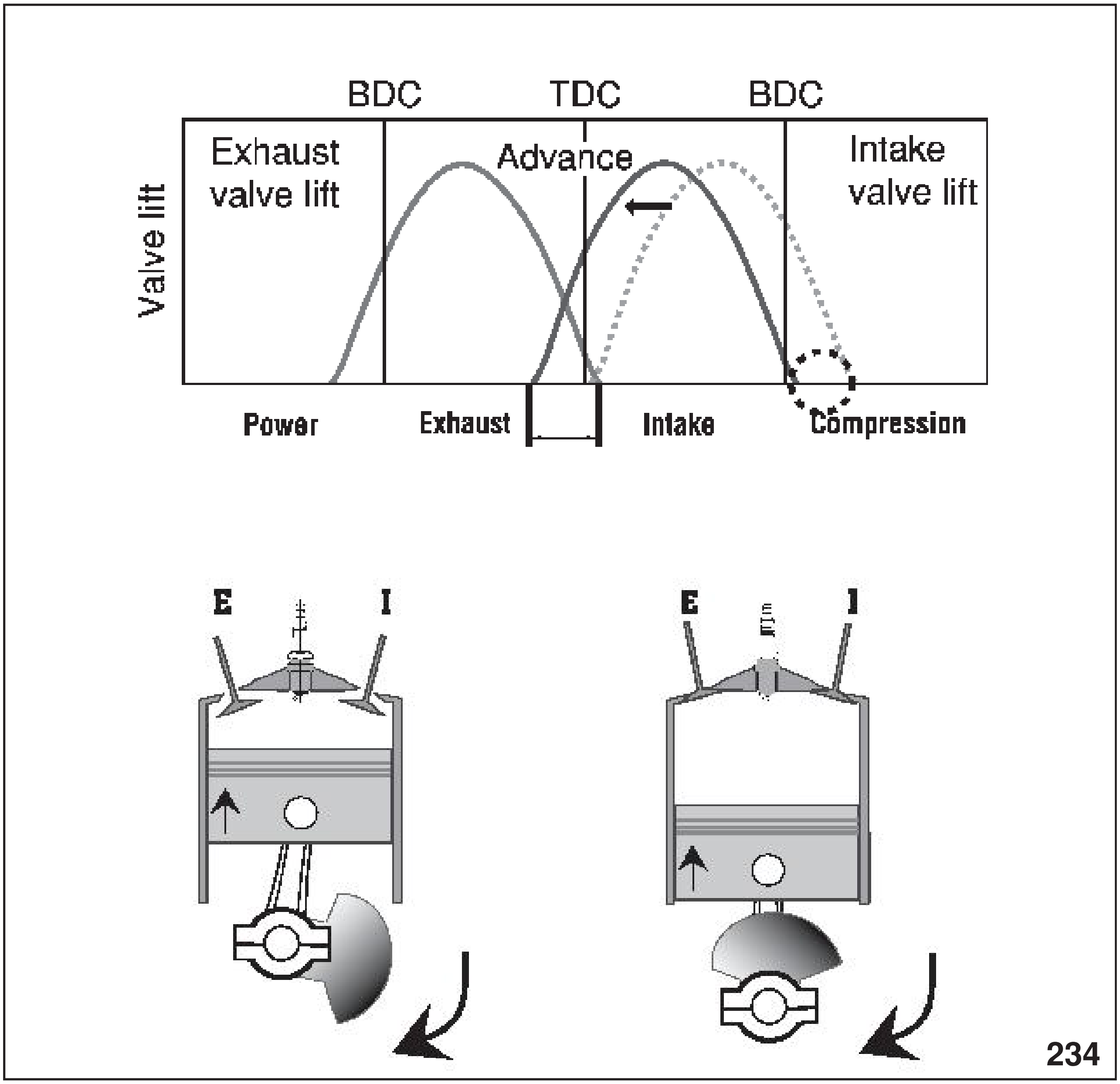
Near the end of exhaust *Moving up on compression stroke*

Medium Engine Load

During small to medium engine load operating conditions the intake valves are opened sooner. This advanced setting allows some of the pressure created during the exhaust stroke to flow back into the intake manifold, creating and EGR effect.

This helps reduce the creation of Nox. As the engine load increases the pressure inside the manifold becomes higher than that of the cylinder on exhaust stroke, eliminating the EGR affect.

The intake valves are closed sooner on the compression stroke improving volumetric efficiency.



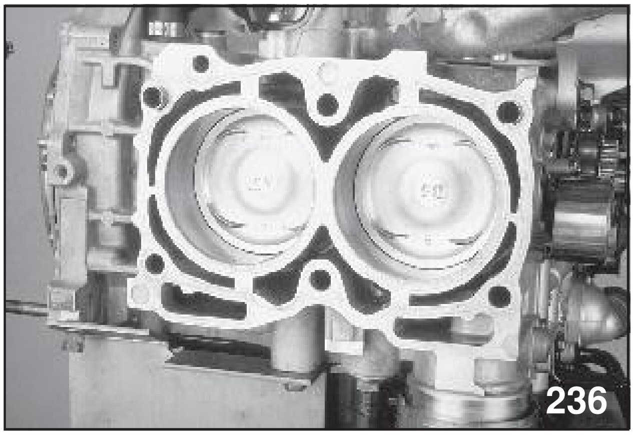
Moving Up On Exhaust Stroke *Near the beginning of compression stroke*

Heavy Engine Load

During heavy engine load operating conditions the intake valves are opened sooner. This produces a scavenging effect to clear the cylinder of exhaust gas.

Closing the intake valves sooner on the compression stroke further increases the volumetric efficiency and assists with generating high engine power output.

2004 2.5 Turbo Engine



Engine Block

Combustion Chamber

The 2.5 liter DOHC turbo engine for the WRX STi is designed with a semi-closed type cylinder block.

The 2004 2.5 engine was also used in the forester with less horsepower and torque due to changes in ht eturbocharger, intercooler, cylinder heads and camshafts.

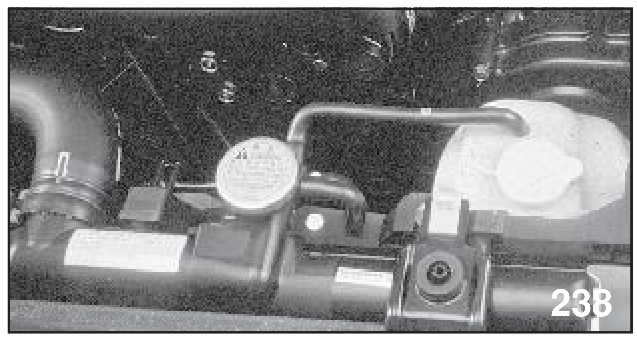
This provides stronger holding of the cylinder liners and improves the gas sealing characteristics between the cylinder block and cylinder head. The cylinder block itself has a cast in reinforcement above the number 5 main shaft journal that improves strength and noise control.

The exhaust valves are sodium filled to improve heat transfer. **Do not resurface exhaust valves. Dispose of discarded valves in accordance with regulations in your area**. The intake valve is hollow to reduce reciprocating weight.

Valve clearance is adjusted by replacing the selective shim less valve lifter.

Spark plugs are made with an Iridium center electrode to improve performance.

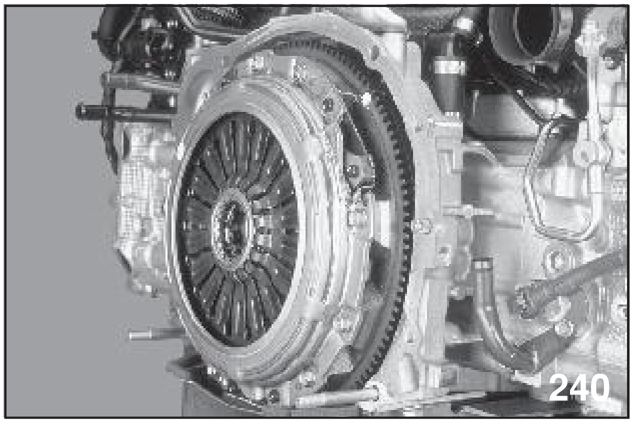
Additional changes include reshaping of the oil pan, to prevent aeration on turns, and the shape of the piston top to control compression ratio.



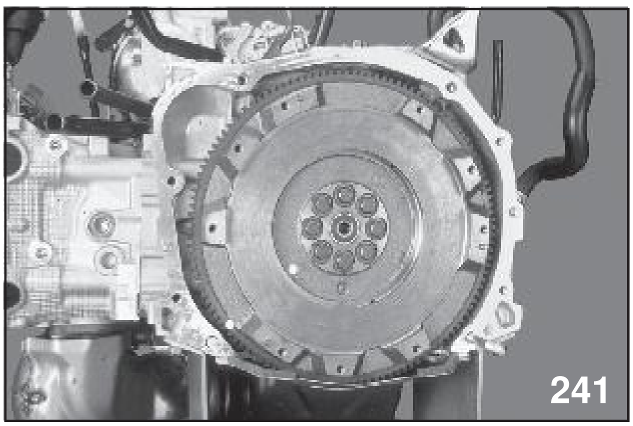
Lower Radiator Cap

Upper Coolant System Cap

The lower radiator cap contains only a pressure relief. The upper coolant system cap contains both a vacuum relief and a pressure relief. The lower radiator will open to pressure at 137+_14.7 kPa. The upper coolant system cap opens to pressure at 108+-15 kPa and under vacuum at -1.0 to - 4.9 kPa.



Pressure Plate

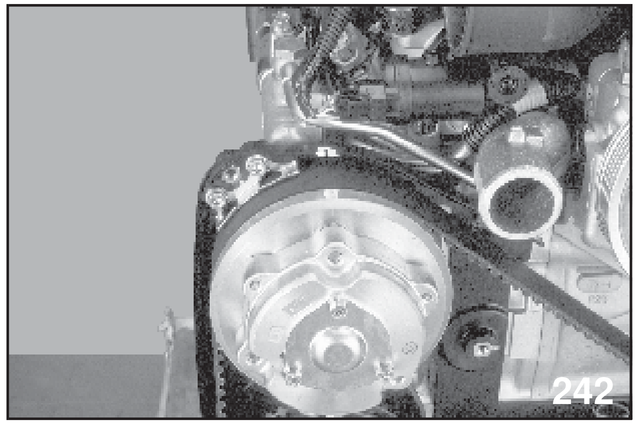


Flywheel

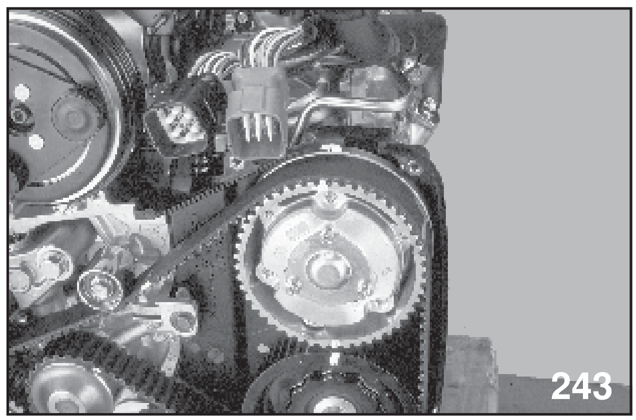
The flywheel is larger and lighter. The clutch is a hydraulic pull type with a clutch disc of 240 mm is longer than WRX.

Position the two heavy marks of the flywheel and pressure plate at least 120 degrees apart upon reassembly.

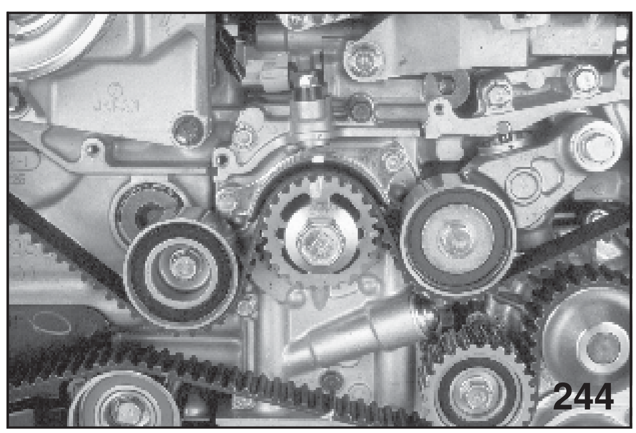
Timing Belt Timing Marks



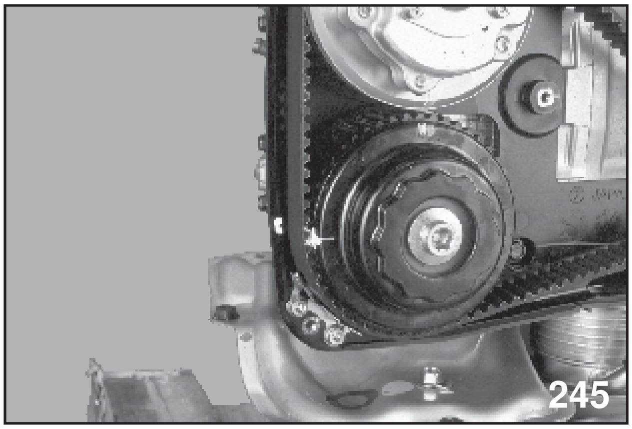
Intake Camshaft Passenger Side



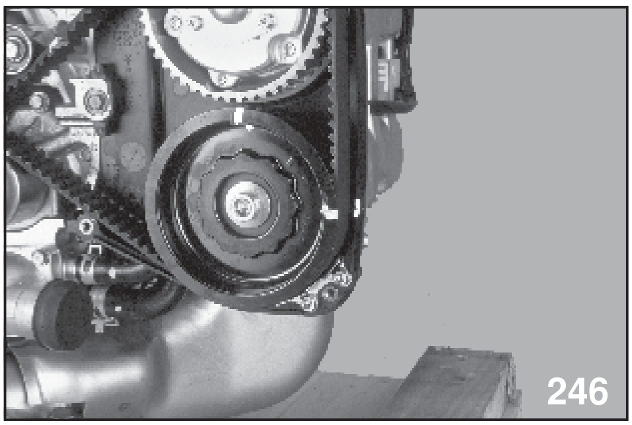
Driver Side Intake Camshaft



Crank Shaft



Passenger Side Exhaust Camshaft



Driver Side Exhaust Camshaft

NOTE: TIMING BELT RETAINERS MUST BE INSTALLED TO AVOID LOSING THE BELT ESPECIALLY ON HARD DECELERATION WHEN ENGINE IS TWISTING.

NOTES:

Engine

"LEGACY 2.5 i, OUTBACK 2.5 i and OUTBACK 2.5 i LIMITED:"

2.5L PHASE II

SOHC 16V HORIZONTALLY OPPOSED 4 CYLINDER
DISPLACEMENT: 2.5 LITERS (2457 CC / 150 CU INCHES)
BORE/STROKE: 99.5 x 79mm (3.92 x 3.11 INCHES.)
HORSEPOWER: 168 HP @ 5600: RPM
TORQUE: 166 LB-FT @ 4000 RPM
COMPRESSION RATIO: 10.0:1
ENGINE TYPE: EJ25

"LEGACY 2.5 GT, 2.5 GT LIMITED, OUTBACK 2.5 XT and OUTBACK 2.5 XT LIMITED:"

2.5L INTERCOOLED TURBO

DOHC 16V HORIZONTALLY OPPOSED HIGH OUTPUT 4 CYLINDER
TURBOCHARGED
MAXIMUM BOOST PRESSURE: 700 mmHg (13.5 PSI)
INTERCOOLED
DISPLACEMENT: 2.5 LITERS (2457 CC / 150 CUBIC INCHES)
BORE/STROKE: 99.5 x 79mm (3.92 x 3.11 INCHES)
HORSEPOWER: 250 HP @ 6000 RPM
TORQUE: 250 LB-FT @ 3600 RPM
COMPRESSION RATIO: 8.2:1
ENGINE TYPE: EJ25
ACTIVE VALVE CONTROL SYSTEM (AVCS) VARIABLE VALVE TIMING

OUTBACK 3.0 R

3.0L

DOHC 24V HORIZONTALLY OPPOSED HIGH OUTPUT 6 CYLINDER
DISPLACEMENT: 3 LITERS (2,999 CC / 183 CU INCHES)
BORE/ STROKE: 89.2 x 80mm (3.51 x 3.15 INCHES.)
HORSEPOWER: 250 HP @ 6600 RPM
TORQUE: 219 LB-FT @ 4200 RPM
COMPRESSION RATIO:10.7:1
ENGINE TYPE: EZ30
ACTIVE VALVE CONTROL SYSTEM (AVCS) VARIABLE VALVE TIMING
ACTIVE VALVE LIFT SYSTEM (AVLS) VARIABLE VALVE LIFT

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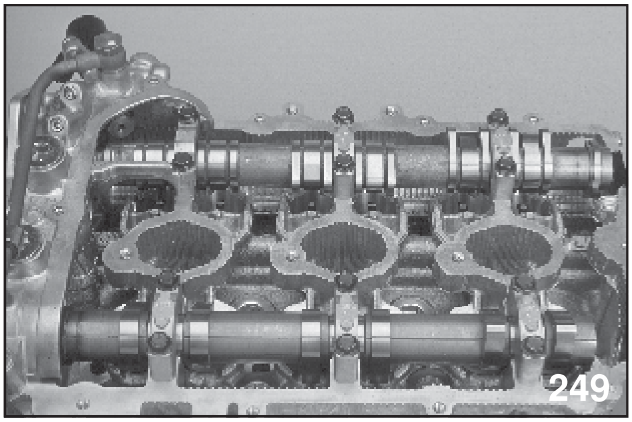
Engine Types

2005 Variable Valve Lift System

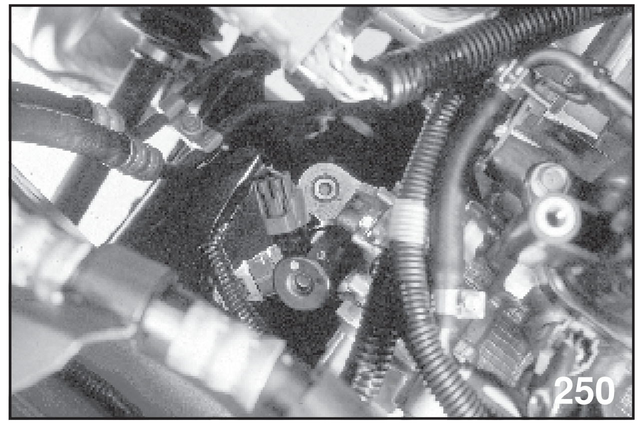


Cylinder Head

The 3.0 Liter engine is equipped with Variable Valve Timing and Variable Valve Lift. The Variable intake control has been replaced with a high efficiency composite resin intake manifold with electronic throttle control. The variable valve timing performs and operates the same as the system that was introduced on the 2004 model year turbo vehicles. The Variable Valve Lift system is designed to provide fuel economy at lower engine speeds and higher engine power output at higher engine speeds. The variable valve lift system optimizes the intake valve lift by switching to the use of low lift cam lobes or high lift cam lobes in accordance with engine speed.

The camshaft is machined with a split lobe for each intake valve. The center of the lobe is described as the low speed cam lobe. The outer cam lobes are described as the high speed cam lobe.

In response to the signals from the ECM, the oil switching solenoid valve operates to switch the valve lift.

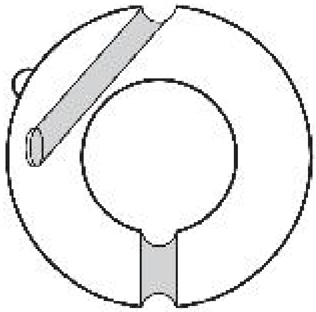


Oil Switching Valve

At low engine speeds, the lift is reduced to increase intake air speed and to obtain effective combustion and higher torque output. The lift of the two valves are different from each other. By differentiating the intake air volume in this way, a swirl occurs in the combustion chamber and combustion is improved.

At high engine speeds, the lift is increased to reduce intake resistance and to obtain higher power.
To protect the engine, the system does not allow racing up the engine to high speeds in P or N range.

Two Lifters



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Two Oil Ports (Artwork)

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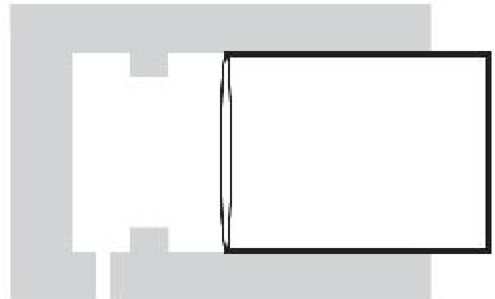
Outer and Inner Lifter

The intake valve lifter is equipped with a location guide that ensures the lifter does not rotate in the lifter bore as it is operated. Two oil pressure ports are visible on the outside of the lifter. The oil port closest to the location guide is used to supply working pressure to the outer lifter locking pin. The other oil port is used to supply lubrication to the inner lifter. The straight sides of the inner lifter ensure the inner lifter does not rotate inside the outer lifter. The lifter is not serviceable and must be replaced as a unit.



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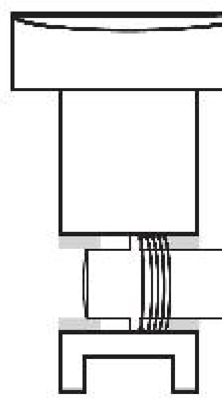
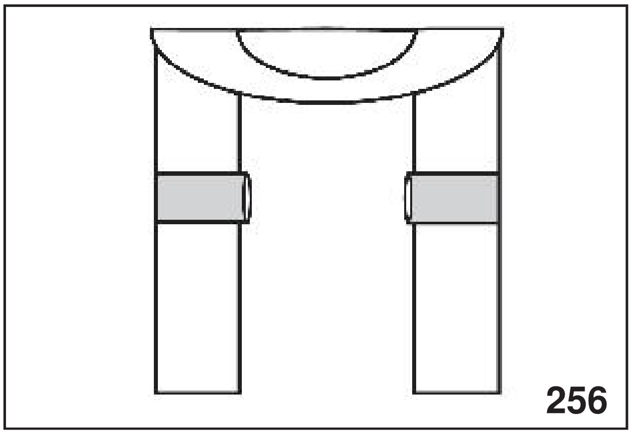
Outer Lifter Locking Pin (Artwork)

Oil pressure delivered into the outer lifter from the oil pressure port of the intake lifter bore pushes the outer lifter locking pin into the inner lifter locking pin. This locks the left side of the outer lifter into the left side of the inner lifter.



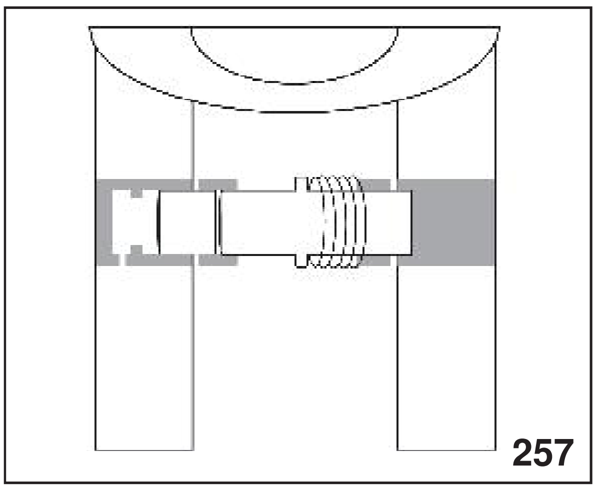
255

Inner Lifter Locking Pin (Artwork)



Outer Lifter (Artwork)

The force from this action compresses the return spring of the inner lifter locking pin and pushes the inner lifter locking pin to the right. This locks the right side of the inner lifter to the right side of the outer lifter.



(Artwork)

As the lifter is moved downward by the movement of the intake cam lobe the outer lifter moves away from the oil pressure port. However the mechanical force placed on the internal parts of the lifter keep it locked together until the intake valve is allowed to close.

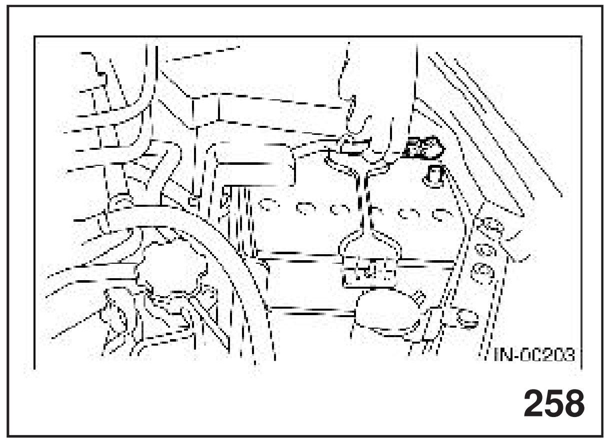
Valve Clearance 3.0 H6

Valve clearance 3.0 H6 on 2005 and newer engines with Variable Valve Lift requires checking with a feeler gauge and then measuring with a micrometer the small lifter placed on top of the valve stem in order to obtain proper clearance.

A: Inspection

Inspection and adjustment of valve clearance should be performed while engine is cold.

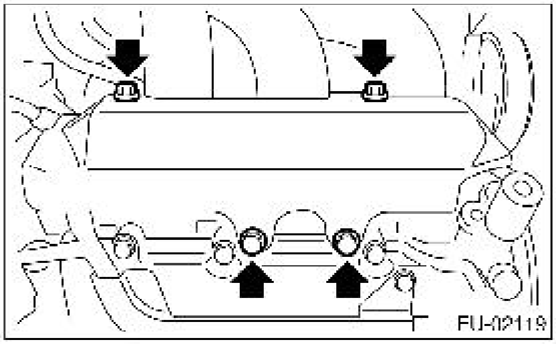
1. Set the vehicle on a lift.
2. Remove the collector cover.



Disconnecting the Battery

3. Disconnect the ground cable from battery.
4. Lift-up the vehicle.
5. Remove the under cover.
6. Lower the vehicle.
7. When inspecting RH side cylinders:

   (1) Remove the air intake duct and air cleaner case. <Ref. to IN(H6DO), REMOVAL, Air Intake Duct.> <Ref. to IN(H6DO), REMOVAL, Air Cleaner Case.>



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Fuel Tank Protector (RH)

(2) Remove the fuel tank protector (RH)

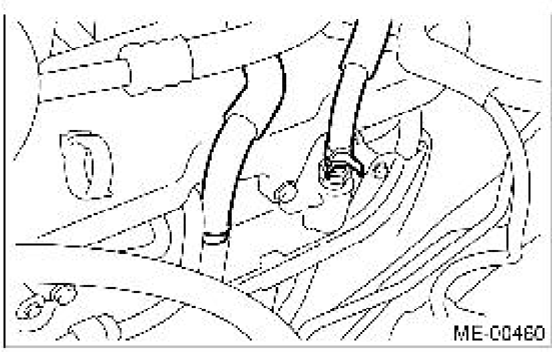
(3) Disconnect the connector of oil pressure switch.

(4) Remove the ignition coil. <Ref. to IG(H6D0), REMOVAL, Ignition Coil and Ignitor Assembly.>

(5) Remove the rocker cover (RH)

8. When inspecting LH side cylinders:

(1) Disconnect the battery cable, and then remove the battery and battery carrier.



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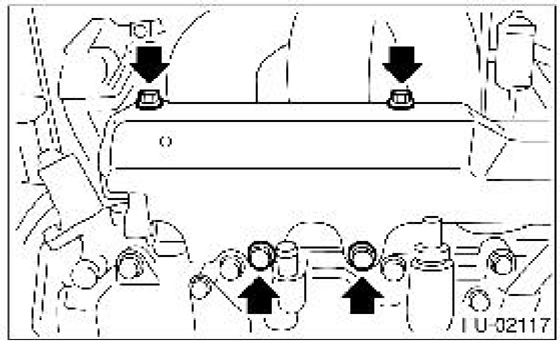
Disconnecting Hoses from Rocker Cover

(2) Disconnect the PCV hose and blowby hose from rocker cover (LH).



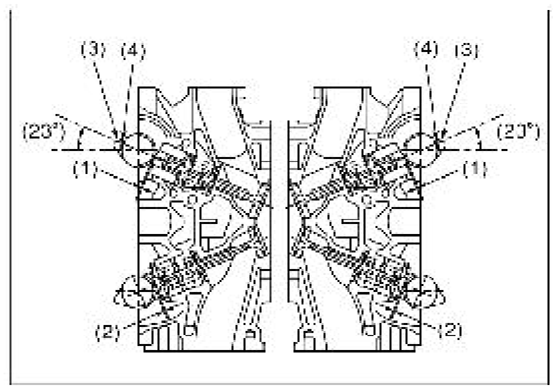
261

Fuel Pipe Protector (LH)

(3) Remove the fuel pipe protector (LH).

(4) Remove the ignition coil. <Ref. to IG(H6DO)-7, REMOVAL, Ignition Coil and Ignitor Assembly.>

(5) Remove the rocker cover (LH).



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Cam set to Position

9. Turn the crankshaft clockwise until the cam is set to position shown in the figure.

(1) Valve clearance (Intake side)

(2) Valve clearance (Exhaust side)

(3) High lift cam

(4) Low lift cam

10. Measure the clearance of intake valve and exhaust valve using thickness gauge (A).

NOTE: MEASURE VALVE CLEARANCE WITHIN THE RANGE OF ±30° THAT SHOWN IN THE FIGURE.

MEASURE VALVE CLEARANCE ON LOW LIFT CAM FOR INTAKE SIDE.

INSERT THE THICKNESS GAUGE IN AS HORIZONTAL A DIRECTION AS POSSIBLE WITH RESPECT TO THE VALVE LIFTER.

VALVE CLEARANCE

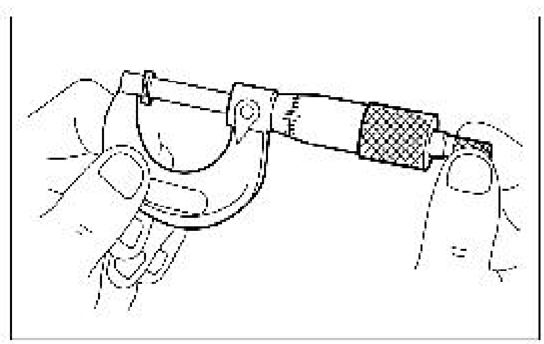
Intake:

$0.20^{+0.04}_{-0.06}$ mm ($0.0079^{+0.0016}_{-0.00024}$ in)

Exhaust:

0.35 ±0.05 mm (0.0138 ±0.0020 in)

- If the measured valve is not within specification, take notes of the value in order to adjust the valve clearance later on.



Measuring Valve Clearance

11. If necessary, adjust the valve clearance. <Ref. to ME(H6D0), ADJUSTMENT, Valve Clearance.>
12. Further turn the crank pulley clockwise and then measure the valve clearances again.
13. After inspection, install the related parts in the reverse order of removal.

ADJUSTMENT

1. INTAKE SIDE

CAUTION: ADJUSTMENT OF VALVE CLEARANCE SHOULD BE PERFORMED WHILE ENGINE IS COLD.

DO NOT WEAR GLOVES DURING REMOVAL AND INSTALLATION OF VALVE LIFTER.

DO NOT USE A VALVE LIFTER WHICH RECEIVED HIGH IMPACT DUE TO DROP, ETC.

WHEN INSTALLING THE VALVE LIFTER, ALIGN THE ANTI-ROTATION OF VALVE LIFTER WITH GROOVE ON CYLINDER HEAD, AND THEN INSERT THE VALVE LIFTER.

1. Measure all valve clearances.

<Ref. to ME(H6D0)-28, INSPECTION, Valve Clearance.>

NOTE:

Record each valve clearance after it has been measured.

2. Remove the camshaft. <Ref. to ME(H6DO)-53, REMOVAL, Camshaft.>
3. Remove the valve lifter.
4. Remove the adjustable shim (cap) from the top of the intake valve stem.
5. Check the thickness of the shim (cap) by stamped mark on the side of shim (cap) which is removed.
6. Select a shim (cap) of suitable thickness using measured valve clearance and shim (cap) thickness, by referring to the following table.

Unit: (mm)
S = (V + T) - 0.20
S: Required shim (cap) thickness V: Measured valve clearance T: Shim (cap) thickness to be used

Part No.	Thickness mm (in)
13218AK890	1.92 (0.0756)
13218AK900	1.94 (0.0764)
13218AK910	1.96 (0.0772)
13218AK920	1.98 (0.0780)
13218AK930	2.00 (0.0787)
13218AK940	2.02 (0.0795)
13218AK950	2.04 (0.0803)
13218AK960	2.06 (0.0811)
13218AK970	2.07 (0.0815)
13218AK980	2.08 (0.0819)
13218AK990	2.09 (0.0823)
13218AL000	2.10 (0.0827)
13218AL010	2.11 (0.0831)
13218AL020	2.12 (0.0835)
13218AL030	2.13 (0.0839)
13218AL040	2.14 (0.0843)
13218AL050	2.15 (0.0846)
13218AL060	2.16 (0.0850)
13218AL070	2.18 (0.0858)
13218AL080	2.18 (0.0858)
13218AL090	2.19 (0.0862)
13218AL100	2.20 (0.0866)
13218AL110	2.21 (0.0870)
13218AL120	2.22 (0.0874)
13218AL130	2.23 (0.0878)
13218AL140	2.24 (0.0882)
13218AL150	2.25 (0.0886)
13218AL160	2.26 (0.0890)
13218AL170	2.27 (0.0894)
13218AL180	2.28 (0.0898)
13218AL190	2.29 (0.0902)
13218AL200	2.30 (0.0906)
13218AL210	2.31 (0.0909)
13218AL220	2.32 (0.0913)
13218AL230	2.33 (0.0917)
13218AL40	2.34 (0.0921)
13218AL250	2.35 (0.0925)

Part No.	Thickness mm (in)
13218AL260	2.36 (0.0929)
13218AL270	2.28 (0.0937)
13218AL280	2.38 (0.0937)
13218AL290	2.39 (0.0941)
13218AL300	2.41 (0.0945)
13218AL310	2.41 (0.0949)
13218AL320	2.42 (0.0953)
13218AL330	2.43 (0.0957)
13218AL340	2.44 (0.0961)
13218AL350	2.45 (0.0965)
13218AL360	2.46 (0.0969)
13218AL370	2.47 (0.0972)
13218AL380	2.48 (0.0976)
13218AL390	2.49 (0.0980)
13218AL400	2.50 (0.0984)
13218AL410	2.51 (0.0988)
13218AL420	2.52 (0.0992)
13218AL430	2.53 (0.0996)
13218AL440	2.54 (0.1000)
13218AL450	2.55 (0.1004)
13218AL460	2.56 (0.1008)
13218AL470	2.57 (0.1012)
13218AL480	2.58 (0.1016)
13218AL490	2.59 (0.1024)
13218AL500	2.60 (0.1024)
13218AL510	2.61 (0.1028)
13218AL520	2.62 (0.1032)
13218AL530	2.64 (0.1039)
13218AL540	2.66 (0.1047)
13218AL550	2.68 (0.1055)
13218AL560	2.70 (0.1063
13218AL570	2.72 (0.1071)
13218AL580	2.74 (0.1079)
13218AL590	2.76 (0.1087)

2. EXHAUST SIDE

CAUTION: ADJUSTMENT OF VALVE CLEARANCE SHOULD BE PERFORMED WHILE ENGINE IS COLD.

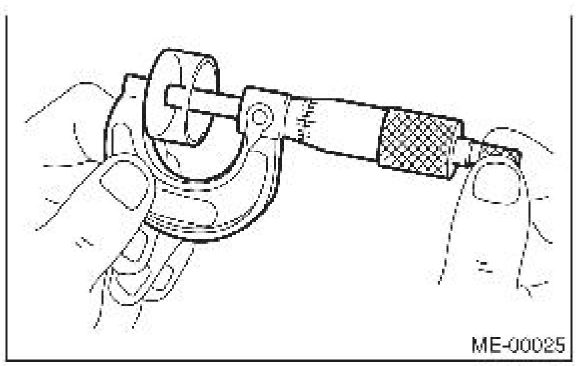
DO NOT WEAR GLOVES DURING REMOVAL AND INSTALLATION OF VALVE LIFTER.

DO NOT USE A VALVE LIFTER WHICH RECEIVED HIGH IMPACT DUE TO DROP, ETC.

1. Measure all valve clearances. <Ref. to ME(H6DO), INSPECTION, Valve clearance.>

NOTE: RECORD EACH VALVE CLEARANCE AFTER IT HAS BEEN MEASURED.

2. Remove the camshaft. <Ref. to ME(H6D0), REMOVAL, Camshaft.>
3. Remove the valve lifter.



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Micrometer Measuring Valve Lifter

4. Measure the thickness of valve lifter with a micrometer.
5. Select a valve lifter of suitable thickness using measured valve clearance and valve lifter thickness, by referring to the following table.

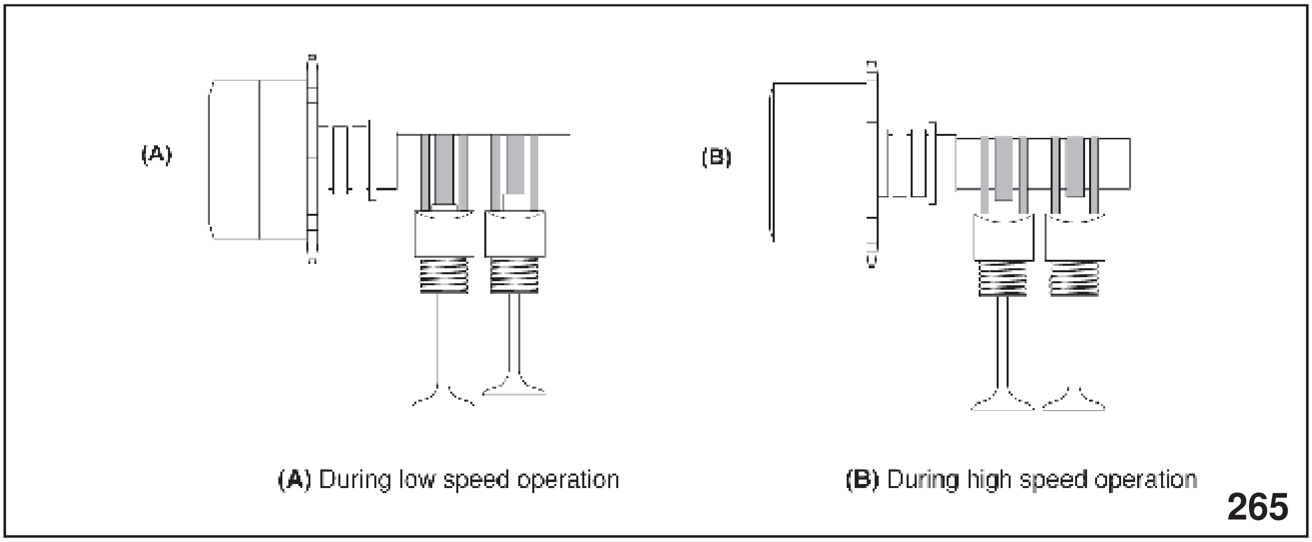
Unit: (mm)
S = (V + T) - 0.35
S: Valve lifter thickness required V: Measured valve clearance T: Valve lifter thickness to be used

Part No.	Thickness mm (in)
13228AD180	4.32 (0.1701)
13228AD190	4.34 (0.1709)
13228AD200	4.36 (0.1717)
13228AD210	4.38 (0.1724)
13228AD220	4.40 (0.1748)
13228AD230	4.42 (0.1740)
13228AD240	4.44 (0.1748)
13228AD250	4.46 (0.1756)
13228AD260	4.48 (0.1764)
13228AD270	4.50 (0.1772)
13228AD280	4.52 (0.1780)
13228AD290	4.45 (0.1787)
13228AD300	4.56 (0.1795)
13228AD10	4.58 (0.1803)
13228AD320	4.60 (0.1881)
13228AC580	4.62 (0.1819)
13228AC590	4.63 (0.1823)
13228AC600	4.64 (0.1827)
13228AC610	4.65 (0.1831)
13228AC620	4.66 (0.1835)
13228AC630	4.67 (0.1839)
13228AC640	4.68 (0.1843)
13228AC650	4.69 (0.1846)
13228AC660	4.70 (0.1850)
13228AC670	4.71 (0.1854)
13228AC680	4.72 (0.1858)
13228AC690	4.73 (0.1862)
13228AC700	4.74 (0.1866)
13228AC710	4.75 (0.1870)
13228AC720	4.76 (0.1874)
13228AC730	4.77 (0.1878)
13228AC740	4.78 (0.1882)
13228AC750	4.79 (0.1886)
13228AC760	4.80 (0.1890)
13228AC770	4.81 (0.1894)
13228AC780	4.82 (0.1898)
13228AC790	4.83 (0.1902)

Part No.	Thickness mm (in)
13228AC800	4.84 (0.1906)
13228AC810	4.85 (0.1909)
13228AC820	4.86 (0.1913)
13228AC830	4.87 (0.1917)
13228AC840	4.88 (0.1921)
13228AC850	4.89 (0.1925)
13228AC860	4.90 (0.1929)
13228AC870	4.91 (0.1933)
13228AC880	4.92 (0.1937)
13228AC890	4.93 (0.1941)
13228AC900	4.94 (0.1945)
13228AC910	4.95 (0.1949)
13228AC920	4.96 (0.1953)
13228AC930	4.97 (0.1957)
13228AC940	4.98 (0.1961)
13228AC950	4.99 (0.1965)
13228AC960	5.00 (0.1969)
13228AC970	5.01 (0.1972)
13228AC980	5.02 (0.1976)
13228AC990	5.03 (0.1980)
13228AD000	5.04 (0.1984)
13228AD010	5.05 (0.1988)
13228AD020	5.06 (0.1992)
13228AD030	5.07 (0.1996)
13228AD040	5.08 (0.2000)
13228AD050	5.09 (0.2004)
13228AD060	5.10 (0.2008)
13228AD070	5.11 (0.2012)
13228AD080	5.12 (0.2016)
13228AD090	5.13 (0.2020)
13228AD100	5.14 (0.2024)
13228AD110	5.15 (0.2028)
13228AD120	5.16 (0.2032)
13228AD130	5.17 (0.2035)
13228AD140	5.18 (0.2039)
13228AD150	5.19 (0.2043)
13228AD160	5.20 (0.2047)

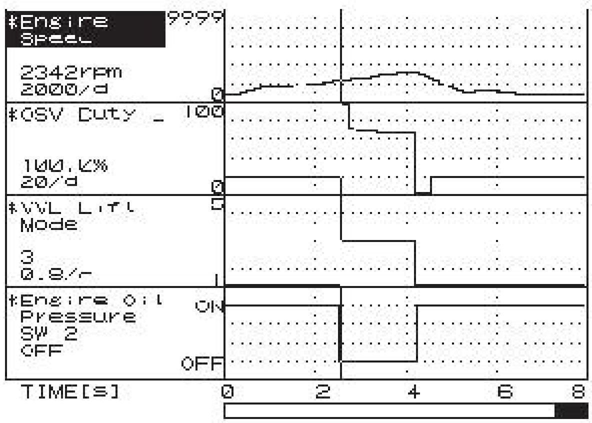
Part No.	Thickness mm (in)
13228AD170	5.21 (0.2051)
13228AD330	5.23 (0.2059)
13228AD340	5.25 (0.2067)
13228AD350	5.27 (0.2075)
13228AD360	5.29 (0.2083)
13228AD370	5.31 (0.2091)
13228AD380	5.33 (0.2098)
13228AD390	5.35 (0.2106)
13228AD400	5.37 (0.2114)
13228AD410	5.39 (0.2122)
13228AD420	5.41 (0.2130)
13228AD430	5.43 (0.2138)
13228AD440	5.45 (0.2146)
13228AD450	5.47 (0.2154)
13228AD460	5.49 (0.2161)
13228AD470	5.51 (0.2169)
13228AD480	5.53 (0.2177)
13228AD490	5.55 (0.2185)
13228AD500	5.57 (0.2193)
13228AD510	5.59 (02201)

When the oil pressure ports align the pressure is reapplied or released dependant on the duty ratio from the OSV. If the pressure is released the return spring of the inner lifter locking pin moves the inner lifter locking pin to the left. This action will move the outer lifter locking pin to the left resulting in the separation of the inner and outer lifter.



Camshafts

Oil Pressure Schematic



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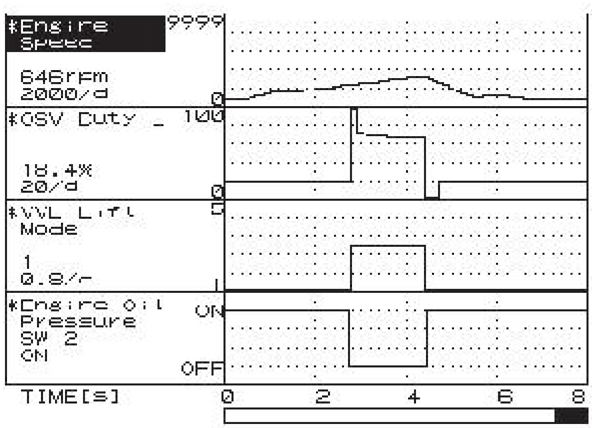
NSM graph 100% OSV Duty



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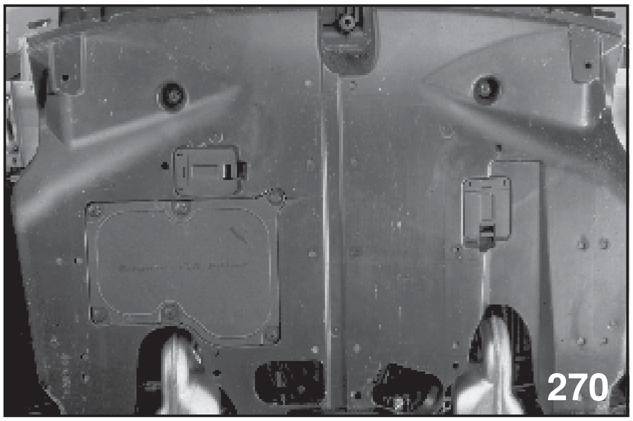
NSM Graph OSV Duty Ratio 86%

The Variable Valve Lift (VVL) is controlled by a duty ratio signal from the ECM to the Oil Switching Valve (OSV). An OSV is located on each cylinder head to operate the VVL components on their respective sides of the engine. An oil pressure diagnosis switch is located on each OSV. The right side is "**Engine Oil Pressure SW 1**" and the left side is "**Engine Oil Pressure SW 2**" when viewing data on the Select Monitor. Both switches monitor the oil pressure in the application circuits of the OSVs. When the oil pressure in the application circuit is **low,** the oil pressure diagnosis switch is grounded and is displayed as "**On**" when viewing Select monitor data. When the pressure is **high,** the oil pressure switch is open and is displayed as "**Off**" when viewing Select Monitor data.

The OSV duty ratio at idle is approximately 18%. This short on time is allowing more oil pressure to drain rather than build up in the application circuit. The resulting pressure reaching the VVL lifters is not strong enough to overcome spring tension so the VVL lifter remains in a low speed operation mode, allowing the center lifter to work with the low speed cam lobes. The Select monitor will display this action as "**VVL Lift Mode 1**".

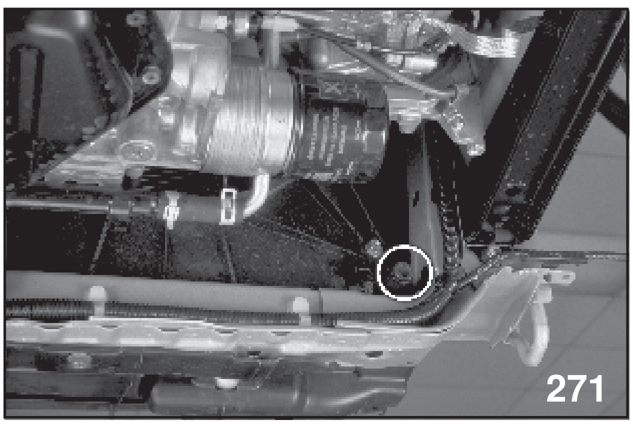
The OSV duty ratio will initially increase to 100% when the ECM decides to change to high speed operation. After pressure has been established in the application circuit, the duty ratio will decrease to approximately 86 %. This longer on time, as compared to the duty ratio at idle, will allow more oil pressure to build up in the application circuit rather than drain. The resulting pressure will be strong enough to overcome spring tension and lock the outer lifter to the inner lifter, allowing operation with the split high speed cam lobes. The Select monitor will display this action as "**VVL Lift Mode 3**".

2006 Subaru B9 Tribeca Radiator Removal



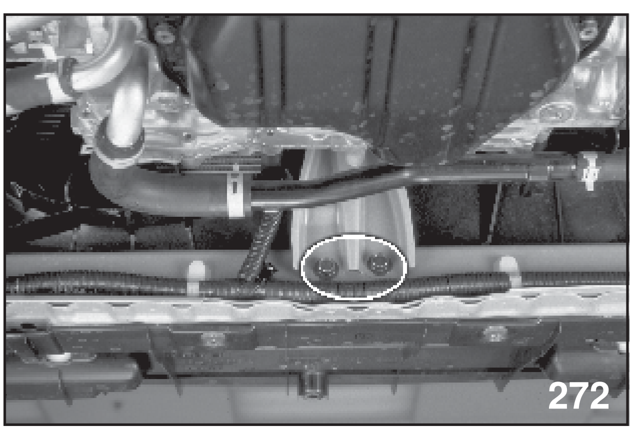
Engine Undercover

Remove the engine under cover.



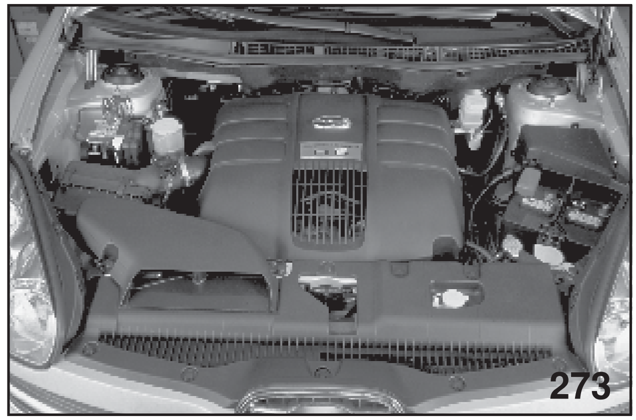
Circled Drain Plug

Loosen the radiator drain plug.



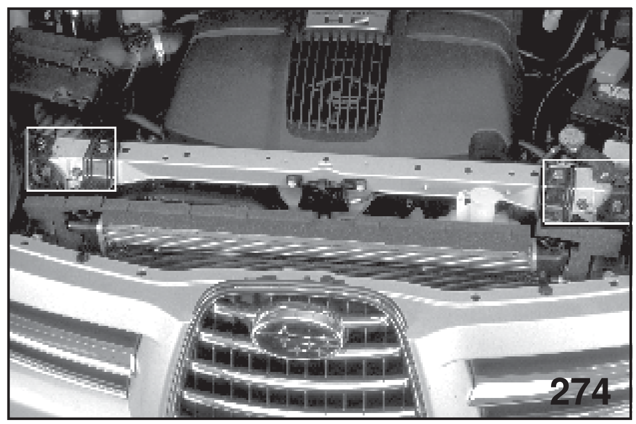
Circled Lower Radiator Support Bar Bolts

Remove the two lower radiator support bar bolts.



Engine Compartment

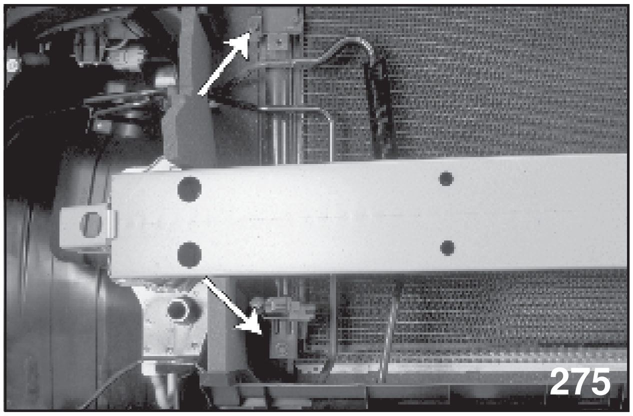
Remove the air intake duct and radiator trim.



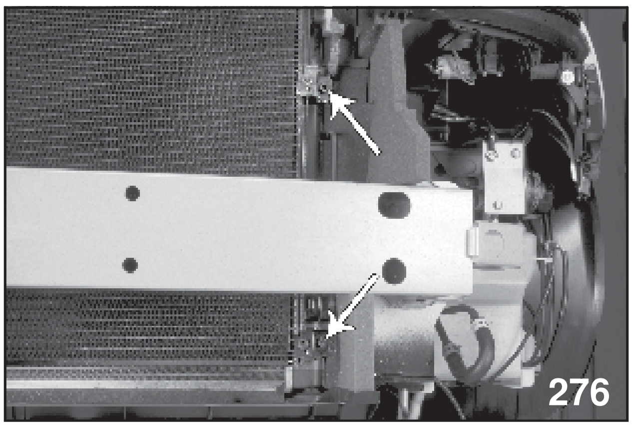
Highlighted Upper Radiator Support Bar Bolts

From the driver side of the radiator support bar, remove the three bolts securing the radiator support bar to the vehicle body. Remove the bolt securing the radiator filler neck to the radiator support bar. Remove the bolt and radiator mounting plate. From the passenger side remove the three bolts securing the radiator support bar to the vehicle body. Remove the three bolts securing the hood latch assembly to the radiator support bar. Remove the radiator support bar from the engine compartment. (Remove wiring tie wrap from radiator support bar.)

Elevate the vehicle and remove the lower radiator hose and lower ATF reservoir hoses.

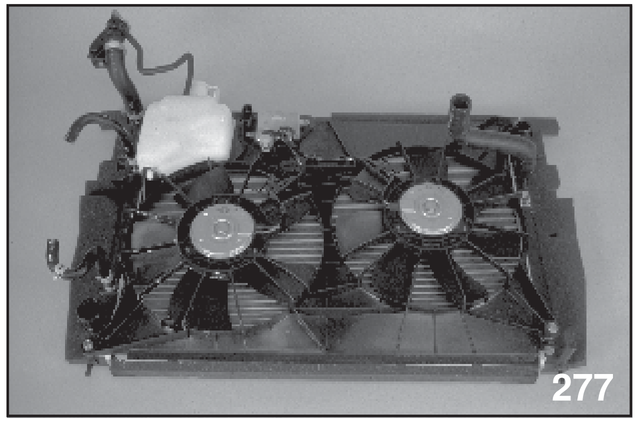


Passenger Side Bolts



Driver Side Bolts

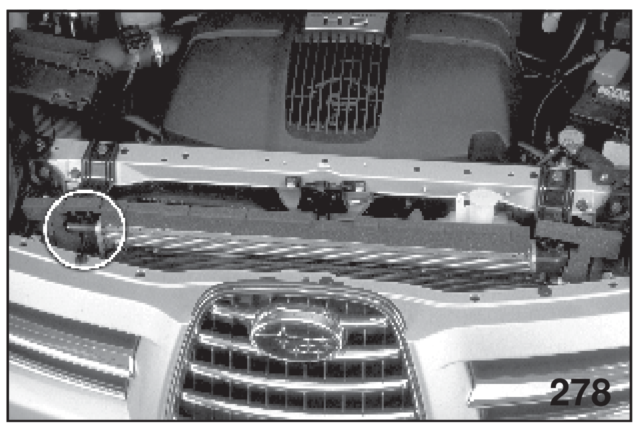
Reach through the front bumper cover and remove the two brackets from the driver and passenger side that connects the condenser to the radiator.



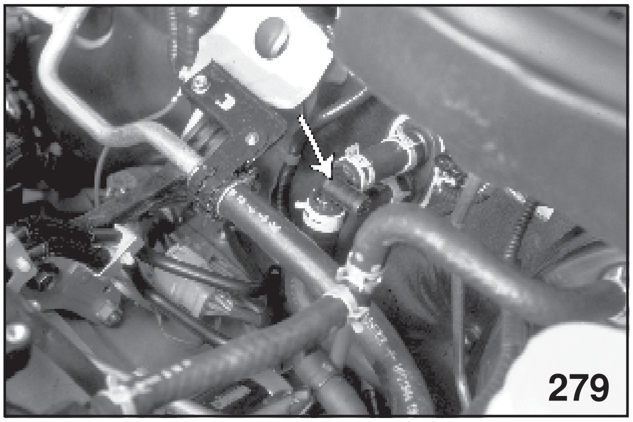
Radiator Assembly

Lower the vehicle and remove the two upper radiator hoses and the upper ATF reservoir hose. Disconnect the fan speed controller connector and remove the radiator from the vehicle.

The fan speed controller and individual fans are serviceable separately.



Circled Air Bleed

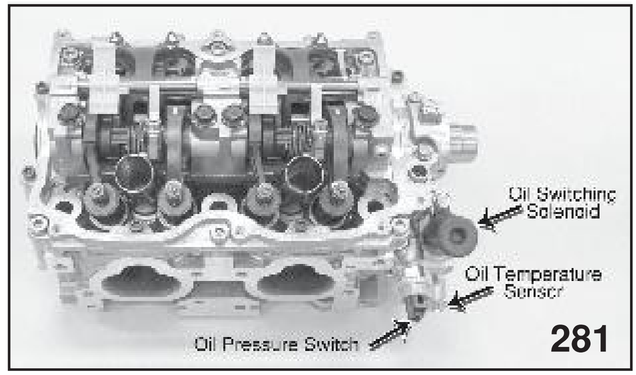


Arrow and Air Bleed

When refilling the coolant system, open the rear and forward air bleeds and continue to add coolant until coolant begins to flow from the air bleeds. Close the air bleeds. Run the engine until the fans cycle and add adequate coolant to the coolant reservoir that will ensure proper radiator coolant level as the coolant system cools.

2006 2.5 Naturally Aspirated Engine

The 2.5 naturally aspirated engine has increased in horsepower and torque over the previous model year. Horsepower is rated at 175 at 6,000 RPM and 169 ft. lbs. of Torque at 4,400 RPM.



Cylinder Head

NOTE: OIL TEMPERATURE SENSOR IS USED ONLY TO DETERMINE OIL TEMPERATURE FOR DIAGNOSIS. (MINIMUM TEMPERATURE 15°C OR 59° F)

Naturally aspirated models are equipped with i-Active Valve Lift System. The system operates similar to the variable valve lift system of 3.0 liter engine of the Legacy and Subaru B9 Tribeca vehicles.

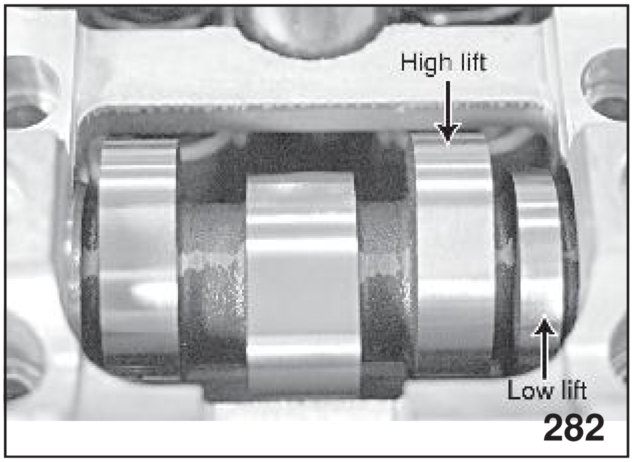
Operating one of two intake valves per cylinder, the i-Active Valve Lift System increases combustion chamber swirl at low engine speeds and increases air flow during high engine speeds.

NOTE: THE REASON FOR CHANGE INTERVALS ON PLATINUM SPARK PLUGS AND WHY SOME NEED TO BE CHANGED AT 30,000 MILES AND OTHERS AT 60,000 MILES.

THE REASON FOR THIS IS THE SPARK PLUGS ON 2.5L NA ENGINES, THE ELECTRODE SIDE OF THIS PLUG IS PLATINUM BUT THE PLUG CORE SIDE IS NOT PLATINUM. THEREFORE, IT IS A MAINTENANCE INTERVAL EVERY 30,000 MILES.

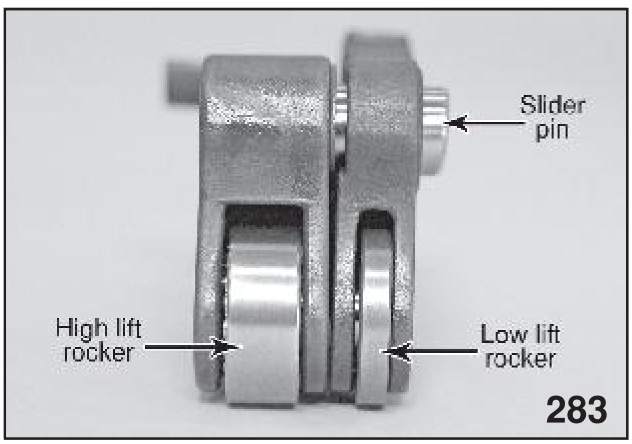
ON THE 2.5L TURBO AND 3.0L ENGINES, BOTH THE ELECTRODE SIDE AND THE PLUG CORE SIDE ARE PLATINUM.

THEREFORE, IT IS A MAINTENANCE INTERVAL EVERY 60,000 MILES.

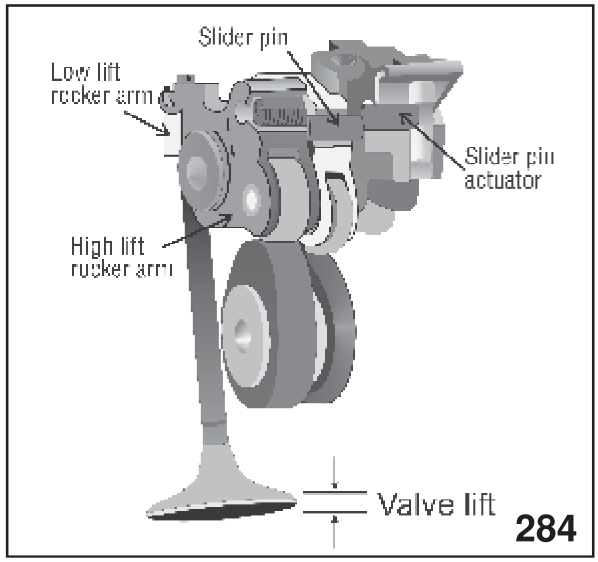


Camshaft

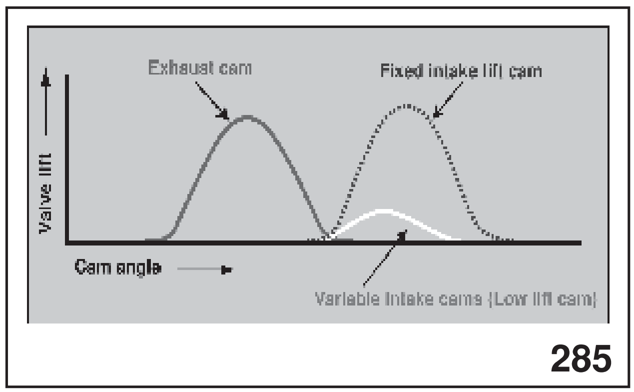
The inboard intake camshaft lobe of each cylinder is actually two lobes. The shorter lobe provides the lift for the low speed or mode 1 operation and the higher lobe provides the lift for high speed operation or mode 3.



Rocker Arm



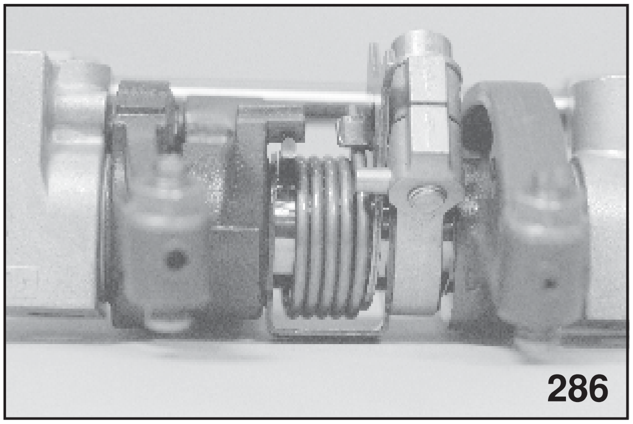
Valve and Rocker Arm (Low Lift)



Lift Graph

(Both rocker arms operate independently)

During low speed operation (mode 1) the low lift camshaft lobe transfers the lift and duration of the low speed camshaft lobe to the top of the intake valve.



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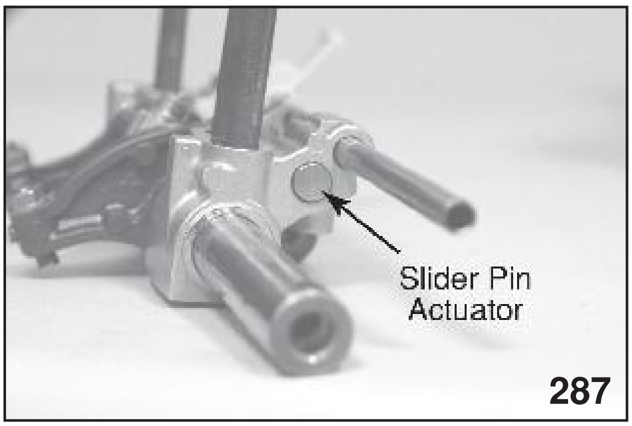
Tension Spring

The high lift rocker arm moves freely and has no affect on the intake valve. The high speed rocker arm utilizes a tension spring to maintain the correct positioning and to prevent noise as it has no load applied to it.



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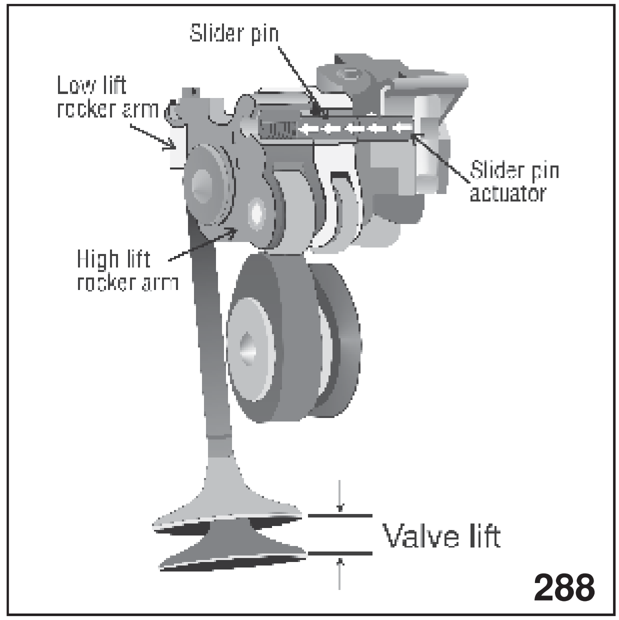
Slide Pin Actuator

A duty ratio signal sent to an Oil Switching Valve on the left and right side engine cylinder heads affects the build up of oil pressure behind a slider pin actuator of each cylinder. An increase in duty ratio closes the oil pressure release and the slider pin moves outward.



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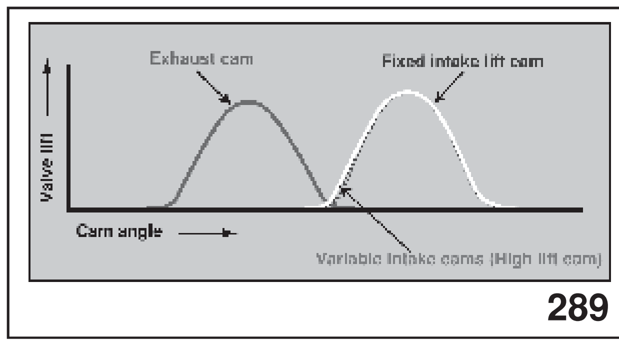
Valve and Rocker Arm (High Lift)



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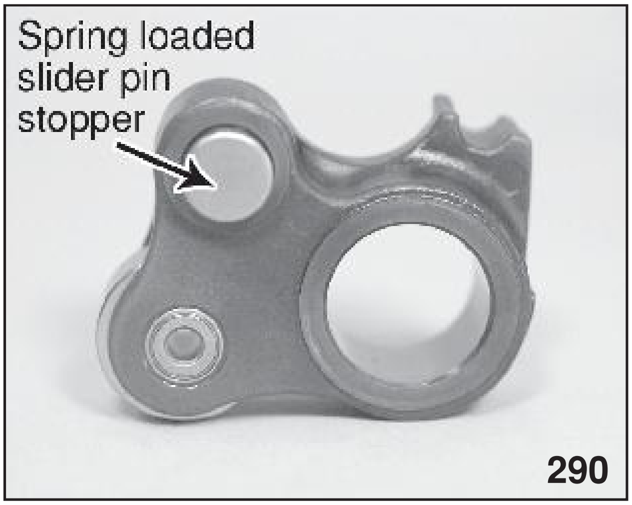
Lift Graph

(Both rocker arms locked together)

During high speed operation (mode 3) the slider pin actuator moves outward from the center rocker shaft support due to the increase in oil pressure behind the actuator. The actuator pushes the slider pin positioned in the low lift rocker arm into the slider pin stopper located in the high speed rocker arm. This action mechanically locks the two rocker arms together. The lift and duration of the high lift camshaft lobe is transferred from through the high lift rocker arm to the low lift rocker arm and then to the top of the intake valve.



Slider Pin Stopper

When the engine returns to mode 1, the oil pressure behind the slider pin actuator is drained away and the spring tension behind the slider pin stopper pushes the slider pin away from the high lift rocker arm and the low lift rocker arm functions from the low lift camshaft lobe only.

Slide Sequence

Slide Sequence

Slide Sequence

Slide Sequence

Slide Sequence

Slide Sequence

General Hand Tools and Supplies

Dial indicator
Dye penetrant
Feeler gauge
Micrometers
Plastigauge
Press
Rubber or Plastic Hammer
Fuji Bond 1105 or equivalent
Fuji Bond 1280B or equivalent
Fuji Bond 1107C or equivalent
Fuji Bond 1215 or equivalent
Torque wrench (ft-lb) and (in. lb.)

Special Tools

		2.0L	2.2L	(1996) (HLA's) DOHC (Phase 1) 2.5L	(97 to 99) (Solid) DOHC (Phase 1) 2.5L	(1999 & Later) SOHC (Phase 2) 2.2 & 2.5L	3.0	(2004 & Later) DOHC
498457000	Engine stand adapter RH	X	X		X		X	
498457100	Engine stand adapter LH	X	X		X		X	
498747100	Piston guide		X		X			
498857100	Valve oil seal guide	X	X		X	X	X	
499017100	Piston pin guide	X	X	X	X	X		X
499037100	Connecting rod bushing remover & installer	X	X		X	X		
499097500	Piston pin remover		X		X		X	
499207100	Camshaft sprocket wrench		X		X	X		X
499587100	Camshaft oil seal installer	X	X	X	X	X	X	X
499587200	Crankshaft oil seal installer	X	X	X	X	X	X	X
499587300	Camshaft oil seal installer							
499587400	Oil pump seal installer							
499597000	Camshaft oil seal guide		X	X	X	X	X	
499718000	Valve spring remover	X	X	X	X	X	X	
499718400	Valve spring compressor adapter		X					
499767000	Valve guide adjuster	X	X					
499767200	Valve guide remover	X	X		X	X		
499767400	Valve guide reamer	X	X		X	X		
499817000	Engine stands (2)	X	X	X	X			
499977000	Crank pulley wrench		X	x				
898968600	Circlip pliers (or SNAP-ON long nose pliers 911CP)		X	X				
499597100	Crankshaft oil seal guide	X	X	X		X	X	
498747300	Piston guide			X	X	X		X

		2.0L	2.2L	(1996) (HLA's) DOHC (Phase 1) 2.5L	(97 to 99) (Solid) DOHC (Phase 1) 2.5L	(1999 & Later) SOHC (Phase 2) 2.5L	3.0	(2004 & Later) DOHC
499207300	Camshaft sprocket wrench			X	X			
498267600	Cylinder head table	X		X	X			
498267700	Valve guide adjuster	X		X	X			
499987500	Crankshaft socket		X	X		X		
J-43979	Shim remover tool	X			X		X	
J-42908	Camshaft sprocket holding tool			X	X			
498497100	Crankshaft stopper	X			X	X	X	X
18254AA00	Piston guide						X	
18253AA000	Connecting rod bushing remover & installer						X	
18350AA000	Camshaft sprocket wrench						X	
499587700	Camshaft oil seal installer	X				X	X	
18251AA000	Valve guide adjuster						X	
499765700	Valve Guide remover						X	
499765900	Valve Guide reamer						X	
499977100	Crank pulley wrench				X	X	X	X
18252AA00	Crankshaft socket						X	
499587500	Oil seal installer					X	X	X
18329AA000	Shim replacer assemble						X	
18233AA000	Piston pin circlip pliers						X	
398744300	Piston guide	X						
499097700	Piston pin remover assembly	X				X		X
499207400	Camshaft sprocket wrench	X				X		
499977300	Crank pulley wrench	X			X			
499987500	Crankshaft socket	X			X			
499587600	Oil seal guide	X						X
499597200	Oil seal guide	X						X
498187200	Shim replacer	X					X	
499767700	Valve guide adjuster (intake)					X		
499767800	Valve guide adjuster (Exhaust)					X		
499817100	Engine stand (2)	X				X		
49949700	Torx plus					X		
499097600	Piston pin remover assembly				X			
498187100	Shim replacer kit				X			
42099AE00	Fuel line connection remover						X	X
18232AA000	Engine stand						X	
498277200	Flywheel stopper	X		X	X	X	X	X
18354AA000	Valve rocker holder 2006 phase two non-turbo							
18258AA000	Spring Installer 2006 phase two non-turbo							

Service Bulletins

No.	Date	Title	Subject
02-90-94R	12/02/94	95MY Legacy with engine numbers between and including 003167 through 042715	Engine oil pump leaks
01-143-96	12/23/96	Recommended sealants and adhesives	
02-92-03	11/28/03	All Legacy H-6 Models	Crankshaft pulley and cover Modification
02-93-04	11/05/04	Legacy, Impreza and Forester Vehicles	Modification of timing belt tensioner bracket
02-94-05	02/02/05	1999~04MY Forester 2.5L SOHC N/A, 1999~04MY Impreza 2.5L SOHC N/A, 2000~04MY Legacy 2.5L SOHC N/A (Except 2004MY Legacy U5 specifictation vehicles)	Revised cylinder block spectifications
02-95-05	03/25/05	1997~99 Legacy; 98MY Forester; 98MY Impreza with 2.5L DOHC engines	Hybrid Engine Short Block Release
02-96-05	09-19-05	Remanufactured SOHC short block release	Various SOHC shrot block availability
02-95-05R	09/22/05	1997~99MY Legacy; 98MY Forester 98MY Impreza with 2.5L DOHC engine	2.5L Remanufactured DOHC short block release
02-97-05	10-06-05	04MY Forester 2.5L turbo; 04MY Baja 2.5L turbo; 04MY Impreza STi 2.5L turbo	Active valve control system (AVCS) union screw filter
09-42-05	04/15/05	All Models	Cautions concerning engine coolant
09-39-04	05/07/05	2005MY Legacy & Outback vehicles	Engine coolant system refilling

Tech TIPS

Date	Subject
02/95	Idle quality complaints on '95 Legacy
02/95	Synthetic engine oil
04/95	Engine testing-back to basics
07/95	Synthetic lubricant usage - updated information
10/95	Oil viscosity change for 1996 Subaru vehicles
01/96	2.5 Liter motor engine knocking or tapping noise
09/96	1997MY engine noise
09/96	Legacy 2.2L and Impreza 1.8L, 2.2L engine oil filling
10/96	Welcome to shim city
04/97	New cam belt tensioner
08/97	Assembling 1997 and Newer engines
10/97	Molybdenum coating on pistons
11/97	Engine noise
11/97	2.5L engine cylinder head bolt tighting sequence
05/98	Legacy engine belt guides
09/98	1996 2.5L exhaust valves
10/98	2.2L front crankshaft oil seals
11/98	1999 Legacy short blocks
01/99	Leaking front crankshaft oil seals
03/99	SIA installed engine oil
04/00	2000MY spark plug application chart (revised 01-31-00)
08/00	Engine noise when cold
01/01	Oil pumps - replacement vs resealing
02/01	3.0L 6 cylinder engine valve train servicing
02/01	Engine noise when cold
05/01	Three Bond 1280B
06/01	2002MY WRX Turbo cool down procedure
03-04/02	Oil filters: H-4 versus H-6 engines
08/02	2.0L Camshaft cap torque correction
09-10/02	DOHC Turbo valve specification
01-02/03	Radiator hose leakage
01-02/03	SOA Replacement ignition wire set
05/03	Coolant seepage from water pump
05/03	2004 Baja and Forester turbo engine oil filters
07/03	Cambelt tensioner replacement

Tech TIPS

Date	Subject
07/03	Vehicle Re-engineering/modifying
11/03	Head gasket repairs
11/03	Oil filter application clarification
12/03	ISC valve cleaning
01/04	Engine noise
04/04	Cruise control cable retainer clip (WWQ-01 campaign)
04/04	H-6 Engine cover torque
08/04	Pressure washing of vehicle engine compartment- All models
09/04	ODS code 29
03/05	Intercooler spray tank
07/05	Oil classification change for 2006MY vehicles
08/05	Shortblocks replaced under warranty
09/05	LH cylinder head assembly /CHANGED PN 11063AB120
10/05	Safe handling of sodium filled valves
04/06	Platinum spark plug change intervals

NOTES

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Technicians Reference Booklet

Brake Systems Series Module

Module 501

MSA5P0170C

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of March 2002.

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Slide Sequence

Introduction

This Technicians Reference Booklet introduces the brake systems used on Subaru vehicles. It covers the component operation, trouble-shooting, diagnosis, and service precautions and procedures. This information is presented with special emphasis on procedures, tools and materials unique to the Legacy, Forester and Impreza vehicles. Subaru-specific servicing procedures and precautions are also included in this booklet.

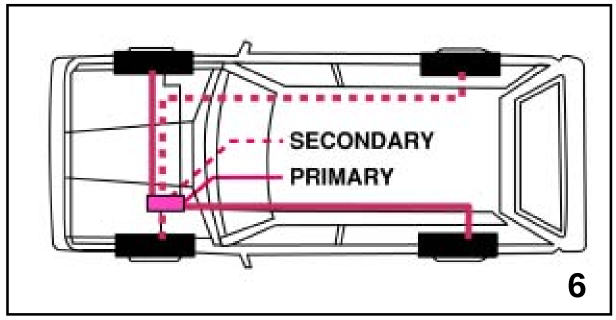
The text and illustrations are derived from and follow the classroom lectures and slide presentations. They are intended to supplement and reinforce classroom instruction and to serve as a home-study reference source. Lists of applicable Service Bulletins, important notes and cautions, and Special Tools are included within this booklet. Pages for noting additional Diagnostic Tips and Notes are also provided.

Technicians Worksheets are to be completed during the hands-on lab work segments of the Brake System Module.

Always refer to the appropriate model year Subaru Service Manual and the Applicable service bulletins for all specifications and detailed service procedures.

General Overview

SUBARU Brake Systems Overview



Dual diagonal brake system

All Subaru vehicles are equipped with a dual diagonal brake system. A master cylinder feeds a crisscross hydraulic circuit consisting of a primary circuit and a secondary circuit. Braking force is transmitted to the right-front and the left-rear brakes by the primary system. Braking force is delivered to the left-front and the right-rear brakes by the secondary system. This safety feature not only provides even braking, but also provides balanced braking in the event of failure of one of the circuits.

Disk Brake Overview

All disc brakes are self-adjusting and feature a single or dual piston in a free floating caliper design. The type of caliper used depends on model type and trim level.

Front Disk Brake

Front disc brakes feature a ventilated disc which has high heat dissipation and superb braking stability. Due to the nature of their design, disc brakes quickly restore the original braking performance when wet.

Rear Disc Brake

Rear disc brakes features are similar in a solid rotor design brake mechanism.

All current Subaru vehicles equipped with a rear drum brake system will be of the self adjusting type.

Front Disk Brakes

Disk brakes on Subaru vehicles feature self-adjusting, single piston or dual piston, free-floating calipers that slide on pins. The calipers are designed to provide easy access to the pads. The pads are equipped with wear indicators that begin to squeal when the pad wears to a specific minimum pad thickness. Ventilated front rotors keep the brakes cooler. Solid rotors are used with rear brakes.

When the brake pedal is depressed and hydraulic pressure is supplied to the caliper, the piston slides through a flexible square-cut seal to push against the inside pad, and the caliper body is pulled against the outer pad. As the pad wears, the piston slides farther through the seal to take up the slack.

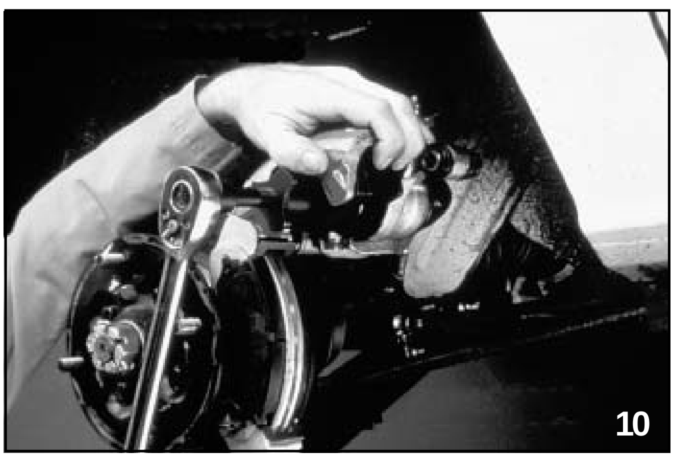
When the brake pedal is released, the piston is pulled away from the pad by the force of the seal returning to its normal square shape.

Pad Replacement Procedures

When replacing disc brake pads, follow the steps listed below. Always replace the pads in sets of four. Remember that the brakes are free-floating; guide pins and the sliding surfaces of the pad and clips must be properly lubricated, and sufficient clearance must exist between the top pad and the holder.

1) Remove the lock pins and raise the caliper
2) Remove the pads
3) Loosen the bleeder screw and push the piston in the cylinder
4) Install new pads
5) Reinstall the caliper and the brake cable

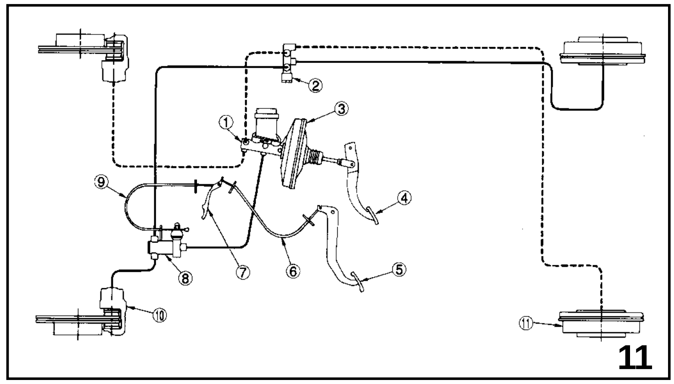
NOTE: IF THE PAD FITS TIGHTLY IN THE PAD HOLDER, RAPID PAD WEAR CAN OCCUR.



Depressing caliper piston (older)

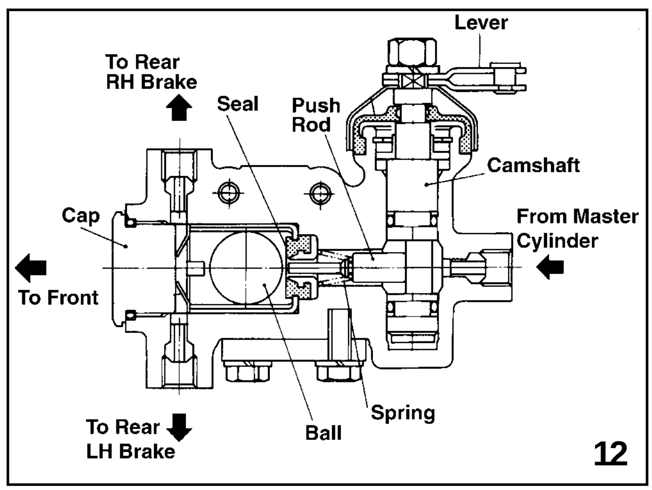
Because the new pads will be thicker than the old ones being replaced, the caliper piston needs to be retracted in the caliper body. Before pushing the piston back into the caliper, loosen the bleeder screw. After the pads are replaced and the brake calipers are reassembled, depress the brake pedal several times to take up the slack between the caliper piston and the brake pad before test-driving the vehicle.

Hill Holder (TM) system



Hill-Holder™ system

Subaru brake systems also incorporate a unique Hill-Holder (TM) system. It is standard equipment on all 1990 to 1994 Legacy vehicles with manual transmissions. The system prevents rollback when the vehicle is starting on an uphill grade. The heart of the Hill-Holder (TM) system is the pressure hold valve (PHV). Connected in series with the primary circuit, it works in conjunction with the clutch pedal via a linking device to hold pressure in the primary hydraulic brake circuit.



Pressure hold valve

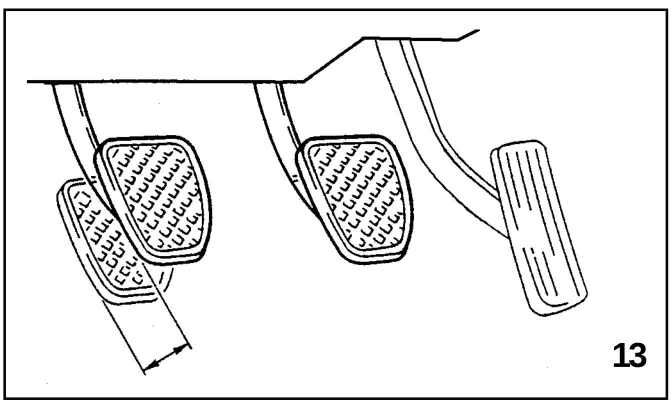
When the vehicle comes to a stop on an uphill grade greater than or equal to 3 degrees, a push rod inside the PHV retracts when the clutch is depressed. This permits a ball in the PHV to roll backwards to seal hydraulic pressure in the primary circuit. When the brake pedal is released, the pressure trapped in the primary circuit by the ball holds the vehicle stationary. When the clutch pedal is released, the push rod extends once more to unseat the ball and release the hydraulic pressure.

NOTE: THE PHV IS NON-SERVICEABLE AND MUST BE REPLACED AS A UNIT.

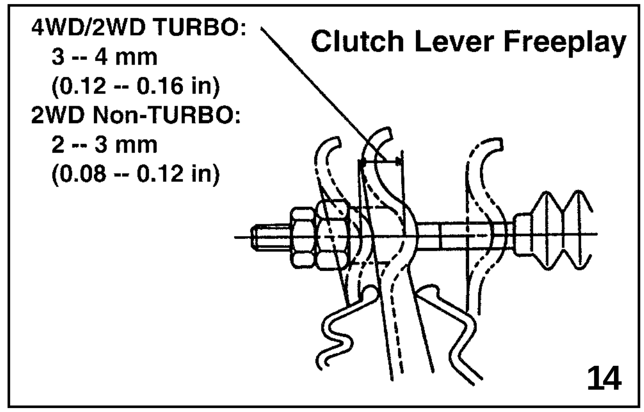
Hydraulic Servicing Precautions

When servicing any of the hydraulic components, follow these precautions carefully.

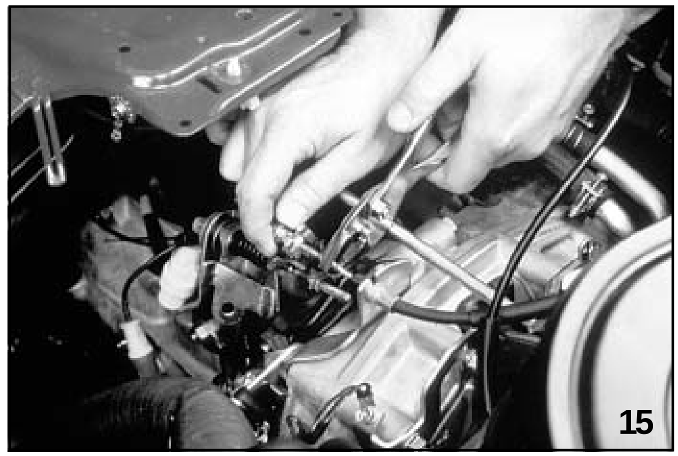
1) Use DOT 3 or DOT 4 brake fluid.
2) Clean internal brake components with alcohol. External brake components may be cleaned with brake clean type solvents.
3) Use specified lubricants.
4) Do not hone aluminum cylinders.
5) Do not use silicone type brake fluids



Clutch pedal free play



Clutch lever free play



Adjusting the PHV

On 1990 to 1994 Legacy vehicles with manual transmission, check the operation of the Hill-Holder (TM) system at every maintenance interval by road-testing the vehicle. If the system does not function properly, first verify the clutch pedal free play. Check it at either the pedal or the lever and adjust as necessary. If the vehicle will not hold on an incline of 3 degrees or greater, tighten the adjusting nut of the pressure hold valve cable until proper operation is achieved. If the brakes release late, loosen the adjusting nut on the PHV.

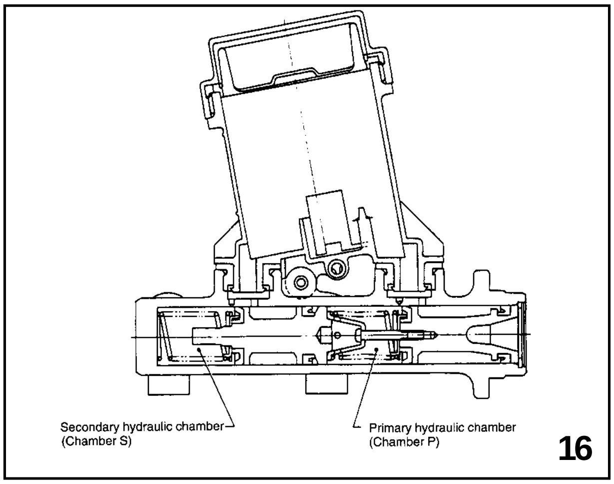
NOTE: CONFIRM PROPER OPERATION BY ROAD-TESTING THE VEHICLE.

The PHV can also be adjusted to operate on very small inclines. Install a shim (P/N: 725807000) between the frame and the support to raise the front of the PHV.

NOTE: ONLY ONE SHIM IS ALLOWED.

Master Cylinder

A sealed reservoir tank has been adopted to extend the service life of the brake fluid

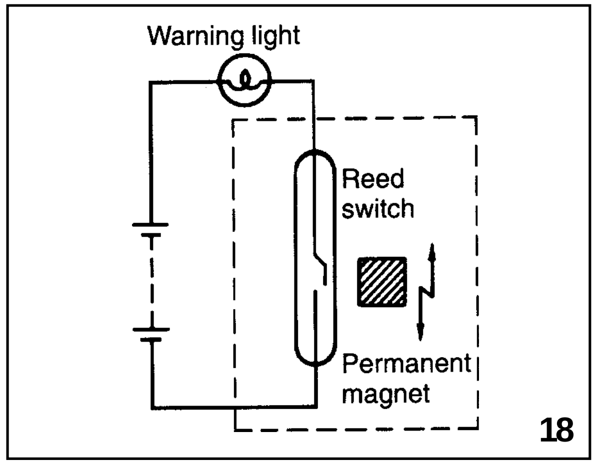


Master cylinder cross-section

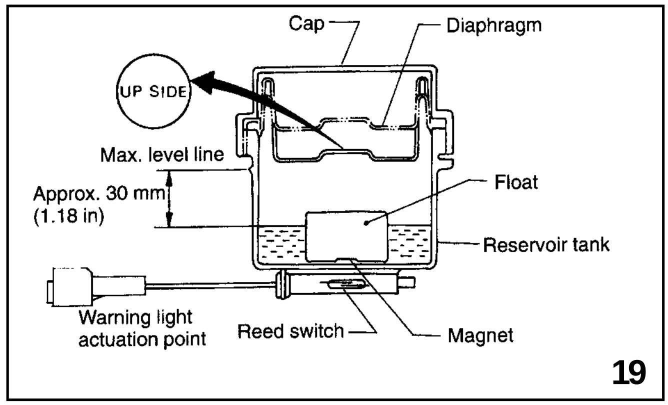
The master cylinder used in all current Subaru vehicles is divided into two chambers: Primary hydraulic chamber (Chamber P) and Secondary hydraulic Chamber (Chamber S).

Master Cylinder

The primary chamber supplies working pressure to the right-front and left-rear hydraulic circuits while the secondary chamber supplies working pressure to the left-front and right-rear hydraulic circuit. In the event of a hydraulic circuit failure, the vehicle will still maintain some braking performance.



Reed Switch Schematic



Reed Switch Construction

Brake Fluid Indicator

Components consist of a reed switch which mounts below the brake fluid reservoir and a permanent magnet housed in a float inside the brake fluid reservoir. When activated, the reed switch completes a ground circuit to turn on the brake warning lamp in the combination meter. Under normal conditions, the float remains above the reed switch, and the magnetic force from the permanent magnet in the float is unable to activate it. As the brake fluid drops, and falls below a specified level, the reed switch will be activated by the permanent magnet, completing the circuit to ground. The brake warning light may light intermittently if the vehicle tilts or swings excessively.

NOTE: WHEN THE BRAKE WARNING LIGHT ILLUMINATES:

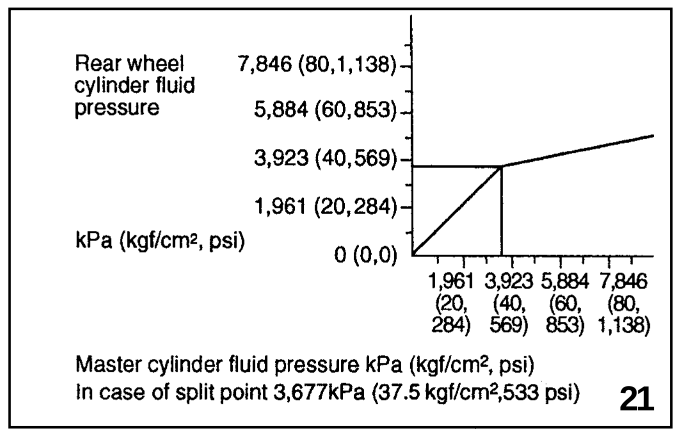
1) The Day Running Lights will not illuminate.
2) The Traction Control System will not operate.

(95 LEGACY WITH TEVES MARK IV ABS/TCS)

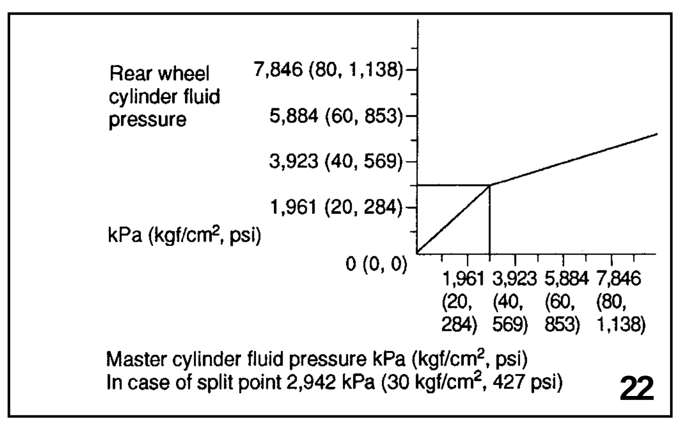
Typical Proportioning Valve

Typical proportioning valve

Another hydraulic component in Subaru brake systems is the proportioning valve.



2001 Legacy Rear drum brake and VDC model

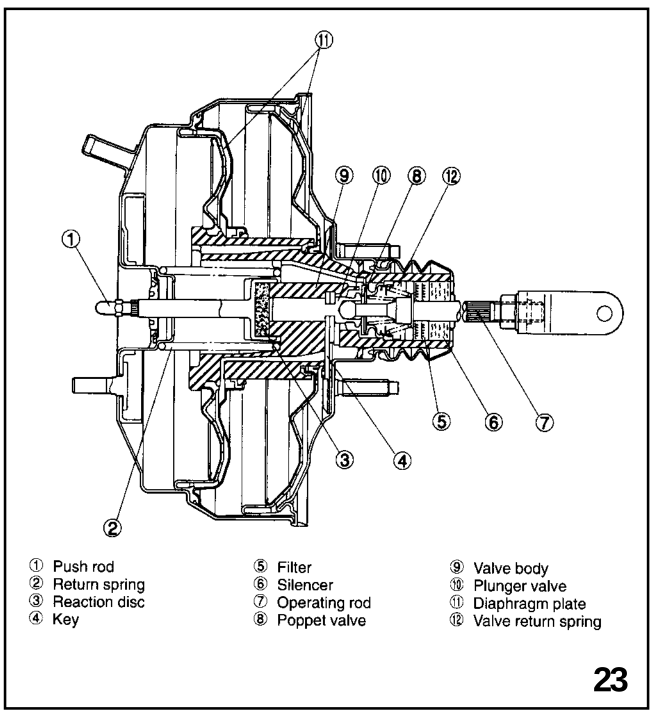


2001 Legacy Rear disc brake model

The job of the proportioning valve is to reduce the possibility of rear wheel lockup. It does this by controlling the brake fluid pressure available to the rear wheel cylinders. When the pressure in the master cylinder reaches a predetermined point, called the split point, the proportioning valve limits the pressure between the master cylinder and the rear wheel cylinders. If either the primary or the secondary circuit fails, the proportioning valve will no longer control pressure to the rear wheels. The pressure in the operative circuit will remain equal to the pressure in the master cylinder.

NOTE: SPLIT POINTS MAY VARY DEPENDING ON VEHICLE TYPE AND MODEL YEAR. ALWAYS REFER TO THE APPROPRIATE MY SERVICE MANUAL FOR THE CORRECT SPLIT POINT SPECIFICATIONS.

Brake Booster

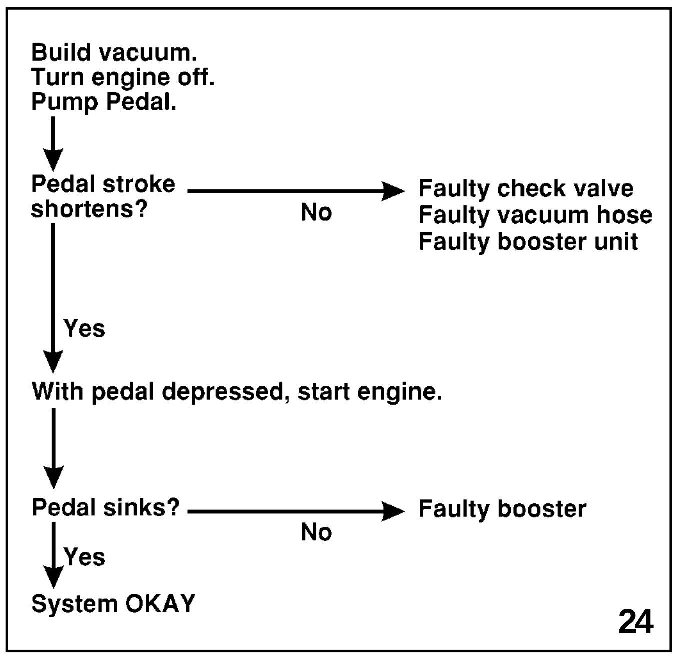


Brake booster

The brake booster, which is attached to the master cylinder, provides vacuum assist to the brake pedal. Manifold vacuum provides the negative pressure to one side of a diaphragm that is connected to the brake pedal linkage. Atmospheric pressure then assists in pedal application. A check valve in the vacuum line traps the vacuum in the booster unit. This ensures booster operation even when manifold vacuum is low.

NOTE: THE BRAKE BOOSTER IS NON-SERVICEABLE AND MUST BE REPLACED AS A UNIT. THE CHECK VALVE MAY BE REPLACED SEPARATELY.

Check the booster operation by following the steps listed below:



Booster check

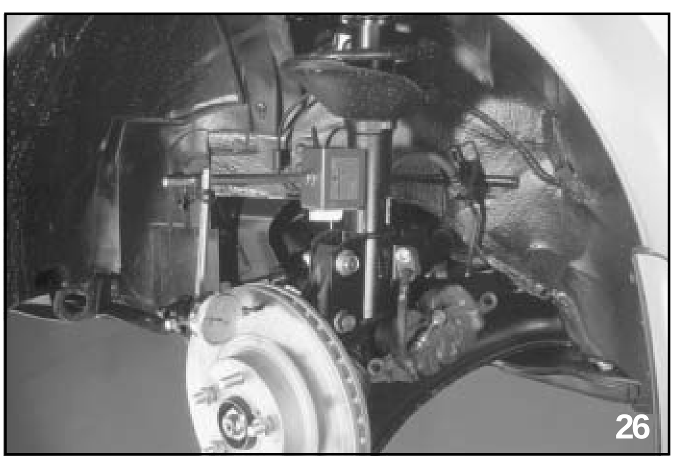
Disc Brake Inspections

Measuring rotor thickness

When servicing disc brakes, always make the following inspections: Measure the pad thickness, rotor thickness, rotor runout, and rotor parallelism.

Parallelism
thickest rotor measurement – thinnest rotor measurement $\leq$ *.0008*

A visual inspection will probably suffice for determining the remaining pad thickness, but rotor thickness should be measured near the center of the rotor with a micrometer. Specifications for rotor thickness may vary from year to year, so consult the appropriate service manual for proper specifications.

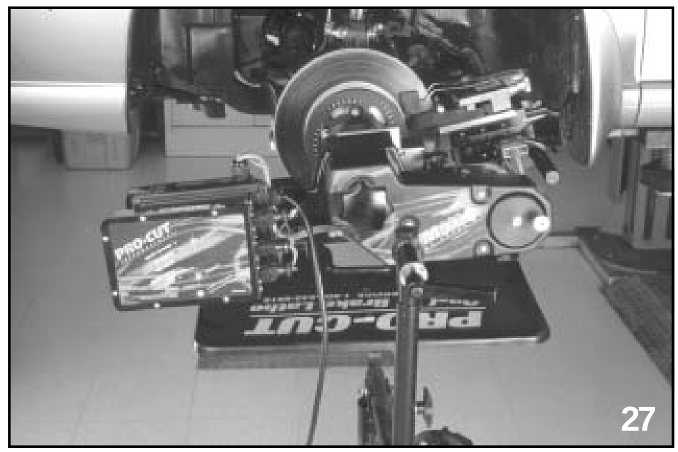


Measuring rotor runout

Rotor runout should be measured within 0.20 inches (5mm) of the outer edge of the rotor. Consult the service manual for the acceptable runout limit. If runout is not within the acceptable limit, machine the rotor within specifications if possible. Do not machine a rotor to less than the minimum thickness stamped on the rotor. Rotor parallelism must be measured at three or more places. If your measurements vary more than .0008 inch, machine or replace the rotor.

Rotor Resurfacing

If you find it necessary to service vehicle rotors, Subaru recommends on-the-car rotor resurfacing equipment.



Rotor resurfacing

Due to the nature of brake system design, resurfacing rotors with off-the-car type brake lathes often results with customers returning to with complaints of brake vibration and judder. Resurfacing rotors on-the-car can minimize comebacks because the rotor and hub are serviced as an assembly. In this manner, stacked tolerances that may have occurred with time can be compensated for. If you a resurfacing a Subaru with a trapped rotor, on-the-car service will save the time and expense of wheel bearing replacement. Subaru has tested and recommended a rotor matching system by PROCUT. Rotor matching refers to servicing the rotor and hub as an assembly. The PROCUT PFM 900 offers quick and accurate setup while proving optimum rotor finish for brake pad break-in.

ROTOR RESURFACING NOTES:

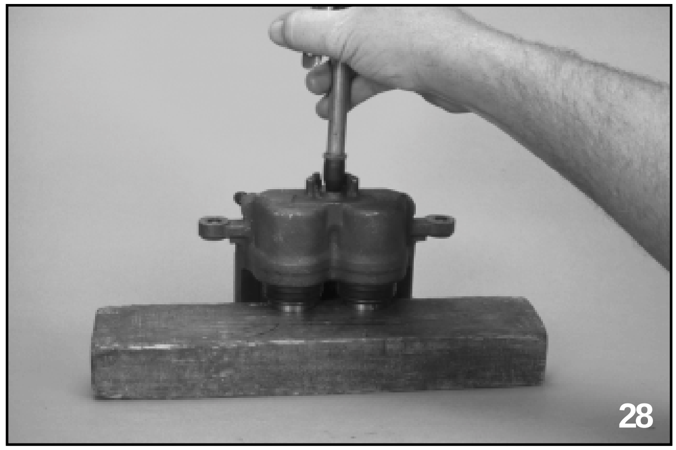
1. Remove rotor and remove any corrosion on the inner and outer hat surfaces. (Only on non-trapped design).
2. Remove any corrosion on the hub surface that mates with the rotor.
3. If the rotor must be removed after resurfacing, mark the rotor and hub so that their relative positions remain unchanged after installation.
4. Remove all metal chips from ABS wheel speed sensors and tone wheels.
5. When reinstalling wheels, use a torque wrench to tighten wheel nuts to proper specifications.

Caliper Overhaul

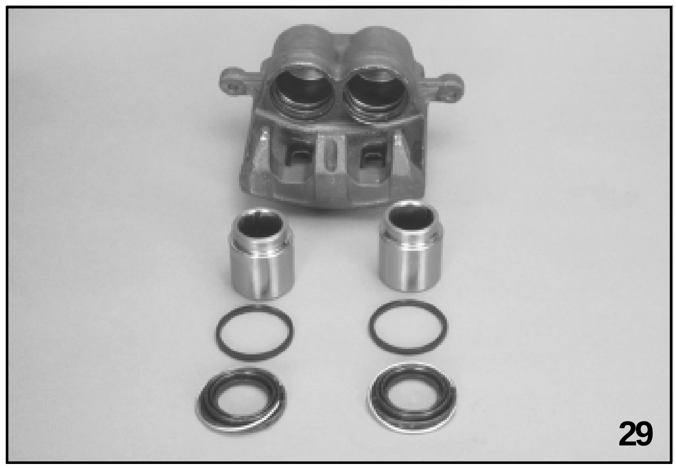
Whenever the brake system is inspected, the inspection should include checking the condition of the calipers. Calipers in need of repair can cause numerous brake problem including pulling to one side, reduced pad life, ABS not operating at optimum performance, and loss of brake fluid.

If the calipers are determined to be the cause of the problem, a caliper overhaul would then be necessary.

Caliper overhaul includes replacement of seals, dust boots, and rubber components of the slide mechanism. Caliper bores with minor corrosion may be cleaned up with a caliper hone. Deep pitting will require replacement of the caliper housing.



Piston removal



Caliper disassembled

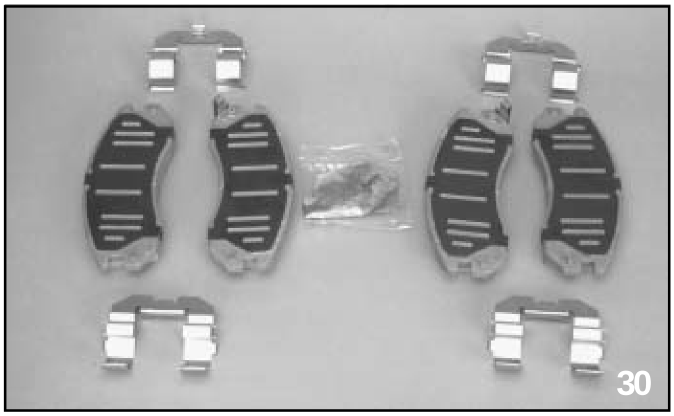
NOTE THE FOLLOWING PRECAUTIONS WHEN OVERHAULING DISC BRAKES ON A SUBARU VEHICLE:

1) Use compressed air to gradually force the piston out of the cylinder.
2) To avoid injury, keep your fingers away from the piston when forcing it out of the cylinder.
3) Avoid scratching the cylinder wall or the piston.

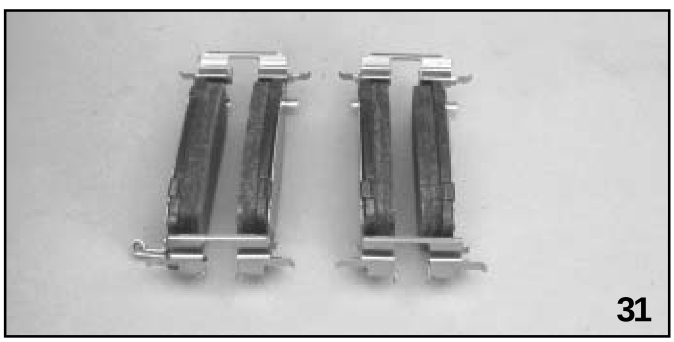
AFTER DISASSEMBLING THE CALIPER, MAKE THE FOLLOWING INSPECTIONS:

1) Check the caliper body for damage.
2) Check the piston for wear and damage.
3) Upon reassembly, use only specified greases and compounds.
4) Bleed the brake system after servicing.

NOTE: USE ONLY DOT 3 OR DOT 4 BRAKE FLUID.



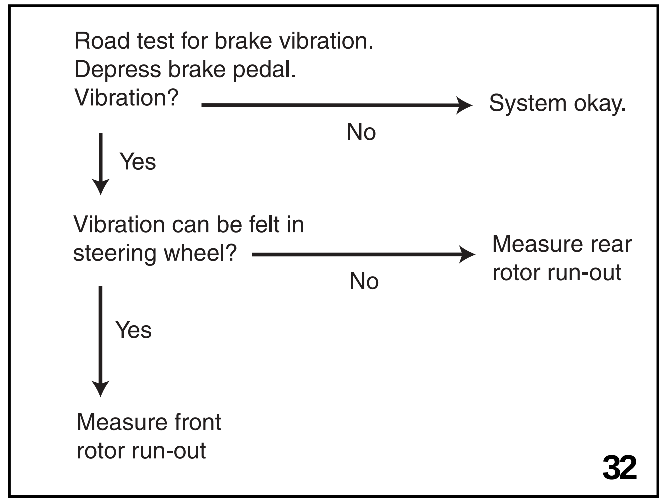
Front caliper lubrication points



Pads assembled

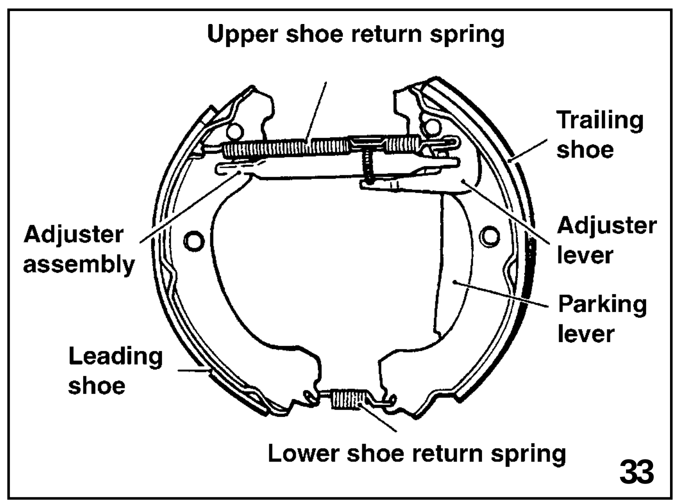
Brake System Inspection

To determine whether the source of a brake vibration is in the front brakes or in the rear brakes, road-test the vehicle. Follow the steps listed below:



Locating brake vibration source

Rear Drum Brakes

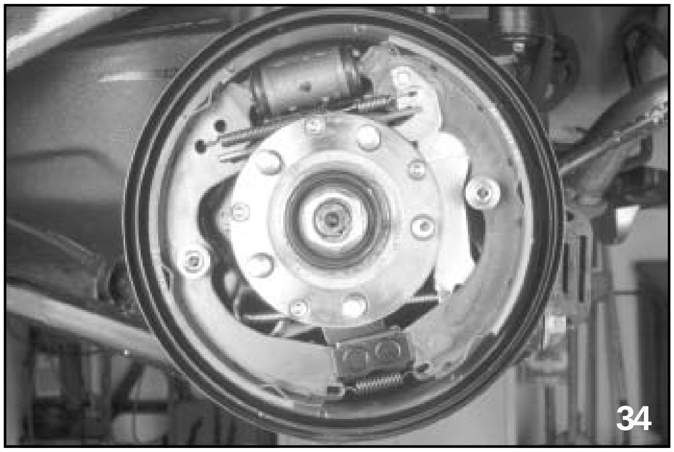


Self-adjuster operation (brakes applied)

Subaru vehicles equipped with rear drum brakes will be of the self-adjusting type. When the drum brake is activated, the self-adjuster lever travel increases. When the brake shoes are contacting, the self-adjusting lever rotates the adjuster assembly's screw to lengthen the whole assembly. This maintains clearance between the shoes and the drum to a specified value.

NOTE: THE SELF-ADJUSTING MECHANISM OPERATES EACH TIME THE BRAKE PEDAL IS DEPRESSED. THE SCREW ROTATES ONLY WHEN CLEARANCE IS EXCESSIVE.

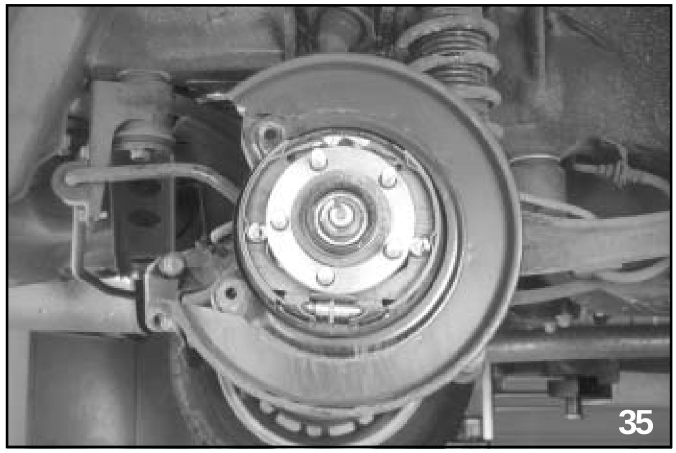
NOTE: ALWAYS RELEASE THE SELF-ADJUSTING MECHANISM BEFORE REMOVING THE DRUM.



Drum brake lubrication points

When servicing rear drum brakes, follow these precautions:

1) Pull the drum if necessary.
2) Replace large and small springs in their proper positions (large spring on top, small spring on bottom).
3) Apply specified grease to lubrication points on the backing plate.
4) Apply specified grease to the contact surface of the self-adjuster and shoe and to the inside wheel cylinder boot.
5) If the wheel cylinder is scratched, replace it. Wheel cylinders cannot be honed.
6) Wheel cylinder piston seats are not replaceable separately. The seals are available with replacement pistons only.
7) Measure the drum diameter. Note that specifications may change from year to year. Consult the appropriate service manual for specifications.
8) If drums are unevenly worn, resurface them on a brake lathe.
9) Replace the cotter pins, lock tabs, or stake nuts with new ones.



Legacy parking brake system

The Legacy, Forester, and Impreza use a rear drum type parking brake system. The drums are located in the rear disc rotors. The mechanically operated parking brake engages the shoes against the drums. When the parking brake lever is released, the shoe return spring disengages the shoes from the drum.

Parking Brake Servicing Procedures

Refer to the appropriate Subaru service manual for detailed servicing procedures.

NOTE: EACH BRAKE SHOE PARKING BRAKE LEVER MUST MOVE SMOOTHLY. DO NOT CONFUSE LEFT AND RIGHT PARKING BRAKE LEVERS AND STRUTS.

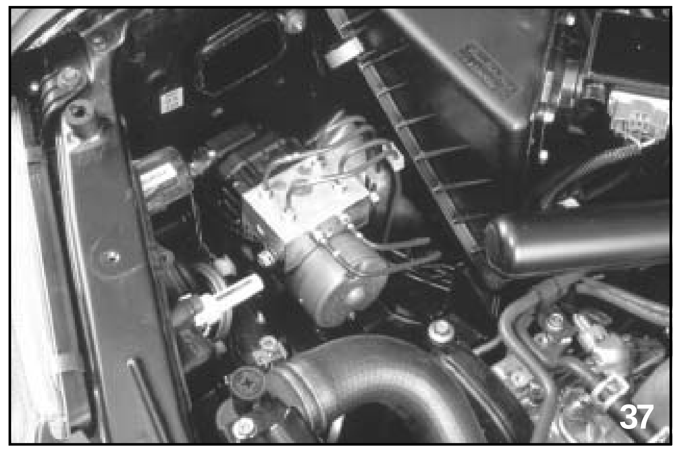
Test drive the vehicle to confirm proper operation of the brake system and also to "break-in" the parking brake linings. Maintain 15 to 20 MPH and lightly pull on the parking brake lever and release. Repeat at least five times.

CAUTION: DO NOT "LOCKUP" THE REAR WHEELS, ALWAYS PULL THE LEVER SLOWLY. DO NOT PERFORM THIS OPERATION ON PUBLIC ROADS.

Check the parking brake for the proper adjustment. Always use the appropriate service manual for exact specifications. The first step is to adjust the clearance between the shoes and drum by rotating the star-wheel located on the parking brake assembly. Then, pull up on the parking brake lever and count the number of notches until resistance is felt. If the count is out of specs, adjust the length of the parking brake cable with the adjusting nut located on the parking brake lever.

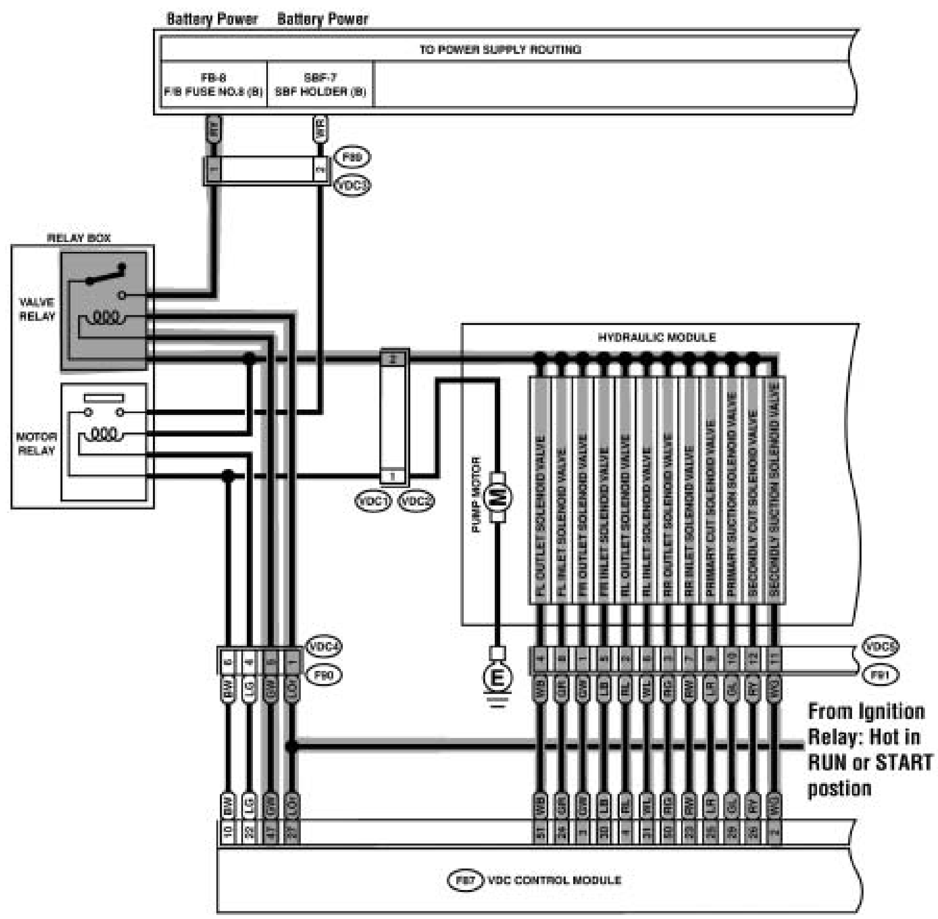
General ABS Operation

The purpose of ABS is to allow the driver to maintain directional control over the vehicle during extreme braking conditions. This is accomplished by using a **H**ydraulic **C**ontrol **U**nit, **Anti-lock B**rake **S**ystem **C**ontrol **M**odule, G-Sensor and wheel speed sensors to determine impending wheel lockup. If wheel lockup is detected, hydraulic pressure to the affected wheel is modulated until wheel slip is controlled.



Hydraulic control unit

The HCU contains an electrically controlled motor plunger/pump. Depending on the ABS model, Subaru HCU's will have three, four, eight, or ten electrical solenoids to help control brake application when ABS is active. To activate a solenoid, it must receive battery voltage and a ground signal. The solenoids receive battery voltage from a valve relay. The valve relay is energized by the HCU. The HCU energizes the valve relay at vehicle start up and remains energized unless the ABSCM detects a problem in ABS circuitry. Upon seeing a fault, the ABSCM de-energizes the valve relay interrupting the power supply to the solenoids in the HCU. Under normal driving conditions, the valve relay remains energized at all times. You can see this information displayed on your Select Monitor. (Only on ABS systems that are Select Monitor compatible).



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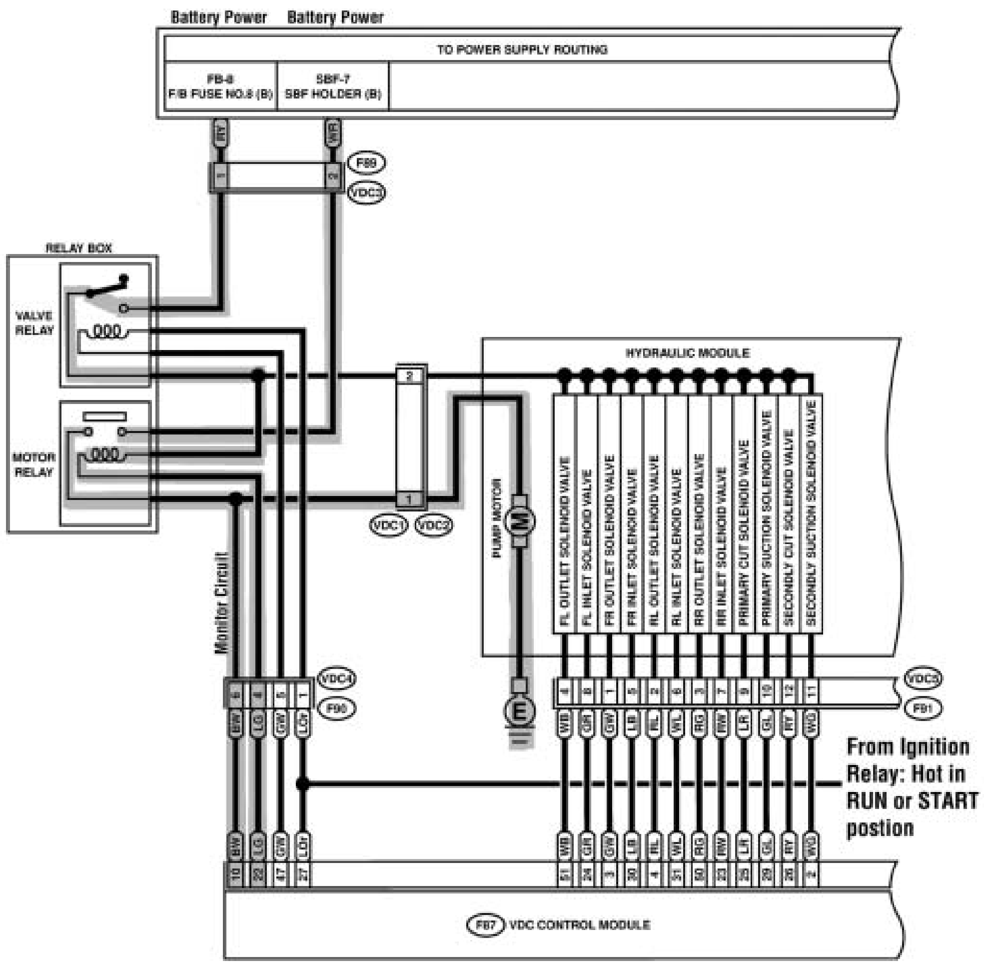
Valve relay circuit

The solenoids receive their ground signal directly from the ABSCM. In actual operation, the solenoid receives constant power and the ABSCM activates a solenoid by providing a path to ground.



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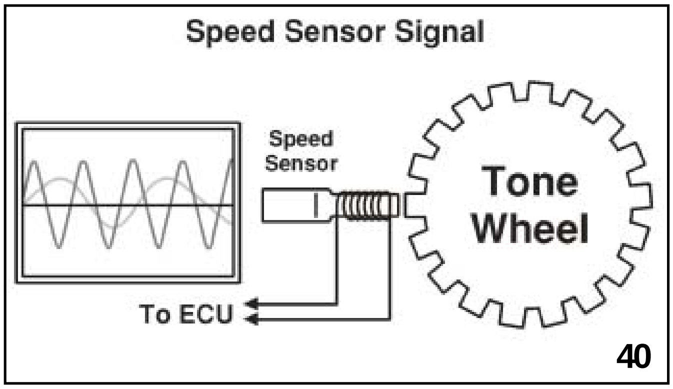
Motor relay circuit

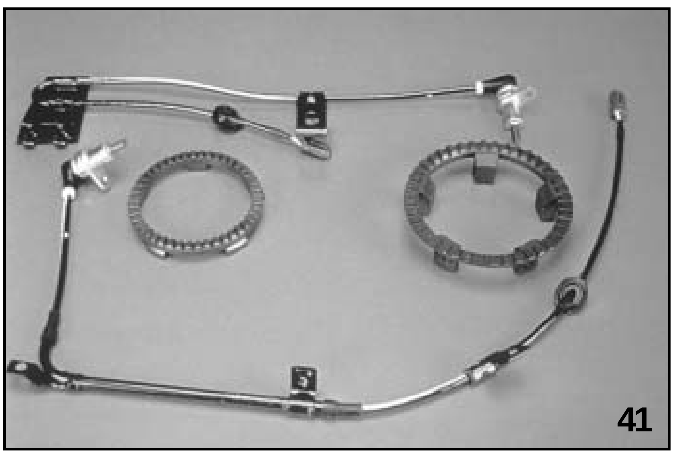
The HCU’s on Subaru ABS systems contain a pump motor which operates a hydraulic pump inside the HCU. The pump motor has a constant ground and receives power from a motor relay. The motor relay is energized by the ABSCM. The only time the ABSCM will energize the motor relay is when ABS is controlling the braking action of the vehicle and during a self-check during initial vehicle start and drive. This can be observed on your Select Monitor. (Only on ABS systems that are Select Monitor compatible)

Wheel Speed Sensors/Tone Wheel

The wheel speed sensor is constructed by coiling fine copper wire around a permanent magnet. A notched tone wheel is attached to each axle or hub and acts as a reluctor which modulates the magnetic field of the speed sensor. The voltage and frequency signals correspond the speed the individual wheels.



Speed sensor operation



Speed sensor components

NOTE: SUBARU RECOMMENDS THAT THE BRAKE SYSTEMS BE FLUSHED AT 30,000 MILE INTERVALS. THIS INSURES THAT BRAKE FLUID THAT HAS DETERIORATED WITH TIME IS REMOVED FROM THE SYSTEM AND REPLACED WITH FRESH FLUID. THIS WILL HELP IN MAINTAINING GOOD PERFORMANCE FROM THE BRAKE SYSTEM.

NOTES:

ABS Quick Tips

Bosch Nippon ABS2SL

- No long term memory
- Electrical faults indicated by ABS warning lamp
- Does not communicate with Select Monitor.
- Only stores 1 trouble code at a time.
- Special bleeding procedure.
- Select Low Control.
- Codes retrieved through cutout in rug underneath passenger seat.

Teves Mark IV

- Combines ABS and TCS
- Long term memory
- Electrical faults indicated by ABS or TCS warning lamp
- Communicates with SMI or SMII
- Special bleeding procedure
- Select Low Control
- Codes retrieved by grounding diagnostic terminal and Observing TCS warning lamp or by using SMI or SMII.
- Separate ABS and TCS sequence control procedures.

ABS 5.3i

- Electrical faults indicated by ABS warning lamp
- Long term memory
- Stores up to three trouble codes
- Special bleeding procedure
- Communicates with SMII
- Select Low Control
- Codes retrieved by grounding diagnostic terminal and Observing ABS warning lamp or by using SMII
- Sequence control

Nippon ABS2E

- Long term memory
- Electrical faults indicated by ABS warning lamp
- Does not communicate with Select Monitor
- Stores up to three trouble codes.
- Special bleeding procedure.
- Select Low Control
- Codes retrieved by grounding diagnostic terminal and observing ABS warning lamp.
- Sequence control

ABS 5.3

- Electrical faults indicated by ABS warning lamp.
- Long term memory
- Stores up to three trouble codes
- Special bleeding procedure
- Communicates with SMI or SMII
- Select Low Control
- Codes retrieved by grounding diagnostic terminal and Observing ABS warning lamp or by using SMI or SMII
- Sequence control

VDC

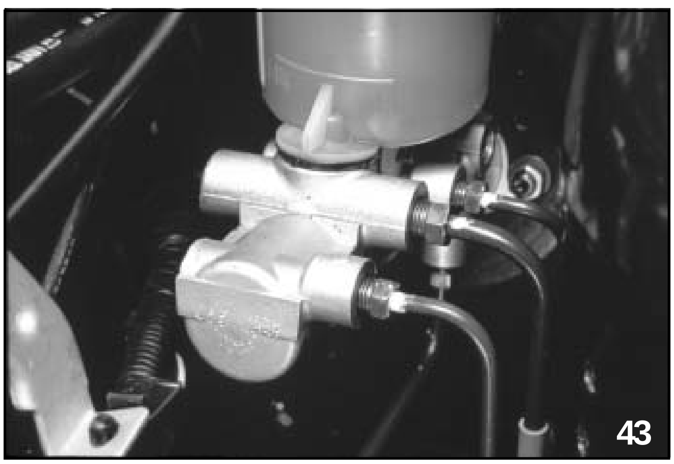
- Electrical faults indicated by ABS or VDC warning lamp.
- Long term memory
- Stores up to three trouble codes
- Special bleeding procedure
- Communicates with SMII
- Select Low Control
- Separate ABS and VDS sequence control procedures
- Special procedure to calibrate steering sensor

Teves Mark IV with ABS/ TCS

In 1995 Subaru introduced the Teves Mark IV Hydraulic Control Unit that featured both an anti-lock brake system and a traction control system. The two systems are interdependent and both systems will go into fail-safe if a common component or signal malfunctions. ABS/TCS is available on front wheel drive, U.S. and Canada spec 5MT or 4EAT equipped vehicles only. Manual transmission vehicles with TCS cannot be equipped with a hill-holder because of hydraulic piping layout and TCS operation.

Master Cylinder

The master cylinder inside diameter is 1 1/16 inches. There are 4 ports located on the master cylinder. (primary, secondary and 2 for ABS/TCS).



Master cylinder - Traction control

A tandem diaphragm booster is used which is 8 and 9 inches in diameter. The pushrod of the booster protrudes inside the master cylinder, resulting in zero clearance between the master cylinder and the booster.

Hydraulic Control Unit

The hydraulic control unit assists in the control of brake fluid flow during normal braking, ABS operation, and TCS operation. The HCU contains 10 solenoid valves that route the brake fluid. They are:

1. Input Front Right (IFR) normally open
2. Input Front Left (IFL) normally open
3. Input Rear Right (IRR) normally open
4. Input Rear Left (IRL) normally open
5. Output Front Right (OFR) normally closed
6. Output Front Left (OFL) normally closed
7. Output Rear Right (ORR) normally closed
8. Output Rear Left (ORL) normally closed
9. Special Valve #1 (SV1) normally open
10. Special Valve #2 (SV2) normally open

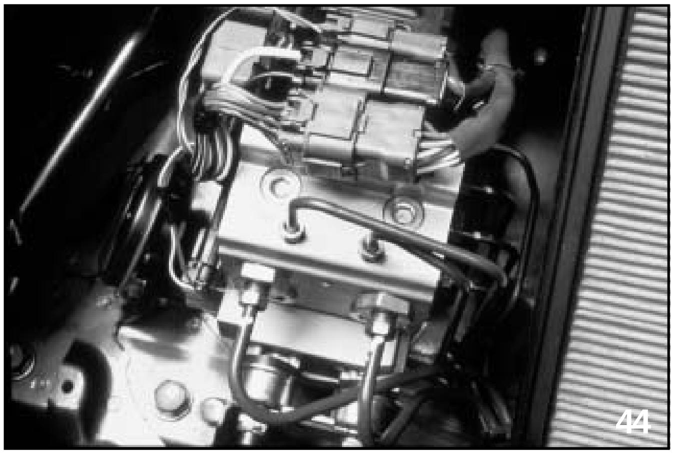
During normal braking and ABS operation SV1 and SV2 remain off (open). During TCS operation, SV1 and SV2 will turn on (closed). Each solenoid has a check valve connected in parallel with it to aid in the flow of fluid. (The solenoid design restricts flow.)

The HCU contains a motor sensor which monitors the rotation of the motor armature and produces a sine wave (2 volts peak to peak), which is sent to the ABS/TCs control module to judge motor operation.

The motor and pump assembly is used to modify brake fluid pressure during ABS operation. The motor and pump assembly activate during TCS and the pressure rise mode of ABS. Pressure generated while in the rise mode is used to apply the brakes. The motor and pump assembly will also activate during TCS operation, supplying brake fluid pressure to the left front and /or right front calipers, which is decided by the control module, to control wheel slip.

The pressure switch monitors the pressure generated by the master cylinder. The control module uses the signal from the switch to suspend TCS operation if any pressure is generated by the master cylinder. (brake applied by the driver)

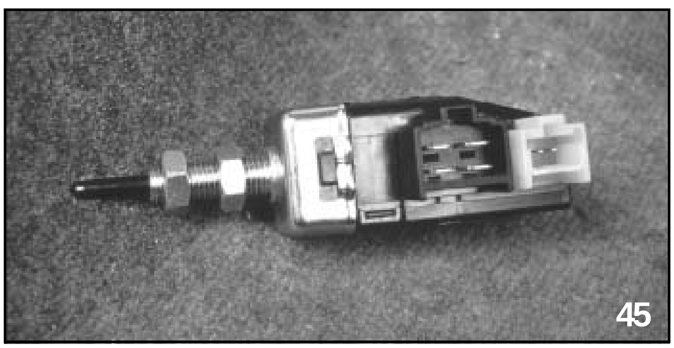
The motor relay controls motor operation via the control module.



Teves Mark IV Hydraulic Control Unit

The valve relay controls the power supply to the ten solenoids inside the hydraulic control module.

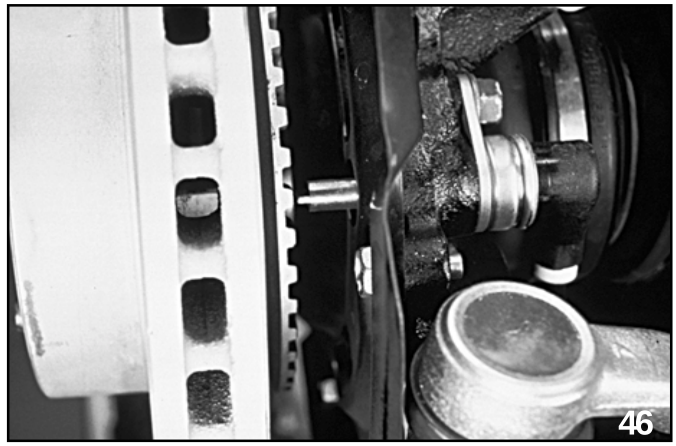
Brake Pedal Stroke Sensor



Brake pedal stroke sensor

A brake pedal stroke sensor is located at the top of the brake pedal. The sensor produces signals for the ABS/TCS control module when the brakes are applied. It consists of six 100 ohm resistors wired in series, a movable contact, and five stationary contacts. The normal resistance at rest is 100 ohms. The operating range of the sensor is 100-500 ohms. The sensor allows the control module to monitor how much effort is applied to the brake pedal. In operation , the control module will cancel TCS operation if any effort is applied to the brake pedal. (backup for the pressure switch)

Wheel Speed Sensors



Wheel speed sensor / tone wheel

Wheel speed sensors and tone wheels, which are located at each wheel, generate a sine wave which is sent to the control module. The control module then calculates the wheel speed for each individual wheel.

Combination Meter

Combination meter

The combination meter contains three lamps that will give information about ABS/TCS system to the driver. They are the ABS warning lamp, the TCS warning lamp, and the TCS operation lamp.

The ABS warning light will illuminate:

1. During the light check cycle
2. During a D-check or read memory check
3. Sequence control
4. ABS malfunction

The TCS warning light will illuminate:

1. During the light check cycle
2. TCS malfunction

The TCS operation lamp will illuminate:

1. During the light check cycle
2. While TCS is controlling the acceleration of the vehicle

TCS Off Switch

TCS off switch

There is a TCS off switch located in the dash to the left of the steering wheel. The TCS off switch is used to disengage the TCS system under conditions that it is being triggered frequently. (space saver spare tire being used) The TCS off switch is also used during the air bleed procedure.

Alight in the TCS off switch will illuminate under the following conditions:

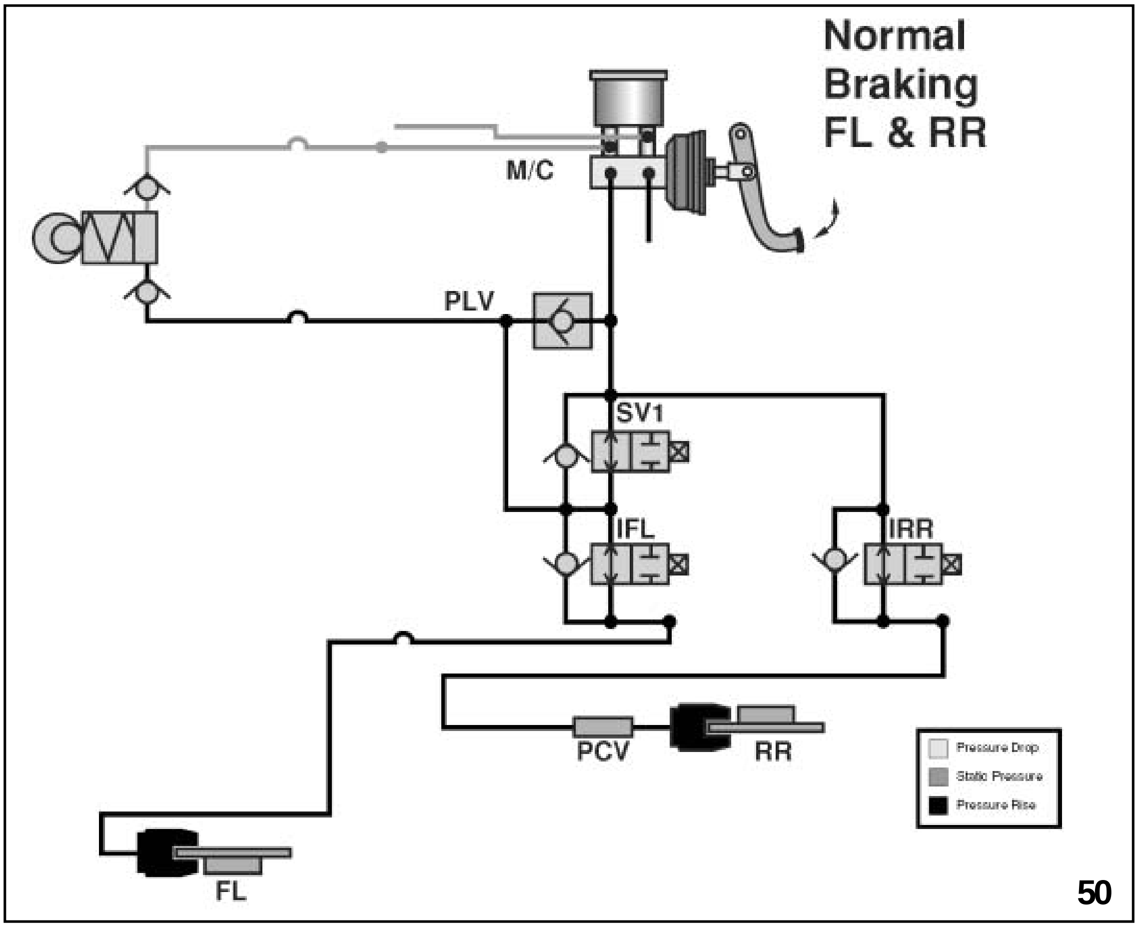
1. During the light check cycle
2. When the TCS off button has been pushed (momentary contact switch)
3. Excessive TCS operation in a short amount of time (driver continually trying to free the vehicle from snow or mud. This can overheat the brake pads and rotor. As a result. The control module will shut down the TCS to allow brake components to cool.)

ABS/TCS Control Module

ABS/TCS control module

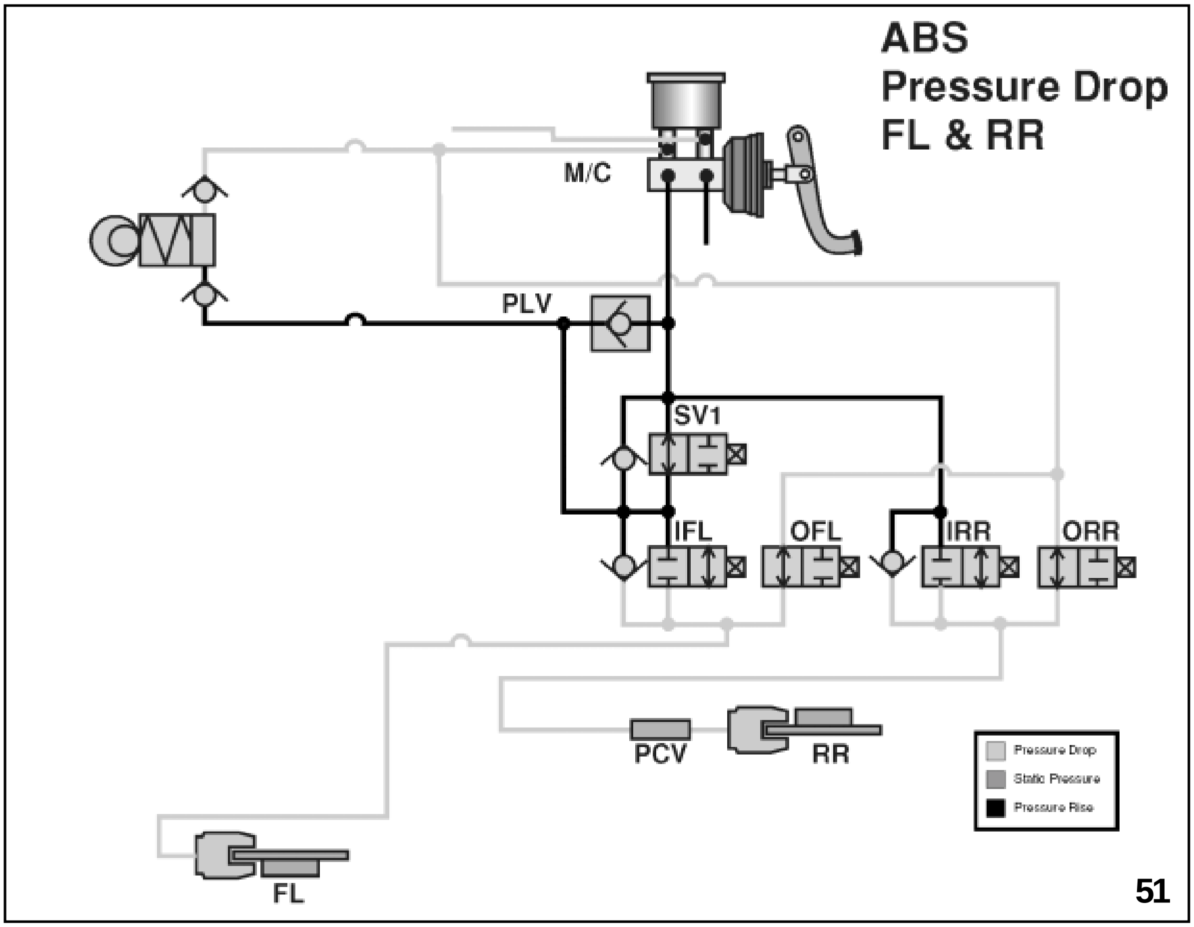
The ABS/TCS control module controls the application of ABS and TCS vehicle functions. It also networks with the engine control module during TCS operation and networks with the transmission control module during ABS operation.

Hydraulic Flow



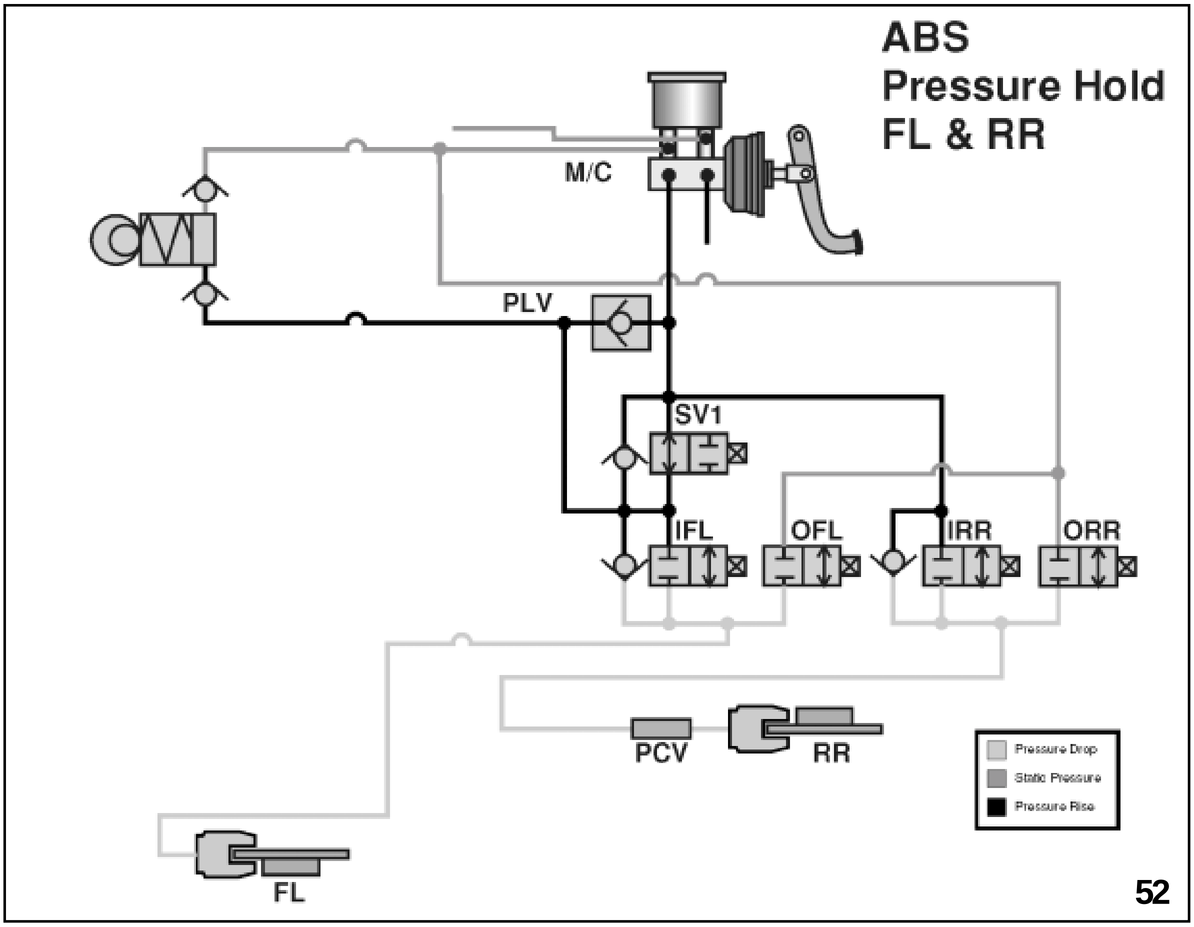
Normal braking

Normal braking – Pressure generated from the master cylinder is routed into the HCU. Fluid then flows to the IRR and through SV1, pressure from SV1 is routed into the IFL and applies the brake. Pressure from the IRR goes through the PCV and applies the rear brake. The PCV is the proportioning valve and performs the same function as past model years. The check valves are used to provide additional flow past the solenoid valves.



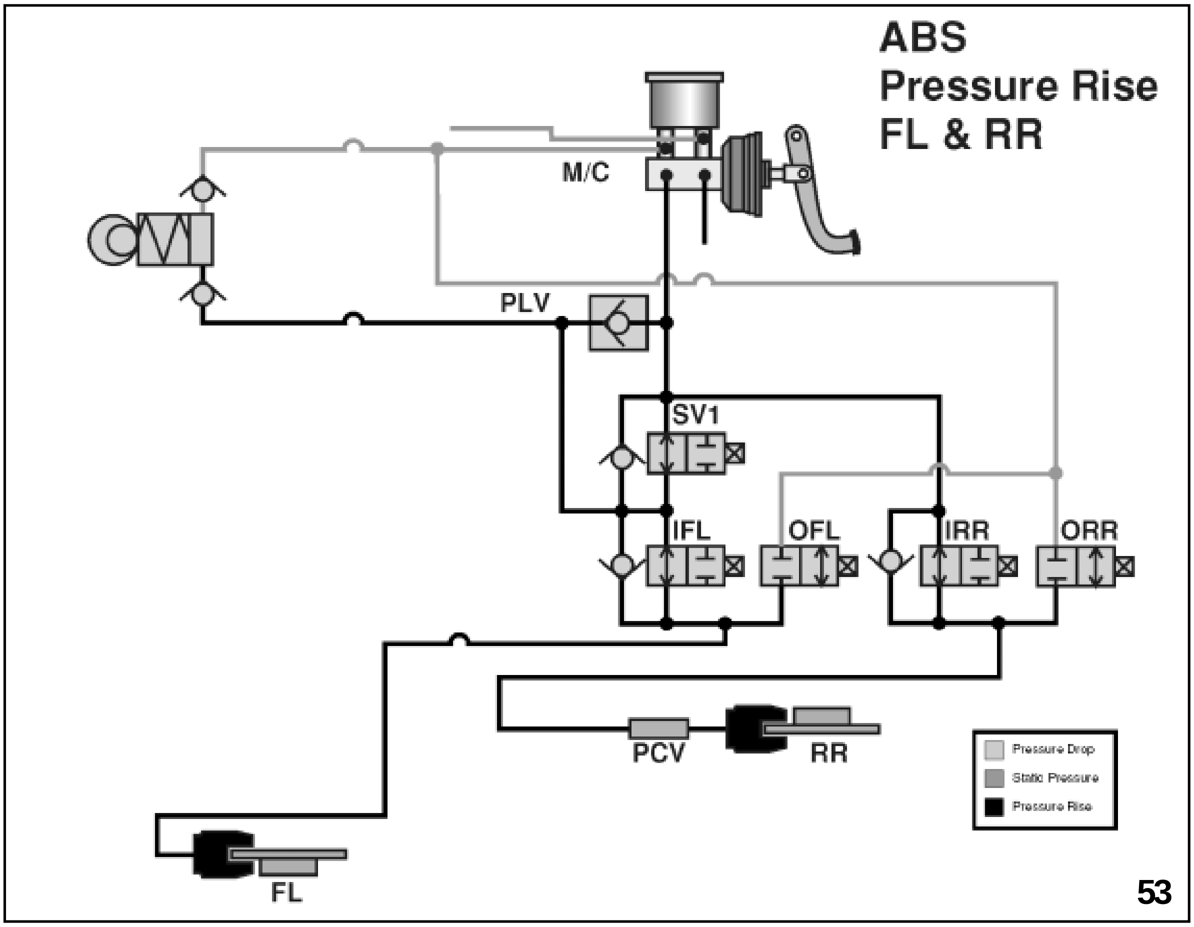
ABS braking pressure drop

ABS Braking Approaching Wheel Lock-up – Pressure drop occurs first. IFL closes, preventing master cylinder pressure from reaching the caliper or wheel. The ABS/TCS control module immediately memorizes the position of the brake pedal from the brake pedal sensor. The OFL opens and reduces the pressure in FL caliper, by providing a passage to the master cylinder reservoir. The lock-up is avoided and the wheel accelerates, the ABS/TCS now enters pressure hold mode.



ABS braking pressure hold

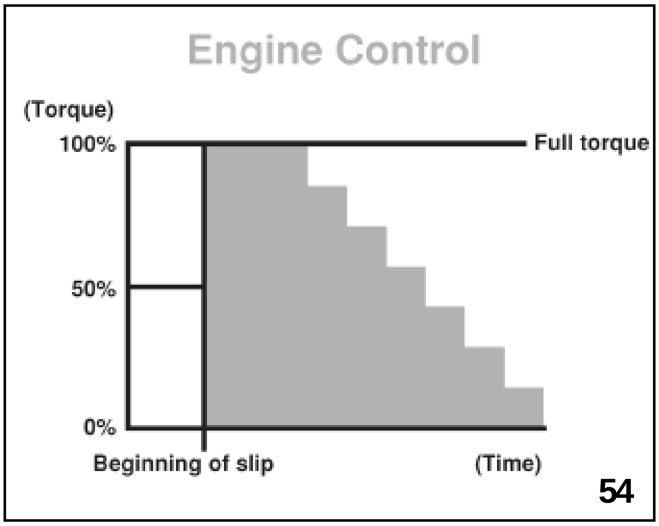
Pressure Hold – The IFL and OFL close, trapping the remaining pressure in the brake caliper. Wheel speed is then reevaluated, and the ABS/TCS will enter pressure rise or drop, depending on whether the wheel need to accelerate or decelerate.



ABS pressure rise

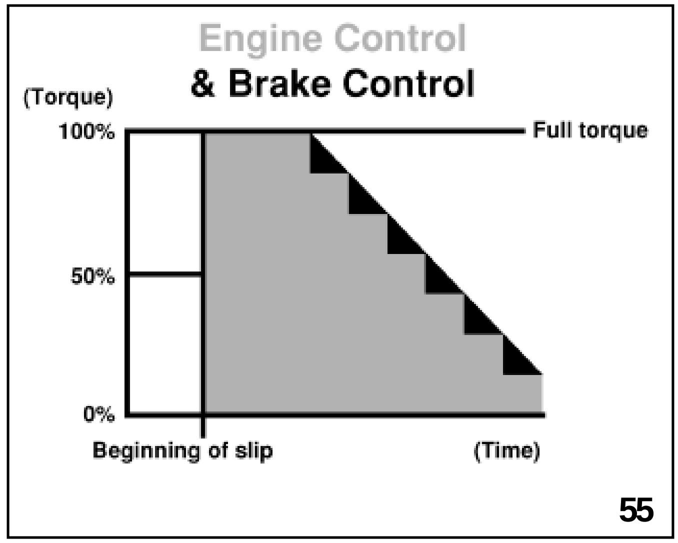
Pressure Rise – The OFL remains closed, IFL opens and the brake pedal begins to move toward the floor. The motor pump assembly activates and pressurizes the hydraulic circuit from the caliper to the master cylinder. At this point the pump output pressure is approximately 150 kgcm2, which overcomes the approximately 100kgcm2 produced by the master cylinder, and pushes the pedal away from the floor and applies the brake. The pump will continue to operate until the pedal is repositioned to the memorized location which occurred in the pressure drop mode. This action produces brake pedal kick back. Pressure drop, hold, and rise will continue until the wheel speed is nominal.

TCS Operation



TCS Logic - Engine Control

TCS improves and controls acceleration on low friction road surfaces, or when one of the driving wheels unloads creating wheel slip. The fuel and brake systems are used together to eliminate wheel slip. The objective of the TCS system is to supply the maximum driving torque to the front wheels. Monitoring of the driving torque is accomplished by observing wheel speed sensor signals. The ABS/TCS control module compares the front wheels (driving) to the rear wheels speed, which represents true wheel speed, to judge wheel slip. Wheel slip is more critical in certain driving conditions than in others. Example: Initial acceleration (high slip) and cruising (low slip), the ABS/TCS control module has nine different programs that will respond to various driving conditions.

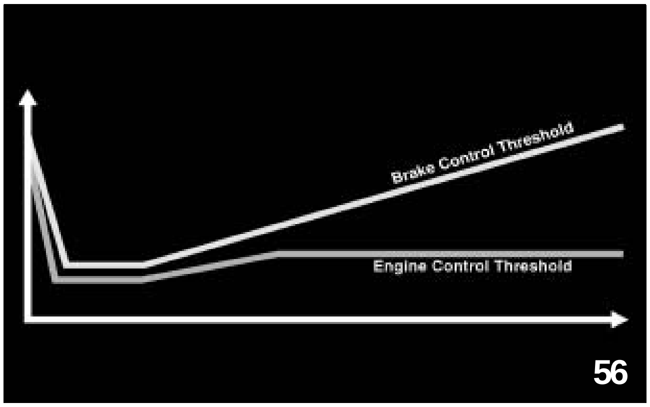


TCS Logic - Engine Control & Brake Control

Traction control is accomplished by a networking of control units. The ABS/TCS control module recognizes wheel slip, picks the program that will best begin control of it and sends a signal to the fuel injection control module. Fuel injectors are cut (turned off) to reduce engine torque. This is called “engine control”. This action alone would produce a vibration at low vehicle speeds while in low gear ratios. To counteract the vibration, the ABS/TCS control module sends signals to the HCU to apply the brake while the engine is recovering from fuel cut. The braking action called “brake control”, slows down a slipping wheel or wheels. Combined with engine control, provides a constant decrease in driving torque.

Torque, which would otherwise transmit to the slipping wheel, in the case of a one wheel slip, is now transferred through the differential to the wheel with traction. This is called a “limited slip differential effect”.

Logic

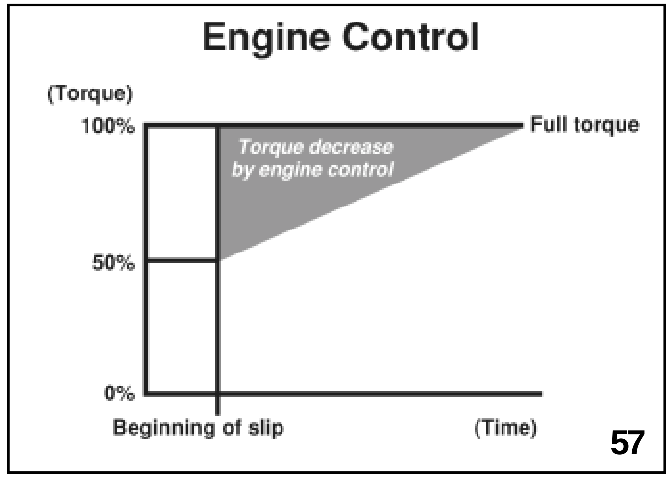


TCS Logic / Wheel slip recognition

The ABS/TCS control module recognizes one or two wheel slip under 31mph. This aspect of TCS concentrates on acceleration. When vehicle speeds are above 31mph, the TCS will focus on vehicle stability in the event of wheel slip and therefore will only recognize two wheel slip. The amount of fuel cut during engine control is dependant on vehicle speed and wheel slip speed. Large wheel slip conditions result in large fuel cuts while small wheels slips result in small fuel cuts. Initial acceleration wheel slips are not recognized until wheel slip speed is 5mph. Vehicle speeds over 31 mph have slightly higher wheel slip speed recognition.

Braking control during TCS operation results in approximately 10% of the total available braking force of the vehicle. Braking control initially occurs just after fuel cut and logic braking control wheel slip recognition parallels fuel cut wheel slip recognition until 31mph. Vehicle speeds over 31 mph result in higher braking control wheel slip recognition than engine control. The means that braking control will be delayed to give engine control time to reestablish control. This results in improved vehicle stability.

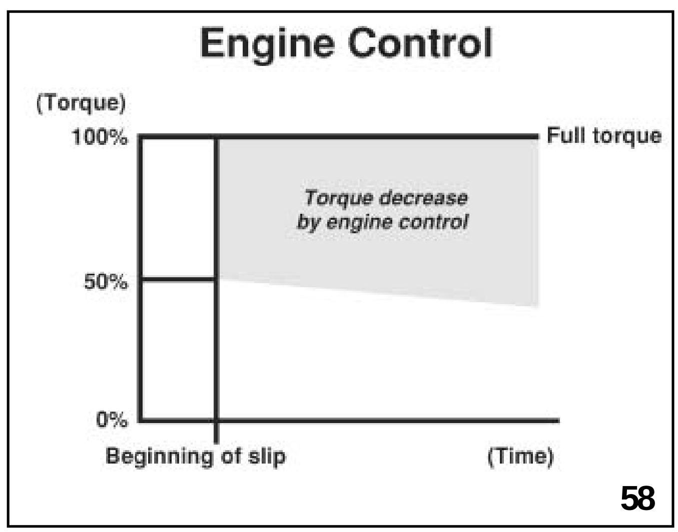
One-Wheel Slip



TCS Logic - One wheel slip

TCS engine control is determined by the severity of the wheel slip and the number of wheels slipping. One wheel slip results in a large fuel cut at first and is quickly reduced to restore torque to the wheel with traction. This concentrates on acceleration.

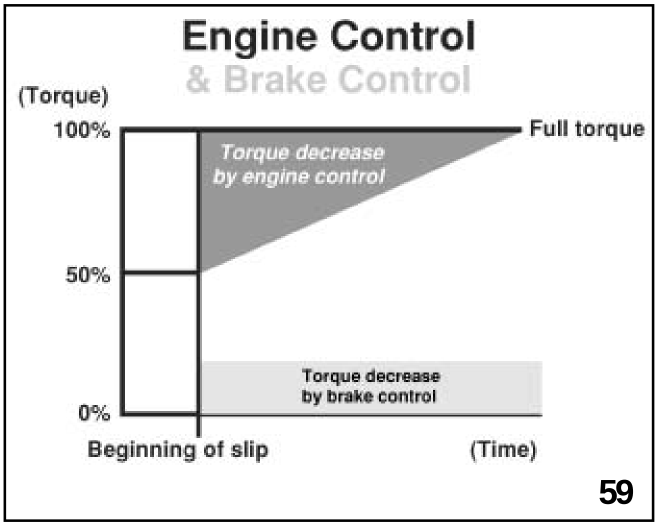
Two-Wheel Slip



TCS Logic - Two wheel slip

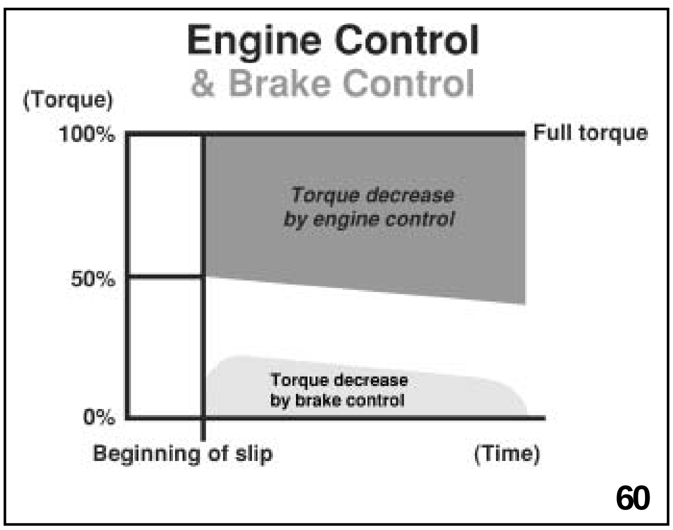
Two wheel slip results in a large fuel cut at first and increases if the slip does not decrease and decreases if the wheel slip decreases. This concentrates on stability.

TCS brake control is also determined by the severity of wheel slip.



TCS Logic - One wheel slip

The maximum amount of braking during TCS operation is approximately 10% of the total braking ability of the vehicle.

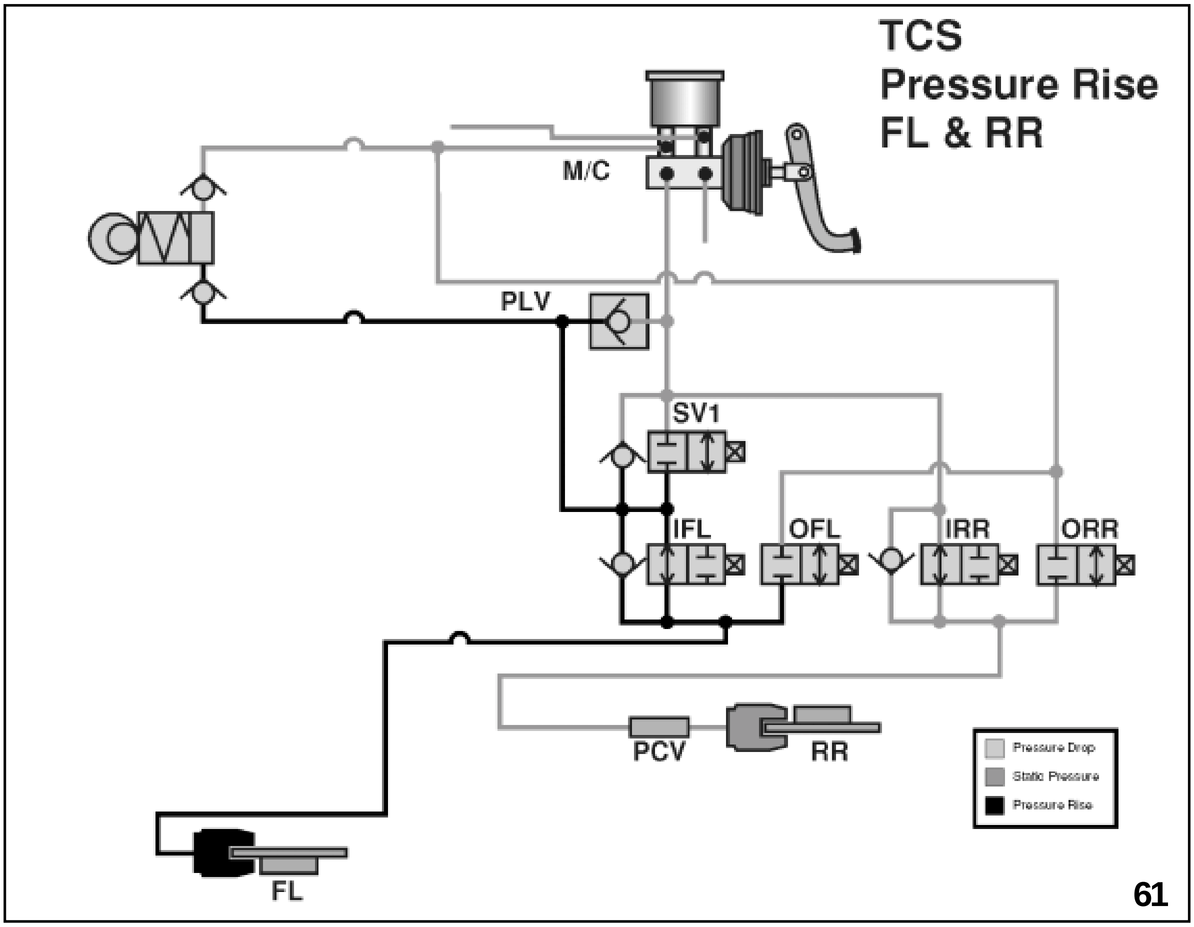


TCS Logic - Two wheel slip

NOTES:

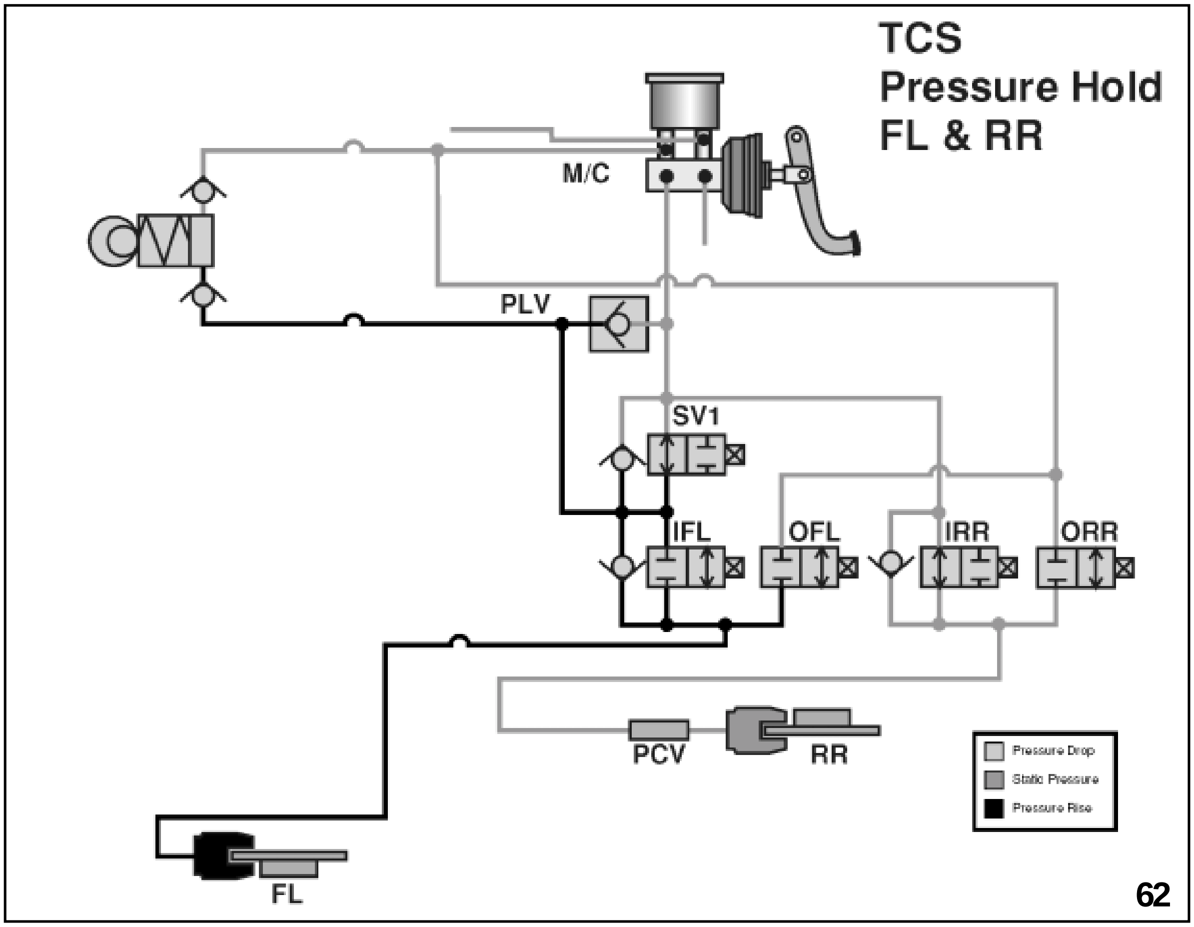
TCS Hydraulic Control

When TCS activates, SV1 and SV2 turn on and close, isolating the rear calipers so that no braking can occur in the rear. The motor and pump assembly turn on, pressurizing the brake circuit. The IFR will close if a left wheel slip is detected, allowing no braking on the FL. The IFL will close if the right wheel slip is detected, allowing no braking on the FL.

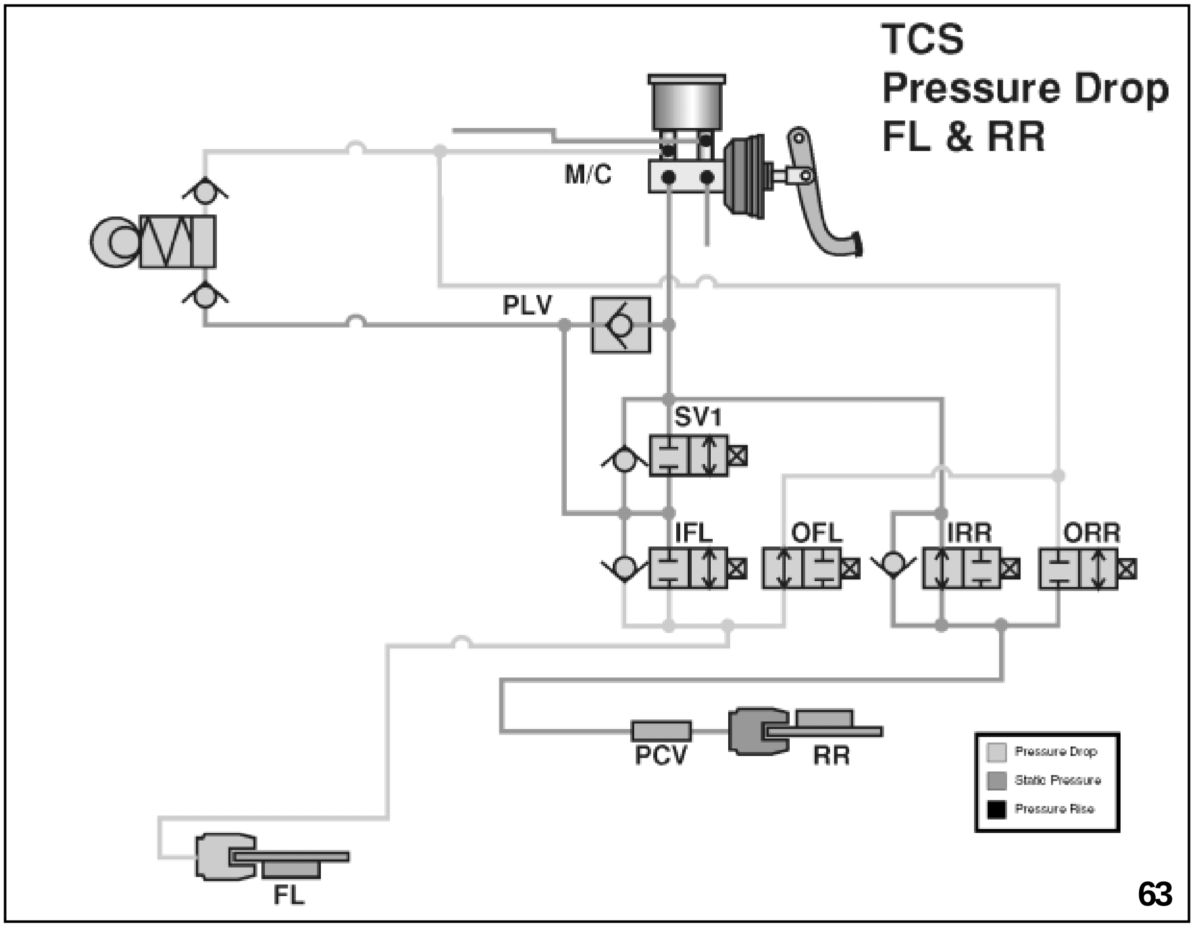


TCS pressure rise

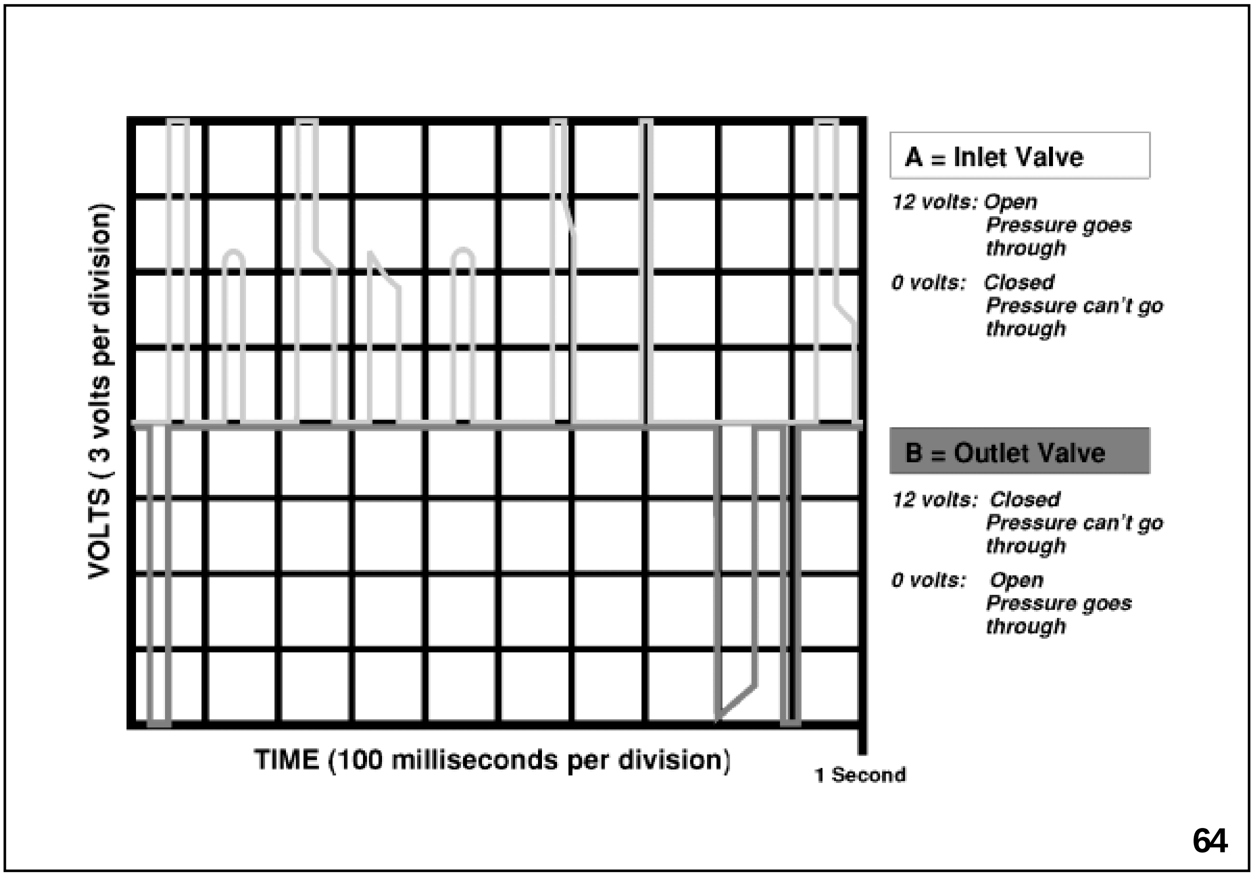
Two wheel slip will result in both inlet valves remaining open, allowing braking on the FR and FL wheels. When braking occurs during one wheel slip, the driving torque that would otherwise go to the slipping wheel is transmitted through the differential to the wheel with traction, creating a **Limited Slip Differential Effect**. During two wheel slip, the objective is to slow down both wheels, reducing driving torque.



TCS pressure hold



TCS pressure drop



TCS Logic / Valve control

Teves Mark IV Diagnostics

Diagnostics begin with verifying the complaint and doing a thorough visual inspection . The following steps should help you diagnose most complaints that did not cause an ABS or TCS warning light to illuminate. This can also help you in cases that no trouble code was stored in the memory of control unit.

1. Check battery voltage to insure battery is fully charged
2. Inspect tires for proper sizing. Ideally, all four tires should be of the same make, model, and size
3. Check air pressure in all four tires and set to specifications.
4. Check all four wheels for excessive brake drag. This could indicate sticky pistons or caliper slides.
5. Inspect all hydraulic lines for leaks and make needed repairs.
6. Inspect wheel bearings for excessive play and make needed repairs.
7. Top off brake fluid level if necessary.
8. Perform ABS and TCS sequence control procedures and compare your results to specifications in service manual.

Access Trouble Codes

Trouble codes can accessed with your NSM or by using the diagnostic connector located under the dash to the right of the steering wheel.

NOTE: THE NEW SELECT MONITOR IS THE PREFERRED METHOD FOR ACCESSING TROUBLE CODES AND INITIATING OTHER SERVICE PROCEDURES. MORE INFORMATION ON USING THE DIAGNOSTIC CONNECTOR CAN BE FOUND IN THE BRAKES SECTION OF THE 1995 LEGACY SERVICE MANUAL SERVICE MANUAL.

If codes are stored, trouble shoot according to the diagnostic charts in the service manual.

Perform the clear memory procedure with the NSM.

Test drive vehicle and verify that ABS and TCS warning lamps remain off.

Verify that no additional trouble codes have been stored.

Sequence Control

On Subaru vehicles equipped with ABS/TCS, there is a procedure called sequence control that can be performed. Sequence control has two basic functions. Sequence control allows the technician to check the mechanical condition of the pump and solenoids inside the ABS/TCS hydraulic control unit. The second function is to help purge air from ABS/TCS hydraulic control unit during a brake bleeding procedure.

There are two separate sequence control procedures that can be used on ABS/TCS equipped vehicles. The first procedure allows you to check the ABS side of the system while the second procedure allows you to check the TCS side of the system. Both sequence control procedures can be accomplished with the NSM. Go to section 4-4 page [W20D0] and [W20F0] of the 1995 Legacy service manual for instructions on how to perform sequence control with the Select Monitor. Below are normal results for ABS and TCS sequence control.

ABS Sequence Control Specifications

	Initial Value	When Decompressed	When Compressed
Front Wheel	3,432 kPa (35 kg/cm^2, 498 psi)	490 kPa (5 kg/cm^2, 71 psi) or less	981 kPa (10 kg/cm^2, 142 psi) or more
Rear Wheel	3,432 kPa (35 kg/cm^2, 498 psi)	490 kPa (5kg/cm^2, 71 psi) or less	981 kPa (10 kg/cm^2, 142 psi) or more

TCS Sequence Control Specifications

	Initial Value	When Compressed	When Decompressed
Front Left Wheel	490 kPa (5 kg/cm^2, 71 psi) or less	1,471 kPa (15kg/cm^2, 213 psi) or more	490 kPa (5 kg/cm^2, 71 psi) or less
Front Right Wheel	490 kPa (5 kg/cm^2, 71 psi) or less	1,471 kPa (15 kg/cm^2, 213 psi) or more	490 kPa (5 kg/cm^2, 71 psi) or less

Air Bleed Procedures

NOTE: ***TO THOROUGHLY BLEED THE HYDRAULIC SYSTEM THE FOLLOWING PROCEDURE MUST BE STRICTLY FOLLOWED. SKIPPING STEPS MAY RESULT IN AIR REMAINING IN THE SYSTEM. THE BRAKE PEDAL SHOULD BE DEPRESSED SLOWLY WITH AT LEAST 3 SECONDS BETWEEN EACH APPLICATION. FOR CONVENIENCE AND SAFETY, IT IS ADVISABLE TO HAVE TWO TECHNICIANS WORKING***

1. Start air bleed operation with the Select Monitor. Refer to section 4-4 [W19C0] or [W19D0} of the 1995 Legacy service manual.
2. Bleed air through RF caliper by depressing the brake pedal.
   a) Fit one end of a vinyl tube onto the air bleeder and keep the other end submerged in a container with brake fluid.
   b) Slowly depress the brake pedal and keep it depressed. Then, open the air bleeder to discharge air together with the fluid. Release air bleeder for 1 to 2 seconds. Next with the bleeder closed, slowly release the brake pedal. Repeat these steps until there are no more air bubbles in the vinyl tube.
3. Bleed air from suction pipe through RF caliper.
   a) Open the air bleeder.
   b) Keep depressing the TCS OFF switch for 20 second or more. Ensure no air comes out from bleeder.
   c) Close the air bleeder.
4. Bleed air through LF caliper by following step 2 above.
5. Bleed air from suction pipe through LF caliper by following step 3 above.
6. Bleed air through RF and LF calipers by operating brake pedal. This is the same procedure as step 2 above. Repeat steps 2 thru 6 until air no longer comes out.
7. Bleed air through RR and LR calipers by operating brake pedal. This is the same procedure as step 3 above.
8. Operate Right Front Outlet valve and Left Rear Outlet valve to bleed air from their specific circuits.
   a) Press TCS OFF switch while depressing brake pedal
   b) Make sure ABS warning light illuminates
   c) Depress and release brake pedal slowly 10 times or more while depressing the TCS OFF switch.
9. Operate Left Front Outlet valve and Right Rear Outlet valve to bleed air from their specific circuits.
   a) Press TCS OFF switch while depressing brake pedal.
   b) Make sure TCS warning light illuminates.
   c) Depress and release brake pedal slowly 10 times or more while depressing the TCS OFF switch.

NOTE: ***WHILE PERFORMING STEPS 8 AND 9, AIR WILL BE RELEASED THROUGH BRAKE FLUID RESERVOIR. THE OPERATIONS IN STEPS 8 AND 9 CAN BE SWITCHED WITH EACH OTHER BY DEPRESSING THE BRAKE PEDAL WHILE DEPRESSING THE TCS OFF SWITCH. EACH TIME THE TCS OFF SWITCH IS DEPRESSED WITH THE BRAKE PEDAL DEPRESSED. YOU WILL SWITCH FROM ONE DIAGONAL, (RF/LR) TO THE OTHER. (LF/RR)***

10. With all procedures completed, fully depress the brake pedal for approximately 20 seconds to make sure there are no leaks in the entire system.
11. Turn off the ignition switch.
12. Perform TCS sequence control.

13. Check the pedal stroke

    a) While the engine is idling, depress the brake pedal with a force of 110 lbs. and measure the distance between the brake pedal and steering wheel. With the brake pedal released, measure the distance again. The difference between the two should be less than 3.740 inches. If the distance exceeds specifications there still may be air in the system.

14. Turn off ignition switch

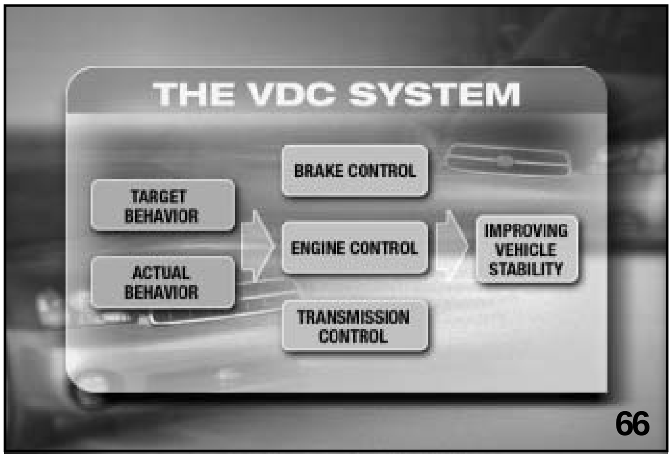
15. Disconnect the select monitor

16. Add brake fluid to the required level of the reservoir.

17. Test drive vehicle to ensure brakes provide normal braking action on all four wheels without dragging and uneven braking.

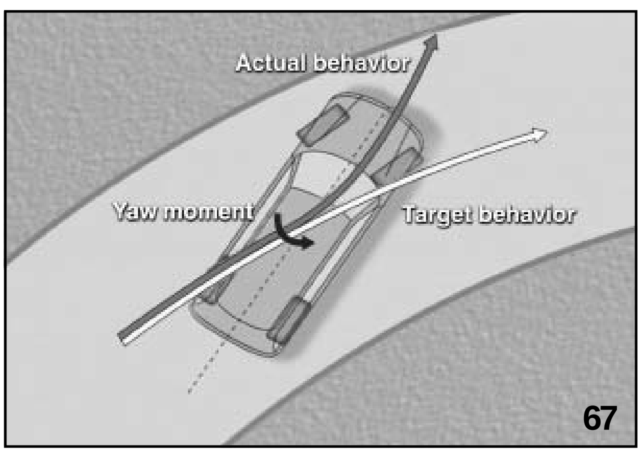
NOTES:

Vehicle Dynamic Control (VDC)



VDC Logic

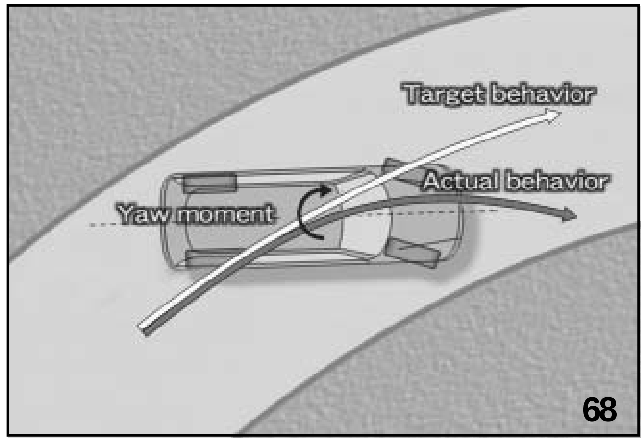
Vehicle Dynamic Control or VDC combines Anti-lock Brakes, Traction Control and new vehicle stability logic. The VDC system is designed to keep the vehicle behavior in the driver's expectations when the actual vehicle behavior may divert from what is expected.



Understeer

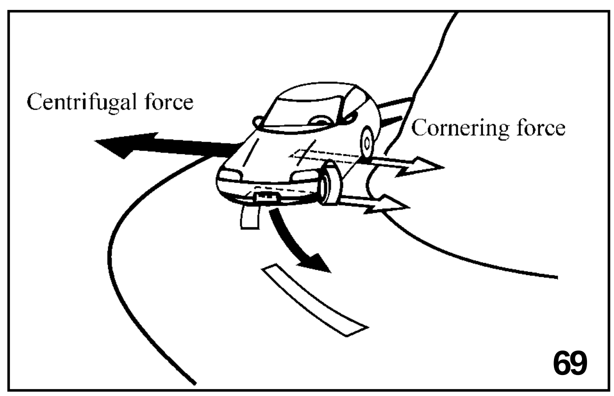
VDC operation comes into use during periods of driving when understeer or oversteer conditions are encountered. Four wheel TCS and ABS functions become active any time the VDC CM determines they are needed.

Understeer is the result of a movement of the vehicle where the driver's intent is to make a change in direction and while the steering wheel is turned the vehicles direction changes little or not at all. This is due to the front wheels slipping across the road surface.



Oversteer

Oversteer is the result of a movement where the driver's intent is to make a change in direction. While the vehicle is doing so, the amount of change is too great. This is due to the rear wheels slipping across the road surface.



Cornering force

Slip occurs whenever a vehicles' cornering force is less than it's centrifugal force. The cornering force is a combination of vehicle weight, tire quality, design, and the road surface.

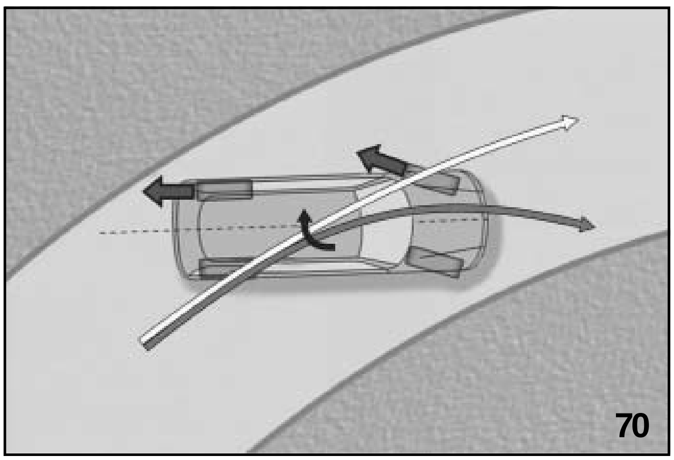
There are two ways to control slip: Produce a force or yaw moment of the reverse direction in the case of oversteering or produce a yaw moment of the same direction as the turning direction in the case of understeering.

These two slip controls can be utilized by three systems acting independently or together.

They are:

- Brake control by utilizing the hydraulic control unit
- Engine torque control with the ECM
- Torque distribution control for the front and rear wheels working with the TCM.

Oversteering and understeering can occur with the accelerator depressed, brake pedal depressed or with no pedal depressed. In each case, the response from the VDC CM is customized to the driving conditions of the vehicle and the resulting vehicle response.



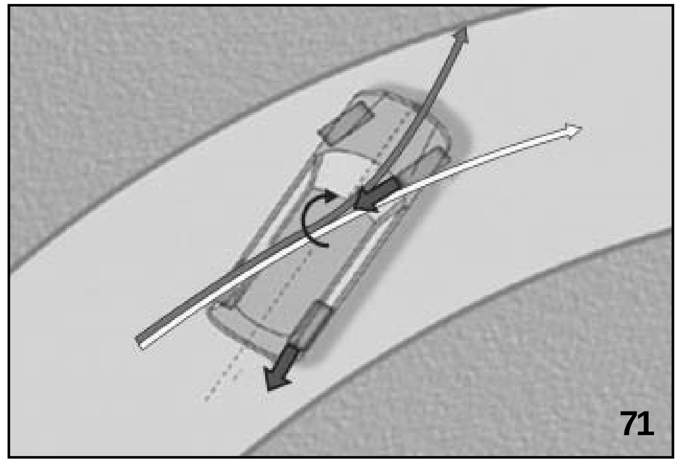
Oversteer While Accelerating

Oversteering while depressing the accelerator pedal

Correction required: Stop the rear wheels from slipping outward, and maintain the front of the vehicle towards the intended path.

Actions taken:

1. Apply strong brake force to the front outer wheel.
2. Apply weak brake force to the rear outer wheel.
3. Increase the transfer clutch engagement.
4. Decrease engine torque by fuel cut.



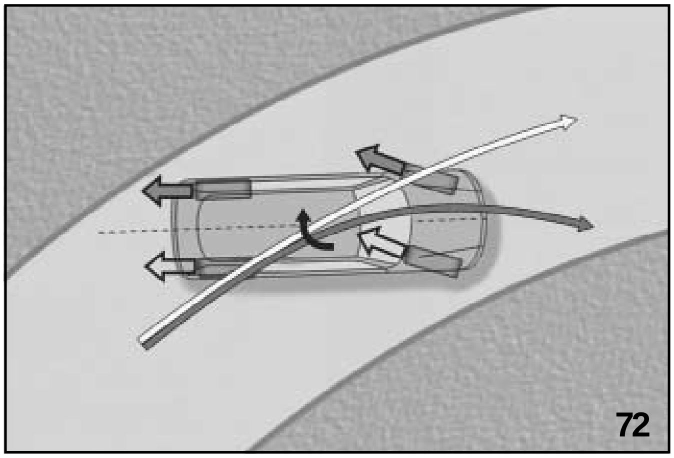
Understeer While Accelerating

Understeering while depressing the accelerator pedal.

Correction required: Stop the front wheels from slipping outward and return the front of the vehicle to the intended path.

Actions taken:

1. Apply weak brake force to the front inner wheel.
2. Apply strong brake force to the rear inner wheel.
3. Release the connection of the transfer to increase driving force distribution ratio to the rear wheels.
4. Decrease engine torque by fuel cut.



Oversteer While Braking

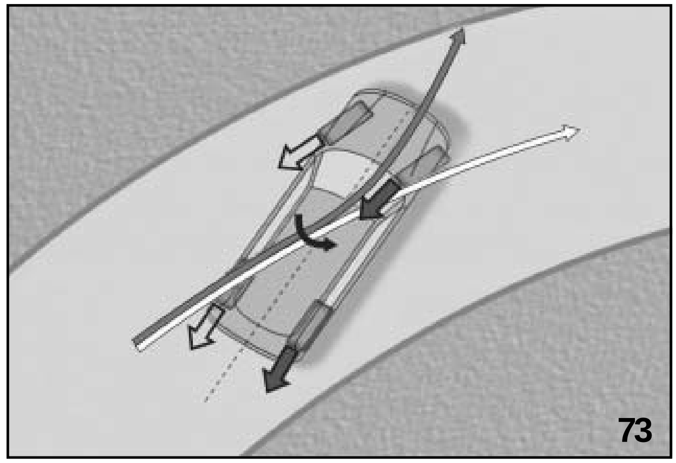
Oversteering while applying the brake.

Correction required: This is the same situation as the ABS system operating and understeering condition is needed.

Actions taken:

1. Loosen the brake for the front inner wheel.
2. Loosen the brake for the rear inner wheel.

If the braking force applied by the driver is insufficient, VDC operates creating hydraulic pressure by the pump to increase the braking force on the front outer wheel.



Understeer While Braking

Understeering while applying the brake.

Correction needed: This is the same as the ABS system operating and oversteering condition is needed.

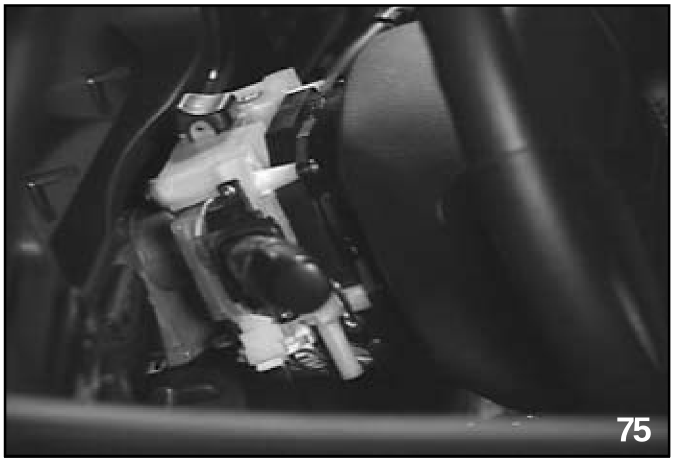
Actions taken:

1. Loosen the brake for the front outer wheel.
2. Loosen the brake for the rear outer wheel.

If the braking force supplied by a driver is insufficient, VDC operates creating hydraulic pressure by the pump, to increase the braking force on the rear inner wheel.

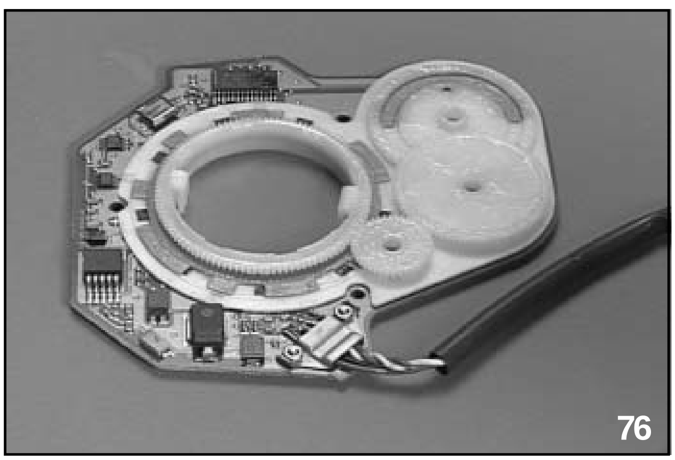
Sensors

Steering Position Sensor



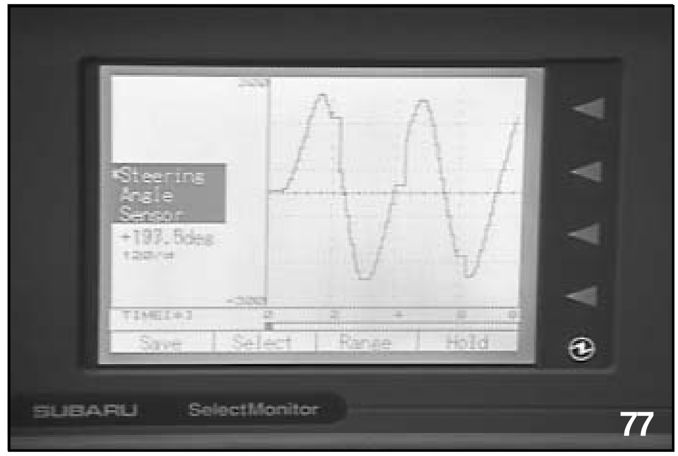
Steering position sensor

This sensor is located under the steering wheel and is indexed with it to create signals as the steering wheel is turned.



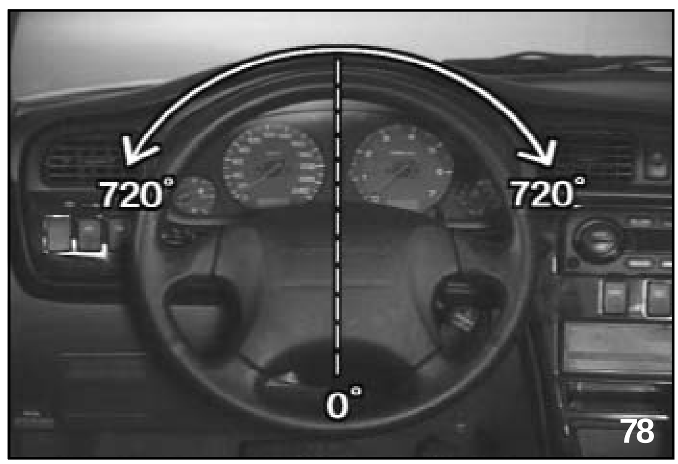
Steering position sensor construction

The internal make up of the sensor consists of two sensing elements.



Steering position sensor waveform

The first is made of a large reluctor with nine hall elements. The positioning of the reluctor over the hall elements creates signals that are sent to the VDC CM control unit that when combined with the second sensing element communicate the position of the front wheels. The output of the steering wheel position is displayed in 2.5-degree increments. The full range of steering wheel detection is 720 degrees.

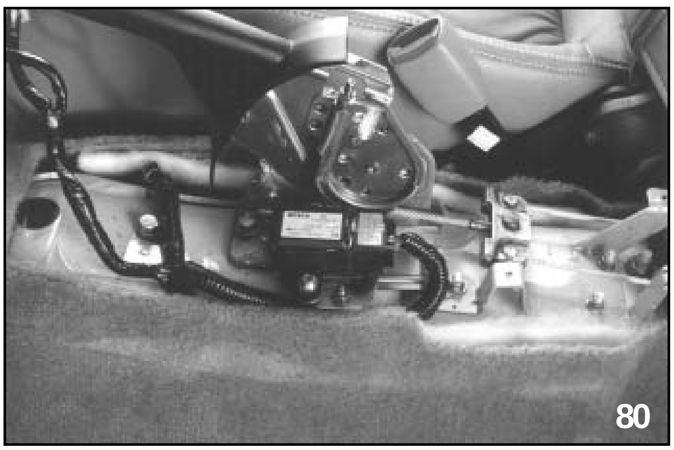


Degrees of turn

360 degrees to the right which shows up as positive and 360 degrees to the left shows up as negative. The movement of the second sensing element tells the control unit to go negative or positive and communicates the number of steering wheel revolutions.

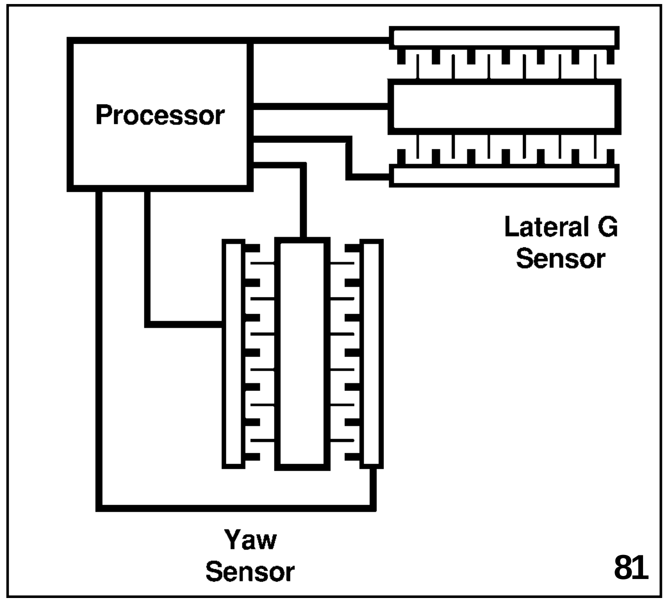
Wheel Speed Sensor

Wheel Speed Sensor-Detects wheel speed by each wheel.



Yaw Sensor

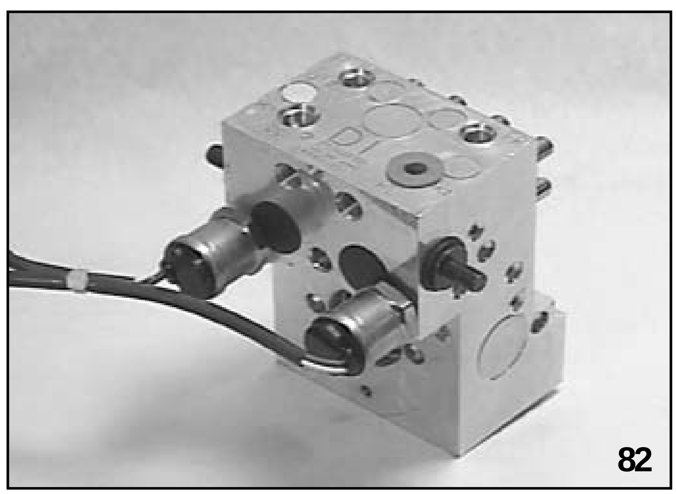
Yaw Rate Sensor- Detects the rotating velocity of the vehicle body during turning.



Yaw Sensor (artwork)

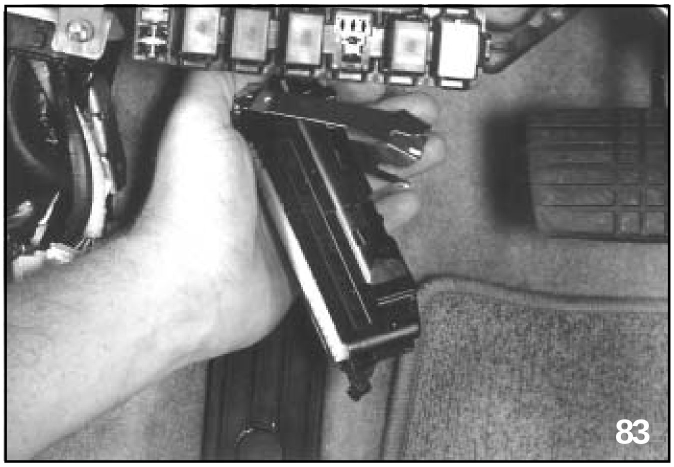
Lateral G Sensor- measures the centrifugal force exerted on the vehicle.

These two sensors are housed in a single unit and is located in the center console near the hand brake.



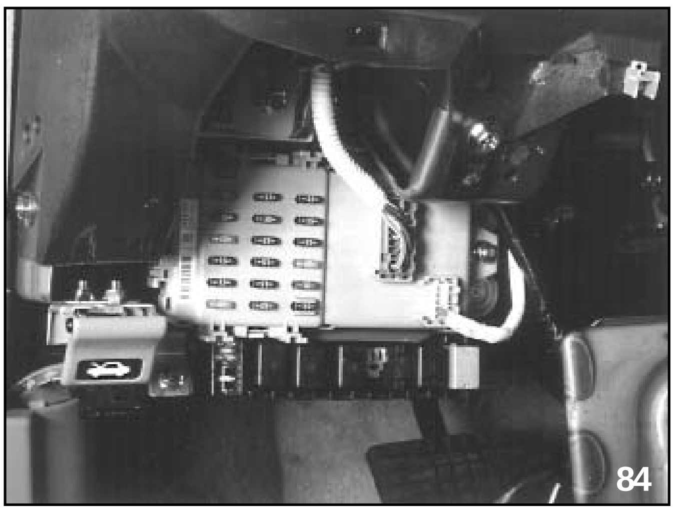
Hydraulic Control Unit

Brake pressure Sensor- Measures the estimated braking force applied to each wheel applied by the driver.



VDC CM connector

Input signals from the VDC CM determines the calculated driving force applied to the wheels.

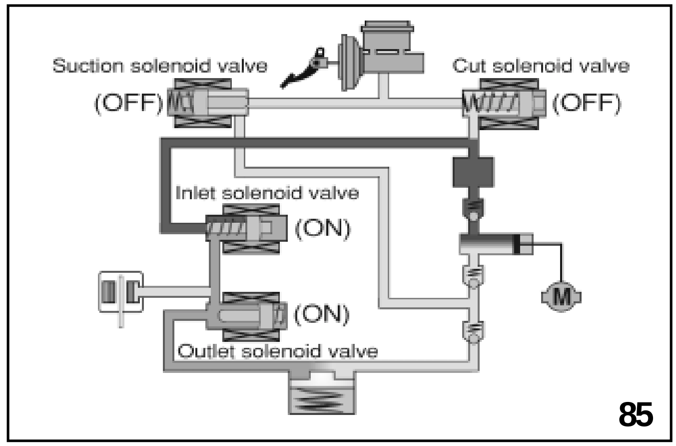


VDC CM location

Signals from the TCM- Using front to rear split information combined with VDC CM information determines the driving force of the engine or braking applied to the wheels.

Hydraulic operation during ABS and or VDC operation when the brake pedal is depressed.

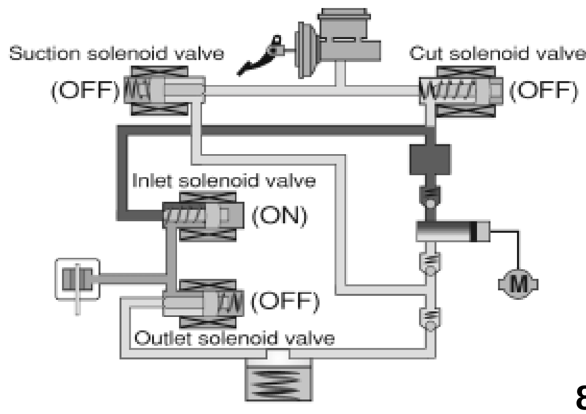
Pressure reducing mode



Pressure reducing mode

When the wheels are about to lock due to the braking action, instructions are issued from the control module and power is supplied to the EV and AV solenoid valves. The EV valve closes, cutting off the master cylinder pressure and wheel cylinder pressure. The AV valve opens reducing the wheel cylinder pressure and power is simultaneously supplied to the motor at this time. The brake fluid temporarily is collected in the reservoir and is sucked out by the self sucking pump, passed through the damper chamber, where pulsations are absorbed and is then returned to the master cylinder side. In this way; a pressure-reducing control is performed with the fluid pressure in the wheel cylinder side being completely separated from that in the master cylinder.

Pressure holding mode



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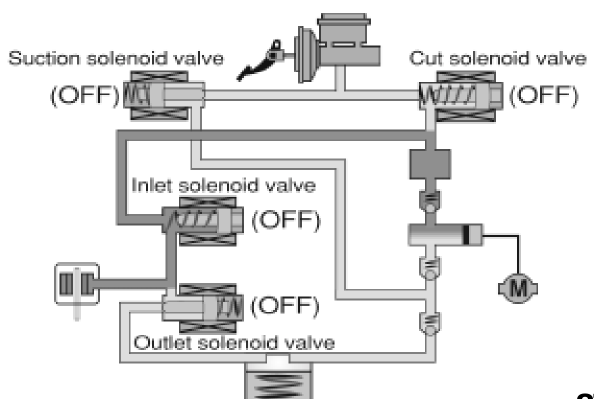
Pressure holding mode

When the optimum wheel cylinder fluid pressure is obtained, power is supplied to the solenoid valve (EV valve) according to VDC CM instructions. The valve closes, cutting off the master cylinder pressure and the wheel cylinder side.

Pressure increasing mode



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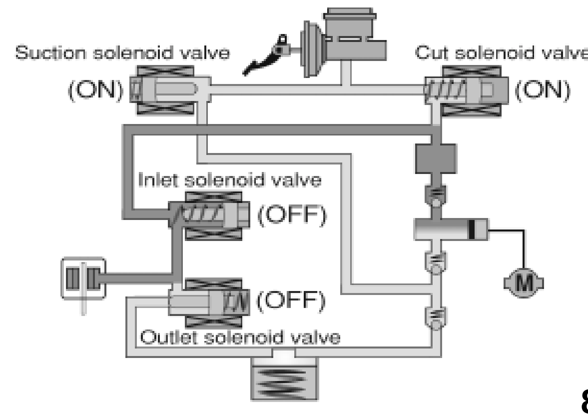
Pressure increasing mode

When the wheel cylinder pressure needs to be increased, power to the solenoid valves are turned off according to VDC CM instructions, resulting in normal braking conditions. Pressure is then applied by the master cylinder.

TCS operation and or VDC operation when the brake pedal is released

Pressure increase mode



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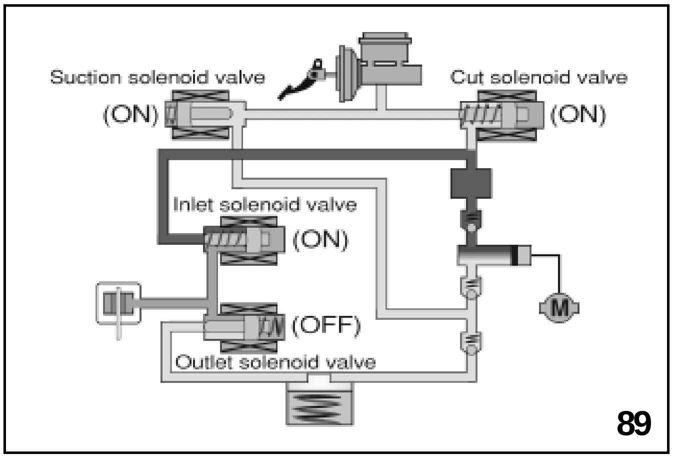
Pressure increasing mode

When the wheels slip while driving, or slip occurs while the vehicle is turning, instructions are issued by the VDC CM and the VDC/TCS control is initiated. Power is supplied to the USV and HSV valves. The USV valve closes and the HSV valve opens at the same time. Power is also supplied to the motor, and the brake fluid in the master cylinder reservoir is sucked through the HSV valve by the self sucking pump, passing through the EV valve and pressurizing the wheel cylinder side.

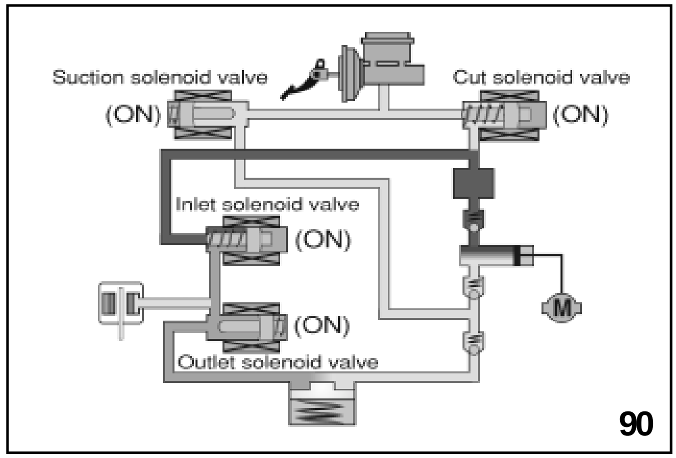
Pressure holding mode



Pressure holding mode

When the optimum wheel cylinder fluid pressure is obtained, power is supplied to the EV valve according to VDC CM instructions. The USV valve, HSV valve and motor power supply conditions are not changed. The EV valve is closed, cutting off the brake fluid pressurized by the self -sucking pump. The brake fluid pressurized by the self-sucking pump is then passed through the USV relief valve and returned to the master cylinder.

Pressure reducing mode



Pressure reducing mode

When the wheel cylinder fluid pressure must be reduced, power is supplied to the EV valve and AV valve according to VDC CM instructions. The USV valve, HSV valve and motor power supply conditions are not changed. The EV valve is closed and the AV is opened. The wheel cylinder fluid pressure is discharged to the master cylinder side through the reservoir and HSV valve, reducing the pressure on the wheel cylinder side. The brake fluid pressurized by the self-sucking pump is passed through the USV relief valve and returned to the master cylinder.

VDC light operation

During the light check cycle all lights will illuminate for a short time.

- VDC Operation (Car with tire tracks)
- VDC
- VDC OFF
- ABS

During VDC operation the VDC Operation light (car with tire tracks) will blink.

During TCS operation the VDC Operation light (car with tire tracks) will be on solid.

A malfunction with the VDC system will illuminate just the VDC light.

A malfunction with the ABS will illuminate the ABS and VDC light.

A malfunction with the ECM or TCM will illuminate the VDC Off light.

A fuse placed in the VDC slot in the fuse box will illuminate the VDC Off light.

VDC Diagnostics

VDC diagnostics begin with verifying the complaint and doing a thorough visual inspection. The following steps should help you diagnose most complaints that did not cause an ABS or VDC warning light to illuminate. This can also help you in cases that no trouble code was stored in the memory of control unit.

1. Check battery voltage to insure battery is fully charged
2. Inspect tires for proper sizing. Ideally, all four tires should be of the same make, model, and size
3. Check air pressure in all four tires and set to specifications.
4. Check all four wheels for excessive brake drag. This could indicate sticky pistons or caliper slides.
5. Inspect all hydraulic lines for leaks and make needed repairs.
6. Inspect wheel bearings for excessive play and make needed repairs.
7. Top off brake fluid level if necessary.
8. Perform ABS and VDC sequence control procedures and compare your results to specifications in service manual.

Access Trouble Codes

Trouble codes can accessed with your NSM or by using the diagnostic connector located under the dash to the right of the steering wheel.

NOTE: THE NEW SELECT MONITOR IS THE PREFERRED METHOD FOR ACCESSING TROUBLE CODES AND INITIATING OTHER SERVICE PROCEDURES. MORE INFORMATION ON USING THE DIAGNOSTIC CONNECTOR CAN BE FOUND IN THE BRAKES SECTION OF THE SERVICE MANUAL.

If codes are stored, trouble shoot according to the diagnostic charts in the service manual. Remember that freeze frame information will be stored for the first trouble code the ABSCM detected. Freeze frame information can help reproduce the driving conditions under which the fault was detected. This can also be used to verify that a repair has been successfully completed.

Perform the inspection mode.

Verify that no additional trouble codes have been stored.

Sequence Control

On Subaru vehicles equipped with VDC, there is a procedure called sequence control that can be performed. Sequence control has two basic functions. The first is to allow the technician to check the mechanical condition of the pump and solenoids inside the ABS/VDC hydraulic control unit. The second function is to help purge air from ABS/VDC hydraulic control unit during a brake bleeding procedure.

There are two sequence control procedures that can be used on VDC equipped vehicles. The first procedure allows you to check the ABS side of the system while the second procedure allows you to check the VDC side of the system. Both sequence control procedures can be accomplished with the NSM.

Below you will find specs for a *2001 Outback Wagon* as an example:

ABS Sequence Control

	FRONT WHEEL	REAR WHEEL
Initial value	3,432 kPa (35 kg/cm2, 498 psi)	3,432 kPa (35 kg/cm2, 498 psi)
When decompressed	490 kPa (5 kg/cm2, 71 psi) or less	490 kPa (5 kg/cm2, 71 psi) or less
When compressed	3,432 kPa (35 kg/cm2, 498 psi) or more	3,432 kPa (35 kg/cm2, 498 psi) or more

VDC Sequence Control

	FRONT WHEEL	REAR WHEEL
When compressed	2,942 kPa (30 kg/cm2, 427 psi) or more	1,961 kPa (20 kg/cm2, 284 psi) or more
When decompressed	490 kPa (5 kg/cm2, 71 psi) or less	490 kPa (5 kg/cm2, 71 psi) or less

Calibration of Steering Sensor and Lateral G Sensor

The VDC system incorporates a steering sensor and yaw rate sensor as part of the input system into VDCCM. The yaw rate sensor also has a lateral G sensor built into it. Always conduct a steering angle sensor and lateral G sensor calibration procedure whenever you have removed or installed the following items.

1. VDC control module
2. Steering angle sensor
3. Yaw rate and lateral G sensor
4. Steering wheel parts (Including airbag)
5. Suspension parts
6. Adjustment of wheel alignment

The calibration procedure can be accomplished with the NSM.

NOTE: BEFORE PERFORMING THE CALIBRATION PROCEDURE, MAKE SURE THE VEHICLE IS ON A LEVEL SURFACE AND THAT IT HAS BEEN DRIVEN AND STOPPED WHILE GOING IN THE STRAIGHT AHEAD POSITION. THIS IS TO INSURE THAT THE CALIBRATION PROCEDURE IS ACCURATELY PERFORMED.

NOTES:

Service Bulletins

No.	Date	Title	Remarks
06-23-87	11/23/87	Subaru XT 1988 Service Manual Corrections	
06-24-91	08/15/91	Secondary Side Bleeding of A.B.S. Hydraulic Control Unit	
06-25-92	09/08/92	Brake Vibration Diagnosis and Repair	
06-23-93	01/12/93	Disc Brake Servicing	
06-27-93 18-21-93	10/29/93	Service Procedures for Codes 1-4, Section 4-4	Revised diagnostic trouble chart
06-28-96	06/11/96	A.B.S. Relay Sticking	
06-29-00	05/10/00	Low Brake Pedal Perception	

501 Module Service Help-Line Updates

Date	Subject
07/95	Reading ABS Codes on early Subaru Legacy Models
08/95	Subaru Legacy-ABS light on
09/95	Brake fluid basics
09/95	ABS and Select Monitor usage
10/95	ABS/TCS equipped Legacy vehicles
11/95	1995/1996 Subaru Legacy with ABS
11/95	1996 Subaru Legacy equipped with ABS/5.3 system
12/95	ABS-2E control units and ABS code 23
12/95	Vehicle not complying with federal and state regulations
12/95	Intermittent wheel sensor codes in early Legacy ABS systems (non ABS-2E)
02/96	Brake noise...What is normal
06/96	5.3 ABS system service manual
08/96	ABS 5.3i ABS warning light operation
02/97	New 5.3i type ABS system
03/97	5.3i ABS system information update
04/97	Identifying ABS systems
10/97	ABS 5.3i ABS warning light operation
01/98	ABS/TCS code 57
05/98	Use of non-approved brake additives
02/99	1999 Forester ABS
03/99	Brake judder and noise; all models
06/01	2002MY Impreza brake rotor “SCORING"

Notes:

SUBARU

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S E R V I C E

CERTIFIED SUBARU TECHNICIAN

Technicians Reference Booklet

Evaporative System Diagnosis

AUTOMOTIVE

Youth Educational Systems

September 2003

MSA5P0922C

Technical Training

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2000 Model Year Evaporative System Diagnosis

Introduction

Testing the on board refueling vapor recovery system involves checking all solenoids, valves and plumbing for air tightness, air flow and proper operation. A failure in any of these items will create a failure in the system.

The evaporative system pressure tester must be used with the Select monitor to achieve the correct results. Begin by first reading the warnings included with the special tool. Section by Section testing will ensure all fittings, hoses, pipes, valves and components are tested.

Legend

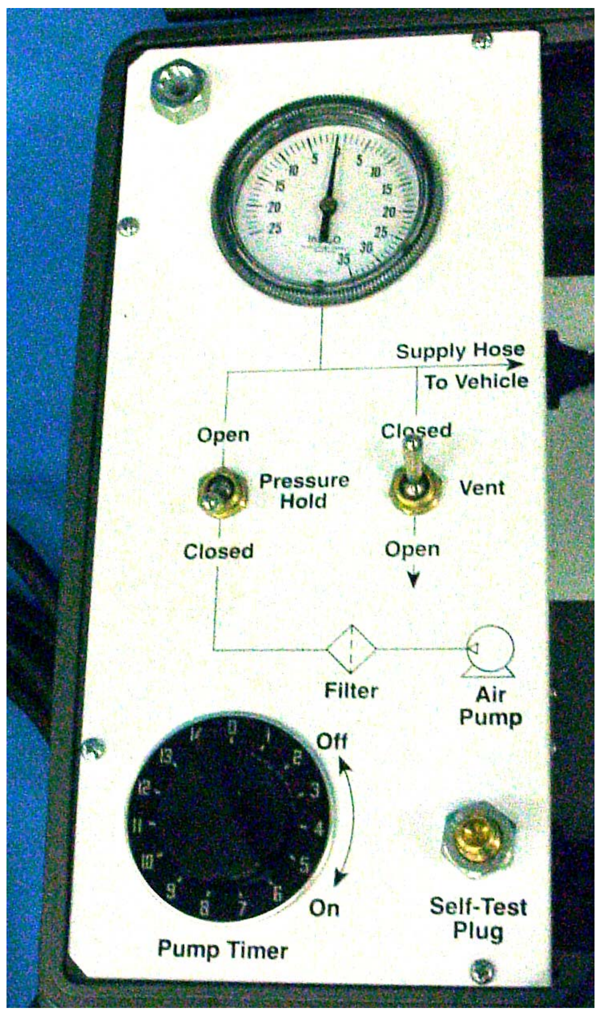
PT .... Pressure Tester
CPC ..... Canister Purge Control
M .... Manifold
D .... Drain
SOV ..... Shut Off Valve

F .... Fuel
FH .... Fuel Hose
PCV ..... Pressure Control Valve
V .... Vent
PS .... Pressure Sensor

Pressurize

This is how you pressurize the tester when instructed to do so.

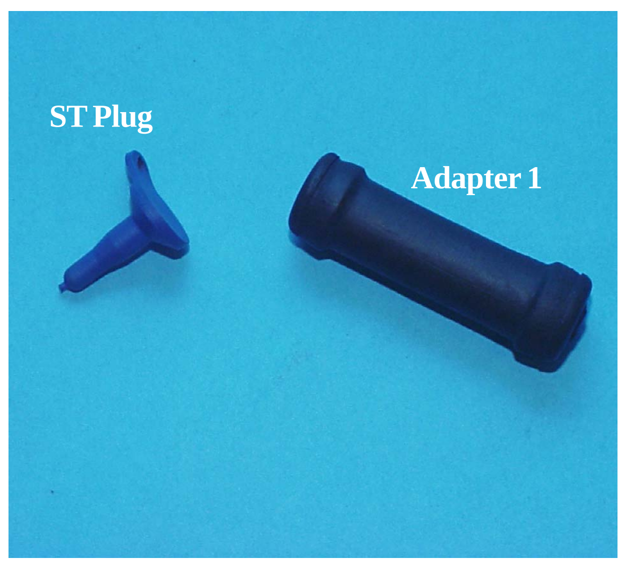
1. Place Pressure hold in open position.
2. Place Vent in closed position.
3. Turn the pump timer on.
4. Observe gauge.
5. When highest pressure is reached place the Pressure hold in closed position.
6. Turn pump timer off.



Abbreviation	Component	Location
CPC	Canister Purge Control Solenoid	Right underside of intake manifold.
PCV	Pressure control valve	Above rear differential.
D	Drain valve	Above canister right rear of vehicle.
SOV	Shut Off Valve behind the right rear inner fender.	Located on the fuel filler neck

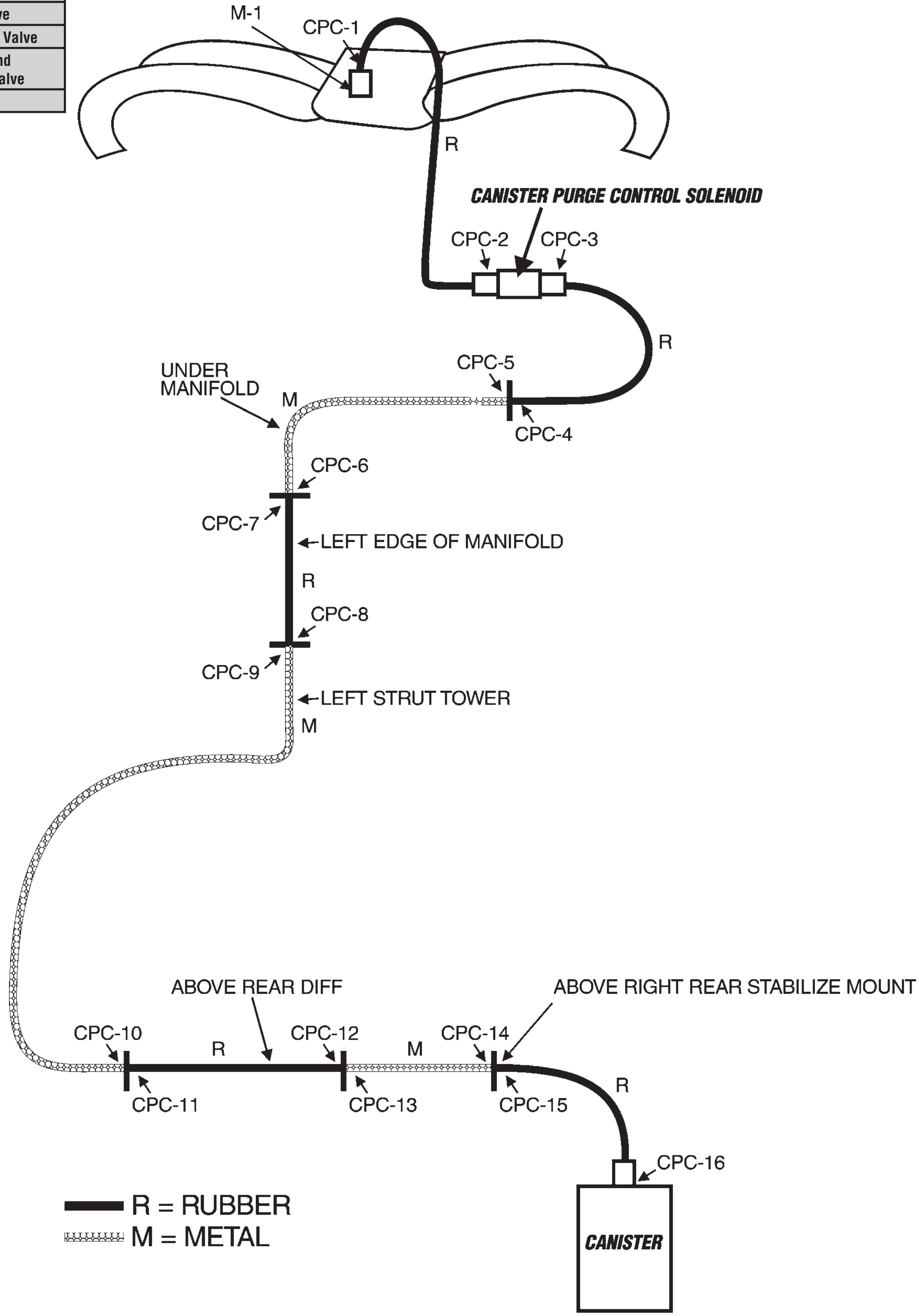
Test Sequence

- **Follow the directions in each of the above tests.**
- **At the end of a given test a stop sign will appear to signify that you need to go to the next test.**
- **Complete all 6 tests to evaluate the entire evaporative system.**
- **Directions are included in each test that guides you through results that indicate a failure.**
- **Always complete the 6 tests even if a failure has been found and repaired early in the test sequence.**



Purge
Drain
Shut off Valve
Pressure Control Valve
Fuel Tank and Vent Control Valve
Canister

2000 Legacy Purge Line



Purge System Test

(1) Disconnect CPC-1 from M-1.

(2) Start engine and check for strong vacuum source at M-1.

(3) Engine off and ignition off

(4) Connect select monitor to data link connector.

(5) Connect inspection mode connectors.

(6) Ignition on and engine off

(7) Turn on select monitor and adjust to system operation check mode.

Activate a component and turn it off to establish full control of all system operation check mode items.

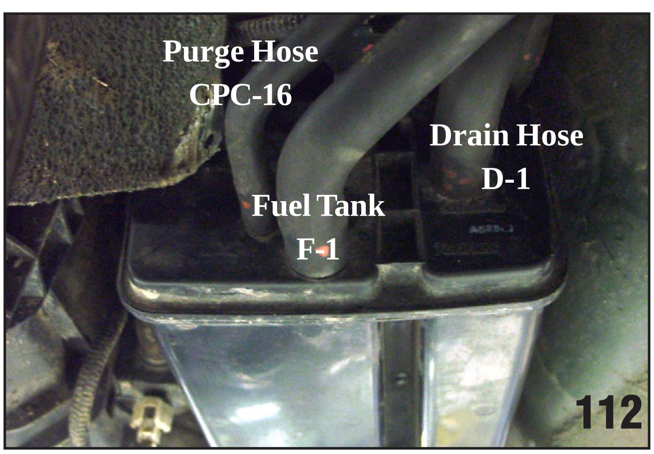
Step 8 and 9 will test the air tightness of the vacuum line from the intake manifold to the canister purge control solenoid. The air tightness of the solenoid is checked at this time also.

(8) Connect PT-1 to CPC-1 and "pressurize".

(9) Did pressure hold?
YES go to step (10).
NO go to step (10F).

Step 10 and 11 will test the electrical and mechanical operation of the canister purge control solenoid and the vacuum line from the out put side of the solenoid to the canister for restrictions or blockages.

(10) Disconnect CPC-16 from canister. Picture 112.



(11) Activate CPC solenoid with select monitor.

(12) Did pressure go to zero immediately?
YES go to step (13).
NO go to step (13F).

Step 13 and 14 will test the vacuum hose from the canister purge control solenoid to the canister for air tightness.

(13) Insert ST plug into CPC-16 to block hose.

(14) Pressurize.

(15) Did pressure hold?
YES go to step (16).
NO go to step (16F).

(16) Turn CPC solenoid off with select monitor.

(17) Remove PT-1 from CPC-1.

(18) Connect CPC-1 to M-1.

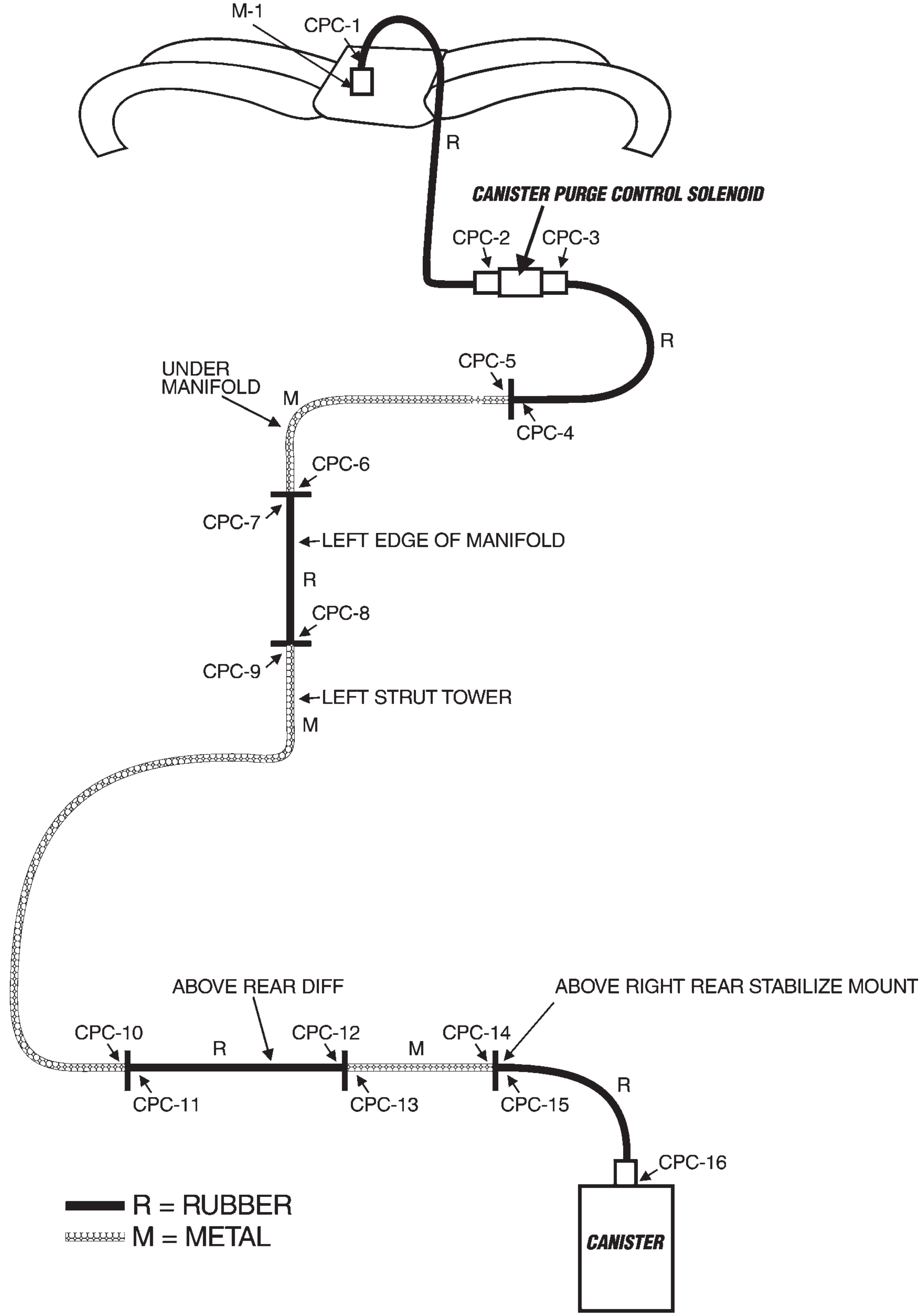
(19) Remove ST plug from CPC-16.

(20) Connect CPC-16 to canister.

Notes:

STOP

2000 Legacy Purge Line



Purge Line 10F

(10F) Disconnect CPC-2 from CPC solenoid.

(10F1) Connect ST plug to CPC-2.

(10F2) Pressurize.

(10F3) Does pressure hold?
YES – Replace CPC solenoid and go to step 8.
NO – Replace hose and go to step 8.

Purge Line 13F

(13F) Turn off CPC solenoid with select monitor.

(13F1) Disconnect CPC-4 from CPC-5.

(13F2) Pressurize and turn on CPC solenoid with select monitor.

(13F3) Does pressure go to zero immediately?
NO go to step (13F4).
YES go to step (13G).

(13F4) Turn off CPC solenoid with select monitor and connect CPC-4 to CPC-5.

(13F5) Disconnect CPC-3 from CPC solenoid.

(13F6) Pressurize.

(13F7) Turn on CPC solenoid with select monitor.

(13F8) Does pressure go to zero immediately?
YES – Replace hose "CPC-3 to CPC-4" and go to step 8.
NO – Replace CPC solenoid and go to step 8.

Purge Line 13G

(13G) Turn off CPC solenoid with select monitor.

(13G1) Connect PT-1 to CPC-5.

(13G2) Pressurize.

(13G3) Disconnect CPC-8 from CPC-9.

(13G4) Does pressure go to zero immediately?
YES go to step (13H).
NO go to step (13G5).

(13G5) Pressurize.

(13G6) Disconnect CPC-7 from CPC-8.

(13G7) Does pressure go to zero immediately?
YES – Replace hose "CPC-7 to CPC-8" and go to step (8).
NO – An obstruction exists in the metal hose from "CPC-5 to CPC-6", clean and remove obstruction or replace hose. Then go to step (8).

(13H) Connect adapter-1 to PT-1.

(13H1) Connect adapter-1 to CPC-8.

(13H2) Pressurize.

(13H3) Disconnect CPC-12 form CPC-13.

(13H4) Does pressure drop to zero immediately?
YES go to step (13I).
NO go to step (13H5).

(13H5) Pressurize.

(13H6) Disconnect CPC-10 from CPC-11.

(13H7) Does pressure drop to zero immediately?
YES – Replace hose "CPC-11 to CPC-12" and go to step (8).
NO – An obstruction exists in the metal hose between "CPC-10 and CPC-9" clean and remove obstruction or replace hose. Then go to step (8).

Purge Line 13I

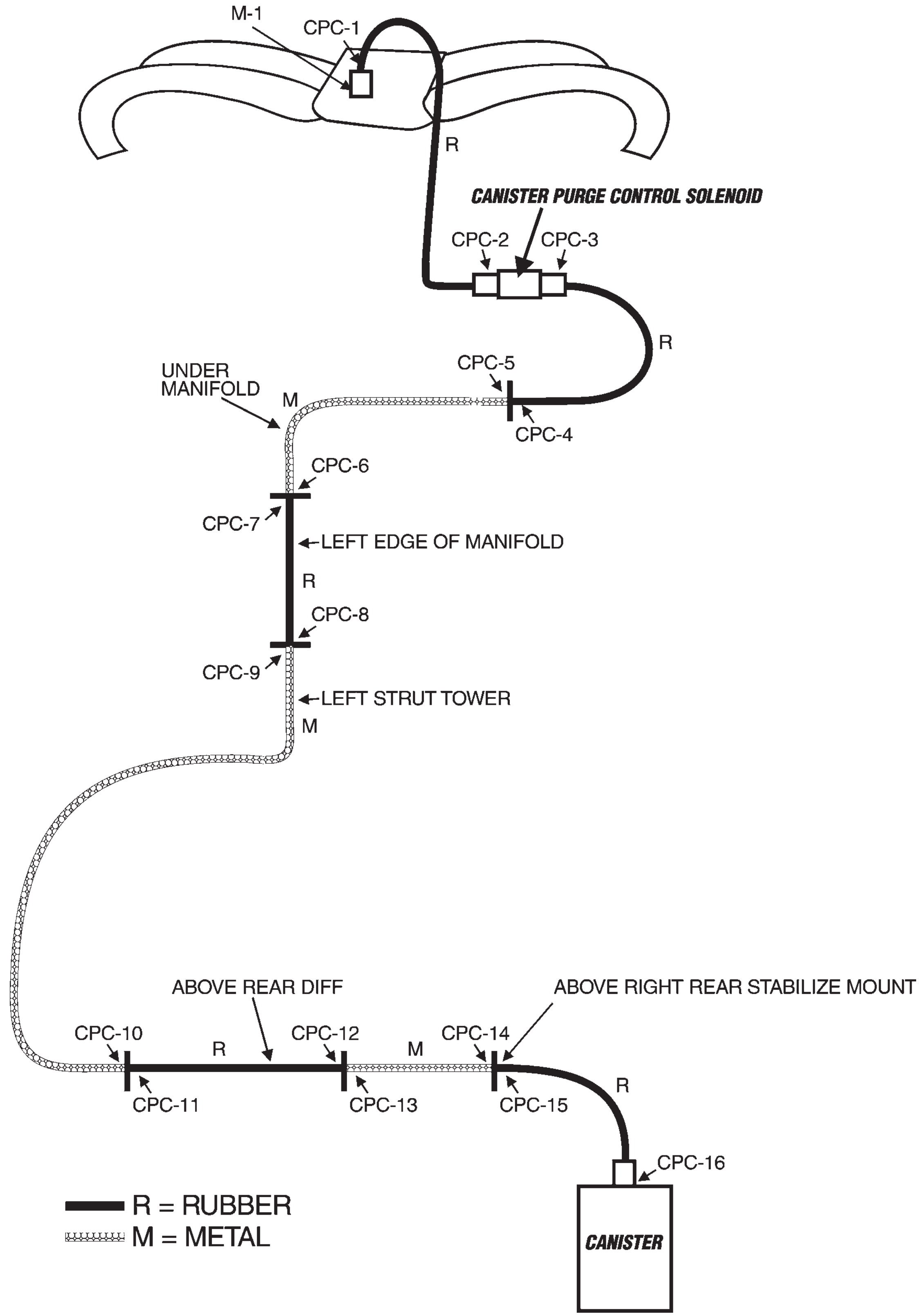
(13I) Connect adapter-1 to CPC-13.

(13I1) Pressurize.

(13I2) Disconnect CPC-14 to CPC-15.

(13I3) Did pressure drop to zero immediately?
YES – Replace hose "CPC-15 to CPC-16" and go to step (8).
NO – An obstruction exists in the metal hose between "CPC-13 and CPC-14", clean and remove obstruction or replace hose. Then go to step (8).

2000 Legacy Purge Line



Purge Line 16F

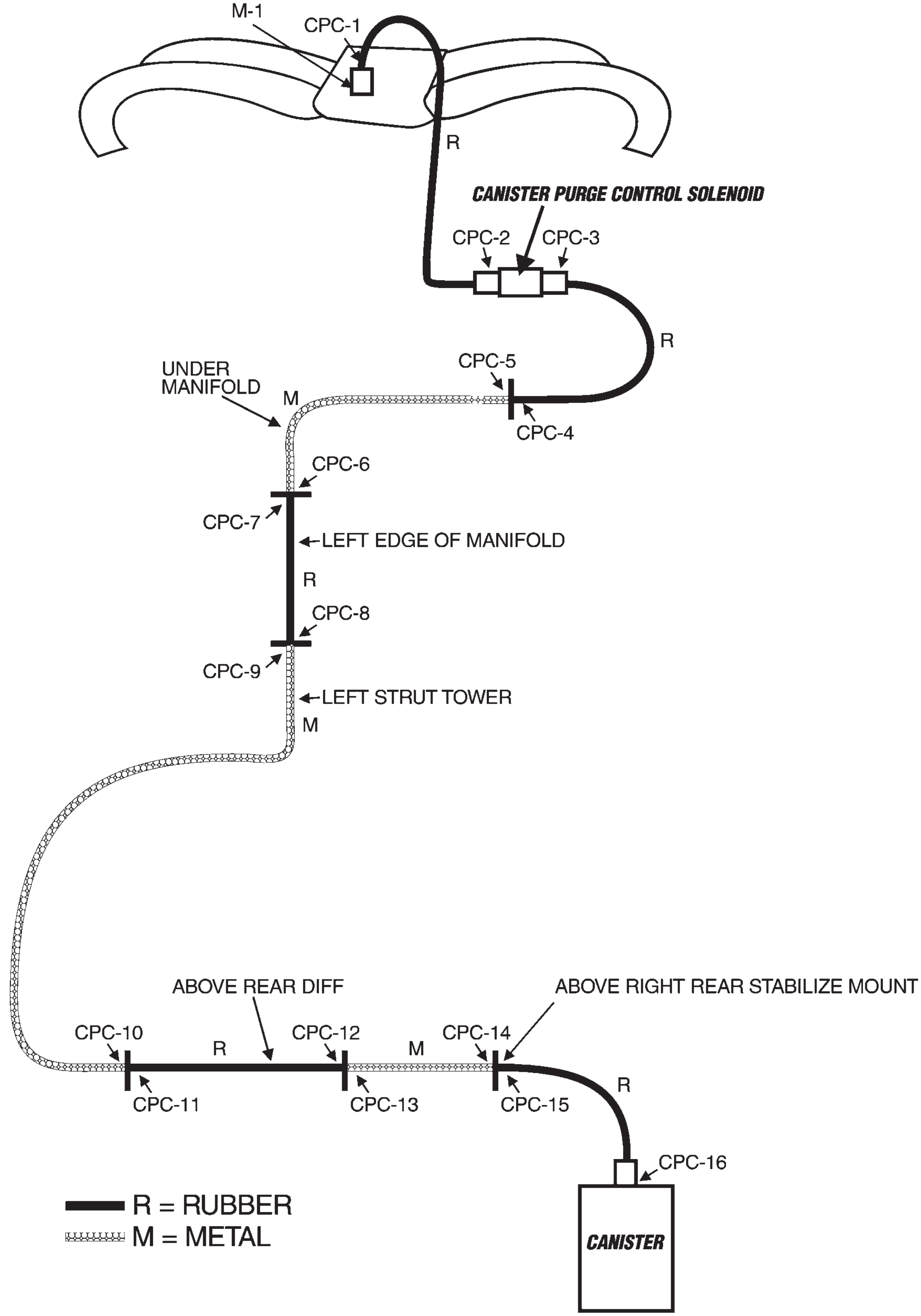
(16F) Turn CPC solenoid off with select monitor.
(16F1) Disconnect CPC-14 from CPC-15.
(16F2) Connect adapter-1 with ST plug to CPC-14.
(16F3) Pressurize.
(16F4) Turn CPC solenoid on with select monitor.
(16F5) Does pressure hold?
NO go to step (16F6).
YES – Replace hose "CPC-15 to CPC-16".
(16F6) Turn CPC solenoid off with select monitor.
(16F7) Disconnect "CPC-12 to CPC-13".
(16F8) Connect ST Plug to CPC-12.
(16F9) Pressurize.
(16F10) Turn CPC solenoid on with select monitor.
(16F11) Does pressure hold?
YES – Replace metal hose "CPC-13 to CPC-14" and go to step 8.
Ensure hoses disconnected in prior step, have been reconnected.
NO – Go to (16F12)
(16F12) Turn CPC solenoid off with select monitor.
(16F13) Disconnect CPC-10 from CPC-11.
(16F14) Connect adapter-1 with ST plug to CPC-10.
(16F15) Pressurize.
(16F16) Turn CPC solenoid on with select monitor.
(16F17) Does pressure hold?
YES – Replace hose "CPC-11 to CPC-12" and go to step 8.
NO – Go to (16F18).

Purge Line 16F18

(16F18) Turn off CPC solenoid with select monitor.
(16F19) Disconnect CPC-8 from CPC-9.
(16F20) Connect ST Plug to CPC-8.
(16F21) Pressurize.
(16F22) Turn CPC solenoid on with select monitor.
(16F23) Does pressure hold?
YES – Replace metal hose "CPC-9 to CPC-10" and go to step (8).
Ensure hoses disconnected in prior step, have been reconnected.
NO go to step (16F24).
(16F24) Turn off CPC solenoid with select monitor.
(16F25) Disconnect CPC-6 from CPC-7.
(16F26) Connect adapter-1 with ST plug to CPC-6.
(16F27) Pressurize.
(16F28) Turn CPC solenoid on with select monitor.
(16F29) Does pressure hold?

Notes:

2000 Legacy Purge Line



Purge Line 16F34

(16F34) Does pressure hold?

YES – Replace metal hose "CPC-5 to CPC-6" and go to step (8).

NO – Go to step (16F35).

(16F35) Disconnect CPC-3 from CPC solenoid.

(16F36) Connect adapter-1 with ST plug to CPC solenoid.

(16F37) Pressurize.

(16F38) Turn CPC solenoid on with select monitor.

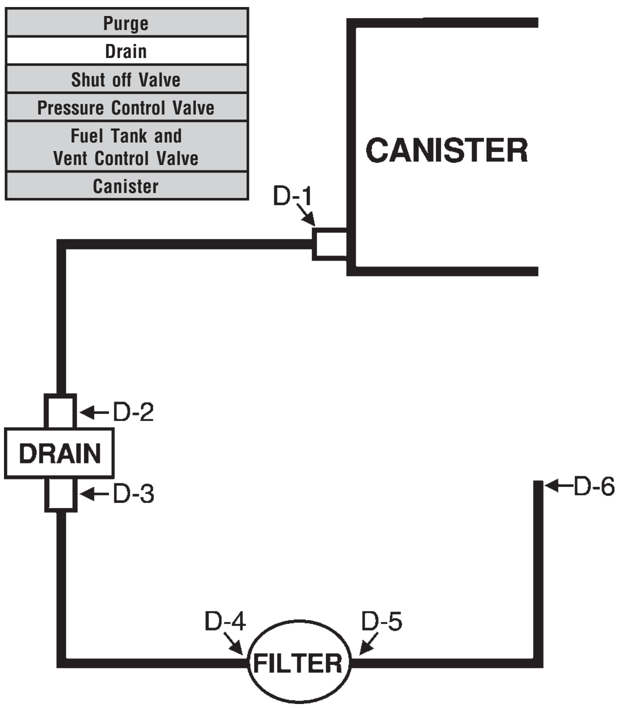
(16F39) Does pressure hold?

YES – Replace hose "CPC-3 to CPC-4" and go to step (8).

NO – Replace CPC solenoid and go to step (8).

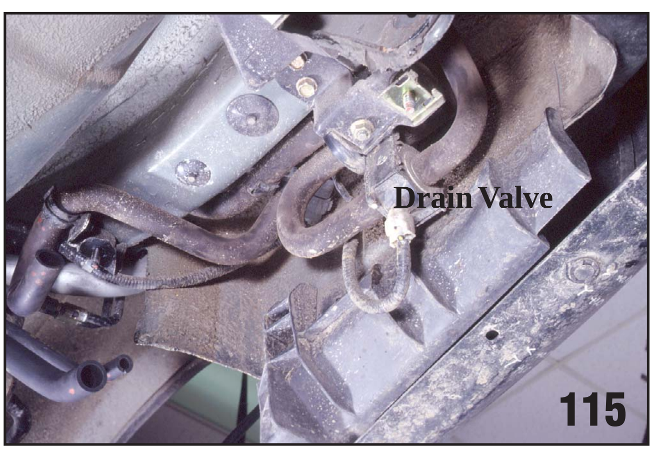
Notes:

2000 Legacy Drain Line



Drain System Test

Steps 1 through 4 are testing the air tightness of the adapter.



(1) Disconnect D-1 from canister. Picture 115.

(2) Connect PT-1 with ST adapter-1.

(3) Block ST adapter-1 with ST Plug and pressurize.

(4) Does pressure hold?
YES go to step (5).
NO, replace Adapter-1 and go to step (1).

(5) Remove ST-plug from ST-adapter-1.
Step 6 and 7 will test the drain hoses, canister, drain valve and filter for restrictions and blockages.

(6) Connect ST-adapter-1 with D-1 hose.

(7) Pressurize.

(8) Did pressure buildup?
NO go to step (9).
YES go to step (9F).

Step 9 and 10 will test the air tightness of the vent hoses from the canister to the drain valve and the mechanical and electrical operation of the drain valve.

(9) Activate vent valve solenoid with select monitor.

(10) Pressurize.

(11) Does pressure hold for the time the solenoid is on and then drop to zero?
YES go to step (12).
NO go to step (12F).

(12) Turn off vent valve solenoid with select monitor.

(13) Remove ST adapter-1 from D-1.

(14) Connect D-1 to canister.

Notes:

STOP

Drain System Test 9F

(9F) Disconnect D-5 from filter.

(9F1) Pressurize
Did pressure hold?
YES go to step (9F2).
NO , replace hose from D-5 to D-6 or remove obstruction from hose.

(9F2) Disconnect D-4 from filter.

(9F3) Pressurize
Did pressure hold?
YES go to step (9F4).
NO , replace filter

(9F4) Disconnect D-3 from Drain Valve.

(9F5) Pressurize
Did pressure hold?
YES go to step (9F6).
NO , replace hose from D-3 to D-4 or remove obstruction from hose.

(9F6) Disconnect D-2 from Drain Valve.

(9F7) Pressurize
Did pressure hold?
YES , replace hose from D-1 to D-2 or remove obstruction from hose.
NO , replace Drain Valve

Reconnect all hose.

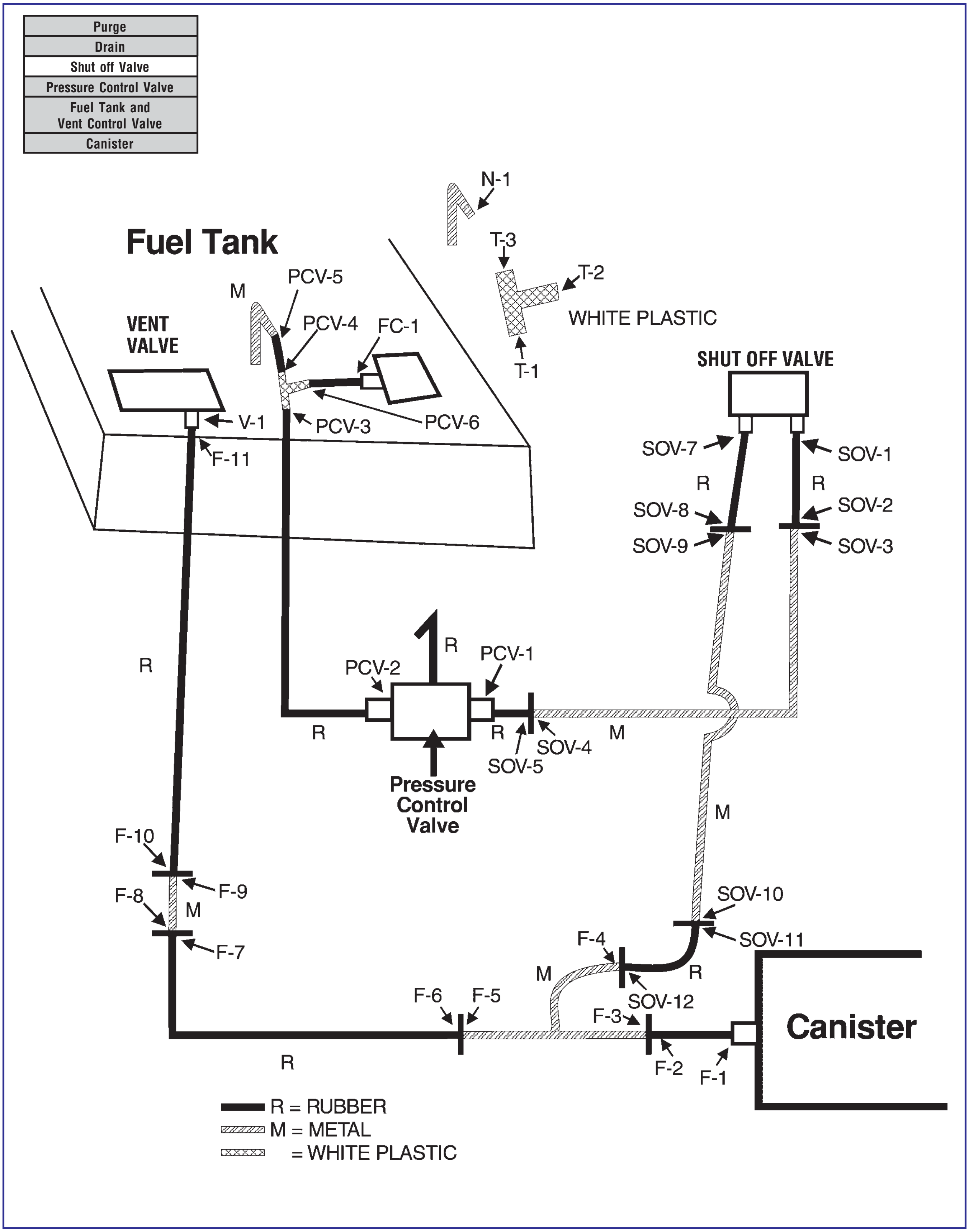
Drain Line System 12F

(12F) Disconnect D-2 from Drain Valve

(12F1) Insert adapter –1 with ST plug into D-2 hose.

(12F2) Pressurize
Did pressure hold?
YES, replace Drain Valve and go to step 9.
NO, replace hose from D-1 to D-2 an go to step 9.

Notes:



Purge
Drain
Shut off Valve
Pressure Control Valve
Fuel Tank and Vent Control Valve
Canister
N-1
Fuel Tank
T-3
T-2
WHITE PLASTIC
T-1
M
PCV-5
VENT VALVE
PCV-4
FC-1
V-1
PCV-3
PCV-6
F-11
SHUT OFF VALVE
SOV-7
SOV-1
R
R
SOV-8
SOV-2
SOV-9
SOV-3
R
R
PCV-2
PCV-1
R
R
SOV-4
SOV-5
M
Pressure Control Valve
M
F-10
F-9
F-8
M
F-7
SOV-10
SOV-11
F-4
M
R
F-6
F-5
SOV-12
F-3
Canister
R
F-2
F-1
R = RUBBER
M = METAL
= WHITE PLASTIC

Shut Off Valve Test

Step 1 through 4 tests the vacuum hose from SOV-12 to the shut off valve, the shut off valve itself, and the vacuum hose from the shut off valve to the pressure control valve for restrictions and blockages.

(1) Disconnect SOV-12 from F-4.

(2) Disconnect PCV-1 from PCV.

(3) Connect PT-1 to SOV-12.

(4) Pressurize.

(5) Does pressure build up?
NO go to step (6).
YES go to step (6F).

Step 6 and 7 will test the air tightness of the vacuum hose from SOV-12 to the shut off valve, the shut off valve itself, and the vacuum hose from the shut off valve to the pressure control valve.

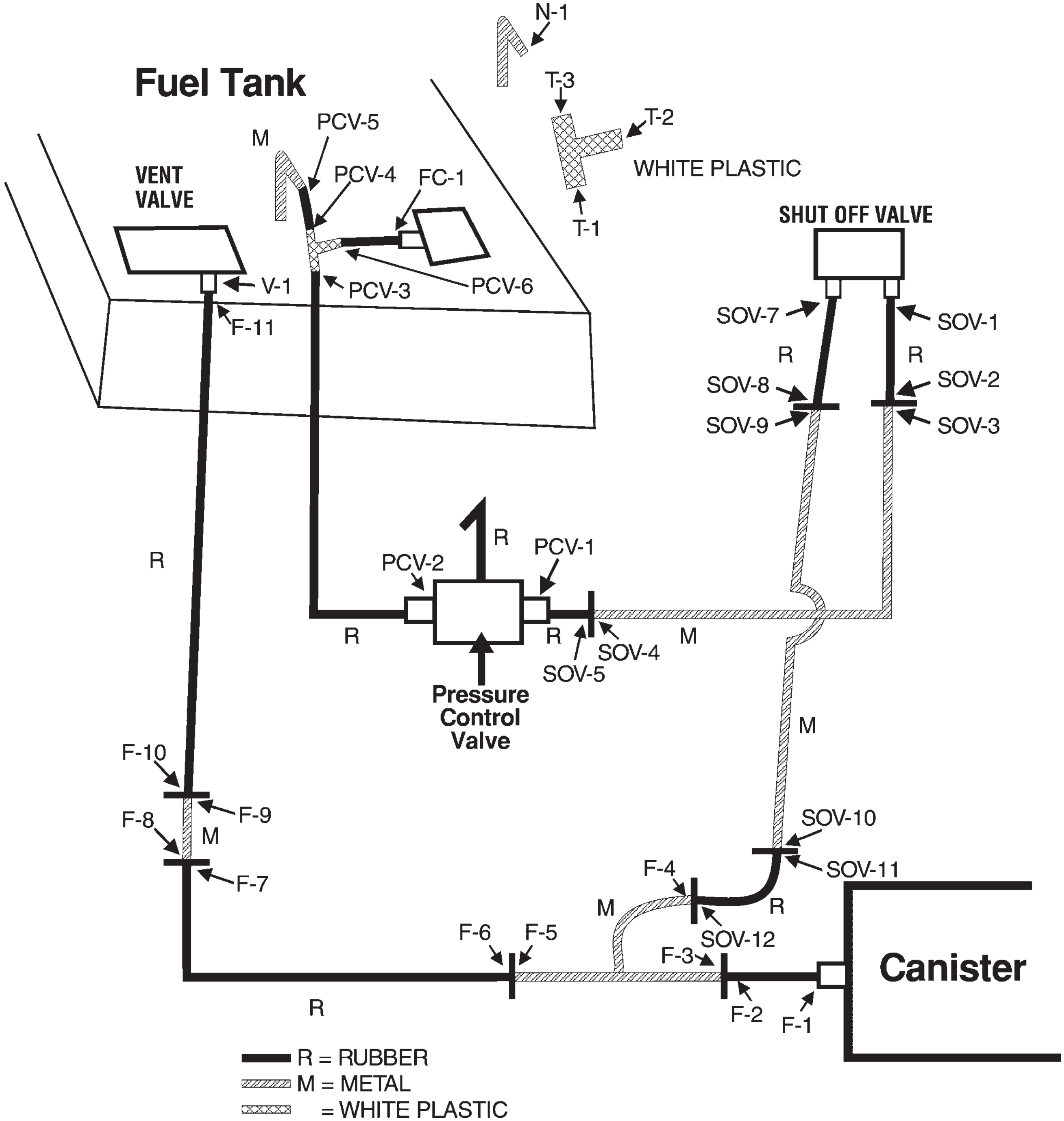
(6) Connect ST Plug to PCV-1.

(7) Pressurize.

(8) Did pressure hold?
YES go to step (9).
NO go to step (9F).

(9) Remove Pt-1 from Sov-12 and connect Sov-12 to F-4.

Notes:


N-1
Fuel Tank
T-3
T-2
WHITE PLASTIC
T-1
M
PCV-5
PCV-4
FC-1
VENT VALVE
V-1
PCV-3
PCV-6
F-11
SHUT OFF VALVE
SOV-7
SOV-1
R
R
SOV-8
SOV-2
SOV-9
SOV-3
R
R
PCV-1
PCV-2
R
R
SOV-4
M
SOV-5
Pressure Control Valve
M
F-10
F-9
F-8
M
F-7
SOV-10
SOV-11
F-4
M
R
F-6
F-5
SOV-12
F-3
Canister
F-2
F-1
R
R = RUBBER
M = METAL
= WHITE PLASTIC

Shut Off Valve Test 6F

(6F) Pressurize.

(6F1) Disconnect SOV-11 from SOV-10.

(6F2) Does pressure build up?
YES – Replace hose "SOV-12 to SOV-11" and go to step (3).
NO – Connect SOV-11 to SOV-10 and go to step (6F3).

(6F3) Pressurize.

(6F4) Disconnect SOV-8 from SOV-9.

(6F5) Does pressure build up?
YES – Clean or replace metal hose "SOV-1 to SOV-9" and go to step (3).
NO-Connect SOV-8 to SOV-9 and go to step (6F6).

(6F6) Pressurize.

(6F7) Disconnect SOV-7 from Fuel Shut Valve.

(6F8) Does pressure build up?
YES – Replace hose "SOV-8 to SOV-7" and go to step (3).
NO – Connect SOV-7 to Fuel Shut Valve.

(6F9) Pressurize.

(6F10) Disconnect SOV-1 from Fuel Shut Valve.

(6F11) Does pressure build up?
YES – Replace Fuel Shut Valve and go to step (3).
NO – Connect SOV-1 to Fuel Shut Valve and go to step (6F12).

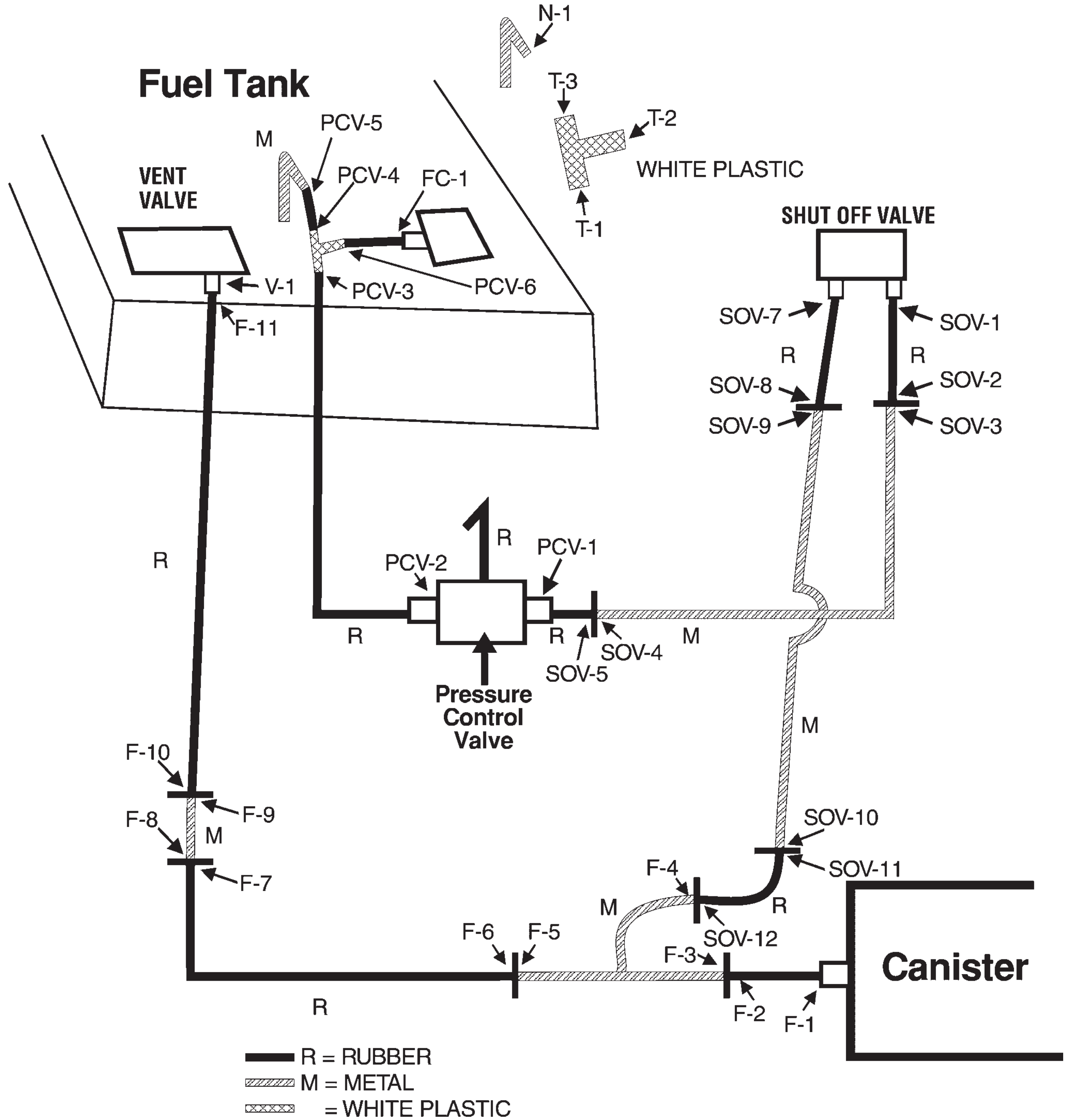
Shut Off Valve Test 6F12

(6F12) Pressurize.

(6F13) Disconnect SOV-2 from SOV-3.

(6F14) Does pressure build up?
YES – Replace hose "SOV-1 to SOV-2" and go to step (3).
NO – Clean or replace metal hose "SOV-3 to SOV-4" and go to step (3).

Notes:


N-1
Fuel Tank
T-3
T-2
WHITE PLASTIC
T-1
M
PCV-5
PCV-4
FC-1
VENT
VALVE
V-1
PCV-3
PCV-6
F-11
SHUT OFF VALVE
SOV-7
SOV-1
R
R
SOV-8
SOV-2
SOV-9
SOV-3
R
R
PCV-1
PCV-2
R
R
SOV-4
M
SOV-5
Pressure
Control
Valve
M
F-10
F-9
F-8
M
F-7
SOV-10
SOV-11
F-4
M
R
SOV-12
F-6
F-5
F-3
Canister
R
F-2
F-1
R = RUBBER
M = METAL
= WHITE PLASTIC

Shut Off Valve Test 9F

(9F) Go to step (9G)

Shut Off Valve Test 9G

(9G) Disconnect SOV-4 from Sov –5.

(9G1) Connect Adapter –1 with ST plug to SOV-4.

(9G2) Did pressure hold?
YES, replace rubber hose PCV-1 to SOV-5 and go to step 6.
NO, go to step (9G3)

(9G3) Disconnect SOV-2 from Sov –3.

(9G4) Connect ST plug to SOV-2.

(9G5) Pressurize
Did pressure hold?
YES , replace metal hose SOV-3 to SOV-4 and go to step 6.
NO, go to step (9G6)

(9G6) Disconnect SOV-1 from shut off valve.

(9G7) Connect Adapter-1 with ST plug to shut off valve.

(9G8) Pressurize
Did pressure hold?
YES , replace rubber hose SOV-1 to SOV-2 and go to step 6.
NO, go to step (9G9)

(9G9) Disconnect SOV-7 from shut off valve and connect ST plug to SOV-7.
Pressurize
Does pressure hold?
YES, replace shut off valve and go to step 6.
NO, go to step (9G10)

(9G10) Disconnect SOV-8 from SOV-9.

(9G11) Connect Adapter-1 with ST plug to SOV-9.

(9G12) Pressurize
Does pressure hold?
YES, replace rubber hose SOV-7 to SOV-8 and go to step 6.
NO, go to step (9G13)

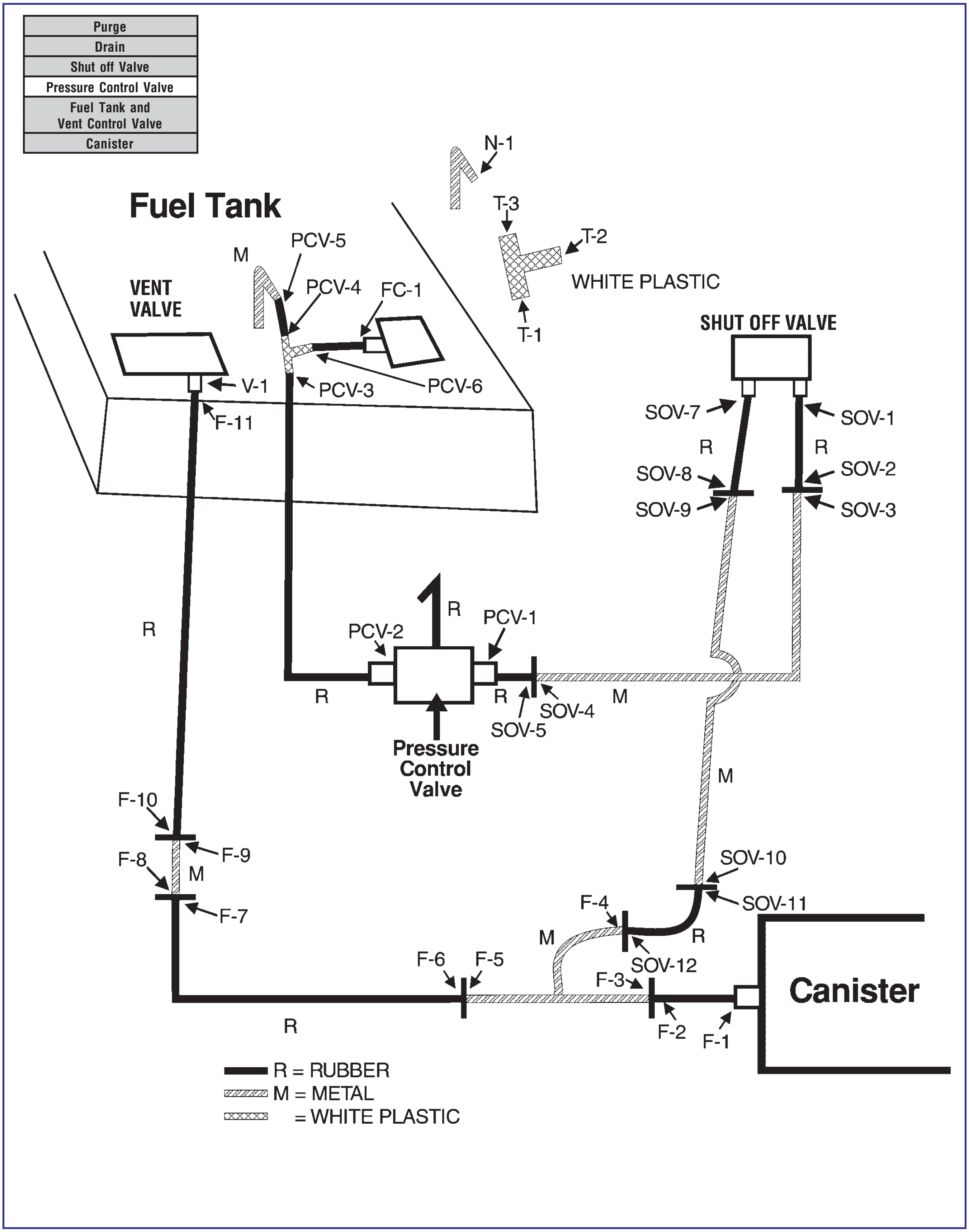
(9G13) Disconnect SOV-10 from SOV-11.

(9G14) Connect ST plug to SOV-11

(9G15) Pressurize
Does pressure hold?
YES, replace metal hose SOV-10 to SOV-9 and go to step 6.
NO, replace rubber hose SOV-11 to SOV-12 and go to step 6.

Notes:

2000 Model Year Evaporative System Diagnosis



Pressure Control Valve Test

Step 1 through 8 will test the Pressure control valve for electrical and mechanical operation.

(1) Remove ST plug from PCV-1.

(2) Connect PT-1 with ST adapter-1.

(3) Disconnect PCV-2 from PCV.

(4) Connect adapter-1 to PCV, applying pressure where PCV-2 connects to PCV.

(5) Activate PCV solenoid with select monitor.

(6) Turn pump timer on with HOLD SWITCH to OPEN position.

(7) Does pressure build to approximately 21 and then fluctuates by 1 as solenoid turns on and off?
YES go to step (8).
NO , replace PCV and go to step (1)
Turn pump timer off.
Turn the Pressure control valve off with the select monitor.

Step 8 test the PCV for air tightness.

(8) Block PCV at PCV-1 and pressurize.
Did pressure hold?
YES go to step (9).
NO, replace PCV and go to step (1).

(9) Turn pump timer off.

(10) Turn off PCV with select monitor.

(11) Remove ST plug from PCV.

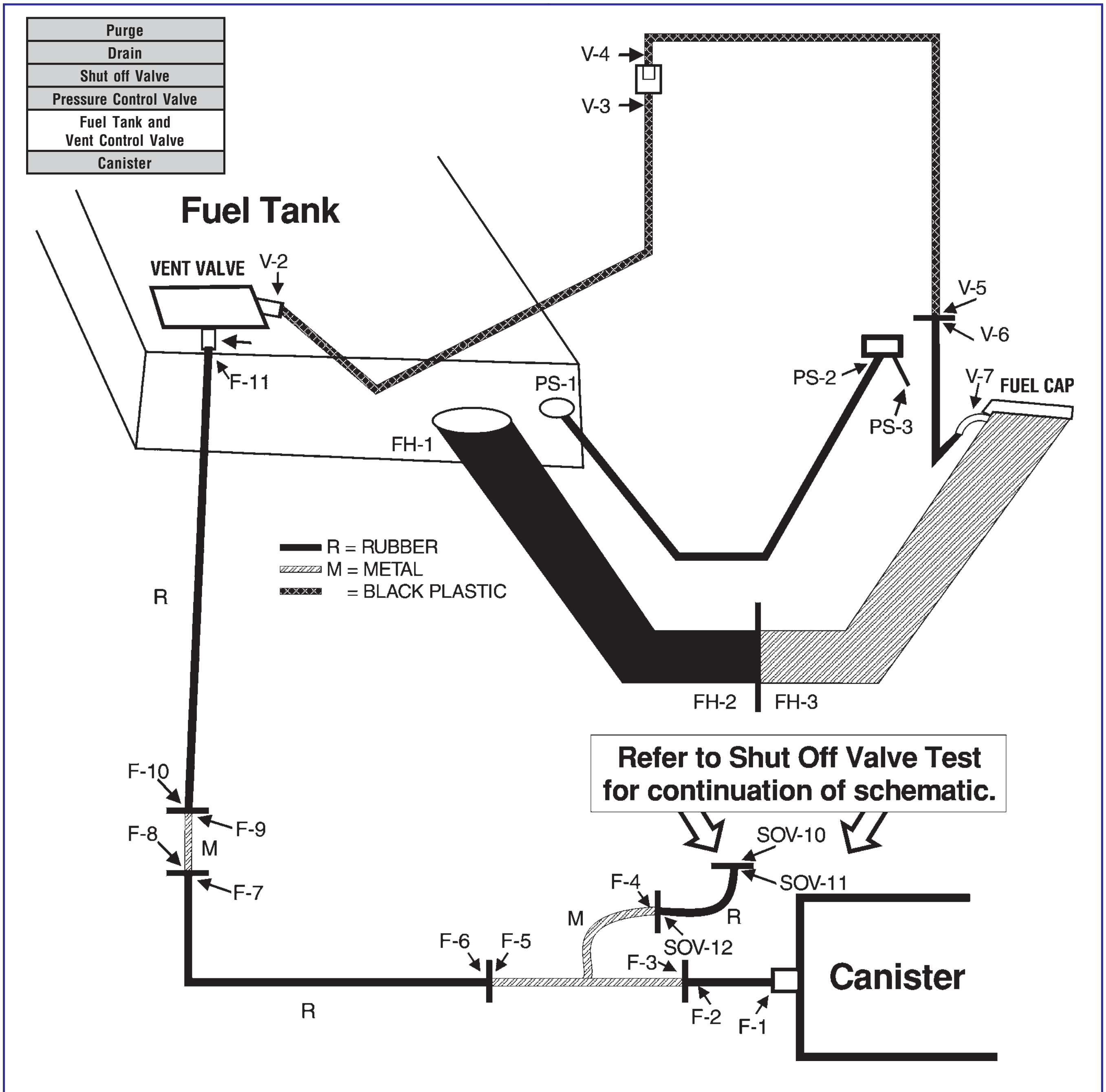
(12) Remove PT-1 wiht ST-adapter-1 from PCV.

(13) Connect PCV-1 to PCV.

(14) Connect PCV-2 to PCV.

Notes:

STOP



Fuel Tank and Vent Control Valve Test

WARNING: Next step introduces fuel vapors into the atmosphere. Test in well ventilated space. NO SMOKING!

Steps 1 through 9 tests the air tightness of the fuel tank, lines, and items shown in the illustration above.

WARNING: The pressure introduced into the fuel tank by the tester can push fuel from an open fuel line into the atmosphere.

- ***Adjust the Select Monitor to read the fuel tank pressure.***
- ***Check and record the fuel tank pressure. (With the cap off the pressure should be near zero.)***
- ***Pressure higher or lower than zero could indicate a blockage in the PS-3 hose,- PS-2 hose, the fuel tank passage or a failure of the pressure sensor.***

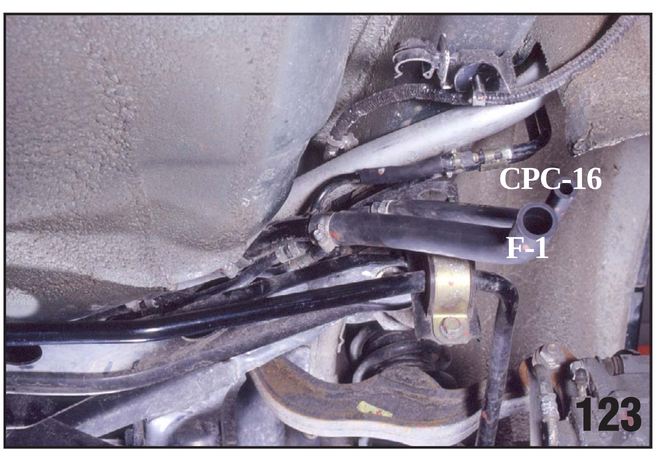
(1) Remove Fuel Cap and connect cap to adapter-2. Picture 121


121

(2) Connect opposite end of adapter-2 to filler neck.

(3) Remove PT-1 from hose and connect to threaded portion of adapter-2.

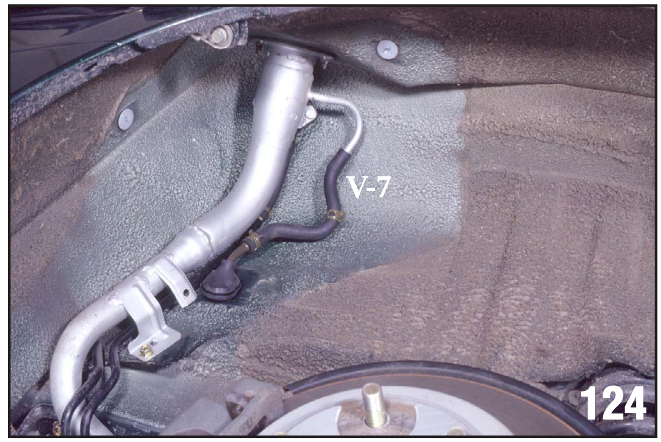
(4) Disconnect F-1 from canister. Picture 123.



123

(5) Connect adapter-1 with ST plug to F-1.

(6) Loosen connection V-7. Do not remove at this time. Picture 124.



124

(7) Pressurize.

Check and record the fuel tank pressure. (At 24in HG on the tester pressure gauge, the pressure reading on the select monitor should be +0.91in HG or +23.3mm HG.) If the pressure is not within specifications check the PS-3 hose for restrictions or blockage, and the PS-2 hose for restrictions, blockage and leaks. Confirm that the fuel tank passage located at PS-1 is allowing fuel tank pressure to exit the tank.

(8) **WARNING: Next step introduces fuel vapors into the atmosphere.**

(9) After 2 minutes, does pressure hold?
YES – go to step (10).
NO – go to step (10F).

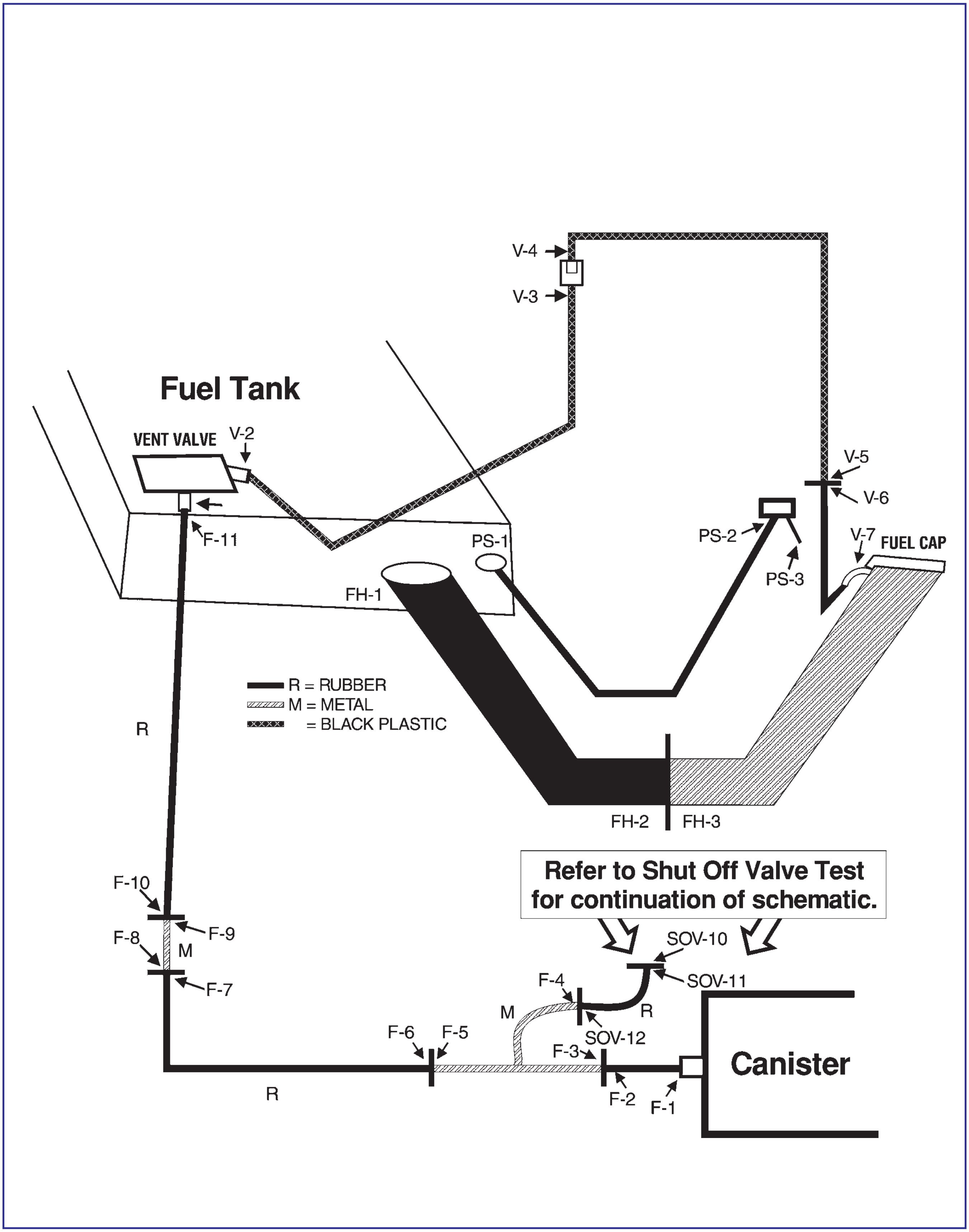
Step 10 and 11 will test the mechanical operation of the Vent control valve.

(10) Listen to the sound of air leaving the tank as adapter-1 with ST plug is removed from F-1. Picture 123.

(11) Listen to the sound of air leaving the tank as V-7 is disconnected. Picture 124.

(12) Did the speed of air escaping the tank increase from steps (10) to (11)?
YES – go to step (13).
NO – go to step (13F).

(13) Connect V-7 to filler neck.


V-4
V-3
Fuel Tank
VENT VALVE
V-2
F-11
PS-1
PS-2
PS-3
V-5
V-6
V-7
FUEL CAP
FH-1
R = RUBBER
M = METAL
= BLACK PLASTIC
R
FH-2
FH-3
Refer to Shut Off Valve Test for continuation of schematic.
F-10
F-9
F-8
M
F-7
SOV-10
SOV-11
F-4
M
R
SOV-12
F-6
F-5
F-3
Canister
R
F-2
F-1

Fuel Tank and Vent Control Valve Test 10F

(10F) Check all fuel lines, fuel cap and Evaporative lines for proper connection.

(10F1) Remove all fuel and tank pressure.

(10F2) Follow instructions in the appropriate Subaru service manual for removing the fuel tank

(10F3) Plug all inlets and outlets from the fuel tank and external valves.

(10F4) Ensure fuel tank is at least half full and pressurize.

(10F5) After leak has been found and repaired go to (10F6)

(10F6) Pressurize.

WARNING: Next step introduces fuel vapors into the atmosphere.

(10F7) After 2 minutes, does pressure hold?
YES – go to step (10F8).
NO – Recheck for leaks and go to (10F5)

(10F8) The following steps will check the operation of the vent control valve.

This should be performed before installing the tank because the tank must be removed to replace a faulty valve.

Steps (10F9) through (10F11) will test the mechanical operation of the Vent control valve.

(10F9) Listen to the sound of air leaving the tank as plug for F-11 is removed.

(10F10) Listen to the sound of air leaving the tank as plug for V-2 is disconnected.

(10F11) Did the speed of air escaping the tank increase from steps (10F9) to (10F10)?
YES, Remove all fuel and tank pressure and install tank-using instructions from the appropriate Subaru service manual.
NO, Remove all fuel and tank pressure and replace Vent control valve using instructions from the appropriate Subaru service manual.

If tank has been removed, perform step 1 through 13 to confirm air tightness of fuel tank and vent control valve after installation.

Fuel Tank and Vent Control Valve Test 13F

(13F) Remove all tank pressure.

(13F1) Remove V-7 from fuel neck and connect PT-1.

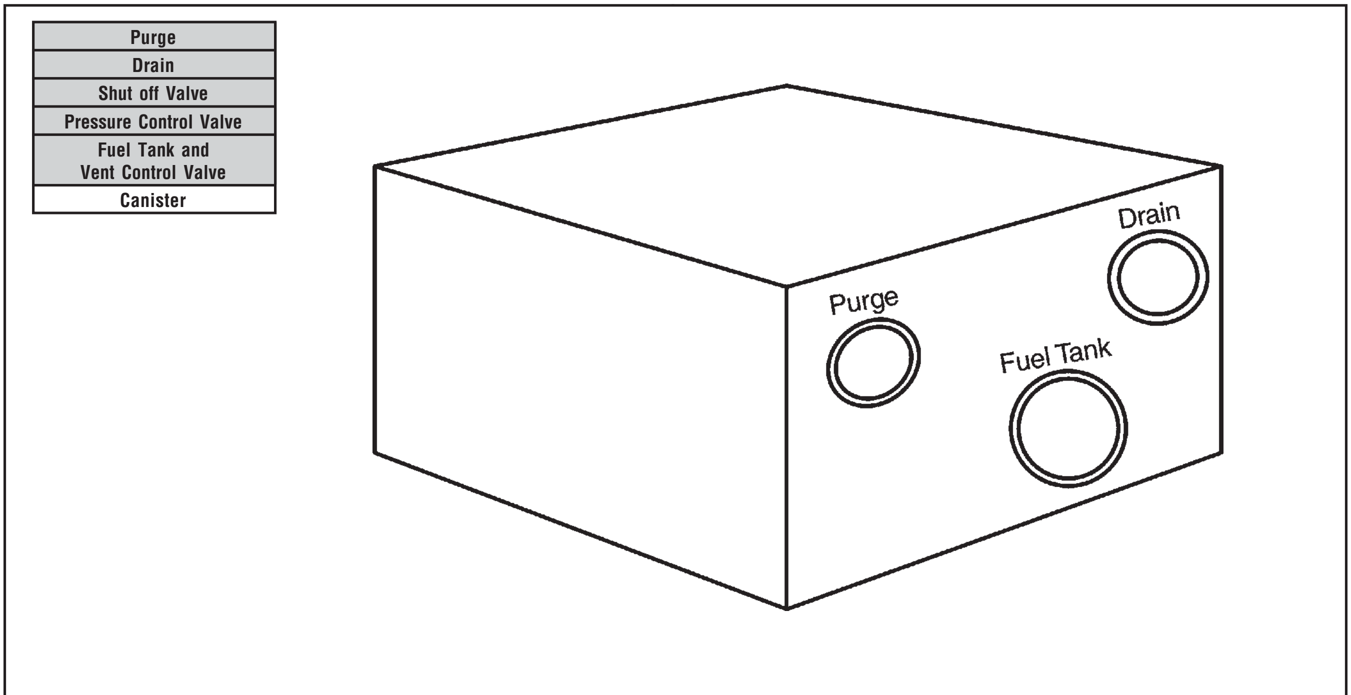
(13F3) Remove V-2 from vent control valve.

(13F4) Pressurize
Did pressure hold?
YES , replace or remove obstruction from rubber hose V-7 through V-2 and go to step 7.
NO , go to (13F5)

(13F5) Insert ST Plug into V-2 hose.

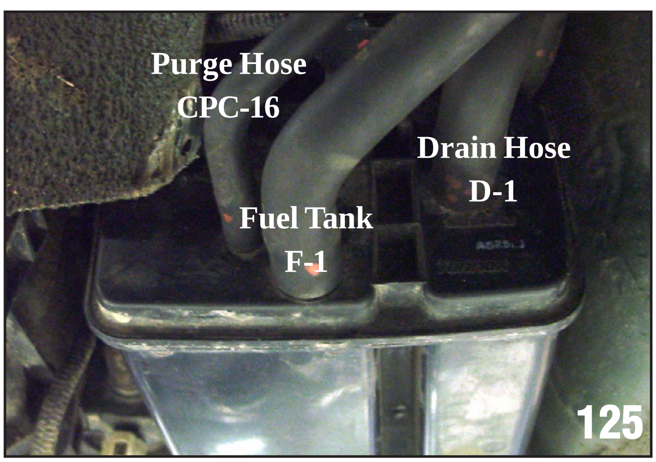
(13F6) Pressurize
Did pressure hold?
YES , Remove all fuel and tank pressure and replace Vent control valve using instructions from the appropriate Subaru service manual.
NO , replace rubber hose V-7 through V-2 and go to step 7.

If tank has been removed perform step 1 through 13 to confirm air tightness of fuel tank and vent control valve after installation.



Canister Test

Steps 1 through 8 tests the air tightness of the canister.



(1) Disconnect 3 hoses from canister. Picture 125.

(2) Reinstall PT-1 to pressure tester hose.

(3) Connect adapter-1 to PT-1.

(4) Connect adapter-1 to purge hose connection of canister. Picture 125.

(5) Connect adapter-3 to fuel tank hose connection of canister.

(6) Connect adapter-4 to Drain hose connection of canister.

(7) Pressurize.

(8) After 2 minutes, does pressure hold?
YES – go to step (9).
NO – go to step (9F).

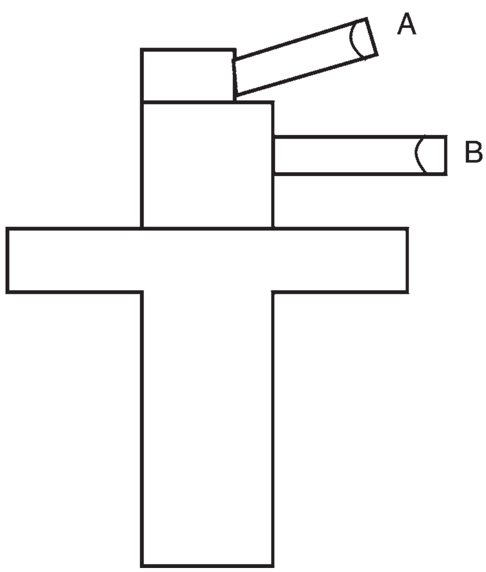
(9) Disconnect 3 adapters from canister.

(10) Connect all hoses back to canister and secure.

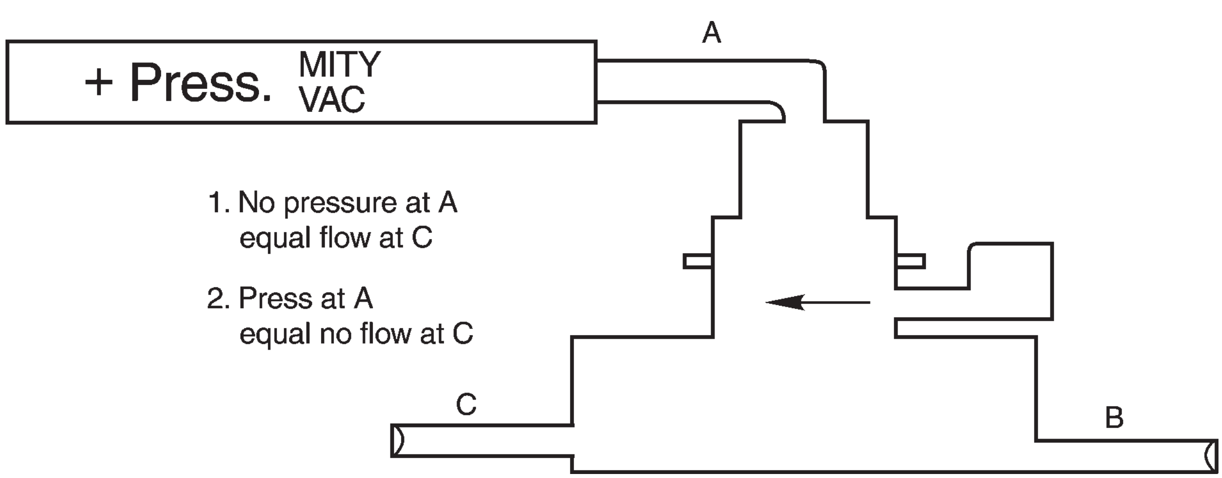
STOP

Vent Valve Test

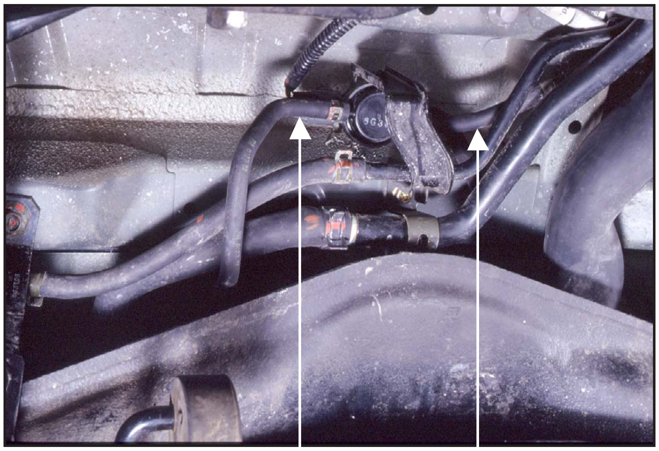
Pressurize tank through Port B or fuel hose.
Allow tank pressure to escape through Port B.
Apply pressure to Port A. Tank pressure should then stay in tank.



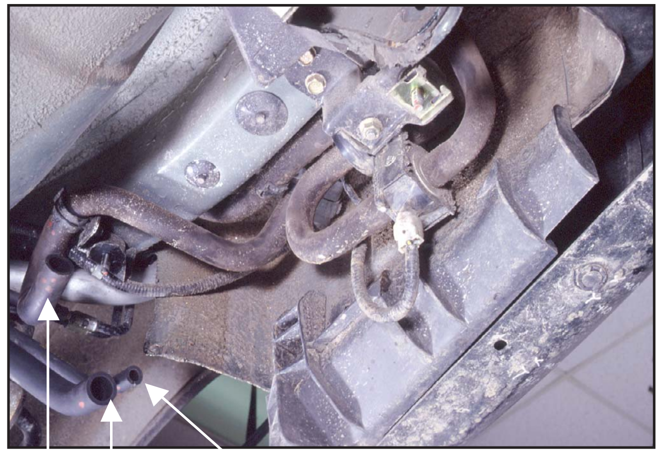
PCV Test

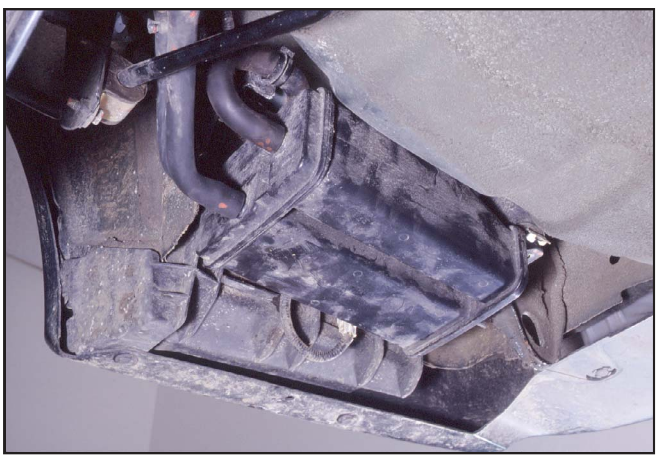


Pressure Control Valve

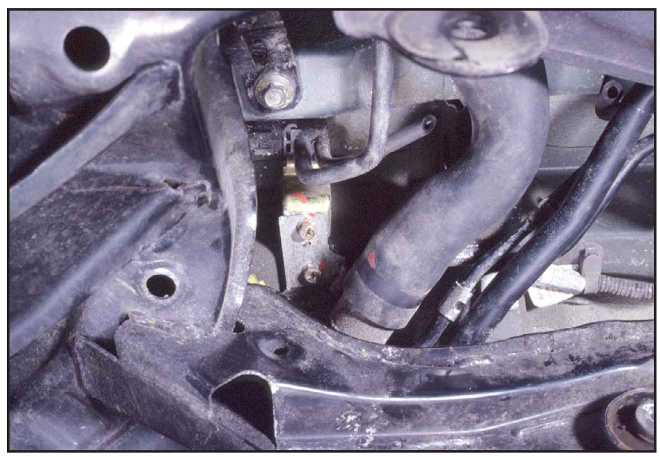


Drain Valve

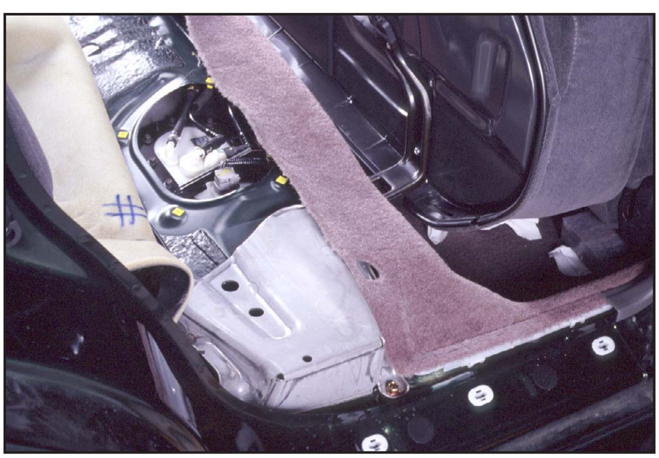




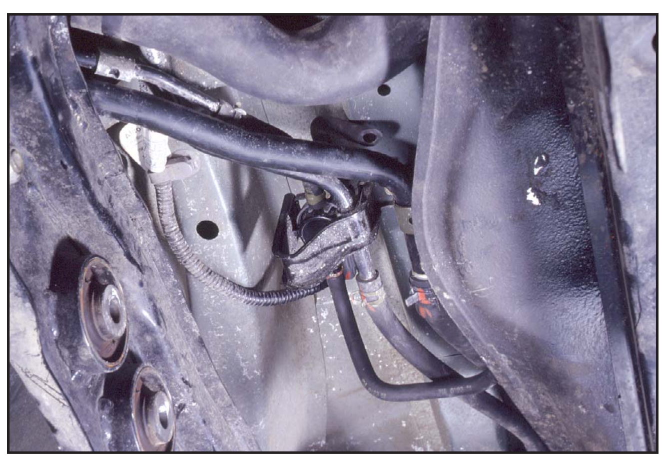
Canister



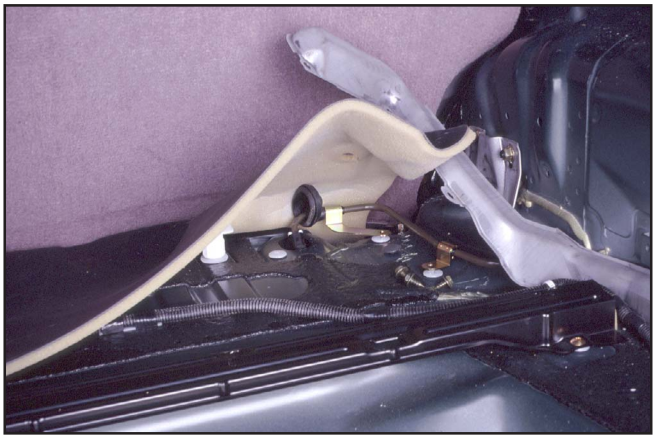
Pressure Sensor



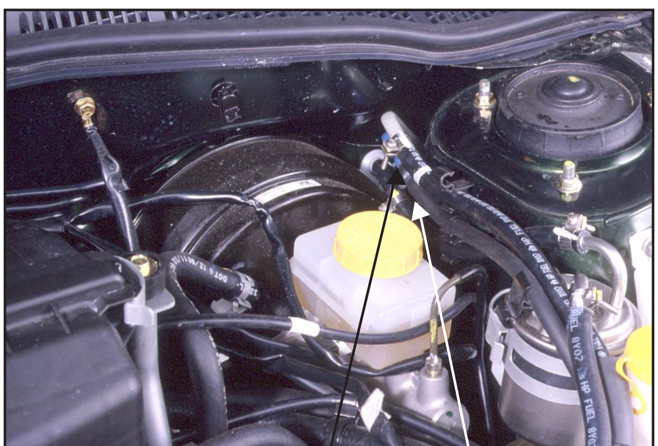
Fuel Pump under rear seat



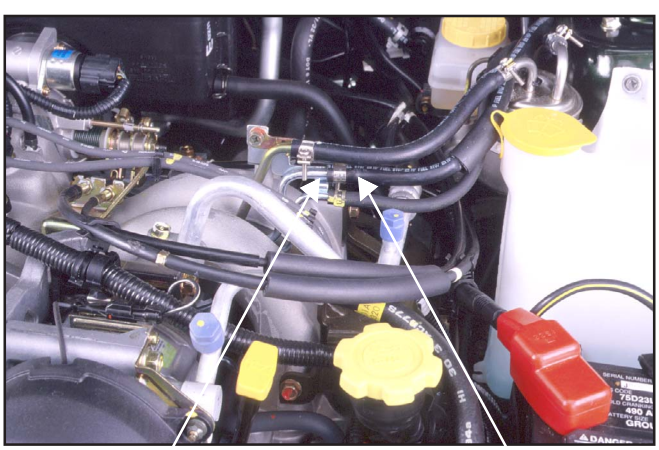
Pressure Control Valve



Quick Connector on Vent Hose
(Located in cargo area of station wagon, trunk of sedan.)

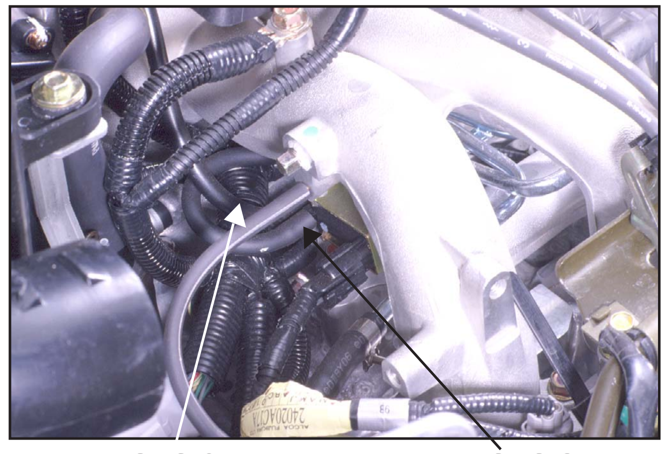


CPC-9 CPC-8

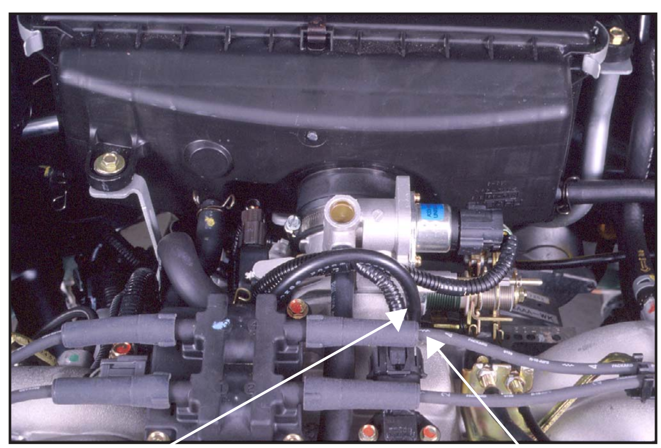


CPC-6 CPC-7

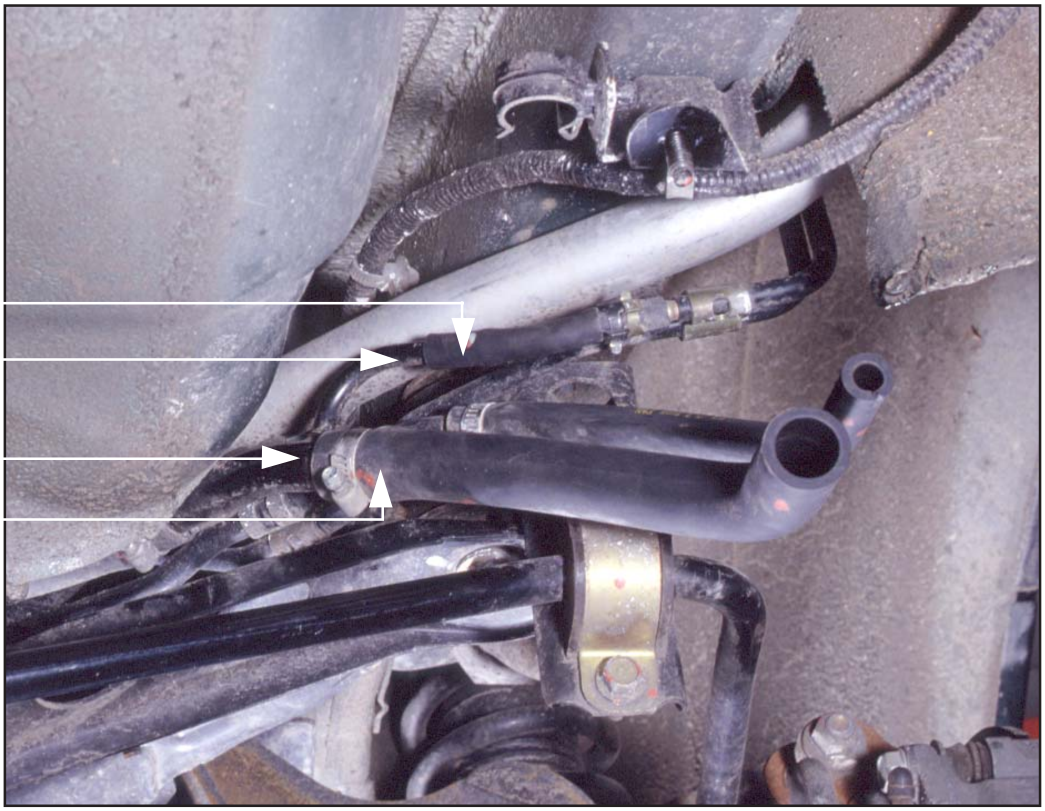
Canister Purge Control solenoid

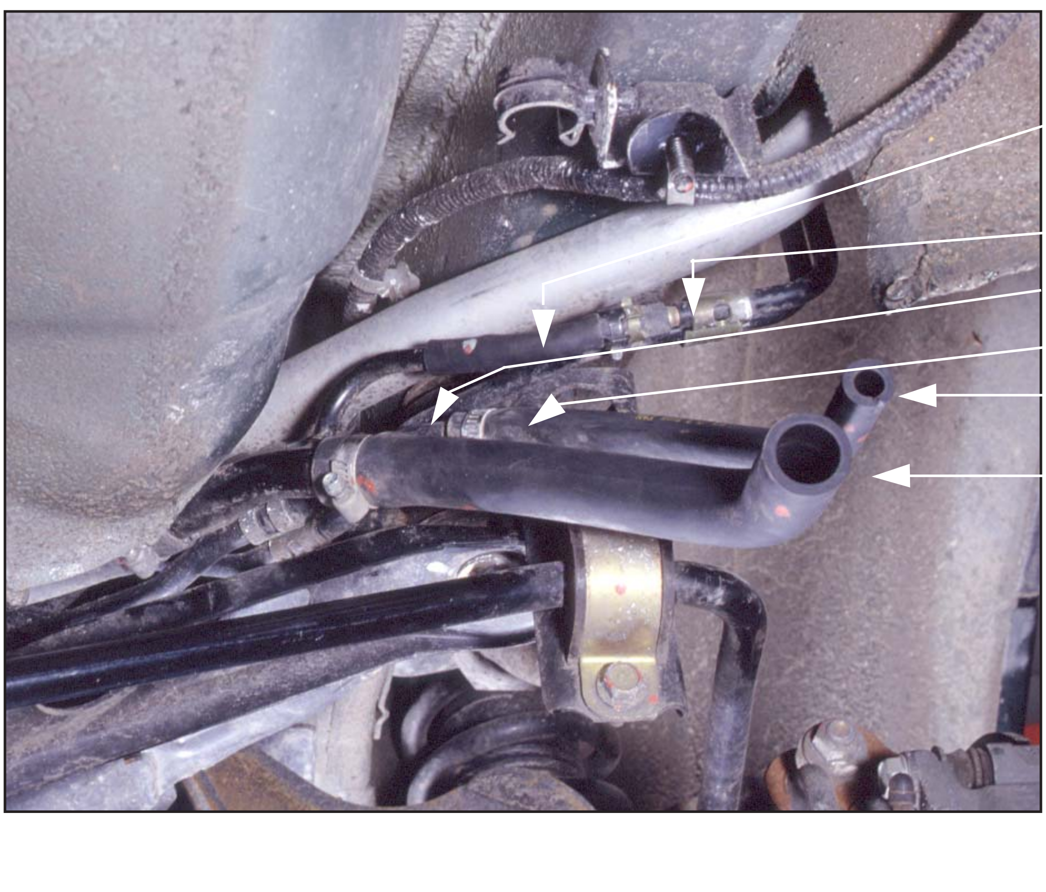


CPC-2 CPC-3



CPC-1 M-1


SOV-12
F-4
F-3
F-2


SOV-12
SOV-10
SOV-14
SOV-15
SOV-16
F-1

Notes:

Notes:

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Technicians Reference Booklet

Fuel Injection and Engine Management

Module 406

AUTOMOTIVE Youth Educational Systems®

May 2006

MSA5P0161C

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of May 2006.

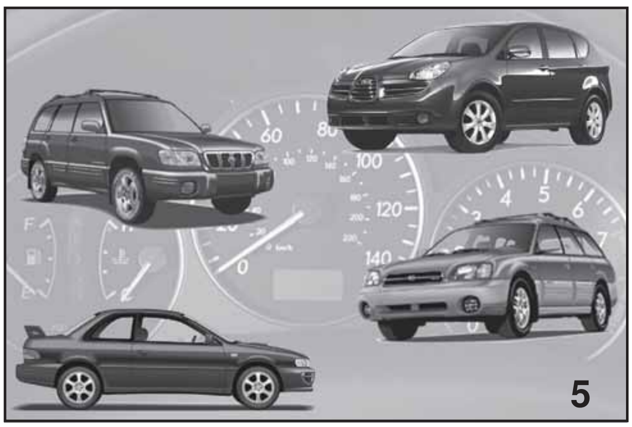
This book is revised with material from New Model Update 913 thru 915.

Table of Contents

Fuel Injection and Engine Management (406)

Introduction

This Technicians Reference Booklet contains information about Subaru Fuel Injection and Engine Management systems. It is not intended to be a stand alone publication on the operation, diagnosis, or repair of any system or component. The objective of this class is to provide training that will assist you with properly diagnosing and repairing the Subaru vehicle in a timely manner the first time. Coverage of information will begin with Subaru Legacy.



Subaru Models

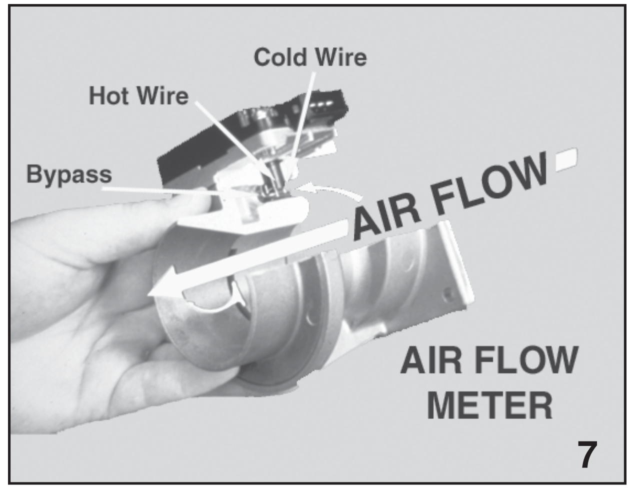
Only the differences of other models will be reviewed and supplemental information will be provided for you to take back to the dealership.

Air Induction System

The Air Induction provides the correct amounts of air to the cylinders under a variety of operating conditions and performance demands. Components include:

Air Induction Piping
Mass Air Flow Meter
Throttle Body
Idle Air Control Valve

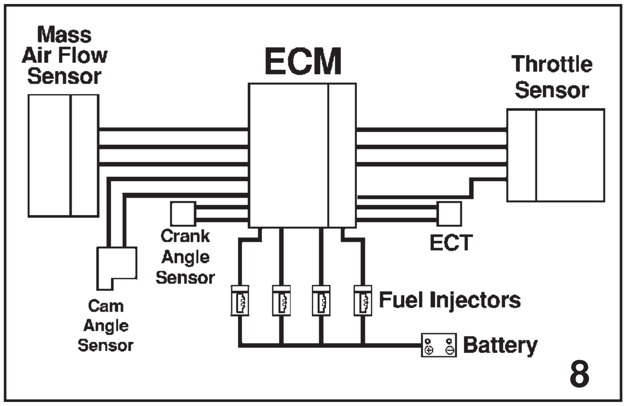
The Air Induction Piping delivers air from the air filter to the Throttle body , Idle Air Control Valve and the PCV system. Fitting to the components of the Air Induction System must be air tight to prevent unmetered air from entering the intake manifold.



Air Flow Meter

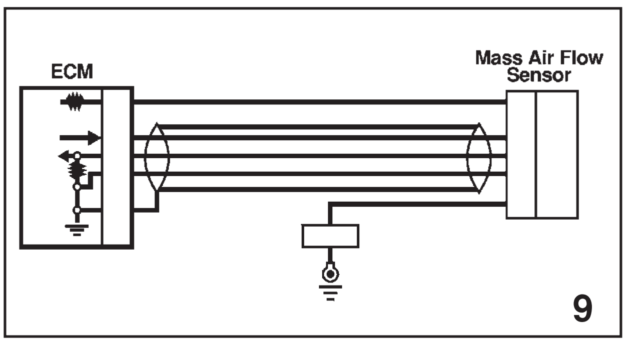
Monitoring the amount of air inducted is the main function of the Mass Air Flow Meter. Described as a "Hot Wire" type air flow meter containing no moving parts, the Subaru Mass Air Flow Meter obtains information by monitoring the voltage of a single wire which is exposed to the incoming air flow. There are actually two wires exposed to the air flow. The "Hot Wire" which is positioned downstream of the cold wire to prevent any influence to the cold wire. Engine Control Module logic monitors the temperature of both wires by knowing their resistance values and voltage in the wire. The ECM will attempt to maintain a fixed difference in the temperature of these two wires. The amount of voltage applied to the "Hot Wire" is what finally determines the value of the signal generated or "Air Quotient".

Air Quotient (QA), is one of the input signals to the ECM that determines the amount or length of time fuel is injected. Two other inputs are the throttle position signal, generated by the throttle position switch (TPS) and the engine speed (EREV), which is a processed signal by the ECM from input of the crank and cam angle sensors.



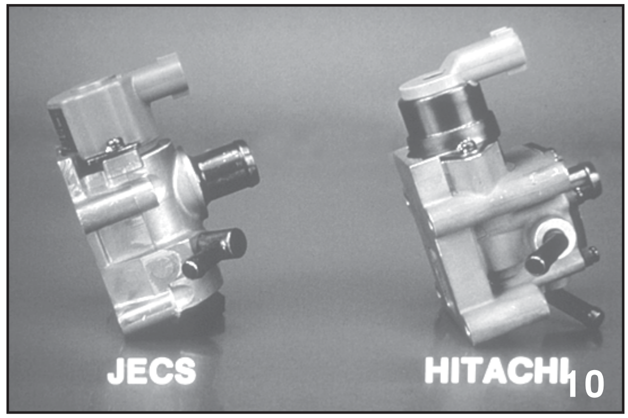
Fail-safe Schematic

Fail-safe results, the action taken by the ECM in the event a component is not operating within established parameters, will force the ECM to determine injection duration using TPS and EREV only.



Mass Air Flow Sensor Circuit

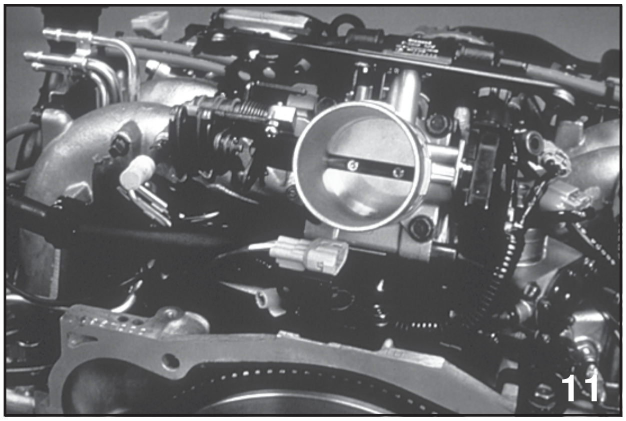
Testing is performed by observing resistance and voltage values. QA Value can be monitored using the select monitor. QA value should increase with engine speed and decrease to approximately 1 volt as engine speed approaches idle. Fail-safe value will result in a constant signal which is not effected by engine speed.



Idle Air Control Valves

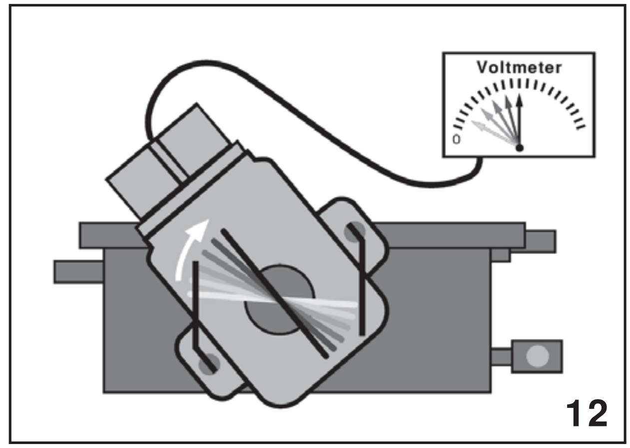
The installation of improper replacement parts will result in a driveability or no start condition. Verify with your parts department using Vehicle Identification and Production Date numbers as necessary. For example earlier production Legacy Vehicles were equipped with either a JECS or HITACHI produced air flow meter dependent on whether they were Automatic or Standard shift transmission vehicles.

NOTE: IN EARLY OBD II SYSTEMS A DTC P0507 (IDLE CONTROL SYSTEM RPM HIGHER THAN EXPECTED) COULD BE SET IF THE ACCELERATOR OR CRUISE CONTROL CABLE WAS NOT PROPERLY ADJUSTED. USUALLY THE CABLE IS TOO TIGHT. CABLE ADJUSTMENT WAS PART OF THE PDI AND SHOULD BE CHECKED DURING 60K CHECKUPS.



Throttle Body with Accel Cable & TPS

The Throttle Body regulates the amount of air into the intake manifold, controlling off idle engine speed. Operation of the throttle body is accomplished from the movement of the accelerator cable. Coolant flows through the base of the throttle body to prevent ice from forming. The throttle body is factory set and no adjustment should be attempted to the throttle plate. Adjustment of the throttle cable is suggested at PDI and Periodic Vehicle Maintenance.



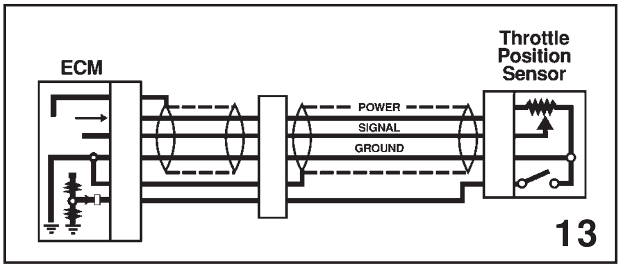
Potentiometer Operation

The Throttle Position Switch is mounted to the throttle body and engages to the throttle shaft. Any movement of the throttle shaft results in the movement of a contact inside the ECM that is acting with a potentiometer. At idle the resistance value is high so the voltage signal at the moveable contact is low. As the throttle is depressed the resistance value decreases and the voltage at the moveable contact increases. The voltage signal which ranges from .3 to 5 volts, is used by the ECM to determine the position of the throttle in degrees of opening. The Legacy also used a TPS where the voltage ranged from approximately 5 volts at idle and decreased as the throttle was depressed.

An idle switch is also provided which signals idle and off idle to the ECM.

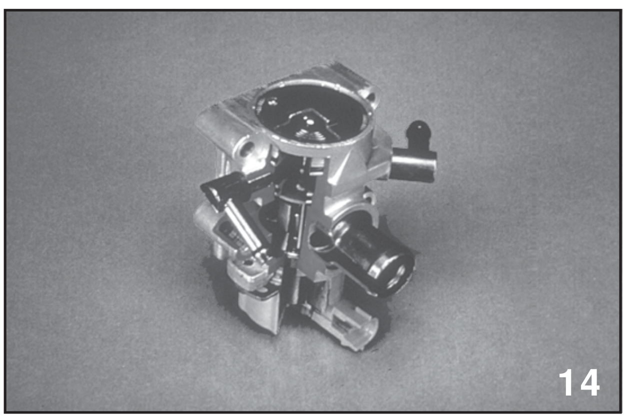
Adjustment is possible through the use of elongated mounting holes.

Fail-safe operation results in a fixed TPS voltage signal while the ECM uses the idle switch, QA and EREV to control injection duration.



Throttle Position Sensor Circuit

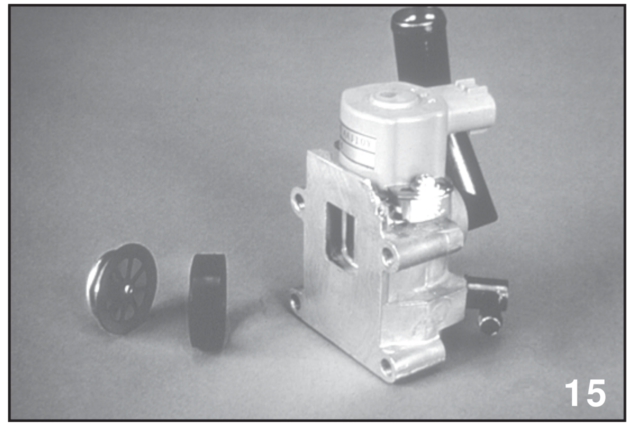
Testing is performed by observing voltage and resistance values. The Select Monitor on earlier models will display THV or throttle voltage and illuminate an LED when the idle switch signal is present. Newer models in addition will indicate throttle opening in degrees.



Idle Air Control Valve

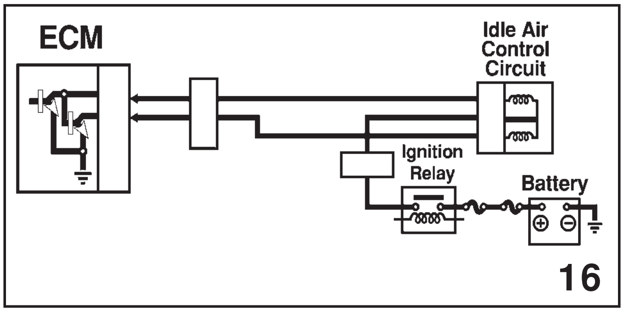
Idle Air Control Valve (IAC) operation controls all idle speeds. Construction includes an air cut valve, duty control valve, intake air passage and a coolant passage. These component parts create a dual control over the IAC. The air cut valve is influenced by the temperature of coolant flowing through the IAC. A bimetallic spring is utilized to act on the air-cut valve, opening the valve when coolant temperature is low increasing air flow and idle speed. When coolant temperature is high the bimetallic spring closes the air cut valve and decreases airflow and idle speed.

Duty control valve operation is achieved by utilizing two electrical coils, one to open the valve and the other to close it. The ECM controls the ground circuits of the two coils and controls them with a duty signal, pulsing the ground circuits.



Turbo Idle Air Control Valve

IAC duty ratio can be monitored with the select monitor. Higher duty ratio will keep the valve open longer increasing idle speed. Lower duty ratio provides lower idle speeds. Optimum idle speed for all engine conditions is part of the ECM logic and will increase or decrease IAC duty ratio as necessary to maintain the correct idle speed.



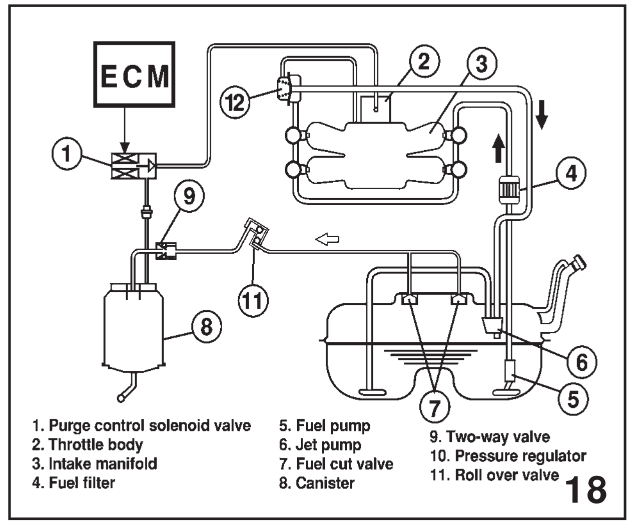
IAC Schematic

Fail-safe results of the IAC can be miss leading. Failure of the bimetallic spring with the air-cut valve in the more open position will result in no problem with a cold engine but as the engine warms the duty ratio of the IAC will be lower than normal to close the duty control valve more to maintain proper idle speed. Failure of the bimetallic spring in the more closed position will result in higher IAC duty ratio with a cold engine but will be normal with a warm engine.

Failure of the duty control valve or loss of duty signal will leave the duty control valve fully open. With a cold engine the air cut valve is also fully open. This quantity of air flowing through the intake air passage would result in an improper high idle speed. To control this condition the ECM will turn off injectors to reduce idle speed. One injector for a warm engine and two injectors for a cold engine.

The intake air passage can be contaminated with carbon which reduces the air flow. This condition would result in a higher than normal IAC duty ratio. If this condition is suspected clean the IAC valve following procedures outline in the Subaru Service Manual on the STIS web site.

Fuel Supply

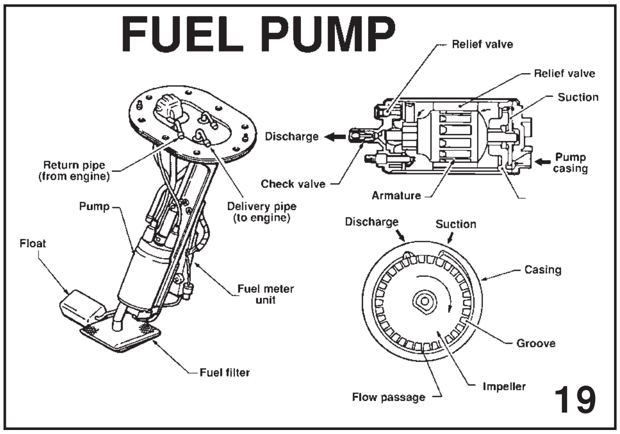


Fuel Supply System

The Fuel Supply system supplies, regulates and monitors gasoline to the injectors. Components include:

- Fuel Tank
- Pump
- Rollover valve
- Separator
- Regulator
- Injectors

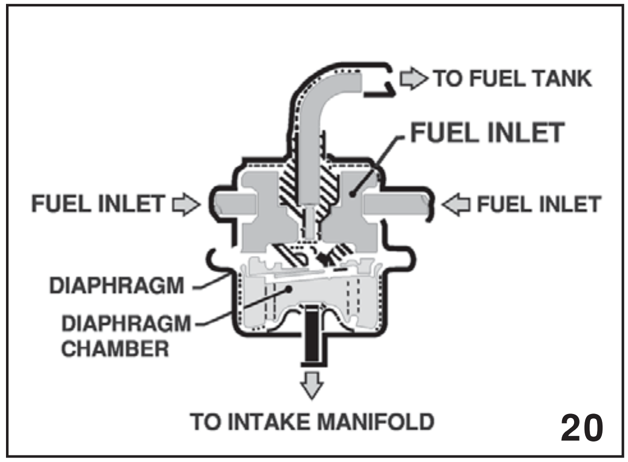
The Fuel Tank houses the fuel pump and on AWD models a jet pump. Interference with the rear differential is avoided by shaping the tank in a saddle type design. This design makes it necessary to supply a means of removing fuel from one side of the tank to the other. The fuel pump is on the right side of the tank as viewed from the rear with the jet pump pickup on the left. The speed of the fuel returning to the tank is used by the jet pump to create a siphoning effect transferring fuel from the left side of the tank to the right. The main fuel pump can then pickup the fuel.



Fuel Pump

The fuel sending units, one on each side of the tank are wired in series to provide the fuel gauge with correct information to show correct fuel level.

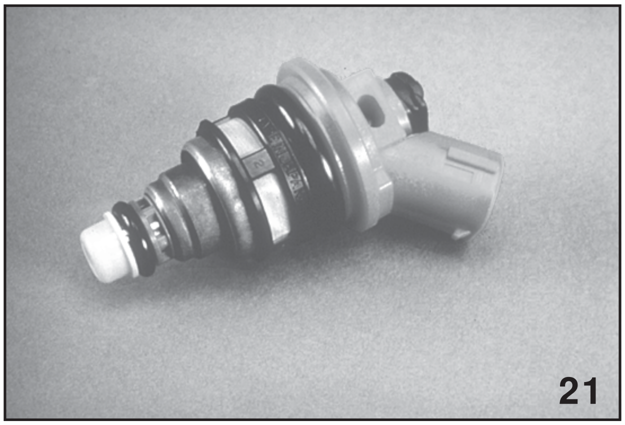
The fuel pump creates pressure by moving the fuel through a series of impeller vanes and centrifugal force. Pressurized fuel flows through the clearance between the armature and the magnet of the motor to the discharge port of the pump. If the pressure output is too high a relief valve opens and the pressurized fuel exits the pump to the tank. When the pressure returns to normal the relief valve will close.



Fuel Pressure Regulator

Fuel pressure regulator operation controls fuel pressure by adjusting the size of a passage, through spring tension and manifold pressure, that allows fuel to return to the tank. When manifold pressure is high during acceleration the opening is small allowing less fuel to return to the tank. This provides higher fuel pressure at the injectors. During conditions of low manifold pressure the opening is large allowing more fuel to return to the tank, reducing the fuel pressure at the injectors. A check valve in the regulator maintains pressure in the fuel system after the engine is turned off.

CAUTION: THE FUEL SYSTEM IS ALWAYS UNDER PRESSURE. DISCONNECT THE FUEL PUMP AND START THE ENGINE TO REMOVE THE PRESSURE. ALLOW THE ENGINE TO RUN UNTIL IT STALLS AND ATTEMPT TO RESTART. TURN THE KEY OFF. THE SYSTEM IS NOW SAFE TO OPEN. FOLLOW ALL SAFETY PROCEDURES OUTLINED IN THE APPROPRIATE SUBARU SERVICE MANUAL ON THE STIS WEB SITE.



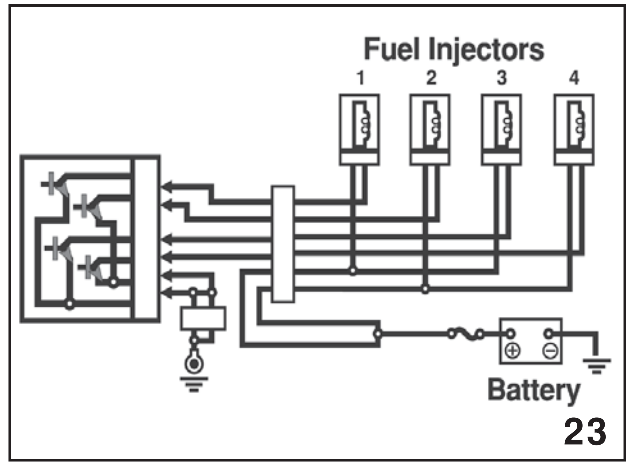
Fuel Injector

The fuel injector is described as a galley or side feed type, that delivers fuel to the intake manifold.

Control is achieved by varying the ground signal of the injector. This is accomplished by the ECM. A magnetic field develops inside the injector when the ground is established. The magnetic field lifts a plunger off of its seat and fuel under pressure enters the injector and exits through the tip of the injector. The design of the tip creates the proper spray pattern that results in the best mixing with air in the manifold.

Tip Design

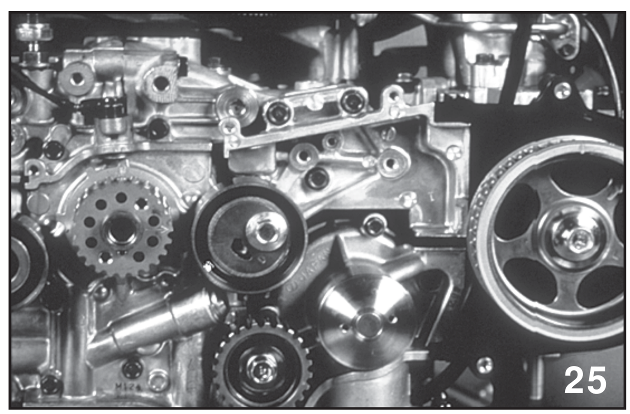
The time or length of grounding of the injector circuit is referred to as injection duration. The select monitor will display injection duration as "TIM". (Injection Duration)



Fuel Injector Circuit

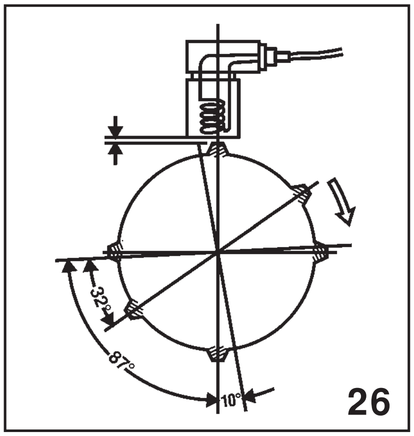
Sensors

Crank angle sensor operation determines crankshaft position and speed by sensing pulses created by a reluctor passing through a magnetic field. The reluctor is machined to the back side of the crankshaft timing belt sprocket. The shape of the reluctor teeth is very important to the strength and clarity of the signal produced. A chip or deformation on any tooth can result in a driveability or no start condition. The signal generated is A/C and varies from approximately .5 to 1.5 volts.



Crank Angle Sensor

The crank angle sensor is made from a permanent magnet and a coil of wire. Do not drop the crank angle sensor as the magnet may be damaged or the shape of the sensor which can alter the signal generated.



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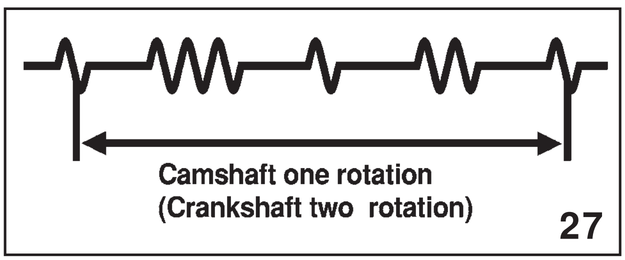
Crank Angle Sensor Reluctor Construction

The crank angle reluctor has 6 teeth making two sets, each having teeth set at 10, 65 and 97 degrees BTDC.

The ECM uses the crank angle sensor input to influence or control the fuel and ignition systems.(Determines engine rpm, fuel injection timing, dwell and timing advance.)



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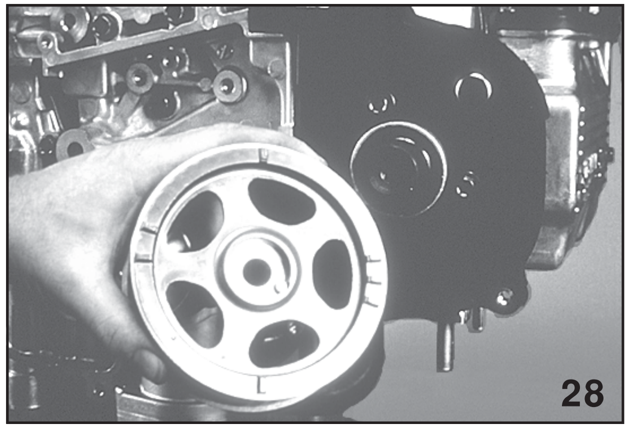
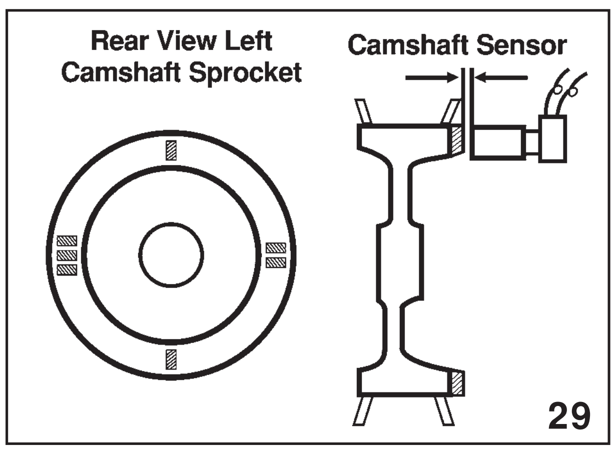
Cylinder Discrimination Signal


28

Cam Angle Sensor and Reluctor

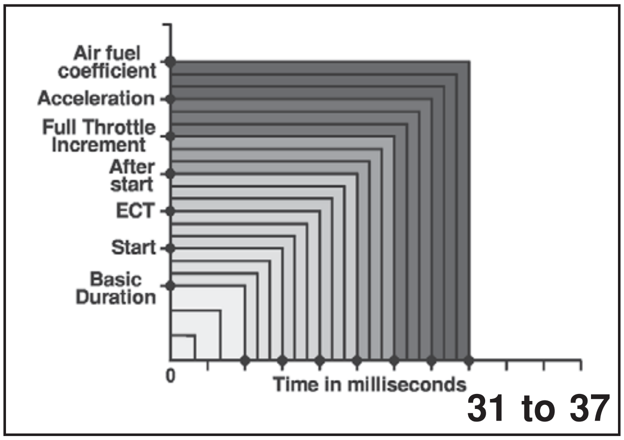
The cam angle sensor in operation functions the same as the crank angle sensor. The value of the A/C signal is slightly lower and the signal pattern is different. Cam angle sensor reluctor teeth are located on the back side of the left side camshaft sprocket. The ECM uses the cam angle sensor to determine fuel injection sequence and to reference the #1 cylinder.



29

Cam Angle Sensor Air Gap

Fuel Injection Logic



Injection Duration

The amount of fuel injected or duration is determined by the following:

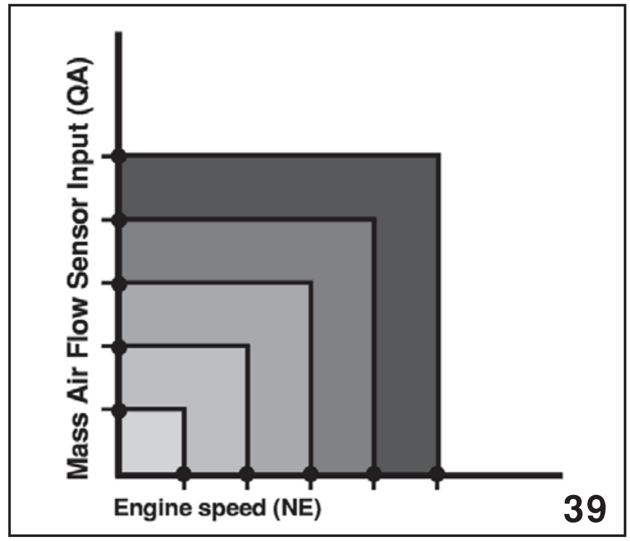
BASIC DURATION + CORRECTION FACTORS + VOLTAGE CORRECTION

Basic duration is determined by comparing QA and engine speed.

Correction factors include:
- Start increment
- Coolant temperature
- After start
- Full increment
- Acceleration
- Air, fuel coefficient

Voltage correction compensates for the injectors time lag affected by battery voltage.

Learning Control

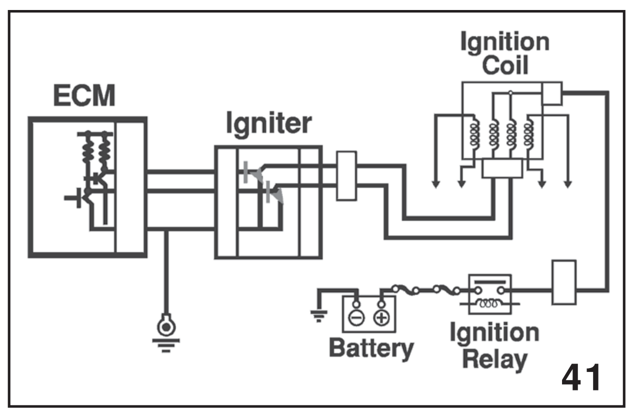


Basic Duration

The amount of air monitored by the mass air flow meter or QA compared to the engine rpm is memorized by the ECM. This results in a representation of engine load.

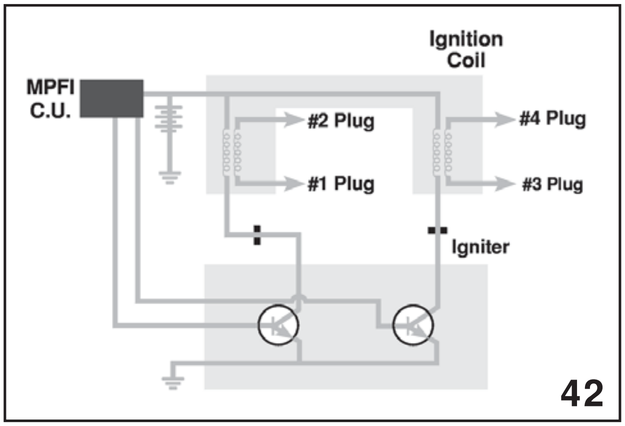
Engine load is used to update Basic duration.

Ignition System Control



Ignition Circuit

The distributorless (direct ignition) system uses the crank and cam angle sensor inputs processed by the ECM to control ignition and ignition timing. This system uses a coil pack that houses two coils that separately supply secondary voltage to two cylinders.

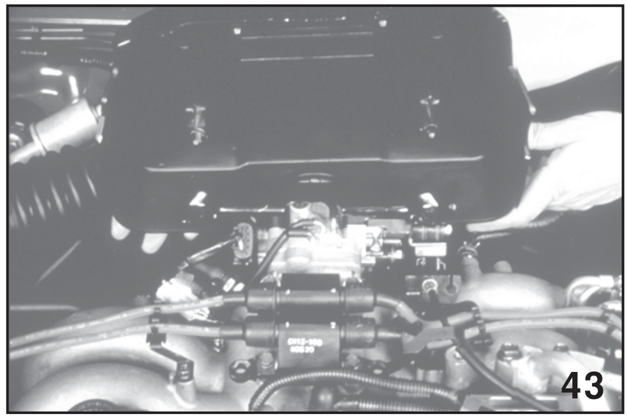


Ignition Coil Construction

Cylinders #1 & #2 - Forward coil
#3 & #4 - Rear coil

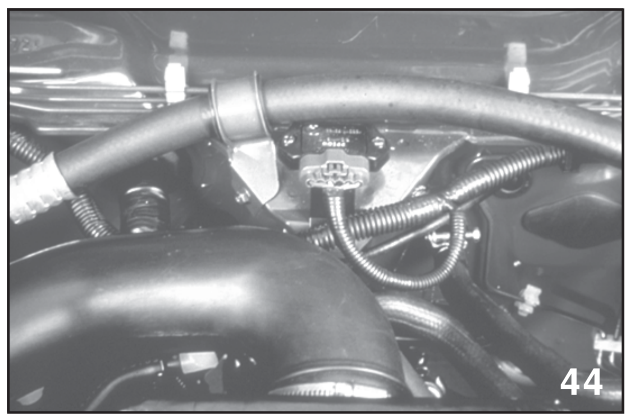
The secondary voltage is sent to the spark plugs of two cylinders simultaneously, one cylinder will be on the power stroke and the other on exhaust stroke.

CAUTION: DURING CYLINDER "POWER BALANCE" TESTS DO NOT ALLOW FUEL TO ENTER THE EXHAUST SYSTEM. ALWAYS DISCONNECT THE APPROPRIATE FUEL INJECTOR HARNESS, DO NOT SHORT SECONDARY VOLTAGE TO THE CYLINDER. SHORTING THE SECONDARY VOLTAGE WILL ALLOW FUEL TO ENTER THE CYLINDER. THE SPARK PLUG MAY FIRE ON THE EXHAUST STROKE WHEN IGNITION IS RESTORED. THIS MAY CAUSE SEVERE DAMAGE TO THE EXHAUST SYSTEM. NEVER START THE ENGINE WITH THE EXHAUST REMOVED AS THE CYLINDER FIRING ON EXHAUST STROKE MAY IGNITE UNBURNED FUEL.



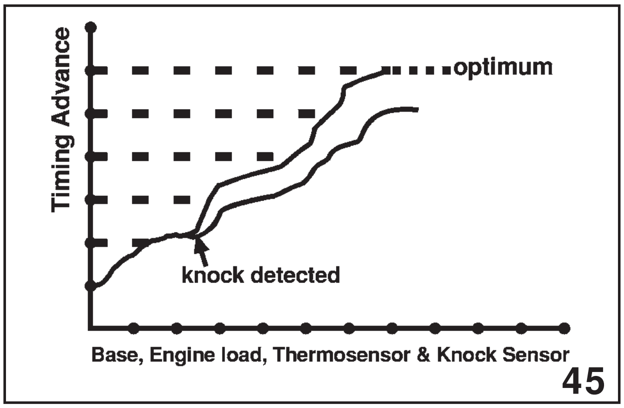
Ignition Coils

The coils are controlled by the ignitor. Ignitor construction is composed of two transistors that control the ground circuits of the primary windings of the coils. Transistors in the ECM control the ignitor. The ignitor is necessary because of the amperage flow through the primary windings would damage the ECM.



Ignitor

Signals from the cam and crank angle sensors are received by the ECM. At engine start the ignition timing is fixed at 10 degrees BTDC. After engine start ignition timing is influenced by the mass air flow meter, coolant temperature, knock sensor and engine load.

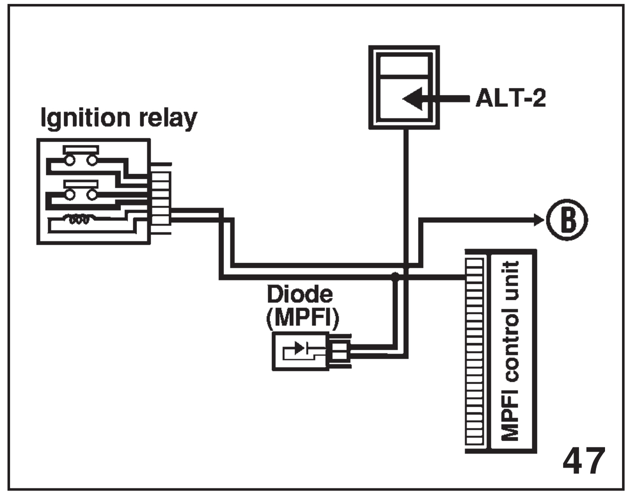


Timing Advance Logic

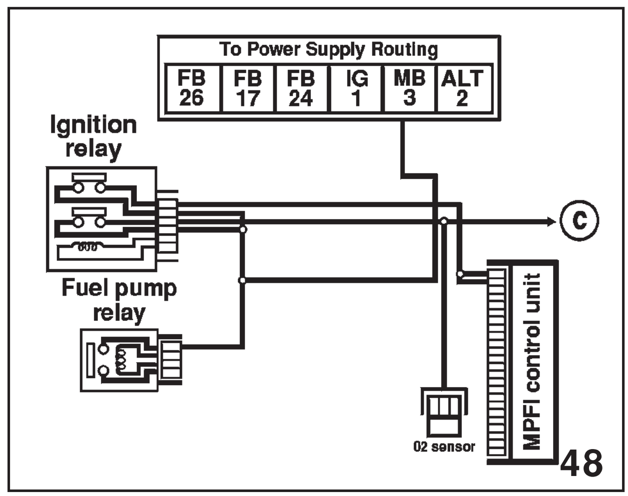
Optimum ignition timing is stored in the ECM. Timing is controlled to be just below the time of engine knock.

Engine knock is detected by the Knock Sensor. The sensor contains a piezo electric element that generates a small A/C voltage signal when a vibration at the correct frequency is present on the engine block surface. The signal that is created is used by the ECM to influence ignition timing.

Power Supply



Ignition Relay Coil Power



Ignition Relay Power Distribution

Self Diagnosis System

Self diagnosis has four modes:

U-check - monitors components necessary for start up. The check engine light will be illuminated during normal vehicle operation when a problem is detected.

Read Memory - Used at the dealer to read past trouble codes. Activated by using the black connectors located under the driver side kick panel, and following the procedures outlined in the Subaru Service Manual on the STIS web site.

D-check - Used at the dealer to check the present condition of all MPFI components. Activated by using the green connectors located under the driver side kick panel, and following the procedures outlined in the Subaru Service Manual on the STIS web site.

Clear memory - Clears all codes in ECM memory. Activated by using the green and black connectors located under the driver side kick panel, and following the procedures outlined in the Subaru Service Manual on the STIS web site.

Select Monitor and Service Connector

In both D-check and Read Memory modes, the control unit outputs trouble codes by using the Check Engine Light. Long flashes equal 10 and short flashes equal 1. By adding together the numerical equivalent of the flashes, you can identify the correct trouble codes. Multiple trouble codes are outputted in chronological order. You will find a list of trouble codes in the Subaru Service Manual on the STIS web site. Always refer to the appropriate MY Subaru Service Manual on the STIS web site when identifying trouble codes.

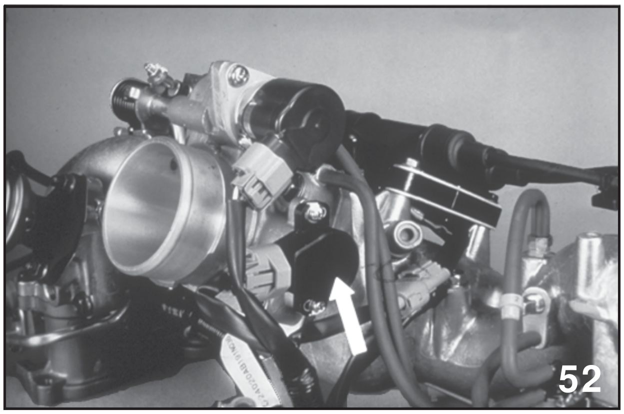
If the self-diagnostic system does not output trouble codes indicating a fault in the MPI system, suspect components may be checked using the check procedures found in the appropriate MY Subaru Service Manual on the STIS web site.

Self Diagnosis for other Subaru models are similar, however, test connector shapes may be different. Consult the appropriate Subaru Service Manual on the STIS web site for connector location and diagnosis procedures.

Impreza 1.8 Liter

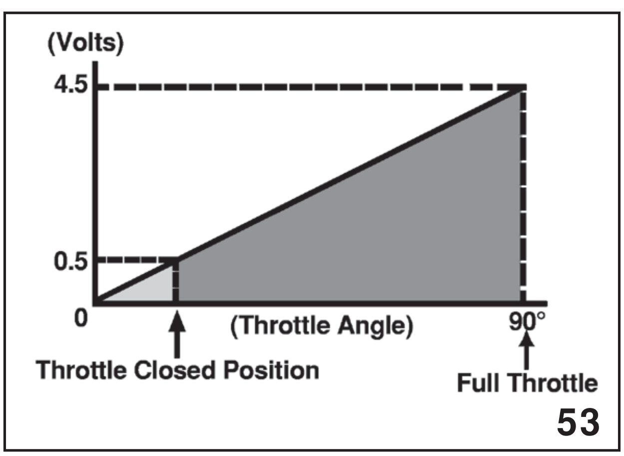
The Impreza 1.8 Fuel and Engine Management system differs from the Legacy in the following:

- TPS
- IAC
- Throttle Body
- Fuel Tank
- Power Supply

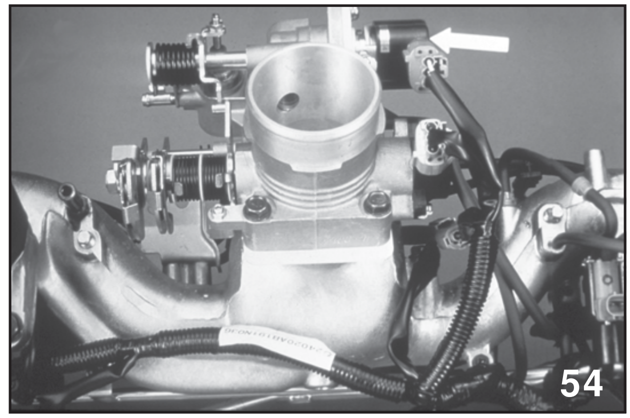


Throttle Position Sensor

The Throttle Position Sensor is connected to the throttle body similar to Legacy. The major difference is the way the idle signal is generated. Impreza uses a "soft idle control", a .5 volt signal that comes from the moveable contact and the potentiometer. Throttle position signal and idle can be observed with the Select Monitor.

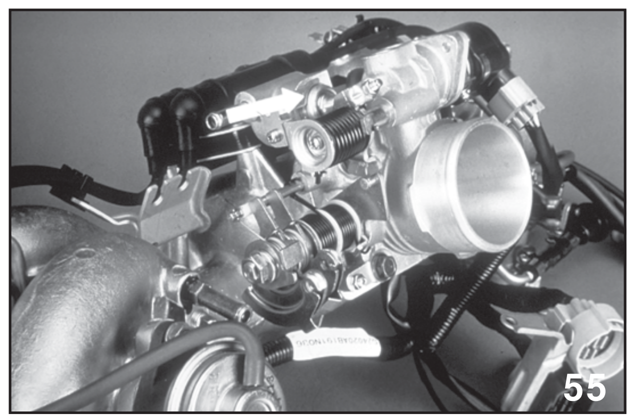


Control Soft Operation



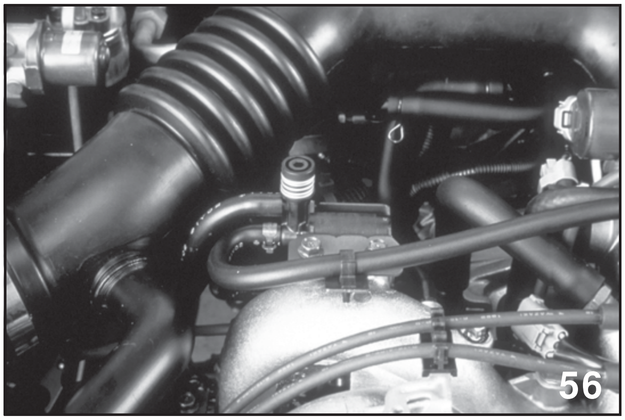
Idle Air Control Valve

Throttle body size and shape differs from Legacy and serves as a mounting for the IAC valve. The IAC valve uses a Duty Control Valve operated from an ECM duty ratio. Control of idle speed during all engine operating conditions is performed by the Duty Control Valve.



Throttle Body with Wax Pellet

However, during cold engine operation it is assisted by a coolant sensitive device that contains a wax pellet. The wax pellet contracts when it is cold and expands when it is heated. During cold operation a spring loaded lever resting on the end of the pellet moves toward the pellet. The opposite end of the lever is cam shaped.

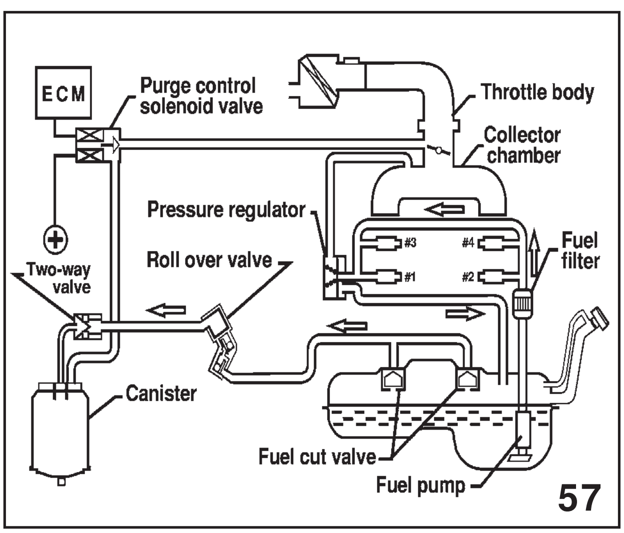


A/C IAC

As it moves upward it pushes on the throttle shaft, mechanically increasing the idle speed. Increasing coolant temperature expands the pellet relaxing the force applied to the throttle shaft. There is also an A/C IAC that allows additional air flow by pass the throttle plate to compensate for load the air conditioner places on the engine.

CAUTION: THE A/C IAC IS FACTORY SET, DO NOT ADJUST. THIS VALVE WILL BE ACTIVATED WHEN THE AIR COMPRESSOR IS ENGAGED FROM AN ECM SIGNAL.

The fuel tank design and capacity does not make it necessary to use a jet pump to transfer fuel on the 1.8 liter engine vehicle.



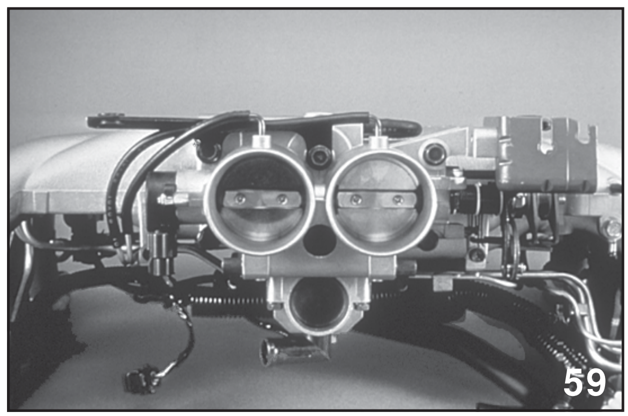
1.8 Impreza Fuel Supply System

SVX

Differences of the SVX fuel injection and engine management system include:

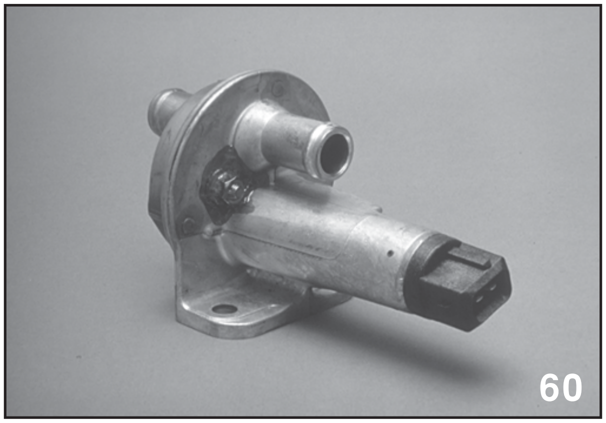
- Air Induction
- Ignition
- Sensors
- Fuel Supply
- Power Supply

The Air Induction system components of the SVX include an Idle Air Control Valve, Auxiliary Air Control Valve and piping. An Inertia Resonance Induction system is also employed to improve low to mid range torque.



Throttle Body and Manifold

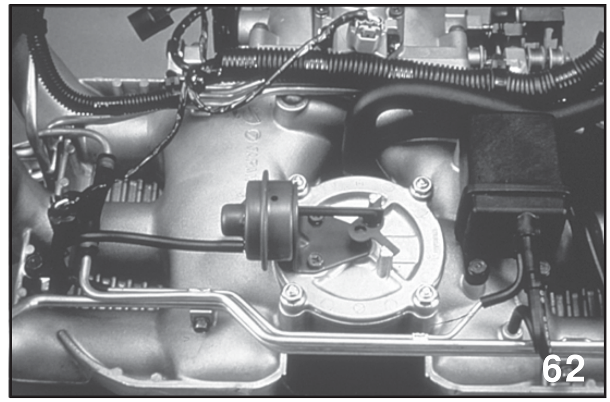
IAC valve operation is accomplished with a duty signal from the ECM which acts on the Duty control valve. The IAC controls base idle, compensates for additional engine load conditions, such as A/C operation, and assists the Auxiliary Air Valve with cold idle control. Auxiliary valve construction includes a rotary valve, bimetallic spring and heater.



Auxiliary Air Valve

Cold engine operation results in the bimetallic spring forcing the rotary valve open to increase airflow bypassing the throttle plate. The heater becomes active after the engine is started heating the bimetallic spring. As the spring changes tension the rotary valve is gradually moved to the closed position reducing idle speed.

Inertia Resonance Induction System (IRIS)

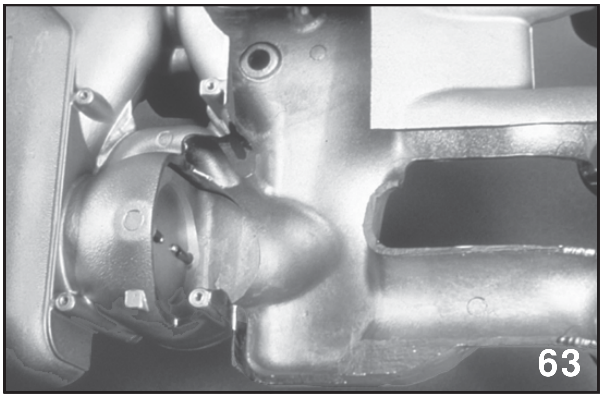


Intake Manifold (Underside)

Iris system components include:

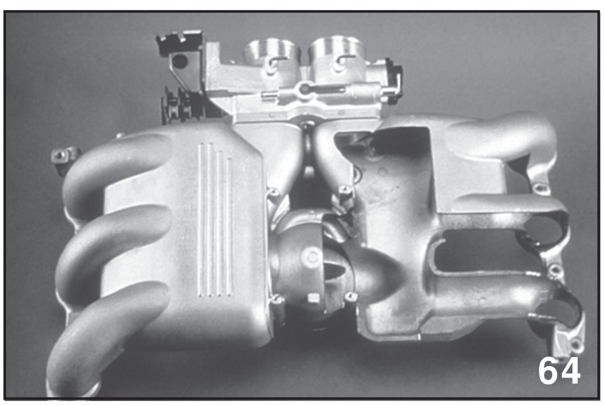
- IRIS Valve
- Vacuum Tank
- Check Valve
- Solenoid

The solenoid provides a vacuum pathway from the IRIS valve to the vacuum storage tank to close the valve and to the atmosphere to open it. Vacuum storage is accomplished with the storage tank and is maintained there with the use of a check valve, for conditions of low manifold vacuum.



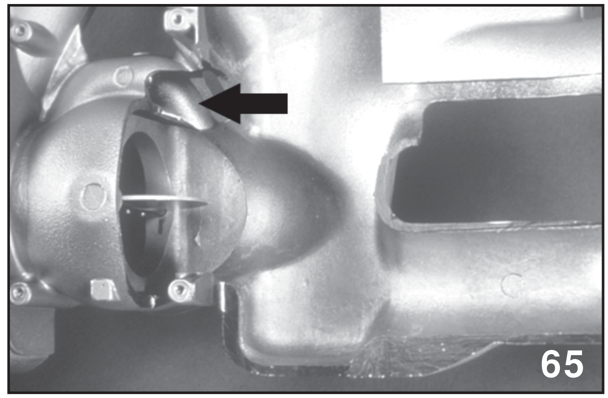
IRIS Valve (Closed)

IRIS operation includes two modes. Mode one is active from low to approximately 4200 RPM. The IRIS valve is closed separating the two sides of the intake manifold. Construction of the intake manifold includes a resonance tube that in mode one synchronizes the intake pulses. Simply stated the air filling one cylinder will continue to move after the intake valve has closed. That air will push the air in front of it into the next cylinder in the firing order. In mode one the resonance tube guides the moving air to the opposite side of the manifold as the firing order is 1-6-5-4-3-2.



IRIS Valve (Open) with Resonance Tube

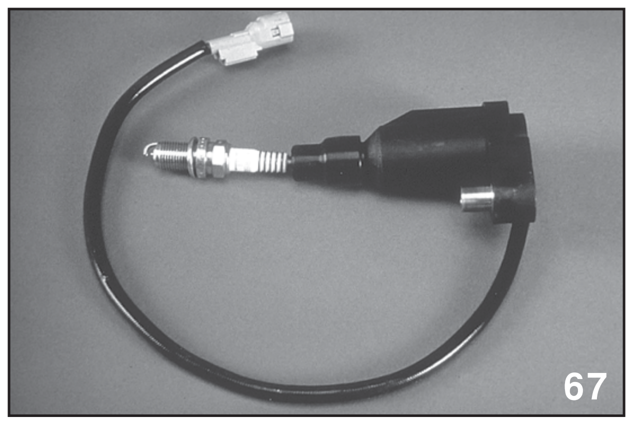
The IRIS valve is closed because the volume of air in mode one is moving too slow for the valve to be effective. Resonance tube operation maintains the speed of the moving air, keeping the pushing effect at maximum.



Resonance Tube

Air flow volume in mode two is too great for the small size of the resonance tube, so just above 4200 rpm the IRIS valve opens and guides the air as in mode one.

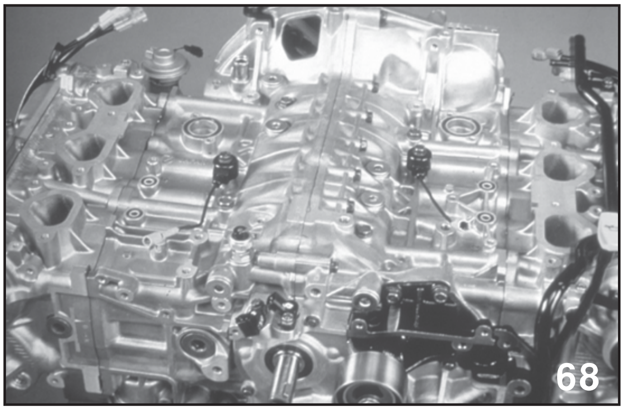
SVX Ignition



Ignition Coil and Spark Plug

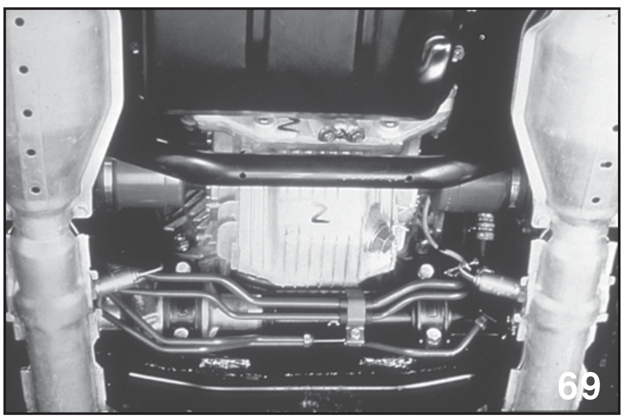
The ignition system of the SVX uses a coil for each of the six cylinders. Coil mounting is accomplished by a captured bolt that goes through the valve cover into the cylinder head. Primary and secondary windings are contained in the coil with a spring loaded contact that completes the secondary circuit to the spark plugs.

The primary circuit is controlled by an ignitor that pulses the ground circuit from a signal generated in the ECM.



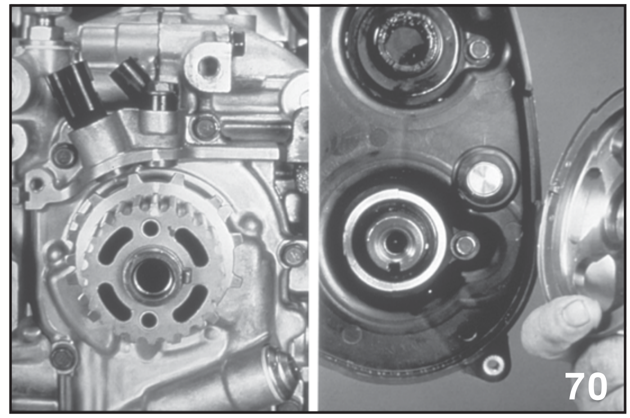
Knock Sensor Locations

The Knock sensors are located on each side of the engine. If either sensor detects a knock the overall ignition timing is reduced.



Oxygen Sensors

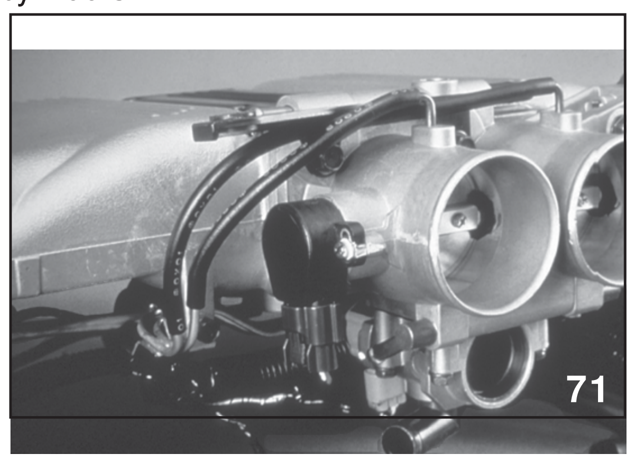
Oxygen sensors are located in the left and right side exhaust pipes ahead of the catalytic converters. Separate alpha readings are available for display on the select monitor.



Crank and Cam Angle Sensors

Two crank angle sensors are installed above the crankshaft sprocket. Crank sensor #1 determines crankshaft position and Crank sensor #2 determines the next cylinder in the firing order.

Cam angle sensor input is used with the crank angle sensor to discriminate between cylinders.

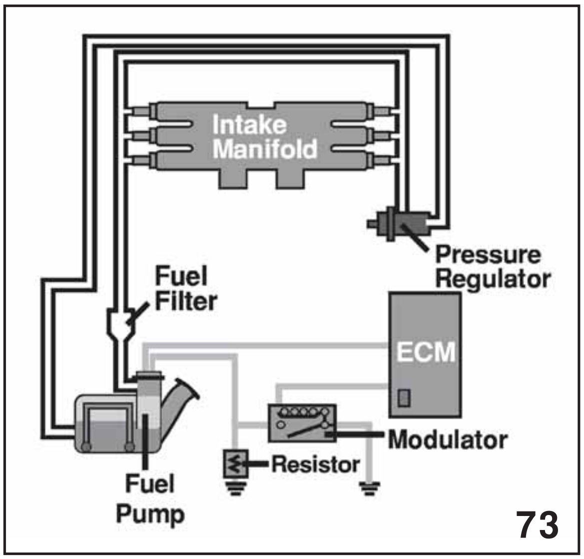


Throttle Sensor

Throttle sensor operation is more similar to Impreza than Legacy. An idle switch is not used rather a reference voltage of approximately .5 volts is used. The voltage will increase as the throttle moves toward wide open with a maximum of 5 volts. A return spring inside the TPS provides a smooth drop voltage as the throttle is released to idle.

SVX Fuel Delivery System

The fuel pump system located inside the fuel tank is similar to the Legacy. It receives its basic power supply from the fuel pump relay.



Fuel Delivery System

An electronic volume control system has been added which reduces fuel evaporation by creating less fuel agitation through the fuel system during low fuel demand driving conditions.

The electronic fuel pump "modulator Unit" is located under the right side of the package shelf. It completes the ground circuits for the fuel pump. There is a direct ground and a resistance ground.

A fuel pump resistor is located next to the fuel pump modulator. It is wired to the pump in parallel with the modulator.

The ECM monitors injector pulse width and engine speed in order to reduce fuel flow during low load and low RPM conditions. The ECM signals the modulator to send the fuel pump ground through the resistor, providing minimum fuel flow during low load conditions. Under high load/high RPM conditions, the ECM signals the "modulator unit" to supply a direct ground to the fuel pump, providing a high fuel flow condition.

Fuel Tank Components

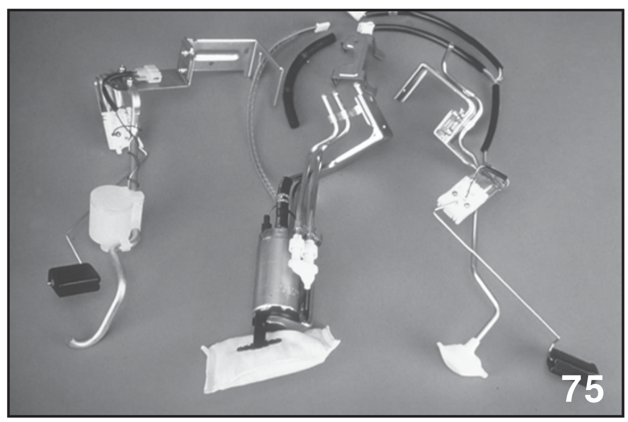
The fuel tank is a saddle tank design made of resin. This provides a weight savings as well as corrosion resistance. It is located under the rear seat area.

The tank design allows for air space which eliminates the need for a fuel separator. It forms a 10 liter air chamber at the top of the tank.

The fuel shut off valve is part of the tank cover assembly. The valve incorporates a float which prevents liquid fuel intrusion into the vapor hose to the charcoal canister.

Example: Fuel slosh during hard driving

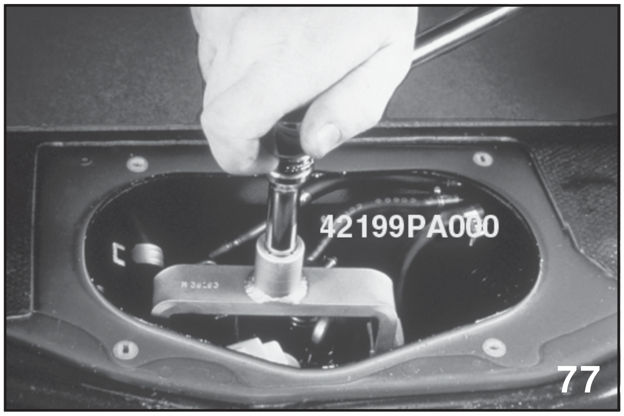
Fuel tank components are serviceable with the tank in vehicle. They are accessed through a large opening in the top of the tank similar to the Legacy.



Sending Units Assemble and Pump

In addition to the fuel pump, there are two sending units mounted inside the fuel tank; a main unit and a sub unit. The main unit incorporates a low fuel sensor. The function and diagnostics for the sending units is similar to the Legacy.

Fuel Tank Servicing

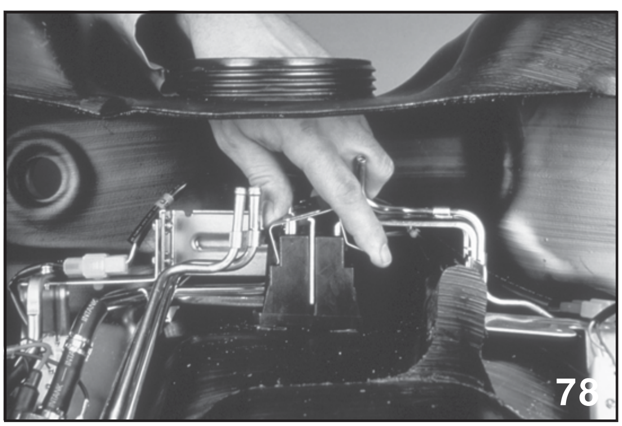


Removing Spanner Ring

Remove all of the fuel tank components in order. Start with the spanner ring using service tool #42199PA000. Then remove the cover after disconnecting the fuel hoses from the pipes in the tank.

NOTE: MARK THE HOSES SO THEY CAN BE CORRECTLY REINSTALLED ON THE DISCHARGE "D" AND THE RETURN "R" LINES.

Disconnect the 2 electrical connectors for the fuel pump and the fuel gauge sending unit. Push the wires back into the tank and remove the crossover hose with its retaining clips.



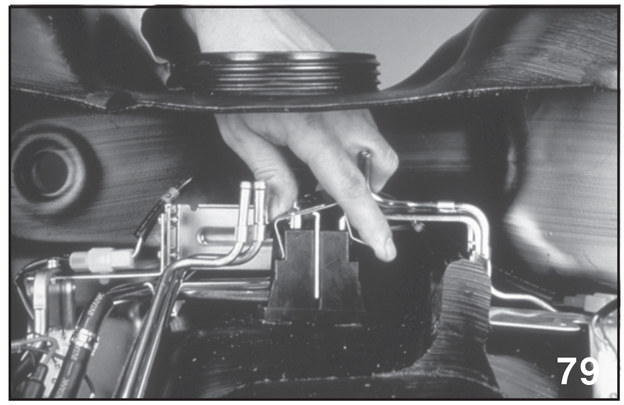
Sub Assembly Retaining Clamp

Now reach inside the tank and remove the metal retaining clamp by lifting the two tabs on the left side of the clamp.

NOTE: THERE ARE THREE ASSEMBLIES INSIDE THE TANK. EACH ASSEMBLY COMES OUT SEPARATELY AND IN ORDER.

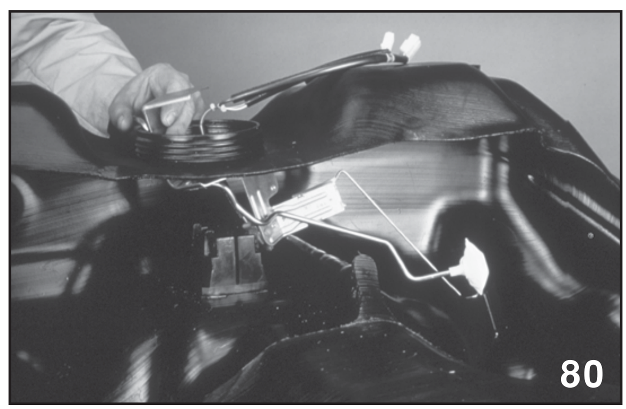
Sub Assemblies

Lift the right hand sending unit assembly from the molded bracket and temporarily set it aside inside the tank. Then lift the fuel pump assembly from the molded bracket.



Removing Fuel Pump

Remove the fuel pump assembly by gently rotating it back and forth. Then gently rotate the right hand sending unit clockwise in order to just clear the tank. Next, disconnect the electrical connector from the sending unit and remove the right hand sending unit from the tank.



Removing Sending Unit

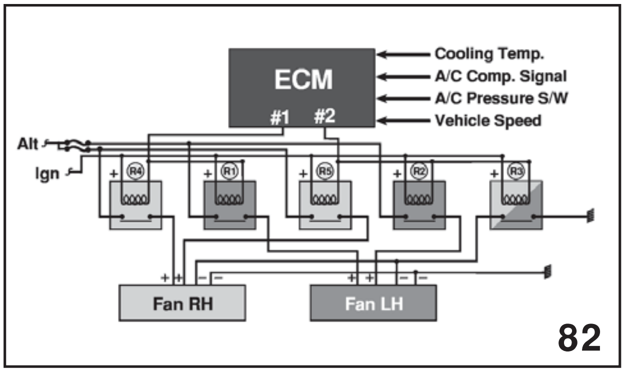
Gently rotate the left hand sending unit counter clockwise until it is upside down. Remove the assembly with the wiring harness attached.

CAUTION: WHEN REMOVING THE SENDING UNITS, USE CARE SO AS NOT TO BEND THE FLOAT ARMS. THIS CAN AFFECT THE FUEL GAUGE CALIBRATION.

For reassembling the fuel tank components, reverse the order of disassembly.

Radiator Fan Control

The radiator fan uses five (5) relays which are located in the main fuse box behind the battery. They are 4 pole (NO) type relays.



Fan Control Schematic

The three speed, dual fan operation allows for quieter operation during idle conditions and it allows for increased air flow during other operating modes.

Example: Slow speed driving

The two 3 speed 160 Watt Fans each have two (2) B+ control wires and two (2) ground wires. The relays are controlled by the ECM. The ECM provides 2 separate control signals (signals #1 and #2) to the fan relays. Signal #1 determines low speed for the left hand and right hand fans. Signal #2 determines "medium speed"" and signals #1 and #2 combined provide high speed.

Several ECM inputs determine the fan operating speeds:

Coolant temperature

A/C compressor "ON/OFF" condition

A/C Pressure switch

Vehicle speed

Relay Control Circuit

Battery B+ power is provided by the ignition switch to all of the relay coils. ECM signal #1 supplies grounds to relay coils #1 and #4 (low speed). Signal #2 grounds relay coils #3, #2 and #5.

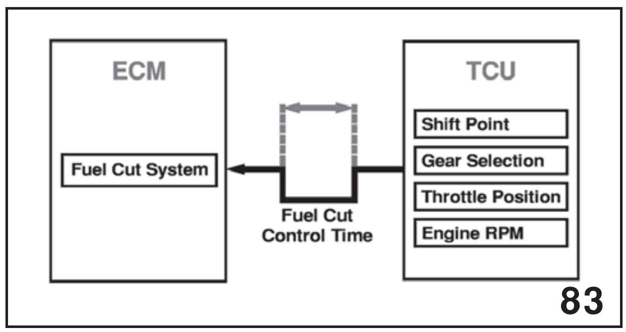
Motor Control Circuit

Relays #1 and #4 supply B+ power to one positive terminal of each fan motor. Relay #1 powers the left hand motor and relay #4 powers the right hand motor. Relays #2 and #5 (mid speed) supply B+ power to the other positive terminal of each fan motor. Relay #5 supplies the right hand motor and relay #2 supplies the left hand motor. Relay #3 supplies an additional ground to both the left hand and right hand motors.

Two (2) fused (20A) circuits supply B+ power for each motor relay power supply circuit. A fuse protection function is part of the ECM fan control section. It initially limits the fan to start from low speed. Then it goes through medium to high speed during hot start-up conditions.

By gradually increasing the fan speed from Low to Medium and then to High, a large current surge across the fuses is prevented.

Torque Reduction System



Torque Reduction System

The 3.3L ECM differs from the 2.2L ECM in the following ways. It has a torque reduction system networked between the TCM and the ECM which reduces shift shock during upshifts when the engine is under a high RPM load (above 6000 RPM or at WOT). ECM momentarily activates fuel cut at the time of the shift. Also has a "soft" control program for enhanced idle speed control. Provides smoother, more precise idle speed control.

1999 Enhancements

The fuel injection and engine management control system for the 1999 model year will be designated L MPI and D MPI. EXCEPT LEGACY 2.5 PHASE 1, WHICH WILL USE THE SAME FUEL AND ENGINE MANAGEMENT SYSTEMS THAT WERE EQUIPPED ON THE 1998 MODEL YEAR VEHICLES. These sequential systems are similar in design sharing most operating and diagnostic functions. The most noticeable difference is the D MPI system, which is California Specification, uses new style air assist injectors.

D MPI

The air assist fuel injector is supplied with fuel from a supply rail, which is connected to the top of the injector.

86

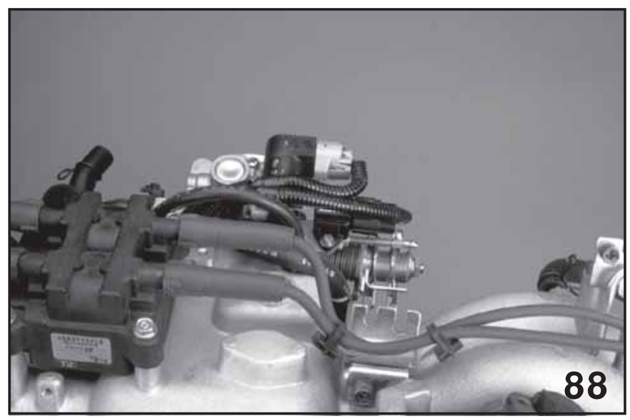
Fuel Supply Rail

Referred to as top feed, this style injector internally functions the same as injectors used on previous model years.

87

Air Assist Injector

Externally the injector is sealed at the top and bottom with O-rings and double lip seals. Additionally the air assist injector is supplied with air from the Idle Speed Control Valve.



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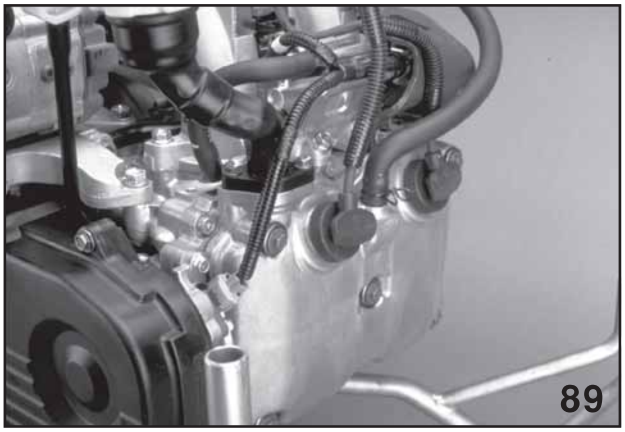
Idle Speed Control Valve

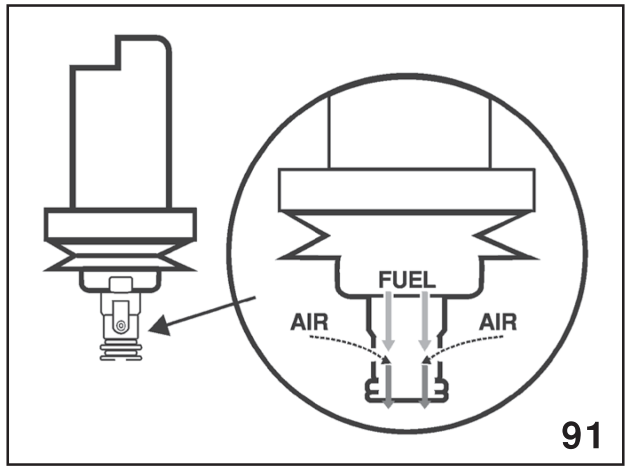
This air is used to provide faster atomization of the fuel, providing lower emission output and improved driveability. The air from the ISC is delivered through a passage made into the intake manifold to the bottom of the injector.



Air Assist Supply Rail

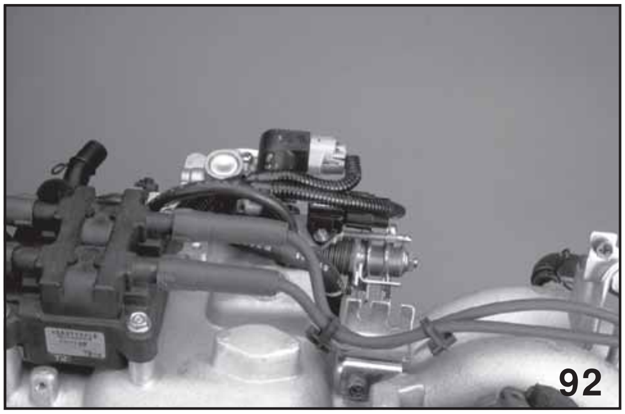
The negative pressure area below the injector is constantly filled with the more positive pressure air from the ISC. The air must travel through a chamber attached to the bottom of the injector.

Injector AA Chamber Tip



AA Chamber (Air Inlets)

The chamber has 4 small holes that meter the air into the fuel stream, beginning the atomization process when the injector is turned on. Looking through the two lower holes of the chamber the four holes of the injector are visible.



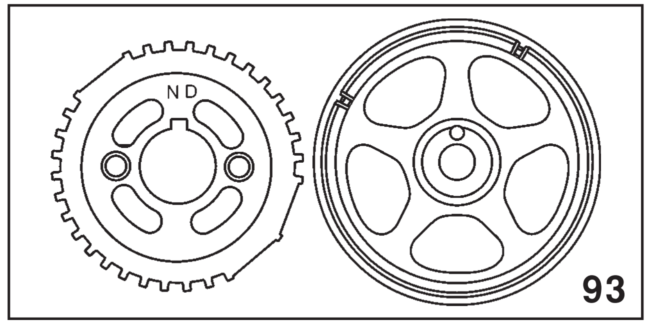
Idle Speed Control Valve

The Idle Speed Control Valve of the D MPI system is a rotary type controlling all idle speeds. The electrical operation of the ISC itself includes a closing coil and an opening coil. The close coil is always on, trying to close the rotary valve. The opening coil is controlled by a signal or duty ratio from the Engine Control Unit, adjusting the ISC to maintain the correct engine idle speed. Part of the controlled air bypasses the throttle plate effecting idle speed. The remainder is delivered to the injectors.

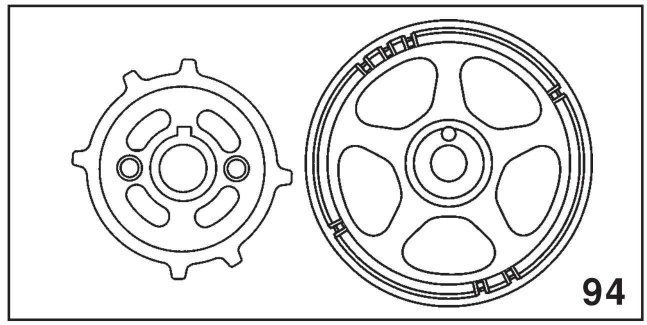
Off idle engine operation results in a larger amount of air delivered to the injectors.

The Pressure Sensor of the D MPI system is a strain type sensor. A set of resistors is mounted to the diaphragm inside the sensor. Changes in pressure of the intake manifold alter the shape of the diaphragm and to the resistors. The changing resistance value is sent to the engine control unit as an input signal.

Crankshaft and Camshaft Reluctors

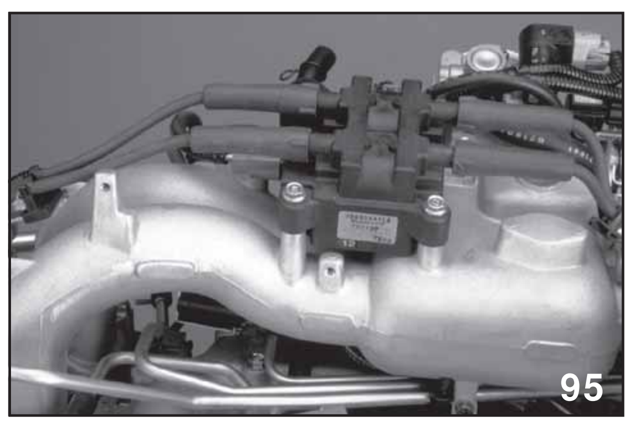


D MPI



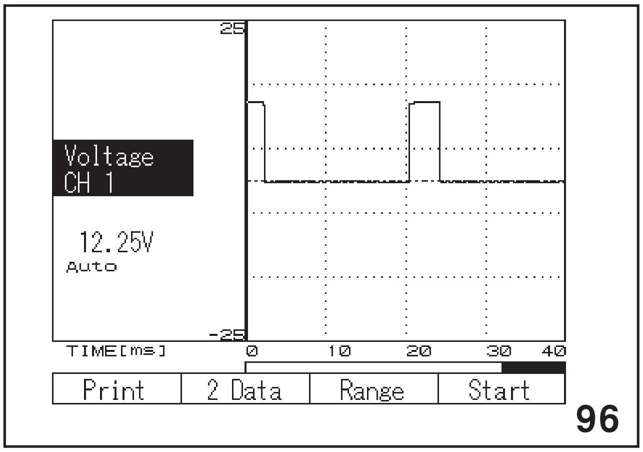
L MPI

The crankshaft and camshaft reluctor of the D MPI system are used to influence ignition and injection timing. The number of teeth on the two reluctors differs from those of the L MPI. Installation of incorrect components will result in a no start condition. The additional teeth assist the Engine Control Unit to shorten the time for cylinder discrimination and improve accuracy of misfire detection.

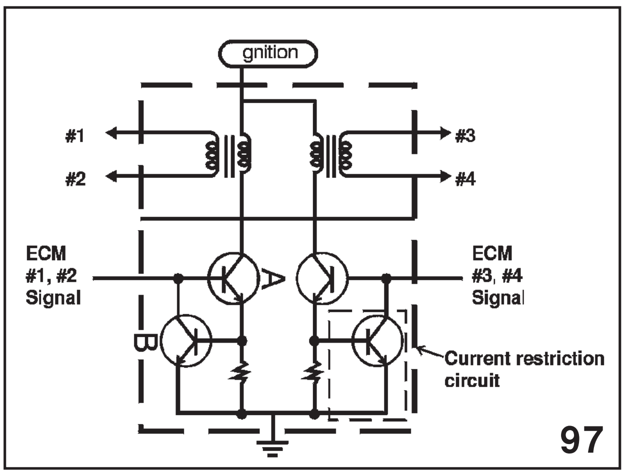


Ignitor Coil

The ignition coil and ignitor are now one unit. A 12-volt square wave signal is sent to the coil from the ECM to control the ignitor. The ignitor in turn controls the coil primary winding.

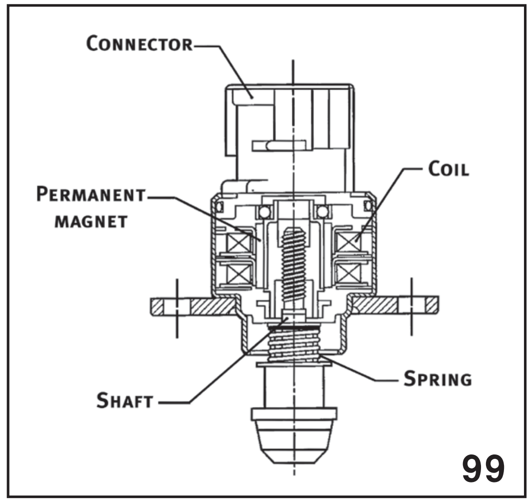


ECM to Coil Signal



Ignition Coil Construction

L MPI



Idle Air Control Solenoid Valve

The injectors of the L MPI system are sealed to the fuel rail and intake manifold in the same manner as the D MPI. Missing is the atomization chamber located below the injector. Operation and diagnostic procedures are also shared.

The ISC of the L MPI system is a stepping type solenoid valve, which consists of coils, shaft, permanent magnet, spring and housing. The housing is built into the throttle body.

In operation current flows sequential through a series of paired coils which are arranged to react with the permanent magnet that is fixed to the shaft. The ECM controls the polarity of the coils, which effects the position of the permanent magnet. This action rotates the threaded shaft of the ISC increasing or decreasing the depth of the air-sealing surface.

When replacing or installing the ISC it must be initialization accomplished by turning on the ignition with the engine off for at least three seconds. The engine may now be started.

The pressure sensor and pressure sources switching solenoid are of the style used in 1998 Subaru vehicles, sampling atmospheric pressure at start up and then cycling over to measure manifold pressure.

The coil and knock sensor of the L MPI are also sheared with the D MPI.

The throttle position sensor functions the same as the D MPI except it is adjustable.

The L MPI system utilizes and Air flow meter with the same operating characteristics of the Air Flow Meter used on the 1998 Model Subaru vehicles.

Oxygen sensors of the L MPI are the same as used on the 1998 model year vehicles.

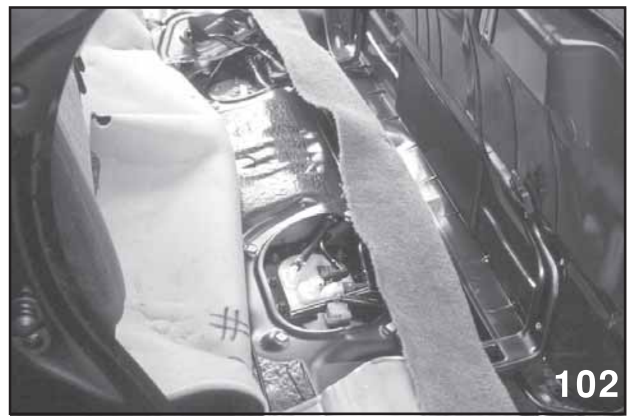
2000 Enhancements

The fuel tank and ORVR components have been relocated on the vehicle. This makes necessary movement of key fuel system plumbing. On such movement involves this new hose.

Vent Control Piping

This hose is routed from the fuel neck to the vent control valve located on the driver's rear of the fuel tank. The routing carries the hose through the inner fender into the passenger compartment. The hose is protected by a metal cover, which must be removed to gain access to the quick connector. The quick connector must be disconnected before the fuel tank is lowered.

Movement of the fuel tank is accompanied by a change in the fuel pump assembly design and location. The fuel pump assembly and sub pump pick up assembly are now accessed from under the rear seat. The pumps are located on the lower level of the fuel tank which makes it necessary to remove the fuel from the tank before removing the fuel pump or sub pump pickup assemblies. **Failure to remove fuel from the tank will result in fuel being introduced into the passenger compartment.**

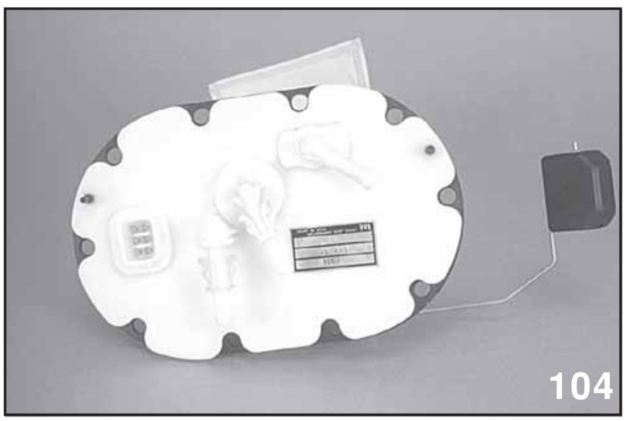


Fuel Pump (Under Seat)

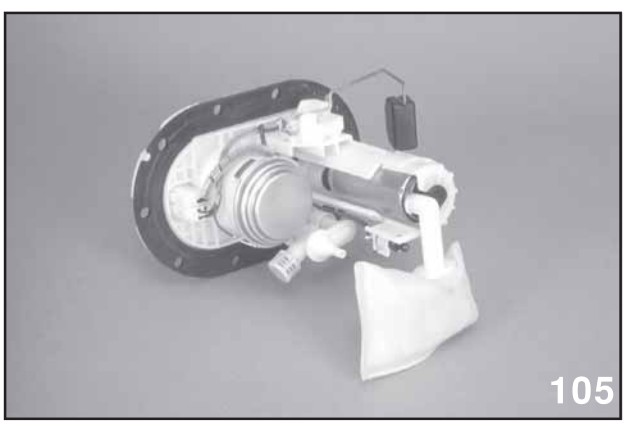
A fuel drain is located on the passenger side, front of the fuel tank. Use of this drain will lower the fuel from the high side of the tank and totally drain the passenger side of the saddle tank. The sub pump pickup side, (the drivers side) of the tank, will remain full. Consult the appropriate Subaru Service Manual on the STIS web site for the proper procedure for draining all fuel from the fuel tank.

Fuel Drain Plug

The body of the new fuel pump assembly is resin based. The gasket for the assembly has two location prongs that must be pulled into the outer cover.

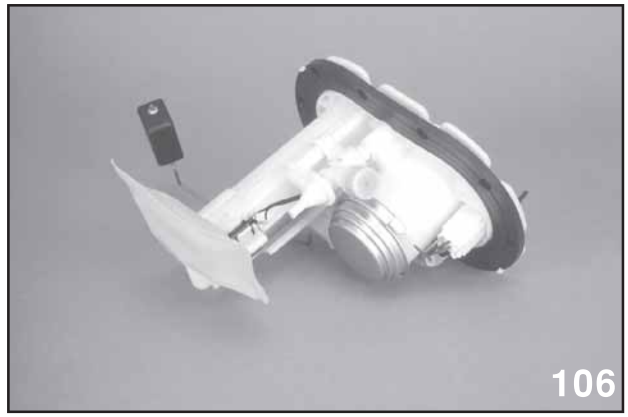


Fuel Pump (Top View)



Fuel Pump (Float Arm View)

This round housing is designed to accept a fuel filter however; the North American market will not use a filter located on the fuel pump.

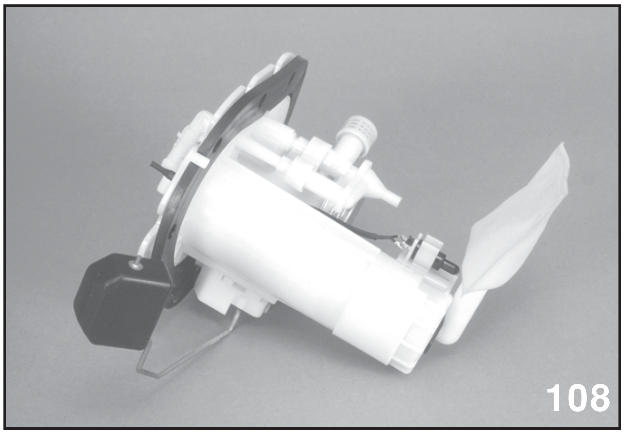


Fuel Pump (Static Strap View)

The small wire connected to cap area of the fuel pump housing carries static charges away from the pump body to vehicle ground.

Static Strap Close-up

The low fuel level sensor operation has been enhanced. The sensor itself works the same however, the low level when sensed triggers a circuit located in the fuel gauge to maintain the low level indicator illumination until the tank has had fuel added.



Fuel Level Sensor

All Legacy vehicles will be equipped with phase 2 2.5 liter engines using the D MPI fuel systems, (California Spec) making the 2000 model Legacy a 50 state car.

Engine Compartment

Two fuel systems will be used for the 2000 model year, the AAI UJ and AAI ND systems.

The AAI UJ system will be equipped on the Legacy automatic, Impreza 2.5 liter, and all Forester models.

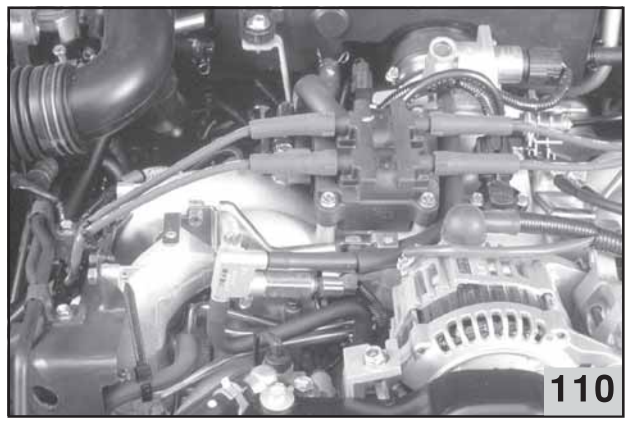
The AAI ND system will be equipped on the Legacy manual transmission and Impreza 2.2-liter models.

The ND system closely resembles the D MPI system that is currently equipped on 1999 California spec models with changes only to the ECM logic.

The UJ system has two new components, an AAI Air Assist Solenoid Valve and an Intake Air Temperature and pressure sensor.

The Air Assist Solenoid Valve is connected to the inlet side of the ISC, which requires the Air Assist Solenoid Valve to regulate the air to the base of the injector. The ND system regulates the air to the base of the injector with the ISC.

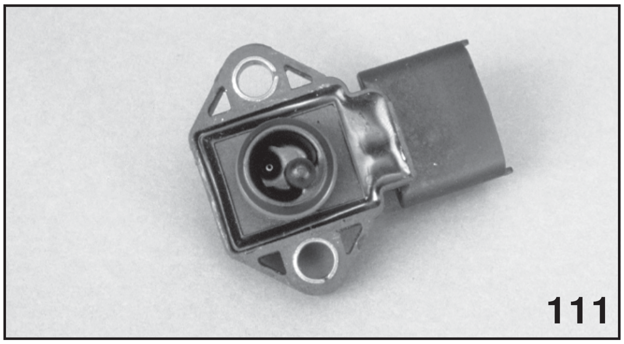
At idle the Air Assist Solenoid Valve is on allowing 20L/min per injector of air to flow. Off idle conditions result in the Air Assist Solenoid Valve turning off allowing only 5L/min per injector of airflow.



Air Assist Solenoid Valve

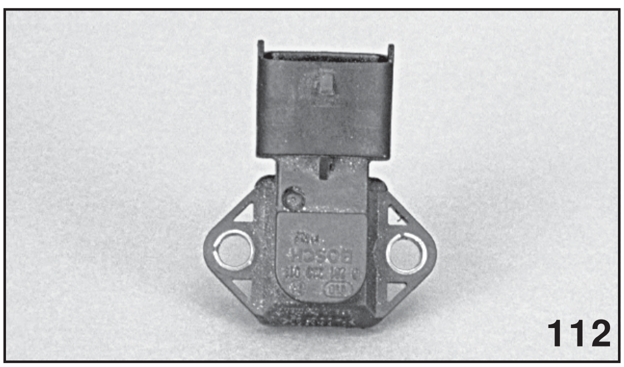
The new Intake Air Temperature and pressure sensor monitors the absolute pressure and the temperature of the air in the intake manifold. The measured temperature and pressure of the air is then converted into electrical signals and sent to the ECM. The ECM uses those signals from the sensor to control the fuel injection amount as well as the injection and ignition timing.

Only the UJ system continues to use the Atmospheric pressure sensor located on the right strut tower. This sensor works with the AFR to monitor air density.



Intake Air Temperature and Pressure Sensor (Bottom View)

The intake manifold pressure sensor is connected directly to the throttle body, and constantly measures the absolute pressure of the intake manifold. The pressure that is measured is converted into an electrical signal, and is sent to the ECM. The ECM controls the fuel injection and ignition timing based on the intake manifold absolute pressure signal from the pressure sensor.



Intake Air Temperature and Pressure Sensor (Top View)

The air induction housing provides air to the throttle body and begins to form the turbulence needed in the combustion chamber for proper air fuel mixing.

Air Induction Housing

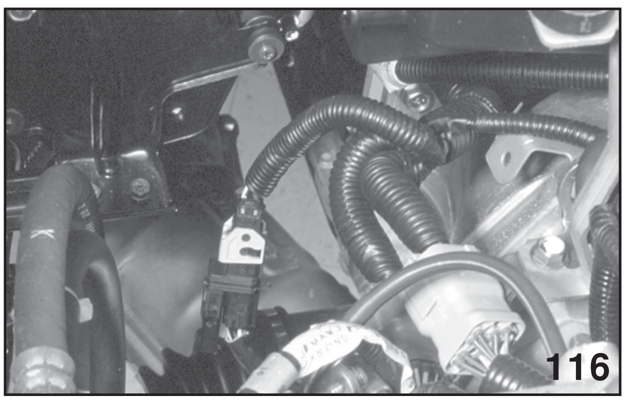
The throttle position, idle speed control motor, and ignition coil have not been changed.

TPS

The throttle position, idle speed control motor, and ignition coil have not been changed.

AFR Sensor

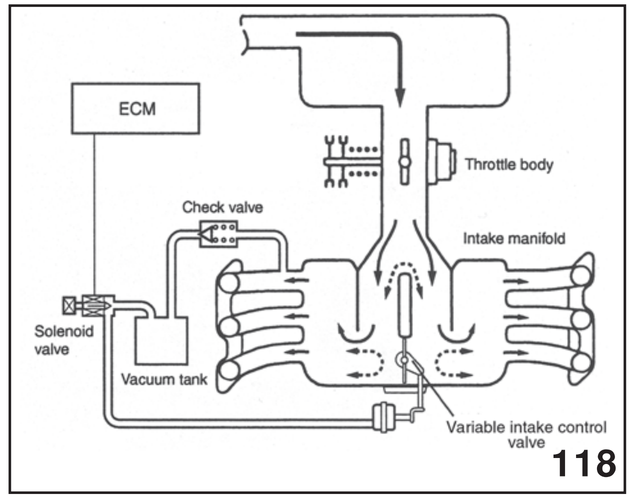
A new type air fuel ratio sensor is used on the UJ system. The harness includes a new-style locking mechanism. Position the locking mechanism as shown and gently separate the vehicle harness from the sensor harness.



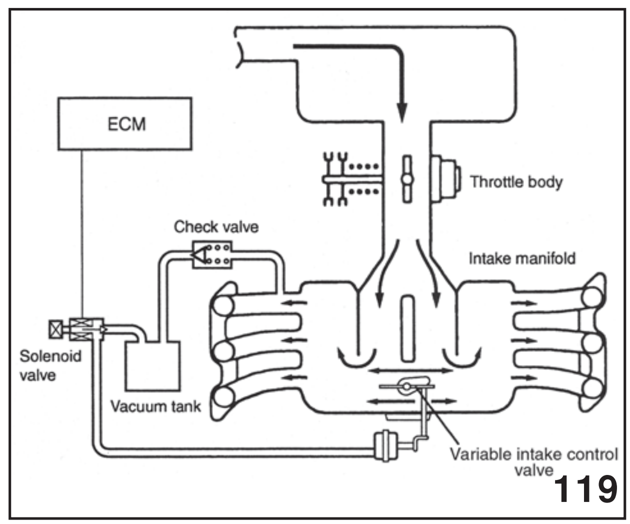
AFR Sensor Harness

The sensor harness includes an electrical compensation device that allows for manufacturing tolerances.

2001 Legacy Enhancements



Variable Intake Control Valve Closed



Variable Intake Control Valve Open

The variable Induction control system opens and closes an airflow valve which is located in the middle of the intake manifold. This action joins or separates the LH and RH sides of the intake manifold.

Components of the system include the airflow valve, vacuum tank, check valve, solenoid and associated piping.

The airflow valve closes during the low to middle engine speeds to control the resonance effect and opens during high engine speeds to increase the inertia effect.

Resonance effect is created during the intake stroke when the intake valve begins to open. The combustion chamber contains a large negative pressure created by the exhaust stroke. This negative pressure will enter the intake runner through the open intake valve creating a shock wave as it is traveling at sonic speeds. This will create a resistance to the flow of the new air charge into the combustion chamber. Left uncontrolled this resistance would spread to all parts of the intake manifold and decrease airflow and overall engine performance. Keeping the airflow valve closed during low to middle speed engine operation will keep the resonance effect isolated to one side of the intake.

As the engine crosses beyond mid-range the inertia effect becomes strong enough to overpower the resonance effect and the airflow valve is opened. This will allow air moving on the LH side of the manifold to assist the RH side.

Variable Intake Control Valve Operation

	Open	Closed
Engine Off	●	
Engine Idling	●	
Light Engine Load any RPM	●	
Heavy Load < 3600RPM		●
Heavy Load > 3600RPM	●	

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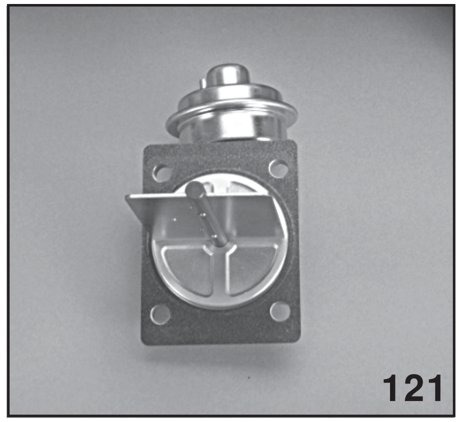
Variable Intake Control Valve Chart



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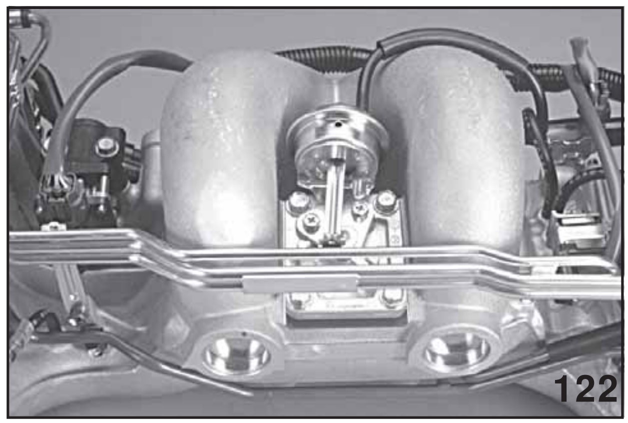
Variable Intake Control Valve



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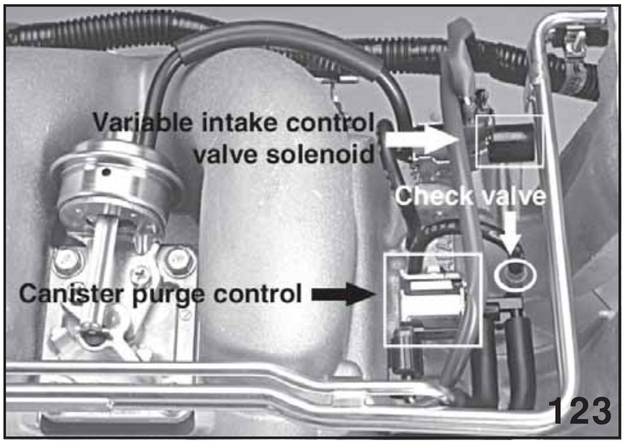
Variable Intake Control Valve Location

The variable intake control valve is positioned on the under side of the intake manifold.

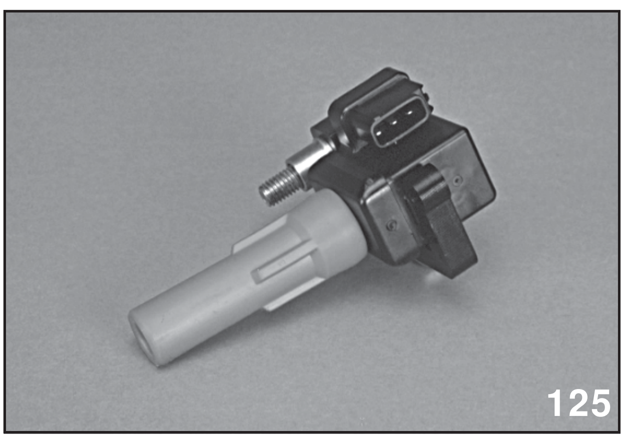
The valve is controlled by the variable intake control solenoid which receives its operating signals from the ECM. The vacuum storage for the solenoid is built into the manifold as a separate tank.

When a signal from the ECM is generated to the solenoid the vacuum in the reservoir tank is routed from the solenoid to the variable intake control valve. This action will close the valve and in the event of low manifold vacuum, the check valve will keep the vacuum to the variable intake control valve steady. When the ECM is ready to open the variable intake control valve the solenoid will be turned off and vent the vacuum from the variable intake control valve to the atmosphere.

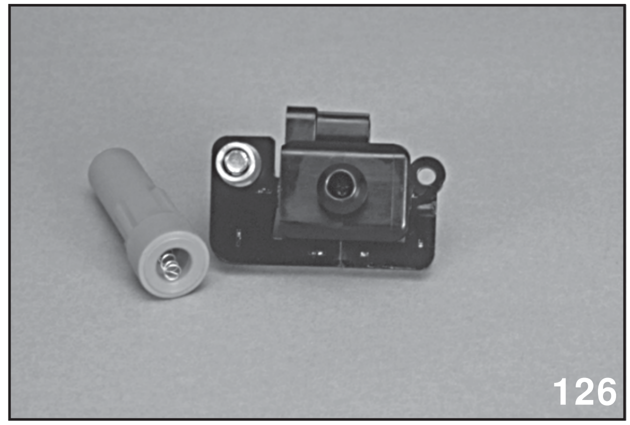


Component Location

Intake Manifold

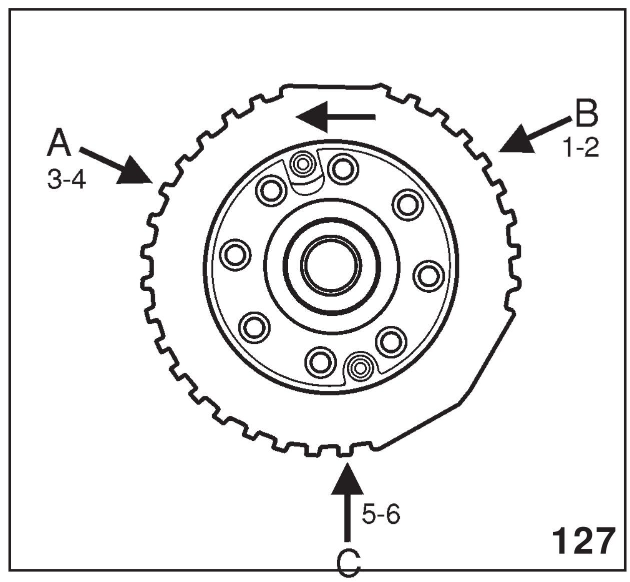


Ignition Coil Complete



Ignition Coil and Spring Contact (Apart)

Direct Ignition coils are used for each cylinder. They contain the ignitor, current control circuit as well as the primary and secondary windings. A 12 square wave sent from the engine control module turns the primary circuit on and off.



Crankshaft Reluctor

Cylinder - Cam Signal

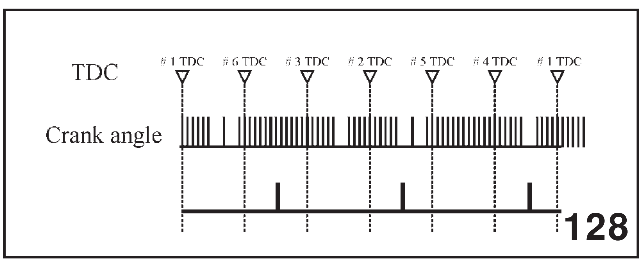
1-Yes
6-No
3-Yes
2-No
5-Yes
4-No

The new crank angle sensor is mounted to the flywheel end of the crankshaft. This end of the crankshaft has less torsional vibrations and offers a more stable signal generating area, providing very accurate crankshaft signals.

As the crankshaft rotates the reluctor produces 30 pulses which are sent to the ECM. The indicated reluctor teeth represent the signals for cylinders.

As the signals from the crank angle sensor are produced they will have a cam signal associated to them ever other revolution. Position A without a cam signal is cylinder 4 and with a cam signal is cylinder 3. Position B without a cam signal is cylinder 2 and with a cam signal is cylinder 1. Position C without a cam signal is cylinder 6 and with a cam signal is cylinder 5.

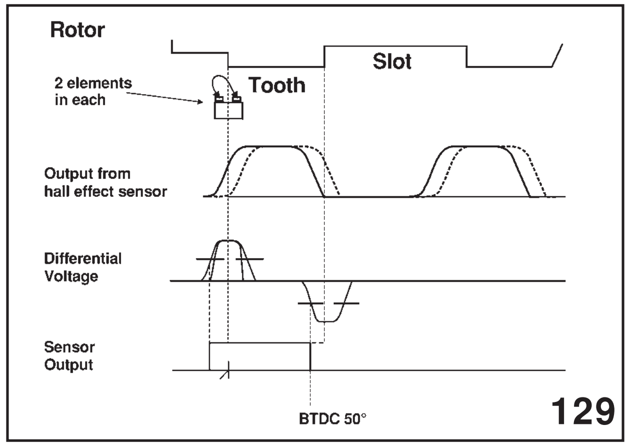
The right bank intake camshaft has a reluctor built onto the end. The new camshaft sensor uses this reluctor to help determine injection and ignition timing.



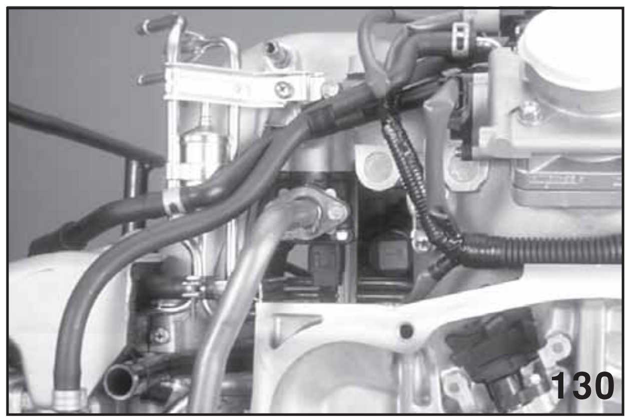
Crank Angle Graph

The cam sensor consists of two elements or windings that sense the slot on the cam shaft reluctor. The sensor also contains an integrated chip that produces a square wave output signal (5 volts).

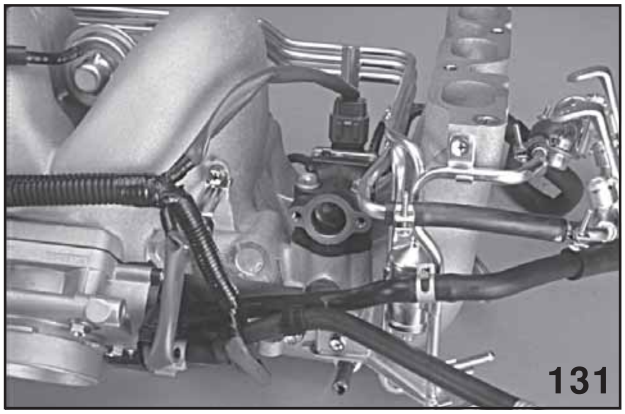
The integrated chip measures the time lag between the beginning and ending of the signals picked up by the two elements, (Hall effect) and converts this information into the output signal.



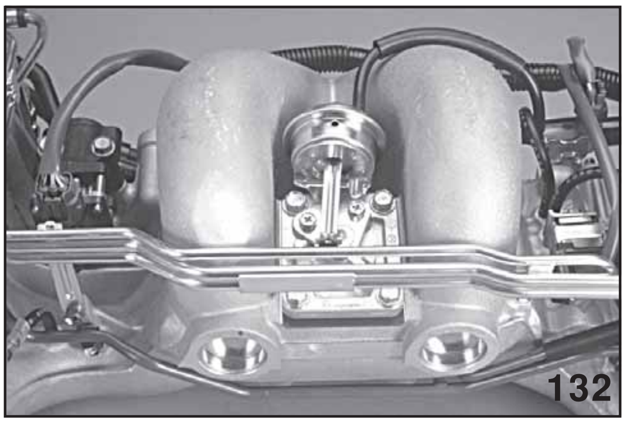
Cam Angle Signal Pattern



EGR Pipe



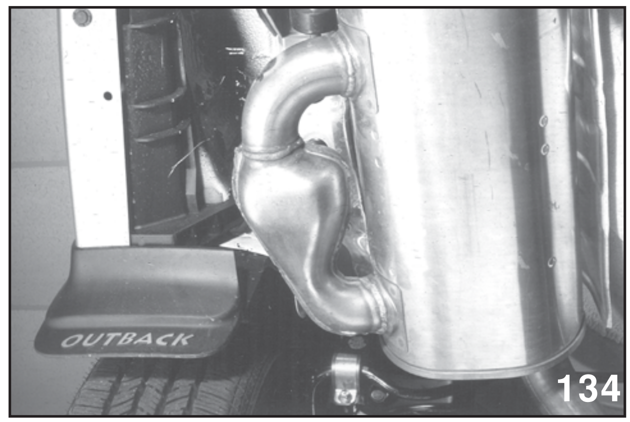
EGR Valve



EGR Harness

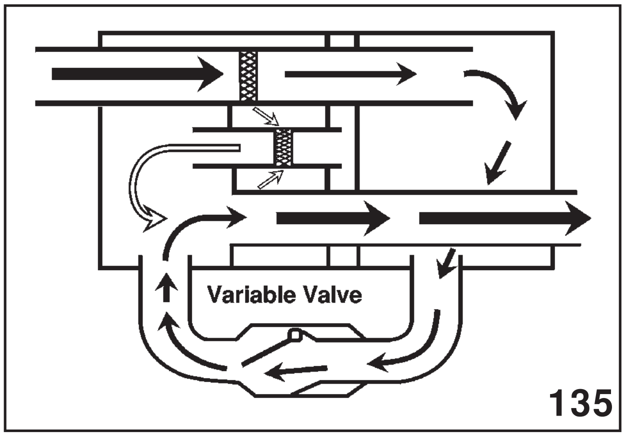
An electronic Exhaust Gas Recirculation valve is utilized on the EZ-3.0 Engine. The ECM controls the number of steps (stepping motor) the valve is opened. Each step will allow a certain amount of exhaust gas to flow through the valve. The ECM will check the performance of the valve (OBDII) by opening the EGR valve to a specified number of steps. The resulting manifold pressure changes are monitored to determine if the performance of the valve is in specifications.

Muffler

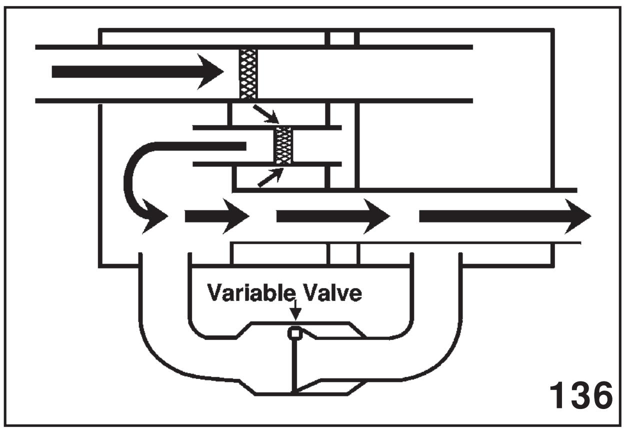


Muffler Bypass Valve

The muffler equipped on the EZ-3.0 Engine is designed with a bypass valve that opens when the exhaust pressure exceeds 45 mm HG. This occurs around 2400 RPM. The bypass valve allows parts of the exhaust to go around some of baffles inside the muffler instead of through them. The result is increased engine performance.



Bypass Valve Operation
(High Engine Speed)



Bypass Valve Operation
(Low Engine Speed)

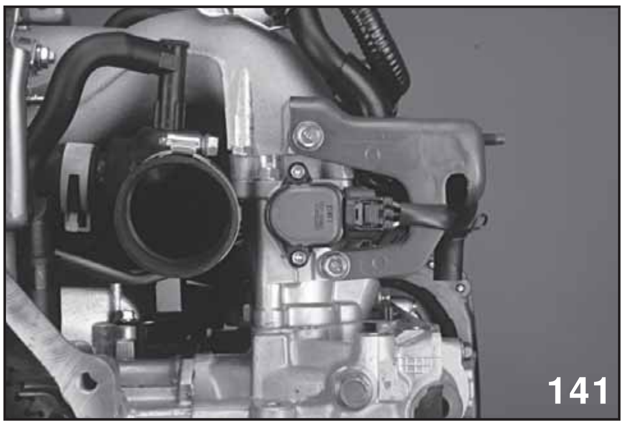
2002 Impreza Enhancements

Tumble Generator Valve Rail

Tumble Generator Valve Motor

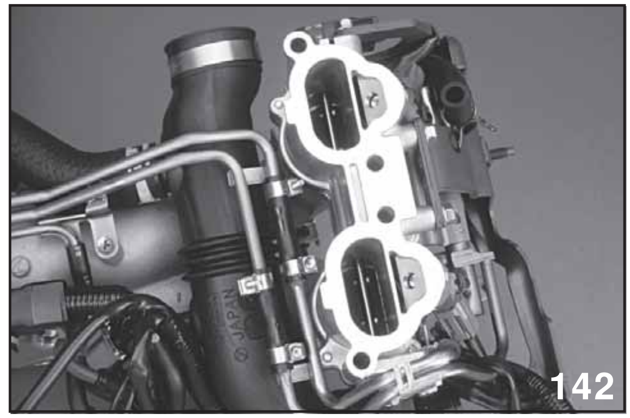
The EJ-2.0 is equipped with a tumble generator valve at each intake runner. This new system uses a shaft for each side of the engine that is driven by a stepper motor. The movement of the shaft is monitored by a sensor on the opposite end.

Vent Hose



Tumble Generator Valve Position Sensor

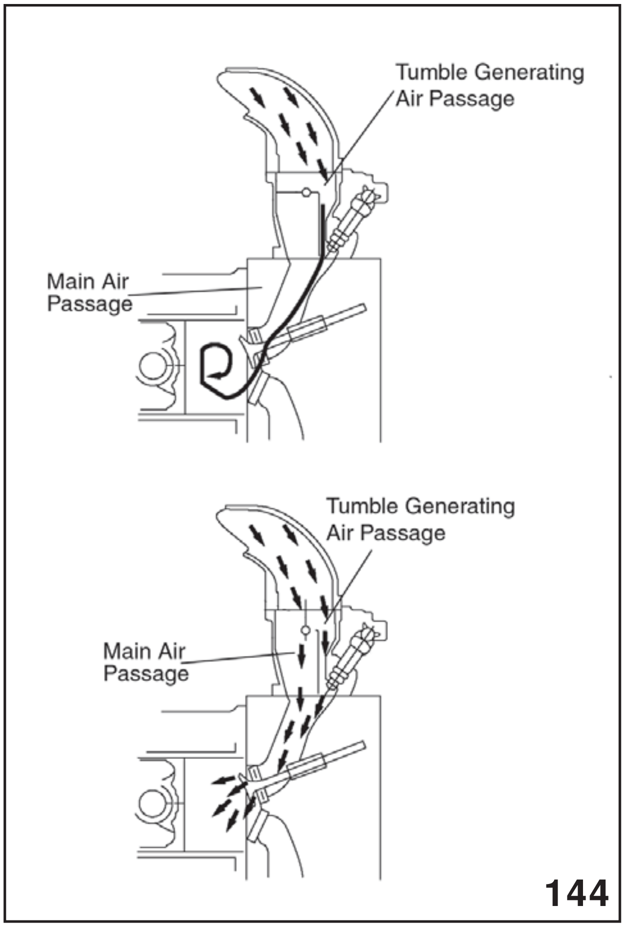
The shaft operates the tumble generator valve, which is a plate similar in design to the throttle plate. At idle the plate is closed (dependant on coolant temperature and time from engine start). Off idle the plate is open.



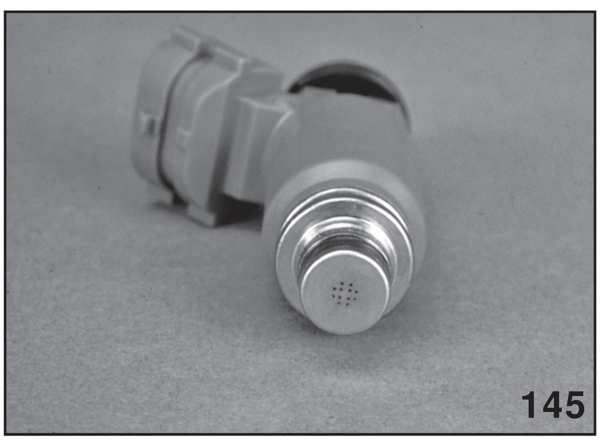
Bottom View of Intake

TGV Channel

When the plate is closed the main air passage through the intake runner is blocked. This will force all air necessary for engine operation during idle to flow through the bypass channel. This action helps to mix the air fuel mixture by producing a tumbling effect to the incoming air, resulting in a cleaner operating engine while idling.



Tumble Generator Valve Operation

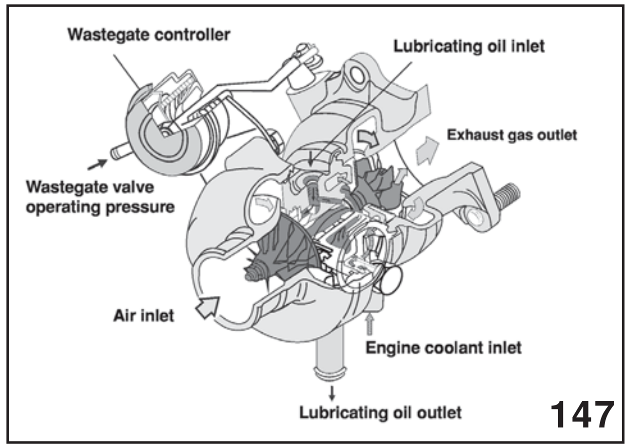


Injector

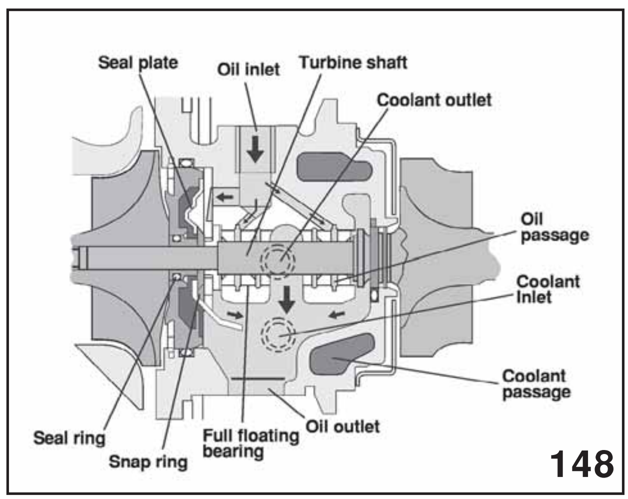
The new fuel injector is a top feed type with 12 holes. The new hole pattern produces a finer spray of fuel which assists with lowering the overall emission output of the vehicle. (No air assist on Turbo models.)

Turbocharger

The introduction of the 2.0 liter engine to North America reintroduces the Turbocharger which was last used on the 1994 Legacy 2.2 liter. The new Turbocharger and fuel system have been designed to produce higher engine performance and lower exhaust emissions.



Turbocharger (Artwork)



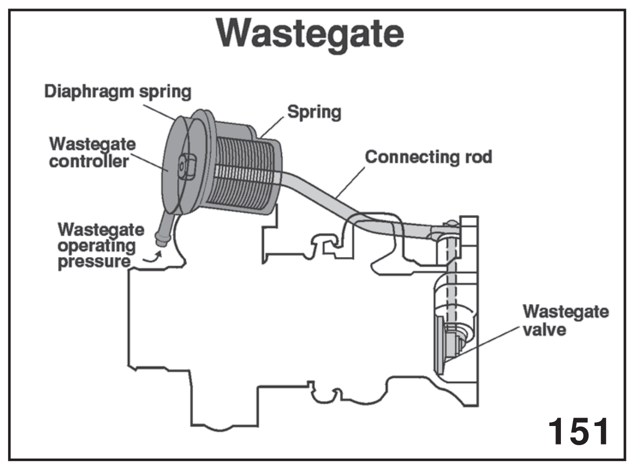
Turbocharger Housing (Artwork)

The Turbocharger consists of two sections, an exhaust side and an induction side. The exhaust side has a turbine wheel with vanes that are shaped to harness the exhaust gas energy. This drives the turbine and center shaft. On the induction side there is an impeller wheel attached to the center shaft which also has vanes but shaped in the opposite direction. The movement of the wheel compresses the induction air as it rotates. Increasing engine speed and load increases the level of kinetic energy in the exhaust gas making the turbine rotate faster. This causes the impeller, which is attached to the common center shaft, to also rotate faster creating greater compression of the induction air. Rotational speeds of the turbine are in the range of 20,000 rev/min. at idle to 150,000 – 200,000 rev/min. at full power. As a result of these very high operating speeds and temperatures, makes lubrication and cooling of the center shaft bearings of prime importance.

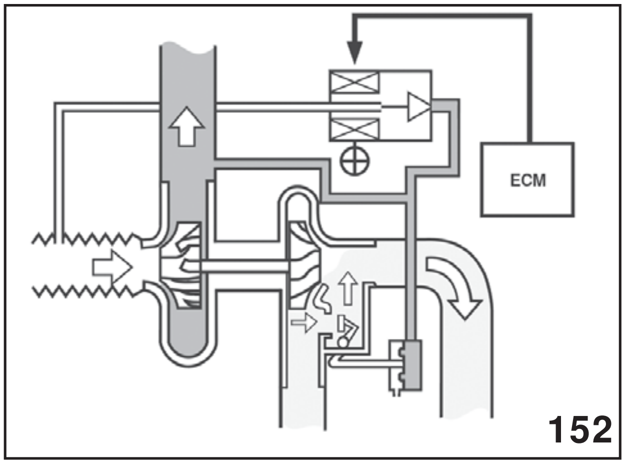
Coolant Connection and Oil Return

Oil Supply and Connection

The shaft bearings are lubricated by a constant supply of engine oil. An oil cooler positioned above the oil filter transfers heat from the oil to the engine coolant. Further cooling of the Turbocharger is achieved by coolant fed from the right cylinder head to coolant passages around the exhaust turbine bearing.



Wastegate (Artwork)



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Wastegate Operation (Artwork)

Due to the limited strength of the engine there is a limit to the amount of boost pressure that can be used. The limiting of boost pressure is achieved by the use of a ‘wastegate’, which bypasses the exhaust gas around the turbine wheel when the desired level of boost is reached.

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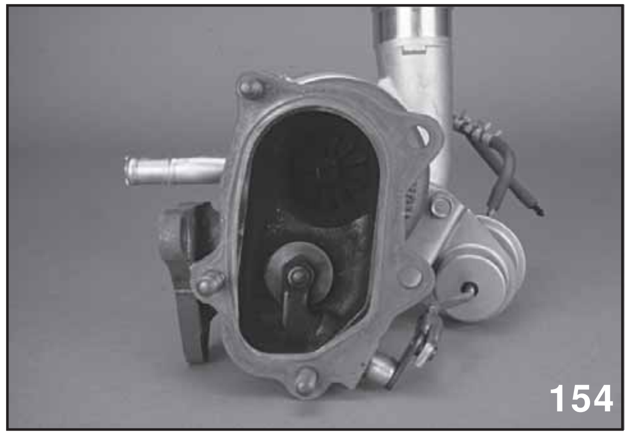
Wastegate Actuator



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Wastegate Valve

The ECM references a boost pressure map programmed into Read Only Memory (ROM) after first reading the input signals. By calculating the actual boost pressure, and after compensating for engine temperature and atmospheric pressure, the ECM is able to provide an output duty ratio signal to the Wastegate Control Solenoid. This regulates the amount of pressure applied to the wastegate controller diaphragm by leaking off boost pressure to the inlet side of the turbine.

Wastegate Duty Solenoid

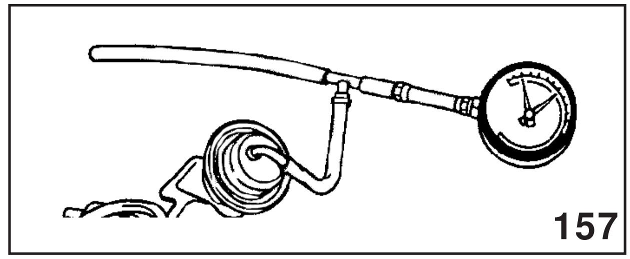
The wastegate controller (in response to the Duty Solenoid) opens the wastegate flap valve to bypass exhaust gas and so decrease the rotating energy of the turbine keeping the boost pressure to the desired level.

When operating at increasing altitudes, the atmospheric pressure becomes lower and therefore the difference between the desired level of boost pressure and atmospheric pressure becomes greater. To maintain the same level of boost pressure the air must be compressed more which requires more turbine rotating energy. Therefore less boost pressure is applied to the wastegate controller via the solenoid valve and boost remains constant.

However, at very high altitudes the extra compression of the air at maximum boost causes a too high intake air temperature even after intercooling and engine knock will occur. Therefore it is necessary to decrease the maximum boost pressure at very high altitudes.

Turbocharger Testing

Wastegate Control



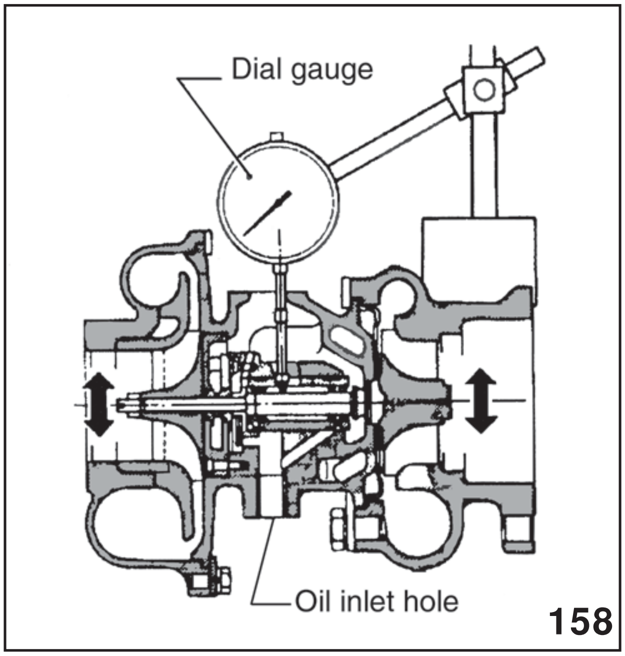
Pressure Gauge Connection

Attach a regulated pressure supply directly to the wastegate actuator hose connection.

The actuator should begin to open at approx. 50.0 - 60.0kPa. (7.2 - 8.7 p.s.i.)

Check all associated hoses for damage or loose connection.

The Turbocharger should be visually inspected for any damage to the compressor or turbine wheels. Check for any oil that may be present in the turbine housing. A small amount of oil due to crankcase ‘blow by’ is acceptable in the compressor housing.

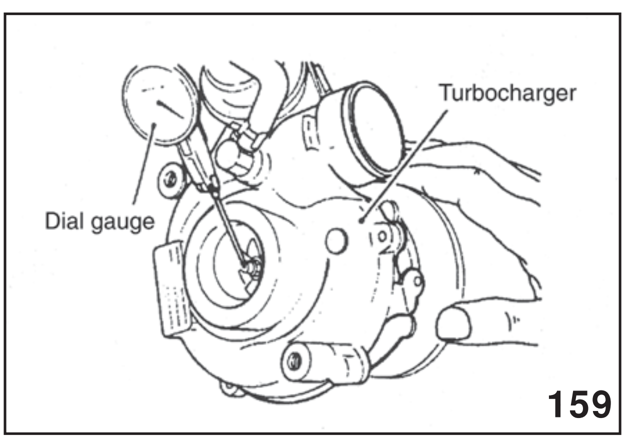


Radial Movement Check

Before testing the electronic components in the boost control system, be sure that the wastegate is operating correctly.

Utilizing a dial gauge, measure the radial movement of the turbine shaft by accessing it through the oil outlet hole. Radial play should not exceed 0.17mm. (.006 inches)

To measure the axial movement of the turbine shaft, place the dial gauge against the end of the shaft at the turbine end, and push against the compressor end of the shaft. Axial play should not exceed 0.09mm. (.003 inches)



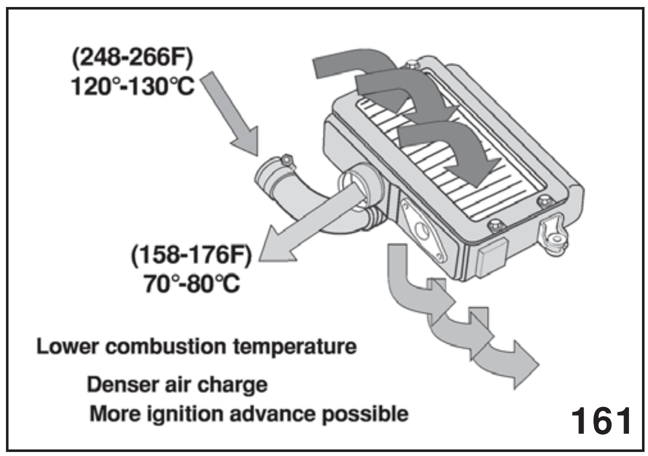
Axial Movement Check

Intercooler

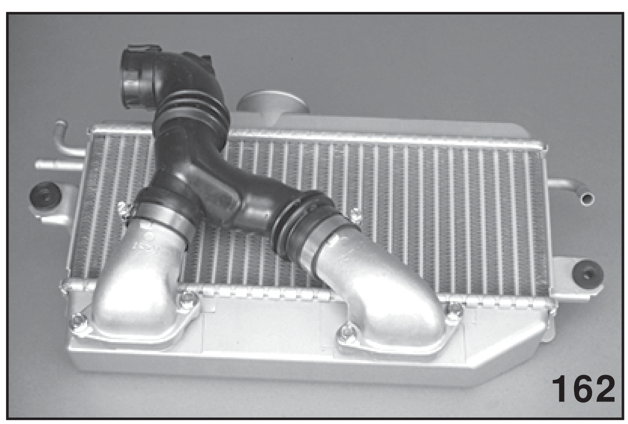
The Turbocharger compresses the intake air by using wasted exhaust gas energy. The Turbocharger turbine is driven by exhaust gas, causing the compressor wheel to rotate. By compressing the intake air, the volumetric efficiency of the engine is greatly improved.

The compression of the intake air by the Turbocharger causes an increase in air temperature, so an intercooler is located between the Turbocharger and the intake manifold. The intercooler reduces the temperature of the intake air from 248-266°F (120°-130°C) down to 158-176 F (70°-80°C) under normal operating conditions.

An Air Bypass Valve redirects high pressures from the intercooler back to the inlet side of the Turbocharger under deceleration.



Effects of Intercooling (Artwork)



Intercooler (Bottom View)

Inlet to Throttle Body

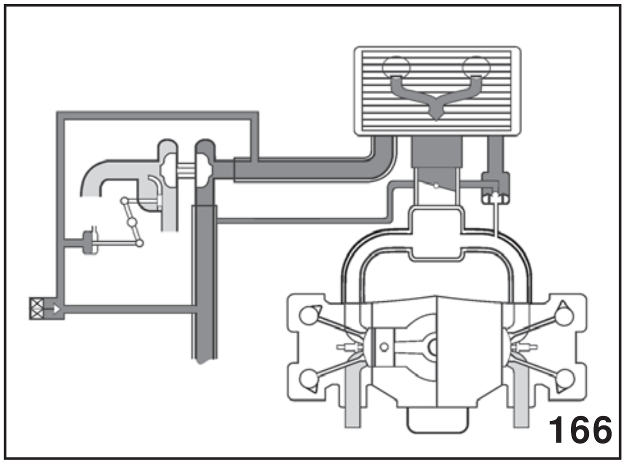
The temperature of the intake air is increased as it is compressed by the Turbocharger. This rise in temperature causes a corresponding expansion of the air, leading to a reduction in air density. The intercooler is designed to transfer the heat of the compressed intake air to the external air flowing through as the vehicle is in motion.

There are two positive by-products of decreased air temperature and increased air density: one; a reduction in combustion chamber temperature allowing for more advanced ignition timing, and two; improved volumetric efficiency due to the increase in air mass for a given air volume. With a denser air charge into the combustion chamber, more fuel can be injected leading to greater power output.

Intercooler Location

Bypass Valve Connection

The Air Bypass Valve is located after the Turbocharger, and provides a bypass passage for the compressed intake air back to the inlet side of the Turbocharger. When deceleration occurs immediately after a period of high engine load (high boost pressure), a large pressure differential occurs at the compressor wheel of the Turbocharger. This is due to the inertia of the Turbocharger, which still generates boost pressure even though the throttle is fully closed. This high pressure may lead to increased noise, and possibly damage the Turbocharger due to the high pressure exerted at the compressor.



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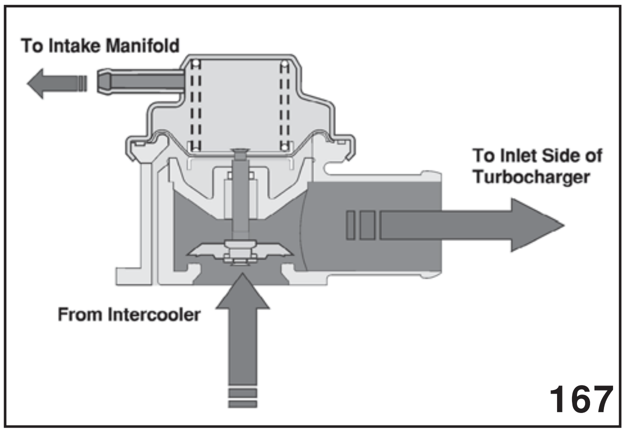
Air Bypass Valve Operation (Artwork)



Bypass Valve (Artwork)

The upper chamber of the bypass valve is connected to the intake manifold, and the negative pressure (vacuum) during deceleration opens the valve by acting on the diaphragm.

Operation of the valve can be tested by attaching a hand held vacuum pump to the intake manifold connection. Apply a negative pressure with the pump and confirm that the valve opens.

External Influences On Boost Pressure

Ambient Air Temperature and Pressure

As air temperature rises, the ability of the Turbocharger to compress the air decreases. This phenomenon is directly due to the decrease in air density and the physical limitation of the Turbocharger. Even when air temperature is low, the air density (barometric pressure) may be low. Under these conditions, lower than expected boost pressures may be experienced. Again this is due to the physical limitations of the Turbocharger.

Exhaust Diameter

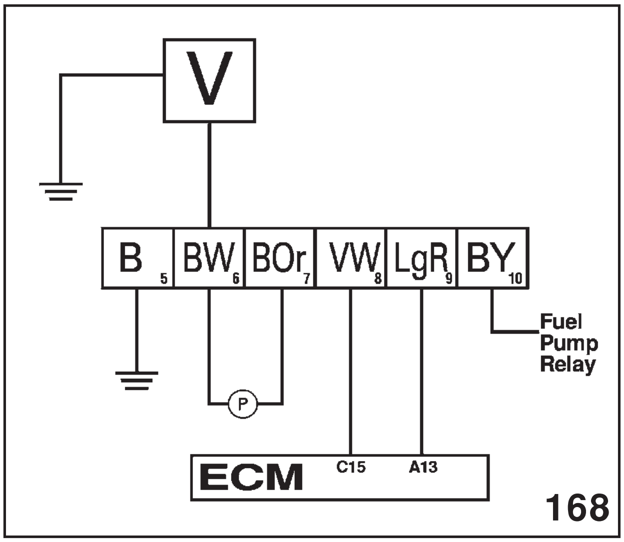
The diameter of the exhaust system will vary the pressure difference across the turbine. A larger exhaust allows the Turbocharger to rotate faster, which results in higher boost pressures. Any increase in boost pressures would require ‘re-mapping’ of the ECM programs to accommodate different air flow rates and resultant ignition change requirements. Over speeding of the turbine can lead to Turbocharger failure, particularly in conjunction with the increase in the pressure differential across the turbine.

Fuel Octane Rating

The high combustion pressures resulting from the increase in volumetric efficiency require a high-octane fuel. If the octane of the fuel is too low, knocking will occur. The end result of knocking is damage to the engine. The ECM is programmed to retard ignition timing if knocking is detected. Excess knocking will cause the ECM to enter a ‘Fail-safe’ mode where the boost pressure is reduced to the minimum value determined by the wastegate actuator.

Turbo Lag

The pressure of the exhaust gas is low at low engine speeds. As the Turbocharger uses exhaust energy to operate, it does not respond immediately when the throttle is opened. This phenomenon is referred to as ‘Turbo Lag’. In an attempt to overcome this phenomenon, design characteristics of the Turbocharger are matched to the prospective use of the vehicle.



Fuel Pump Controller Terminal Layout

The WRX Impreza is equipped with a fuel pump controller. This device is designed to adjust the speed and volume output of the fuel pump. The controller is located in the right rear trunk or cargo area behind the trim panel. The controller receives a 5-volt signal input from the ECM. This signal or duty ratio has 3 levels. The first level is 33% duty ratio, which produces a 5.0-volt drop on the ground circuit of the fuel pump. This results in the fuel pump operating at its slowest speed and producing the lowest volume. The ECM will select this duty ratio on a warm engine after the engine has been operating for 30 seconds (if the vehicle remains at idle). The next level or duty ratio is 67%. This duty ratio input to the controller produces a 3.4-volt drop on the ground circuit of the pump.

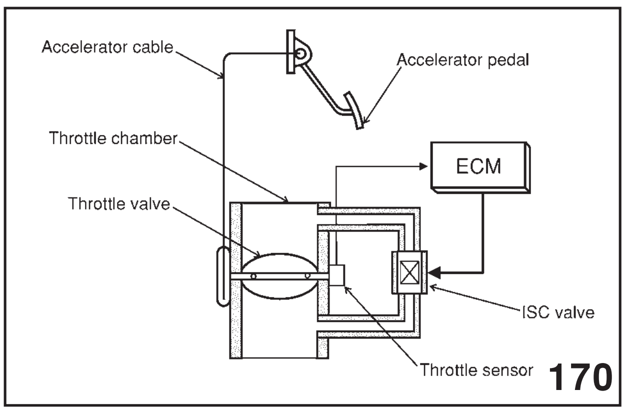
If the vehicle is cruising at a light engine load the ECM will select the 33% and increase the duty ratio to 67% upon medium to heavy acceleration. Full throttle acceleration will result in the ECM adjusting the fuel pump duty ratio to 100%. 100% duty ratio is also used for 30 seconds after a warm or cold engine start. This duty ratio will result in a .9 volt drop on the fuel pump ground circuit. This level produces the fastest fuel pump speed and largest volume output. The duty ratio will remain at 100% until the rate of acceleration has been decreased. The duty ratio at all levels operates at 81.4 HZ.

The 10-pole connector at the fuel pump controller contains 6 wires. Terminal 5 (B), a Black wire, is the ground for the controller. Terminal 6 (BW), a Black wire with a White tracer, is the ground from the fuel pump. Measure the voltage drop at this wire when checking for proper controller operation. Terminal 7 (BOr), a Black wire with an Orange tracer, is the power supply to the fuel pump at battery voltage. Terminal 8 (VW), a Violet wire with a White tracer, is the ECM duty ratio signal to the fuel pump controller. Terminal 9 (LgR) a Light Green wire with a Red tracer, is also an ECM input to the fuel pump controller. This signal, approximately 10.80 volts, signals the fuel pump controller that the engine is operating. If the value of this signal drops to zero the fuel pump controller will remove the power supply from the pump and it will stop. The signal at terminal 9 will terminate after 2 seconds after the ignition has been turned on if the start signal is not received at the ECM. Terminal 10 (BY), a Black wire with a Yellow tracer is the power supply for the controller and the fuel pump. This power is received from the fuel pump relay.

Electric Throttle Control System

Traditional Throttle System

The traditional throttle control system used an accelerator cable to connect the throttle pedal with the throttle valve on the throttle body. Idle control was achieved with an Idle Speed Control (ISC) motor that bypassed the throttle plate to provide extra air when the conditions required idle changes. Cruise control was achieved with the help of a cruise control module that held vacuum in a diaphragm that physically held the throttle open when a driver activated cruise control.



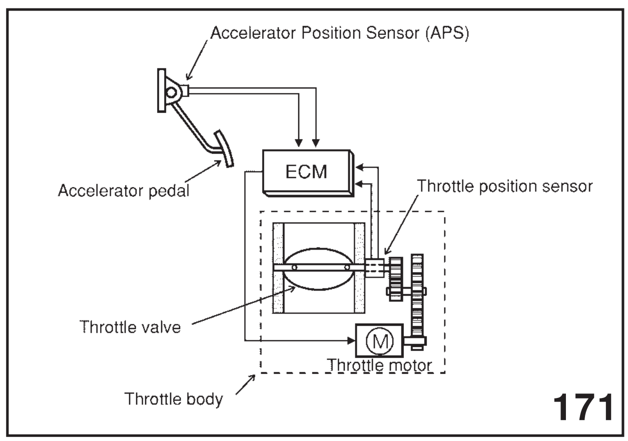
Current Throttle System

Electronic Throttle Control System

The Electronic Throttle Control System dispenses with the accelerator cable that was used in the traditional system. The throttle valve opening and closing speed can be controlled by the ECM. This can produce quick acceleration without having to be proportional to the speed at which the accelerator pedal is depressed. This system has many advantages over the traditional system since the ECM can position the throttle valve for optimum performance.

Electronic control relies on a control module that uses various types of input sensors to decide on an output control of the throttle position. Relying on these sensors provides for fine-tuning and a more precise control of idle. Electronic control can include cruise control functions as part of its programming. Also, the air/fuel mixture can be precisely matched to the position of the throttle. This has an additional benefit of helping to reduce exhaust gas emissions since the air fuel mixture can be balanced so that more of it is burned in the combustion process. There is a fail-safe backup program in the event of a failure that will allow the vehicle to limp in if the system has a fault.

This system was first introduced on the 2.5L turbo STI, Baja, and Forester in 2003 model year and was also used on the midyear 2003 PZEV. (Partial zero Emission Vehicle).



Electronic Throttle Control System

Idle and cruise control can be incorporated into the program of the electronic throttle control system.

There is a fail safe and fail-soft system that will allow the vehicle to limp in if the system has a fault.

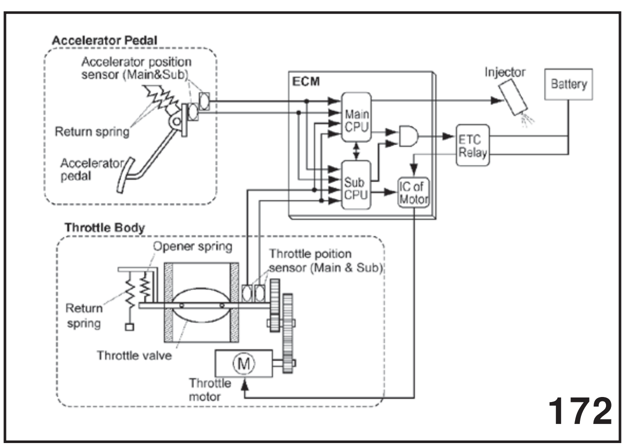
Cruise Control Changes with ETC

Since the ECM is controlling the position of the throttle plate, there is no need for a cruise control module or a vacuum diaphragm to hold the cruise position. ETC vehicles come equipped with an electronic cruise control program built into the ETC system. One result of this is that the cruise light will flash when a problem is detected with the ETC system.

ETC Microcomputers

The Electronic Throttle Control program inside the ECM is equipped with two parallel microcomputers; one is called the main CPU and the other is called the sub CPU. The parallel computers look at the inputs and control the output. The inputs and outputs of both microprocessors are compared to verify this system is operating correctly.

The main CPU computes the target throttle opening from the acceleration position sensors signal, while the sub CPU determines the difference between this target opening and the actual throttle opening. The ECM then drives the throttle motor to control the throttle opening. The two CPUs share sensor signals and constantly monitor each other to ensure that their computational results are correct.



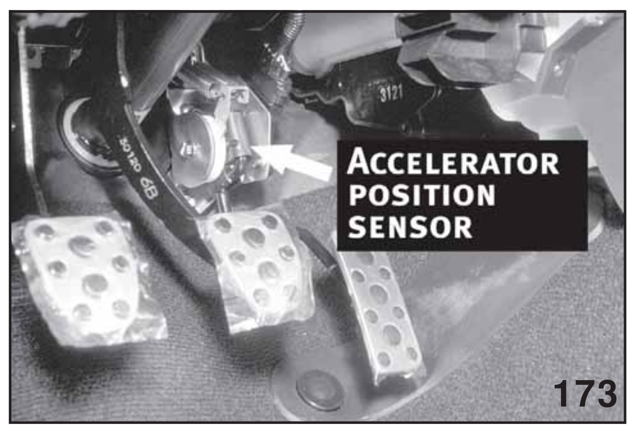
ETC System Layout

ETC System Inputs

The ETC input comes from the Acceleration Position Sensor (APS) which is mounted on the accelerator pedal. The input from the APS can be processed and the throttle motor controls the throttle opening. The ETC system has a feedback sensor mounted on the throttle body that provides information on the position of the throttle valve called the Throttle Position Sensor (TPS). The Acceleration Position Sensor and Throttle position Sensor are arranged in a dual main and sub system for improved reliability. Each sensor has a backup parallel sensor in case the primary sensor fails or has a problem with its operation.

Acceleration Position Sensor

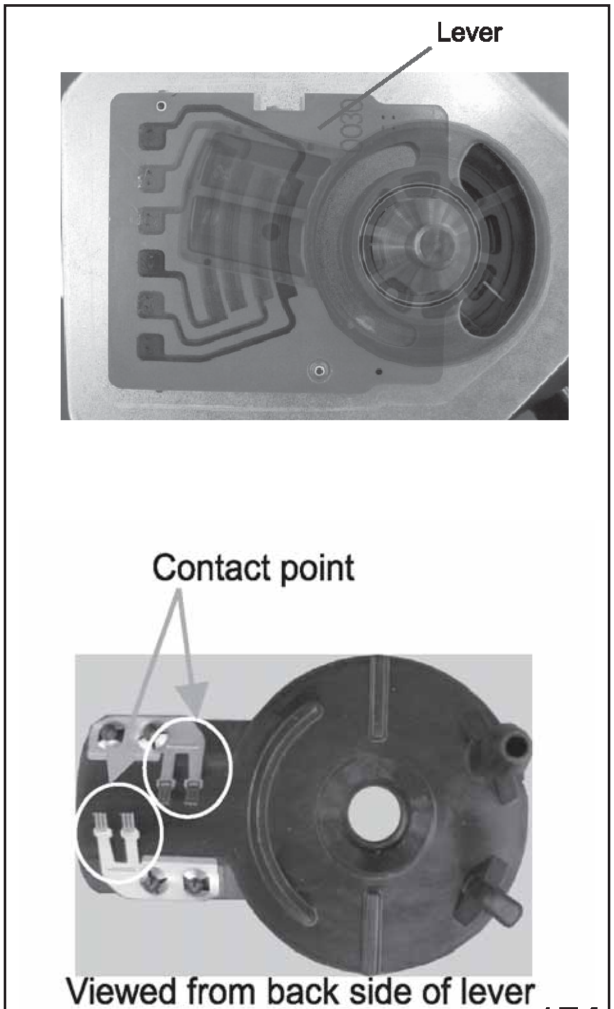
The Acceleration Position Sensor is mounted on the accelerator pedal inside the passenger compartment. It provides information on the movement of the accelerator pedal on two separate circuits that can provide detailed information on the position of the accelerator pedal.



Accelerator Position Sensor

The main acceleration position sensor has three wires. Five volts is supplied to the Main sensor feed circuit. The output voltage indicating accelerator position is fed to the ECM on the Main Sensor Signal Circuit. A ground wire from the acceleration position sensor to the ECM completes the main acceleration position sensor circuit.

The sub sensor is a completely separate circuit from the main sensor. Five volts is supplied to the Sub sensor feed circuit. The output voltage indicating accelerator position is fed to the ECM on the Sub Sensor Signal Circuit. A ground wire from the acceleration position sensor to the ECM completes the Sub acceleration position sensor circuit.



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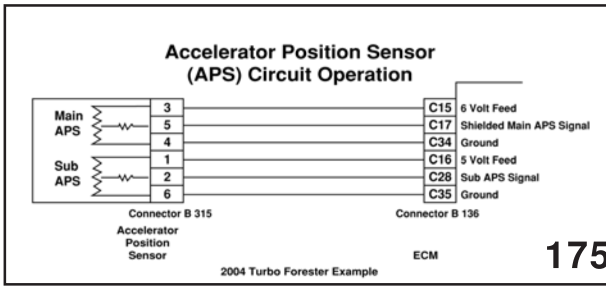
Contact Lever

Electrically the sensor has two potentiometers and two wiper arms. The wiper arm inside the sensor is mechanically connected to the accelerator pedal. The wiper arm moves as the accelerator pedal moves. The wiper arm is moving across a resistor and as the accelerator pedal moves, the wiper arm moves on the resistor. This changes the output voltage of the sensor. This voltage indicates the position of the accelerator pedal.



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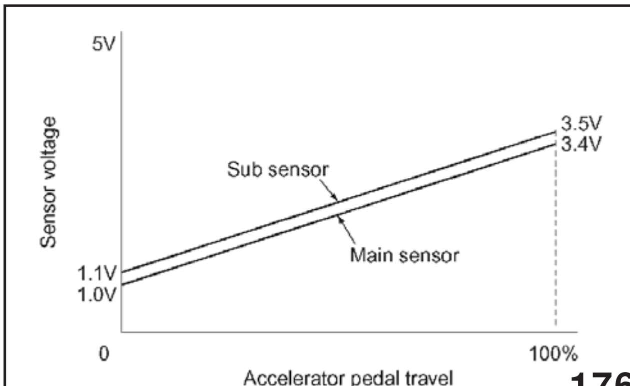
Contact Points of Lever

Both the main sensor and the sub sensor vary the voltage in proportion to the accelerator pedal travel. The voltage of the main sensor should be 1.0 volts when the accelerator is fully released (throttle closed) and 3.4 volts when the throttle is fully depressed (wide open throttle). The sub sensor voltage should range from 1.1 volts with the throttle closed to 3.5 volts with the throttle fully depressed. Having two sensors helps the ECM compare the voltages so it can detect problems with the circuit and set DTCs as necessary.



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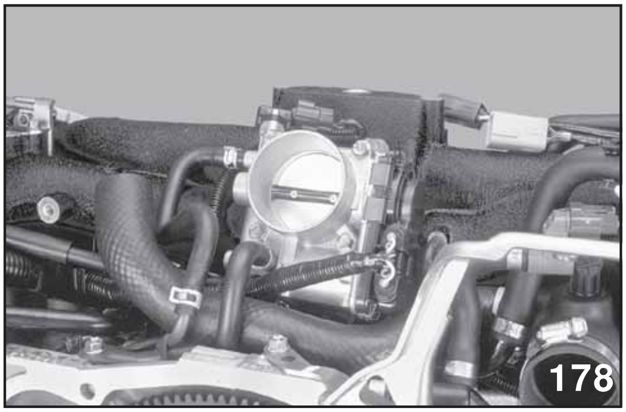
Accelerator Pedal Travel

The ECM is looking for this. 1-volt difference to verify the acceleration position sensor is working properly.

ETC Components

Throttle Body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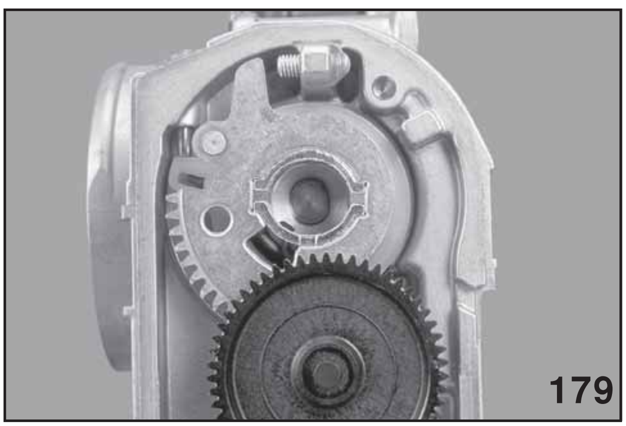
Throttle Body

The throttle body is composed of the throttle valve, throttle position sensor, throttle motor, reduction gear, and throttle opener/return springs.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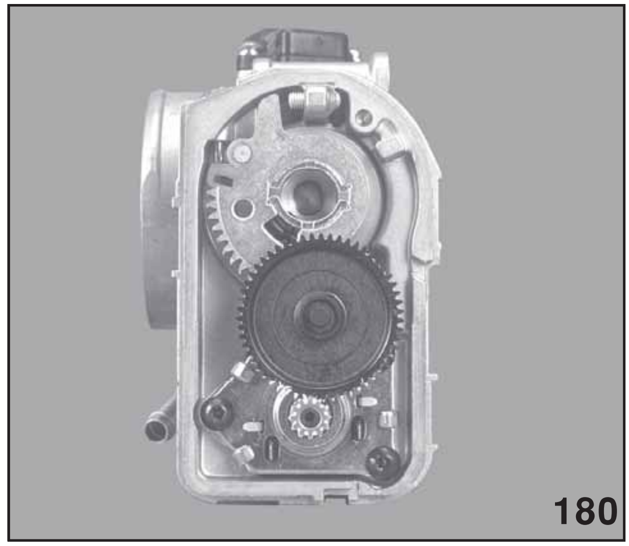
Reduction and Throttle Shaft Gear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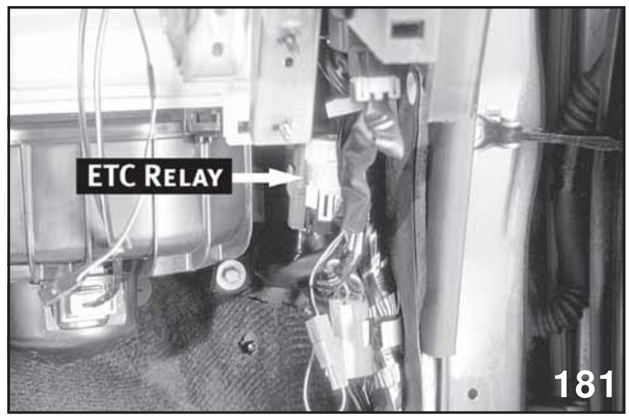
Motor, Reduction and Throttle Shaft Gear

ETC Relay



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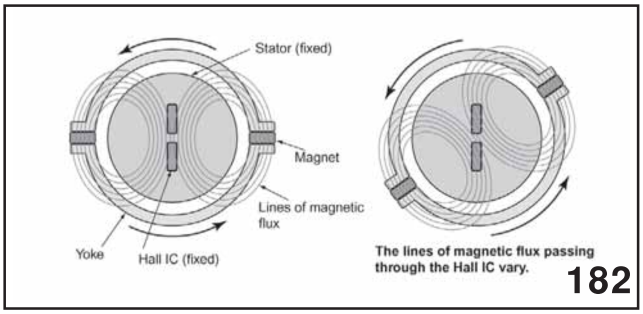
ETC Relay

Throttle Position Sensor

The Throttle Position Sensor provides information to the ECM regarding the position of the throttle valve. The Throttle position Sensor has two build-in Hall Integrated Circuits (a main and sub sensor) each providing a feedback signal to the ECM. The main and sub sensors output voltages at different rates of voltage increase. The Hall effect sensor is mounted in the cover plate. The magnets are imbedded in the gear.

TPS Hall Effect Throttle Opening Detection Principle

The sensor inside the motor has two magnets integrated into the gear set. The magnets are placed on the outside of the stator. Two Hall Effect Integrated circuits (main and Sub) are placed inside the stator.



Hall Effect (main and sub)
Valve Opening Detection Principle

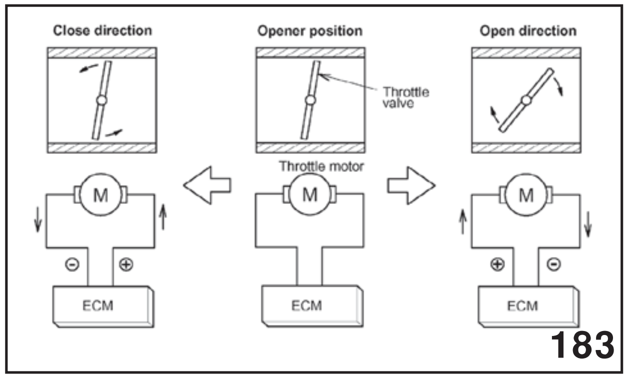
Since the magnet is integrated into the gear, it rotates and changes its output signal as the valve opens and closes.

The Hall IC has the property of changing its output voltage according to changes in the number of lines of magnetic flux that passes over it. Therefore, the voltage output from the sensor changes according to the valve opening.

Throttle Motor

The throttle motor, which is driven according to the throttle valve opening determined by the ECM, opens and closes the throttle valve via a reduction gear.

The throttle valve opener position (valve is free with no spring fore at work) is used as a reference point to control the throttle valve position in the closing direction and opening direction. Accordingly, the throttle motor controls the valve position by changing the direction of current (+, -) in the circuit in the closing direction and opening direction.



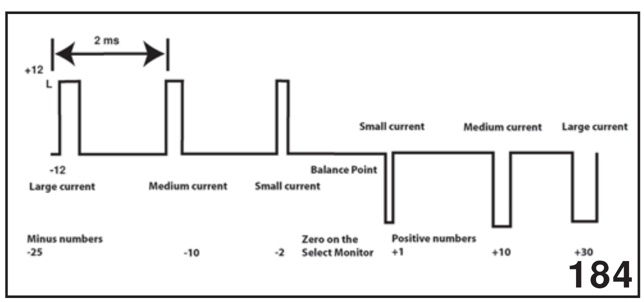
Throttle Motor Line Art

The valve opening/closing speed and the valve position are maintained by controlling the duty ratio. The duty ratio that maintains the valve position is determined by balancing the spring force of the return spring or the opener spring.

ETC Throttle

The ETC throttle body is equipped with two springs. An opener spring and a return spring. The return spring assists with closing the throttle body while the opener spring assists with moving the throttle away from idle. The balance point, the opening of the throttle controlled only by the tension of these two springs is about 1800-2000 PM on a warm engine.

The throttle body is also equipped with a motor that precisely controls the movement of the throttle plate by operating from a signal created in the ECM. This signal is positive or negative dependant on the need to increase throttle opening or decreased throttle opening.



Throttle Body Duty Ratio Wave Form

NOTE: THIS PATTERN IS NOT WHAT WOULD BE SEEN ON A LAB SCOPE, IT EXPLAINS HOW THE CURRENT REVERSES AS THE MOTOR HITS THE BALANCE POINT.

Fuel Injector

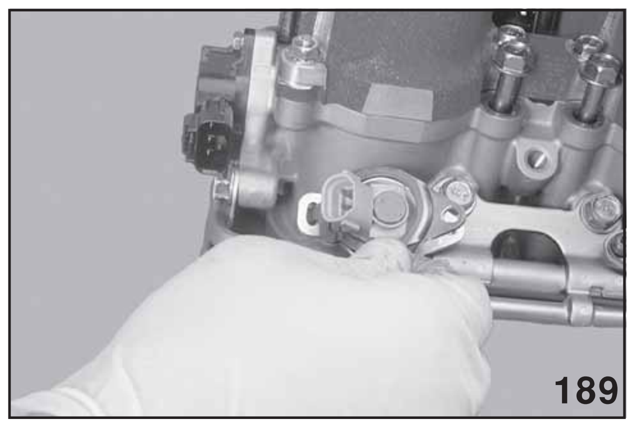
Fuel Injector Pattern

Fuel Injector Spray Pattern

Fuel Injector Rail

The injectors are classified as side feed type. The multi hole nozzle makes it possible for the injector to produce fine fuel particles which enhances the combustion efficiency and output performance of the engine.

The low profile shape of the injectors provides crash protection and eliminates the need for additional injector guards or covers.

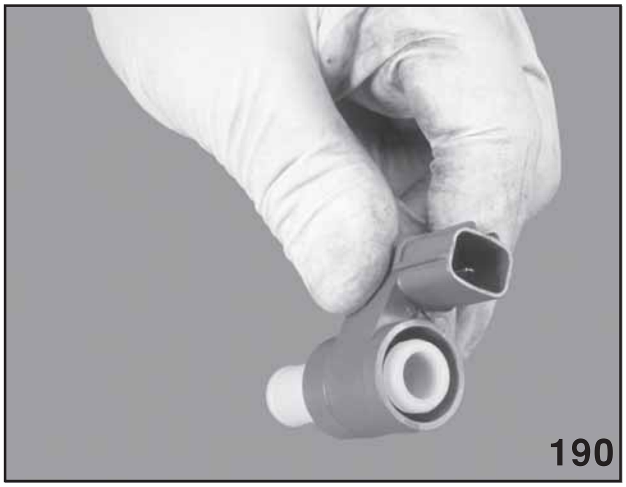


Injector Removal

The injectors are secured to the injector rail with a T-25 bolt and notched retaining ring.

Removal of the injector is accomplished by removing the bolt and lifting the retaining ring from the notch in the rail.

CAUTION: BE CERTAIN TO RELIEVE THE FUEL PRESSURE ACCORDING TO THE APPROPRIATE SUBARU SERVICE MANUAL ON THE STIS WEB SITE BEFORE REMOVING THE INJECTOR.



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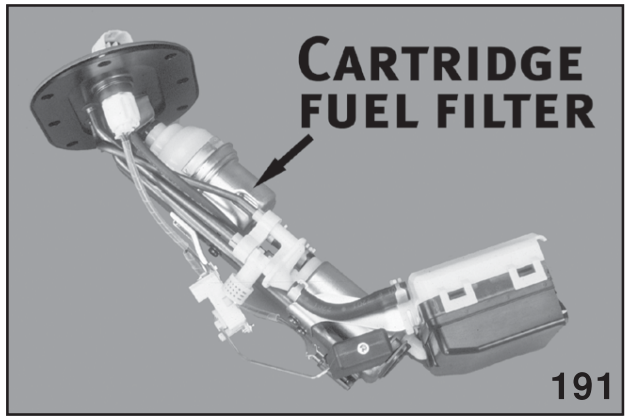
PVC Connector

A Positive Crankcase Ventilation system connector is installed on the WRX STi. This connector is used to detect an open hose by simply opening the circuit from the ECM that monitors the connector. The electronic construction of the connector is a shorting loop built inside the connector. When the connector is moved away from its corresponding connector (carrying the PCV hose with it) the ECM detects the opening and triggers the Diagnostic Trouble code.

Fuel Pump

The fuel pump for the WRX STi is equipped with two filters. The mesh filter located at the inlet side of the pump can remove large particles from the fuel before it goes into the pump. The second filter is a cartridge type that filters the smaller particles from the fuel before the fuel is delivered to the injectors. This filter is recommended for replacement every 60,000 miles and according to the maintenance schedule.
Follow: The instructions provided in the appropriate Subaru Service Manual on the STIS web site on pump and filter.

The mesh filter housing is designed to hold enough fuel to prevent aeration on turns during vehicle operation with lower fuel levels.



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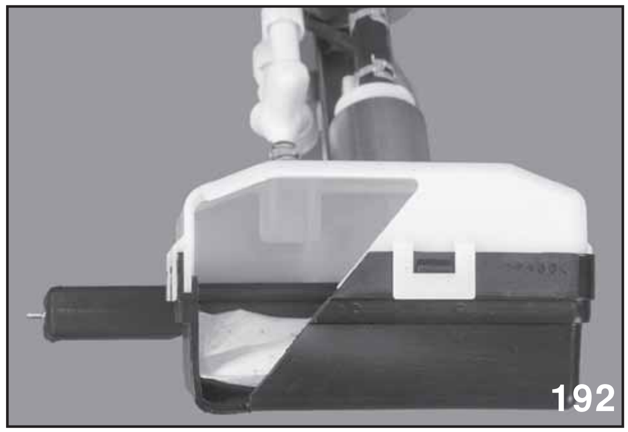
Fuel Pump



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Mesh Filter

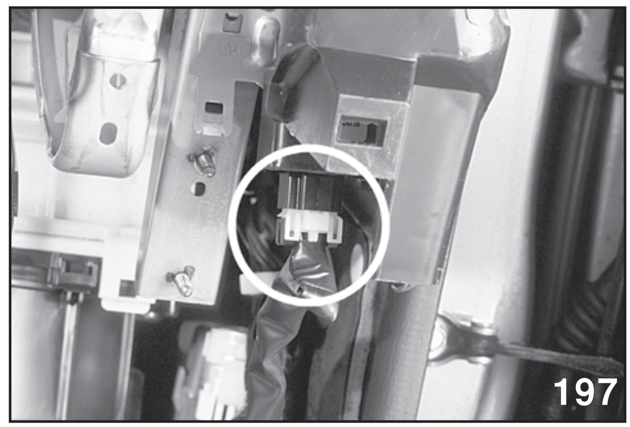
Intercooler Water Spray

Intercooler

Hood Scoop

The intercooler of the WRX STi is 470 mm by 168.5 mm. Air from the hood scoop is directed over and through the intercooler decreasing intake the air temperature. This allows for improved volumetric efficiency and more advanced ignition timing. To further increase efficiency of the intercooler an intercooler water spray has been added to the vehicle. A water spray nozzle is mounted to the bottom of the hood scoop that when activated sprays water in a pattern to cover the full width of the intercooler. This will assist with providing additional cooling of the intake air temperature as the water is pushed through the intercooler cooling fins by the air from the hood scoop.

I/C Water Spray Control Button



Timer

The I/C water spray button is mounted to the drivers left near the head light leveler control. When activated the button sends a signal to the I/C water spray timer. The timer is located on the A pillar post behind the glove box.

Normal Access to the Water Tank

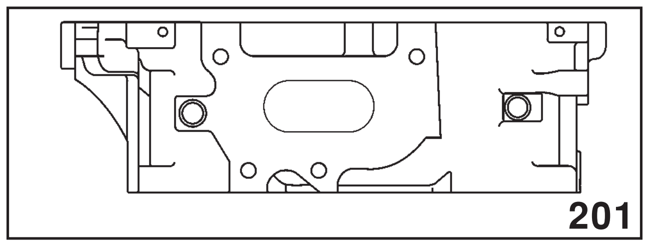
Water Tank Complete

The timer will send a 2 second signal to the I/C water pump. The pump is located in the side of the I/C water tank, located in the trunk. The tank holds about one gallon of water. Do not fill the water tank more than 50% during times of low ambient temperature where freezing conditions are expected or damage to the tank will occur. A warning light on the combination meter will illuminate when the water level in the tank becomes low.

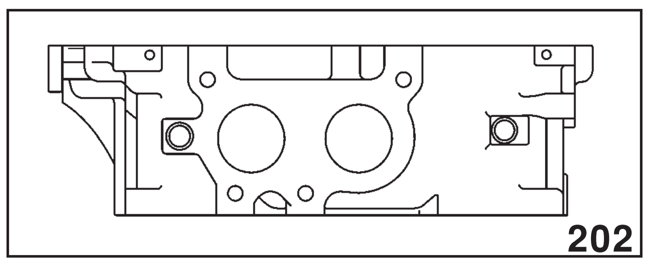
Partial Zero Emission Vehicle (PZEV)

A Partial Zero Emission Vehicle (PZEV) has been designed for sale in California, Maine, Massachusetts, New York and Vermont. The vehicle is equipped with a 2.5 NA engine with an Emission warranty for 15 years or 150,000 miles.

There are two major engine changes for the PZEV which are the design of the cylinder head and the pistons.

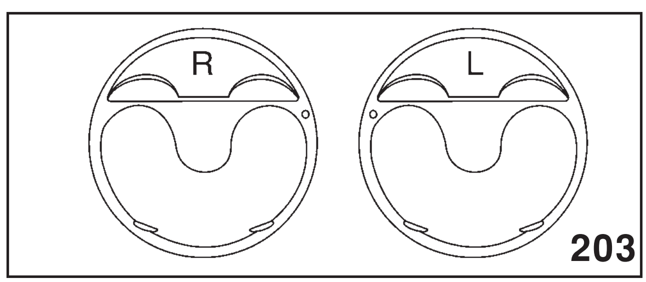


PZEV



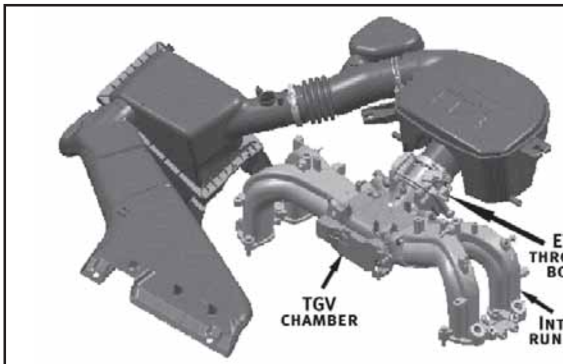
Federal

The cylinder head exhaust ports have been unified to a single port to promote faster warming of the catalyst.



Piston Shape

The piston design assists with better mixing of the air/fuel mixture before combustion.

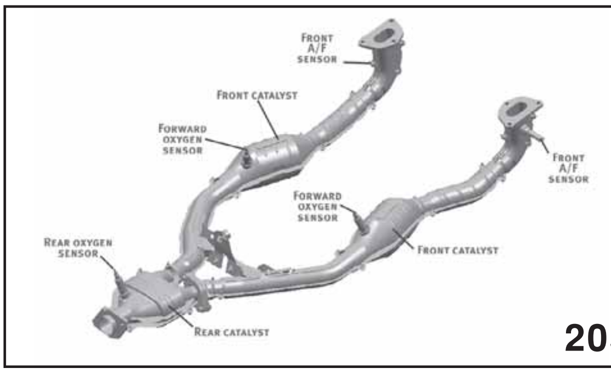


204

Intake Manifold

The three piece intake manifold contains a center TGV chamber with intake runners bolted to each side. The TGV chamber contains all components of the TGV system. The motors and sensors can be serviced separately from the chamber.

The PZEV is equipped with ETC, which incorporates cruise control.



205

Exhaust System

The exhaust system for the PZEV is equipped with an A/F sensors near the exhaust inlet on each side of the engine, two front catalysts, with an oxygen sensor at the rear of each catalyst and the rear catalyst. An oxygen sensor is located at the rear of the rear catalyst.

The front A/F sensors are used to produce main feed back for each side of the engine. Catalyst efficiency (front only) is judged from information from the front A/F and the forward Oxygen sensor for each catalyst.

The rear most Oxygen sensor monitors the total A/F feedback for proper operation.

A new evaporative cannister is installed with a built in drain valve, and filter.

206

Canister Complete

207

Drain Valve Separated from Canister (NOT SERVICEABLE)

208

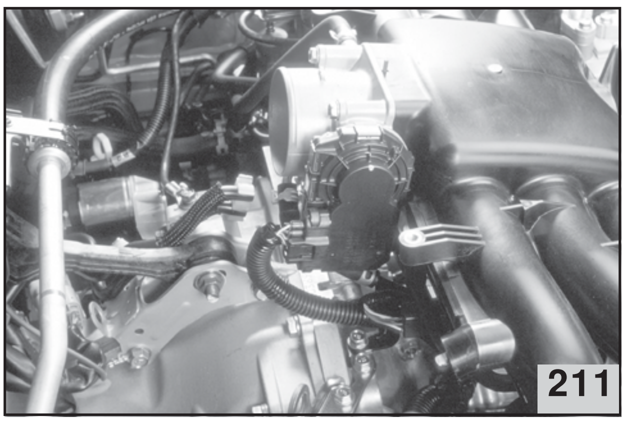
Canister Filter

Legacy H6 Fuel System

210

Engine Cover

The 3.0 liter engine is equipped with Electronic Throttle control.

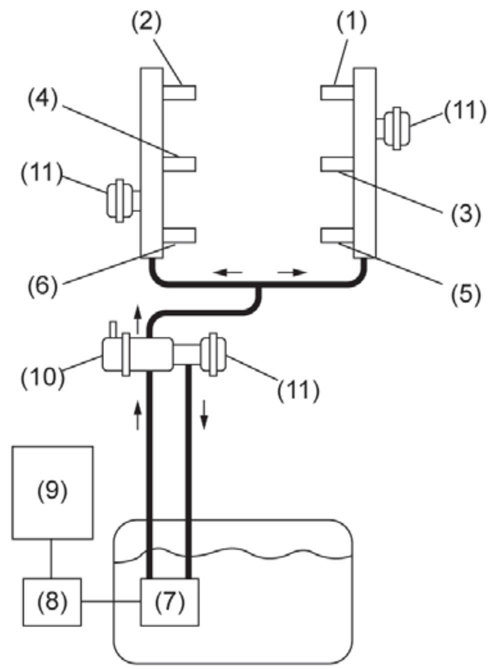


211

Throttle Body

Components include the ETC throttle body with TPS, accelerator sensor and ECM.

The engine top cover must be removed to gain access to the fuel system components on or near the intake manifold.



(1) #1 fuel injector
(2) #2 fuel injector
(3) #3 fuel injector
(4) #4 fuel injector
(5) #5 fuel injector
(6) #6 fuel injector
(7) Fuel pump
(8) Fuel pump control unit
(9) ECM
(10) Pressure regulator
(11) Pulsation damper

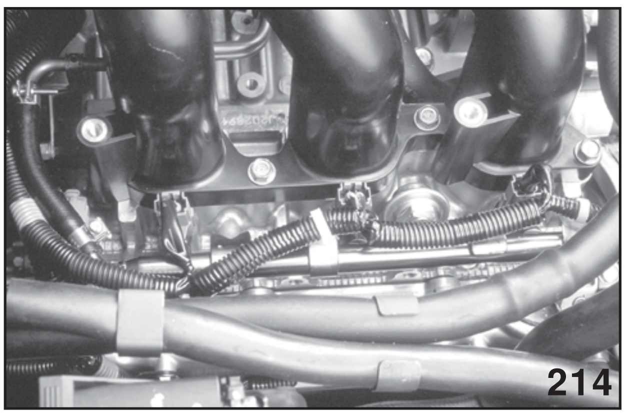
212

Fuel Schematic

The top fed fuel injectors of the 2005 Legacy 3.0 liter engine are mounted directly to the cylinder head and receive fuel through a direct fuel rail.

Fuel Injectors

The top fed fuel injectors of the 2005 Legacy 3.0 liter engine are mounted directly to the cylinder head and receive fuel through a direct fuel rail.



Fuel Damper

The rail has a built on fuel pulsation damper that is serviceable with rail replacement only.

Fuel Pressure Regulator

The fuel pressure regulator which is located near the left front strut tower, delivers regulated fuel to the direct fuel rails and bypasses fuel back to the fuel tank. The regulator has a built on pulsation damper which is serviceable with regulator replacement only.

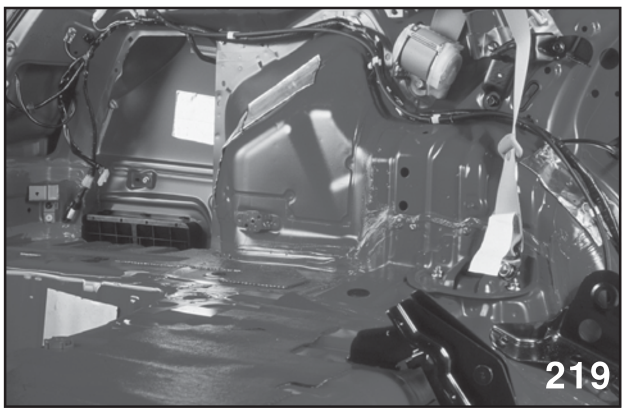
Quick Connector

The fuel delivery and bypass hoses are secured to the fuel lines with quick connectors that are released by special tool 42099AE000. Properly release the fuel pressure before disconnecting any quick connector.

Tool 42099AE000

Fuel Pump Control Unit

A fuel pump controller is utilized to control the volume output of the fuel pump. 3 different duty ratios are used. (33%, 67% and 100%)



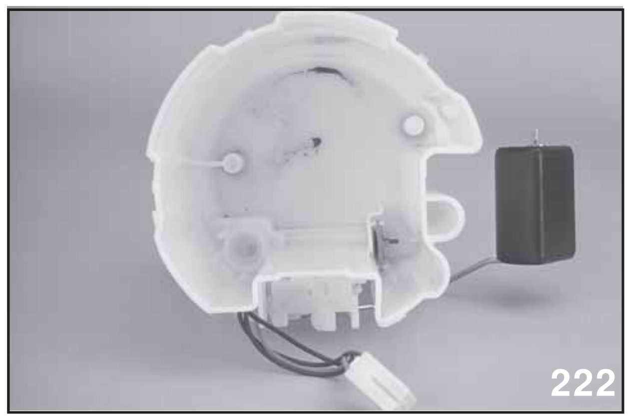
Left Corner of Vehicle

The fuel pump controller is located in the left rear of the vehicle.

Fuel Pump, Vertical

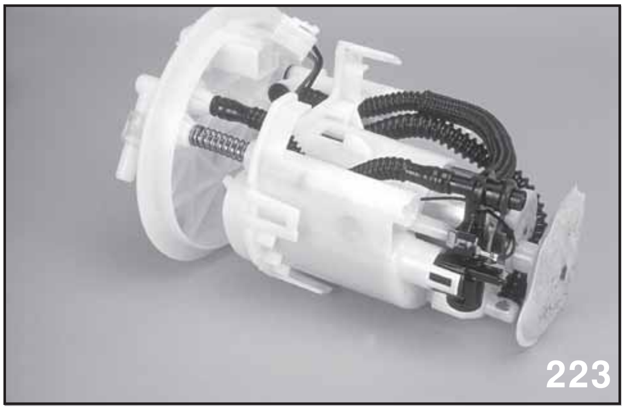
Fuel Pump, Horizontal

The fuel pump is located in the fuel tank and is supported on the top by the spring loaded access plate mount and on the bottom by 3 rubber pads that rest on the bottom of the tank.



Main Sending Unit

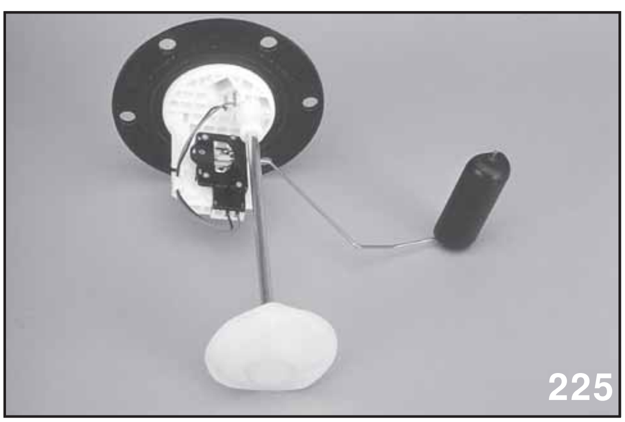
The sending unit can be removed by the pump and replaced separately.



Pump Assembly

The fuel pump housing contains the main fuel filter, pick up filter and jet pump. These components are not serviceable separately. (The fuel filters and pump are replaced as a unit)

Sub Unit, Side View



Sub Unit Straight View

A sub unit is used on the passenger side of the fuel tank.

Carpet

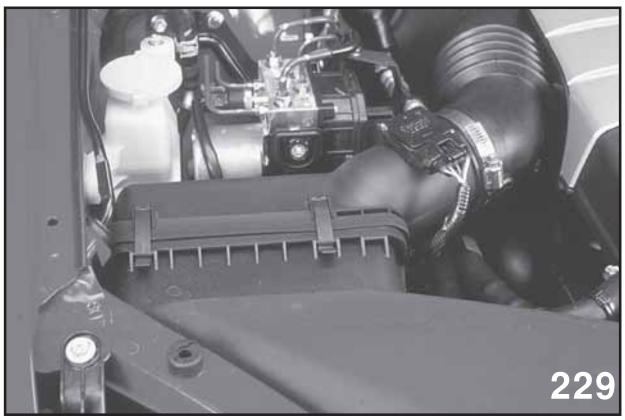
The ECM is accessed from the floor of the passenger seat. The door trim must be removed and the weather seal loosened to remove the carpet locating tabs. Remove the carpet stay tab from the right front corner of the carpet and pull the carpet up slightly.

ECM

Remove the 5 bolts that secure the ECM cover plate and remove the ECM cover plate. The inspection mode connectors are located above the ECM.

Relays

The ignition, fuel pump and ETC relays are located behind and to the right of the glove box.



Air Flow Meter

An air flow meter is mounted in the air induction hose.

Pressure Sensor

A pressure sensor is mounted in the front of the resin intake manifold.

Canister

The evaporative canister is located under the left rear inner fender.

Canister Hoses

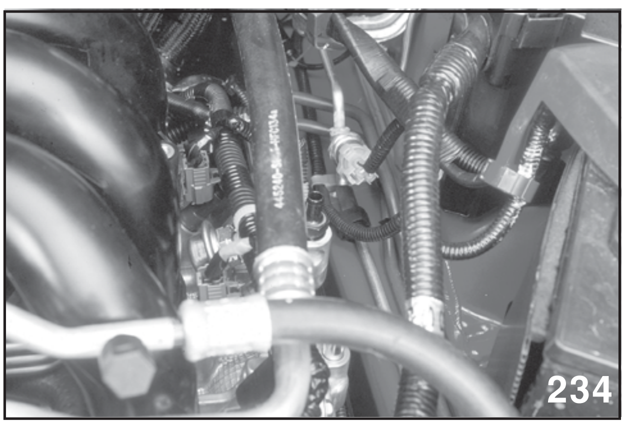
The canister is equipped with the drain valve of the On Board Vapor Recovery (ORVR) and the drain valve filter. All components are replaced as a unit.

Vent Tube

The vent tube for the fuel shut valve is routed through the cargo area under the carpet.

The fuel tank pressure sensor and the fuel tank sensor control valve are located above and to the right of the fuel tank.

The pressure control valve is located to the left of the rear differential.

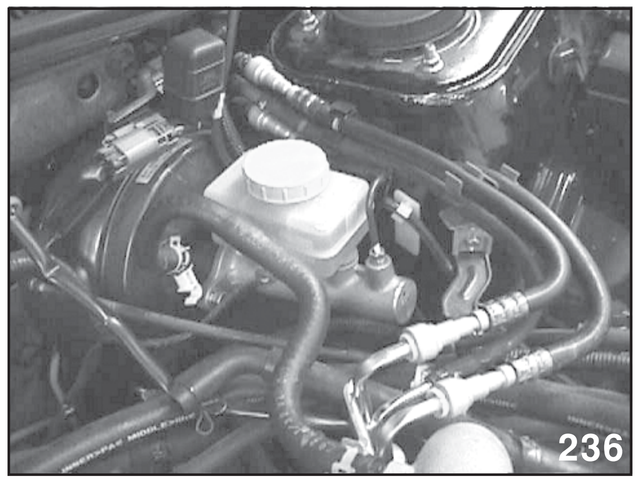


PCV (Crankcase)

The positive crankcase ventilation valve is located on the left bank valve cover.

Quick Connect Fuel Line Service Procedures

In 2004 a new fuel line with a Quick Connector end was introduced on the 6 cylinder Legacy. In 2005 it was added to the Forester and will be used on most models by 2006. This hose must be removed to check fuel pressure since each end of the hose has a quick connector. Once the quick connect fuel hose is removed, the current fuel pressure gauge can be attached to the metal fuel line in place of the fuel line. (Consult the Subaru Service Manual on the STIS web site for the proper procedure of removing fuel pressure).



Quick Connect Fuel Hose

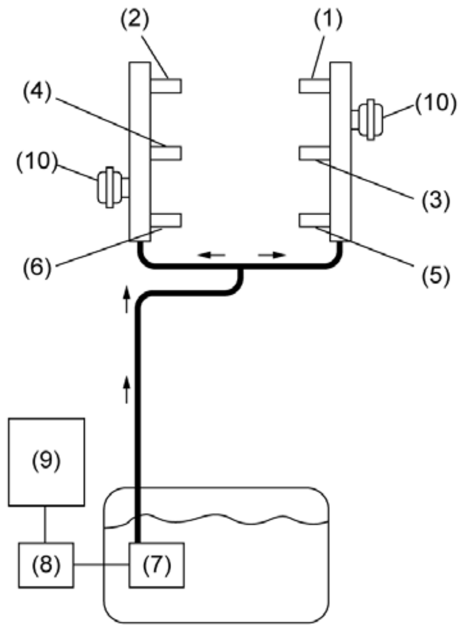
Fuel Delivery Quick Connector

The quick connector fuel system was originally intended to be a one time use only "Quick Connector". This quick connector must be disconnected when removing the line for parts replacement or fuel pressure checks.

Quick connector service procedure:

1. Separation - Push the internal retainer with a finger in the arrow direction, pull the connector to separate it. After separation, the retainer will remain attached to the pipe.
2. Connecting – Make a visual inspection of the line and the fittings where the line attaches. Check the connecting portion of the pipe for damage to the sealing surface. Clean any foreign particles on the pieces.
3. Align the pipe and the connector; insert the end of the pipe into the connector until an audible click is heard.
4. Confirm connection by pulling the connector backward. Also check that the two parts of the retainer are engaged to the connector.
5. The external clip is the only necessary replacement part if it is damaged.

Subaru B9 Tribeca Fuel System



(1) #1 fuel injector
(2) #2 fuel injector
(3) #3 fuel injector
(4) #4 fuel injector
(5) #5 fuel injector
(6) #6 fuel injector
(7) Fuel pump & Pressure regulator
(8) Fuel pump control unit
(9) ECM
(10) Fuel pulsation dampener

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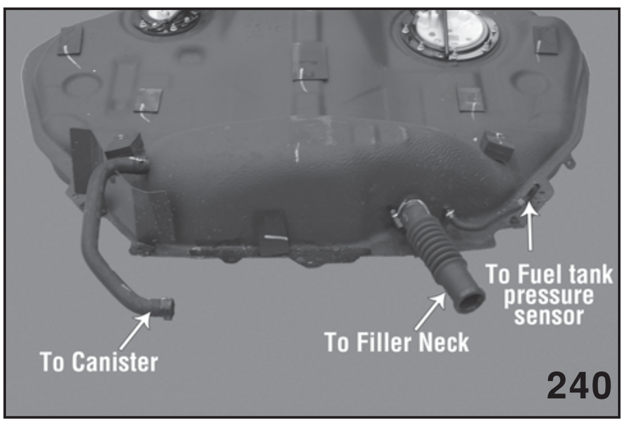
Fuel Routing System (Artwork)

Evaporative System

Fuel Tank

The Evaporative System of the Subaru B9 Tribeca consists of the canister, drain valve, fuel tank vent valve, FCV sub and FCV main with orifice which are built into the tank.



Fuel Tank Hoses

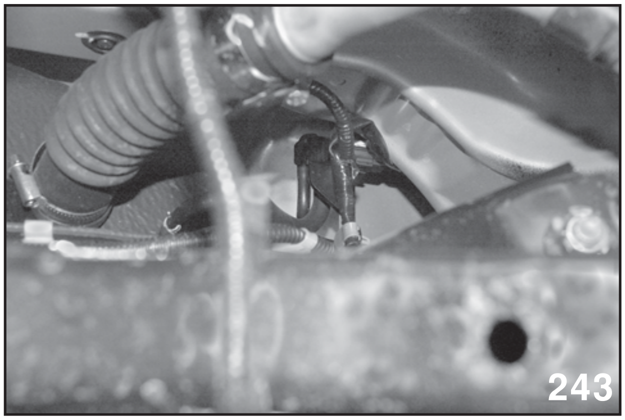
Sub Pump

Main Pump

During tank refilling the tank pressure increases and is routed to the canister through the vent valve and sub and main FCVs. The multi chambered canister absorbs the fuel vapors and routes the air from the tank to atmosphere through the drain valve. As the liquid in the tank rises the vent valve and sub FCV are closed, leaving only the main FCV open. The FCV incorporates an orifice that is used to throttle the tank evaporation and is not large enough to vent the tank during refilling. At this point the pressure in the tank will begin to increase and turn off the refilling gun.

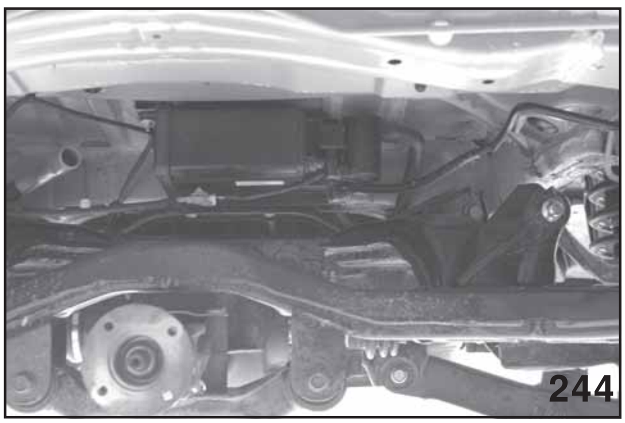
The drain valve will be closed by the ECM when evaporative system integrity is being checked.

The fuel tank is constructed with an enlarged chamber that serves as an expansion tank and a mounting surface for the FCVs. All components of the FCVs are located inside the tank and are not serviceable.



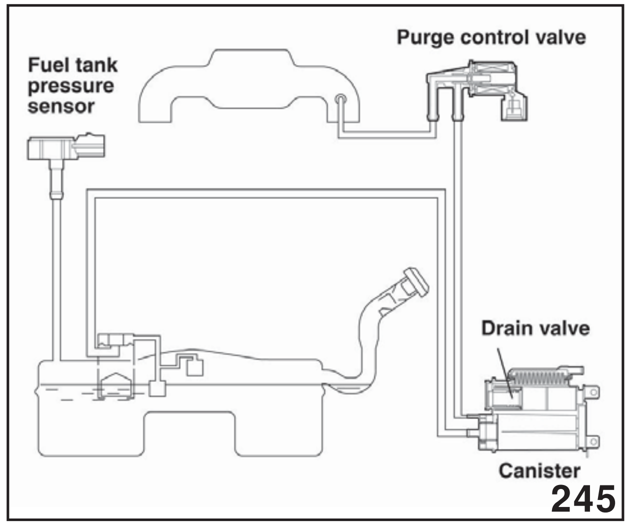
Pressure Sensor

The pressure sensor can be accessed from the right rear of the fuel tank and does not require tank removal. (Note: The pressure sensor should be removed from the tank before removing the fuel tank from the vehicle.)

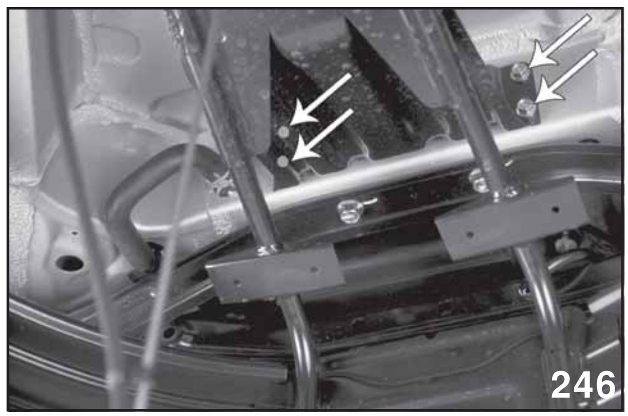


Canister

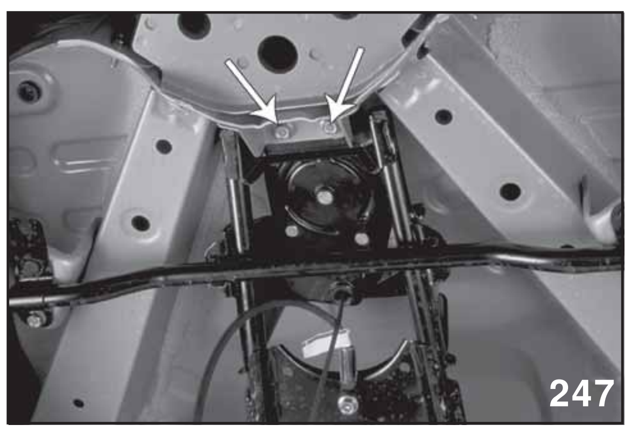
The canister is located above the rear suspension and behind the fuel tank.



Evaporative System (Artwork)



Four (4) Forward Mounting Bolts



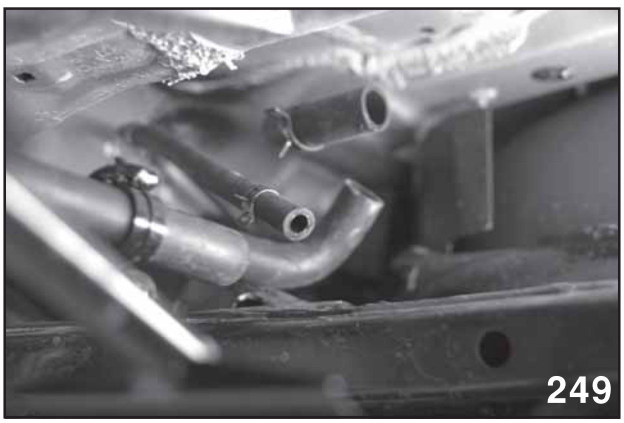
Two Rear Bolts

Canister removal is achieved by removing the spare tire and removing the four forward mounting bolts of the spare tire compartment and the two rear bolts of the spare tire compartment.

248

Lowered Spare Tire Well

Lower the spare tire compartment by the amount pictured.



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Three (3) Hoses

Remove the three hoses and electrical connector from the drain valve.

Next lower the rear suspension slightly and the canister can be removed.

* The suspension must be supported while it is not torqued to the vehicle.

250

Canister Body (Side View)

The canister is secured to the vehicle with three nuts. The canister itself is built with rubber inlays inside the mounting holes that assist with canister installation.

251

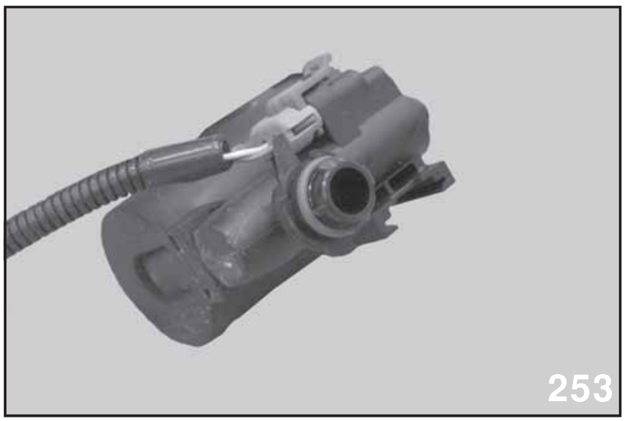
Canister (Bottom View)

The inlays hold the canister in place while the mounting nuts acre being installed.

The drain valve can be removed by releasing the upper latch and twisting the drain valve counter clockwise.

252

Canister (End View)



253

Drain Valve Separated from Canister

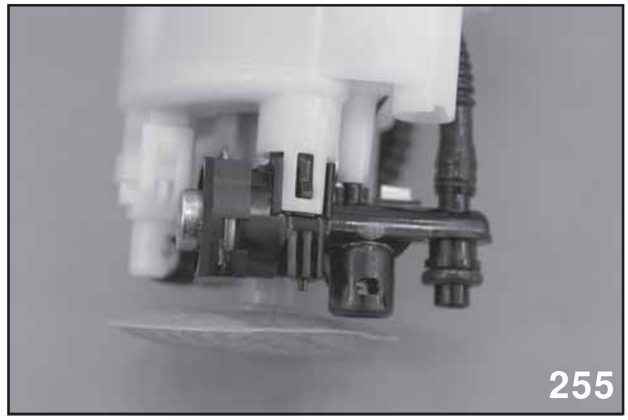
(NOT SERVICEABLE)

The drain valve connection on the canister is designed to lock with the shape made onto the drain valve input to the canister.

254

Fuel Pump

The fuel system of the Subaru B9 Tribeca is designed with a return less fuel delivery system.



255

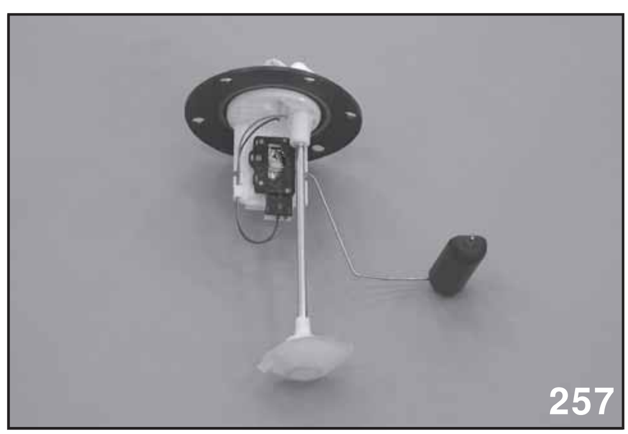
Fuel Pressure Regulator

The fuel pressure regulator is located on the fuel pump assembly and eliminates the fuel return hose from the engine compartment to the fuel tank as used on other Subaru models.

256

Fuel Filter

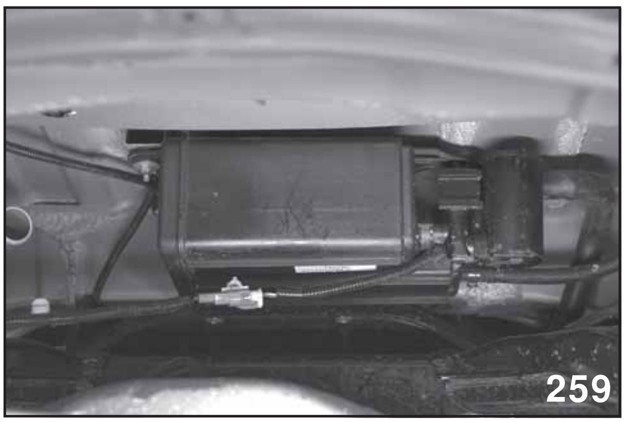
The fuel filter is incorporated into the fuel pump and is not serviceable.



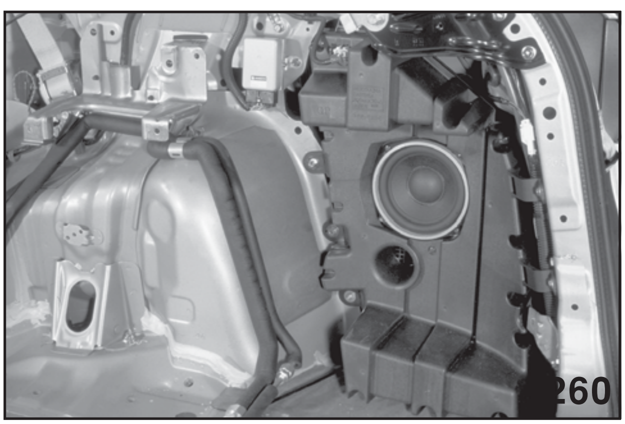
257

Sub Pump

Main Pump and Sending Unit



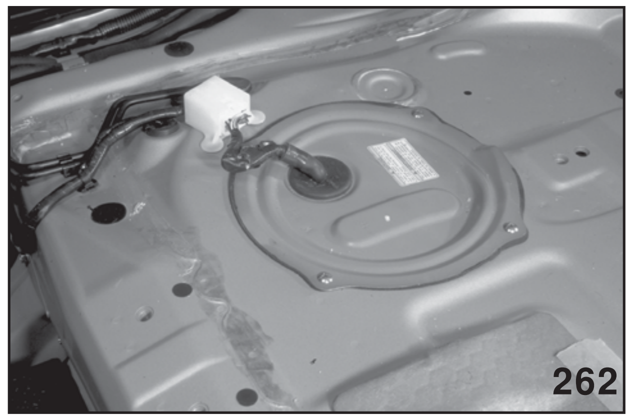
Canister



Fuel Pump Controller

The fuel pump is controlled with a controller that is mounted to the right rear of the vehicle behind the interior trim.

Sub Pump Access



Main Pump Access

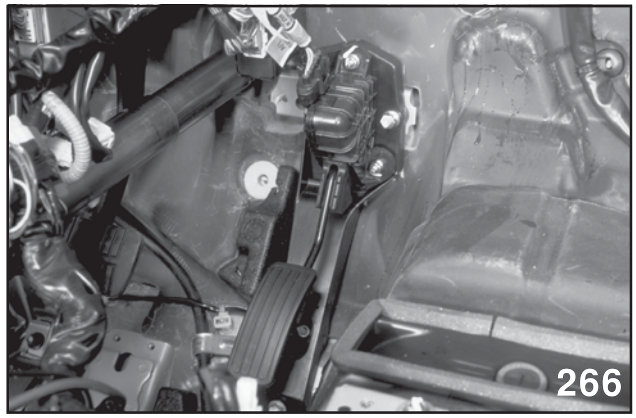
Tank Removed, Sup Pump Access

Tank Removed, Main Pump Access

The fuel pump and sub pump are accessible from under the second row seat.

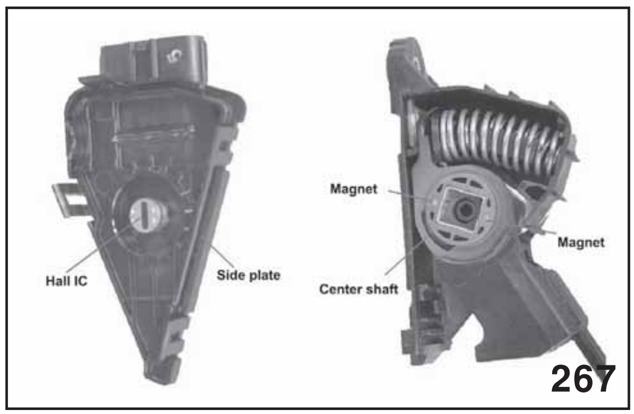
NOTE: ALWAYS SET THE FUEL LEVEL TO APRX. ½ FULL BEFORE REMOVING THE FUEL PUMP.

Accelerator Sensor



Accelerator Pedal Sensor Apart

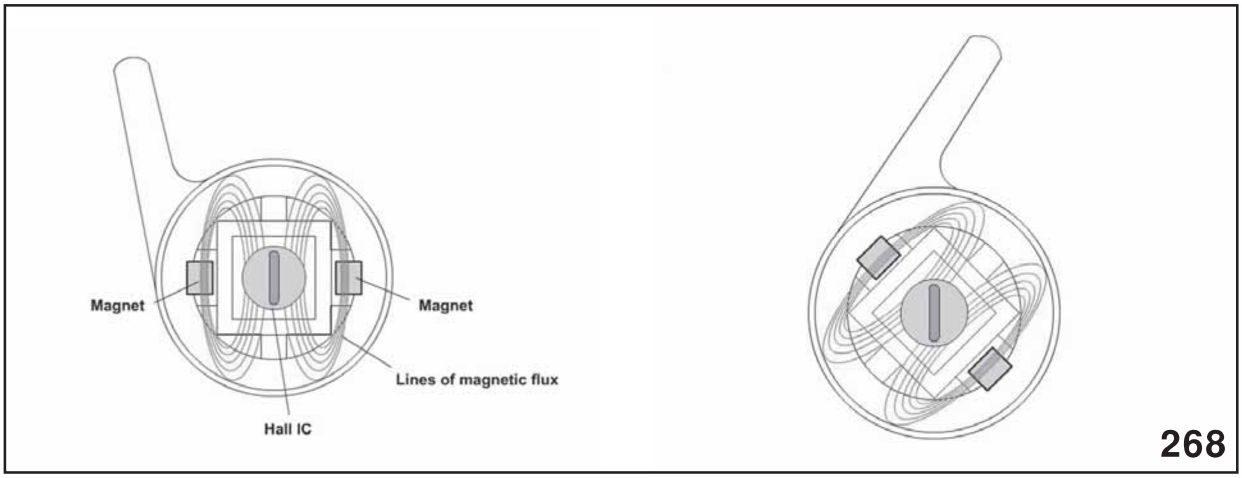
The Accelerator Sensor has changed to a Hall type sensor to enhance the input of the accelerator pedal to the ECM.



Accelerator Pedal Sensor Apart

The Accelerator Pedal Sensor consist of two magnets integrated into a center shaft and a Hall IC (with sensor element) placed on the side plate.

* *The pedal position sensor is not serviceable and must be replaced as a unit.*



Sensor (Artwork)

When the accelerator pedal is operated, two magnets rotate around the Hall IC. The Hall IC has the property of changing its output voltage according to changes in the number of magnetic flux line that pass through the hall sensor element. Therefore, the sensor output voltage changes according to the position of the accelerator pedal.

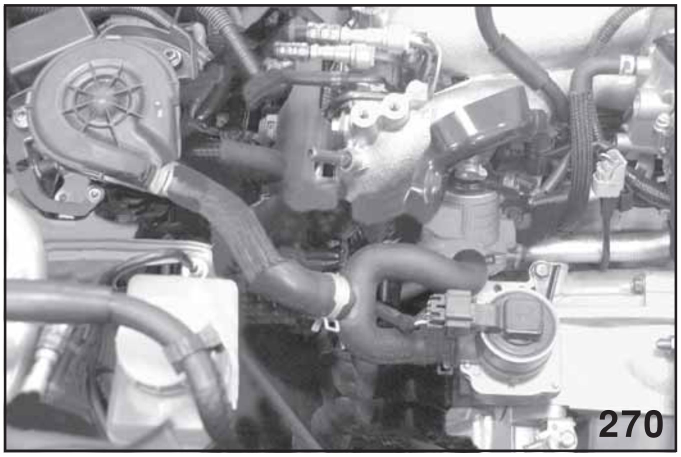
Additional information

The case of the ECM is plastic.

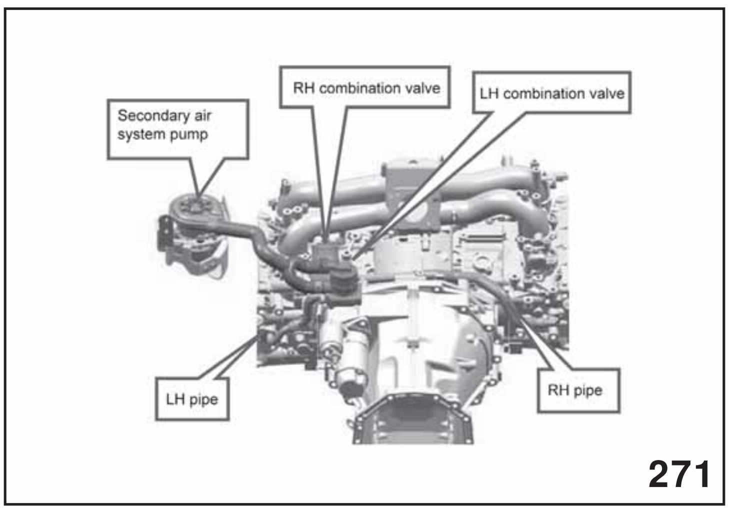
The knock sensor is a two wire type, receiving a ground from the ECM.

Secondary Air Injection System-2006

2.5L Turbo Engine



Secondary Air System Pump in car



Model of Secondary Air Injection System

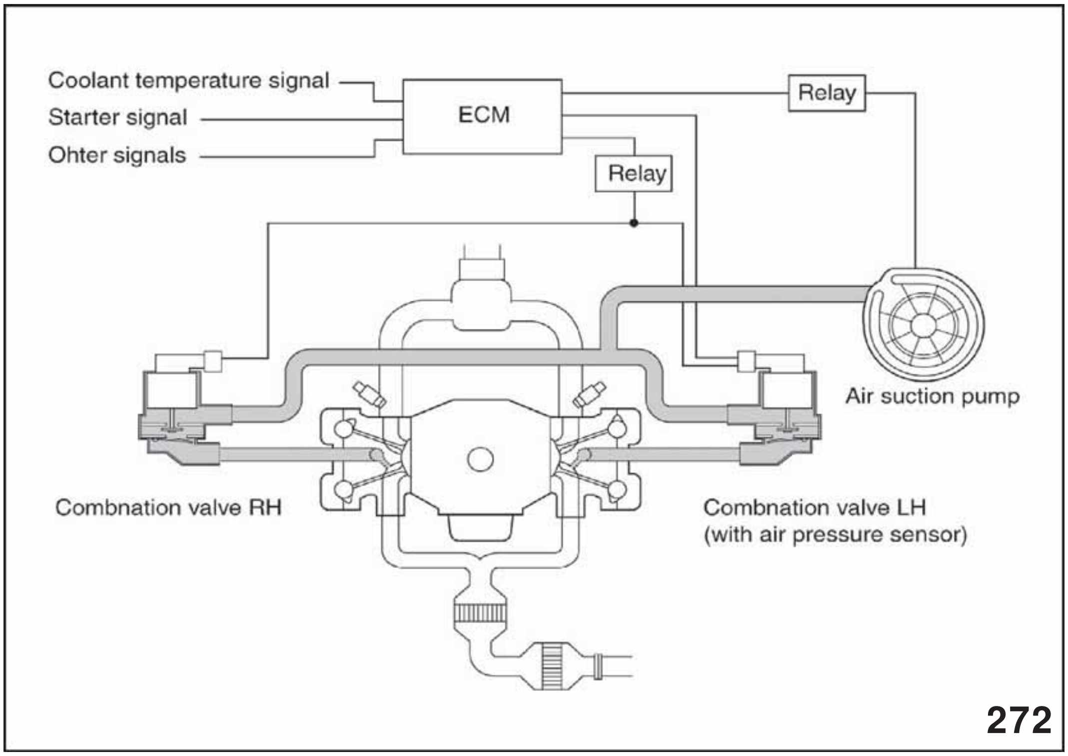
Turbo engines except the STi are equipped with a secondary air injection system, beginning with the 2006 Model Year.

The Secondary Air Injection System reduces harmful exhaust emissions by introducing a supply of fresh air into the exhaust before it reaches the catalytic converter. The fresh air mixing with the hot exhaust causes the unburned emissions to burn and brings the catalytic converter to operating temperature must faster.

The fresh air enters the exhaust from behind a fresh air port located behind each exhaust valve. An electric Secondary Air Pump provides the force necessary to supply the quantity of air needed for mixing with the exhaust. The air from the secondary air pump is divided between the left and right side of the engine. The fresh air is admitted into the exhaust by the action of a reed valve contained in the left and right side combination valves. A metal pipe carries the fresh air to each cylinder head. The pipe must be disconnected from the cylinder head before head removal.

Secondary Air Pump

The Secondary Air Pump compresses the fresh air which enters the pump from the bottom side through a non-serviceable air filter. The performance of the pump is monitored by a pressure sensor located in the top of the left hand combination valve. This check also monitors the performance of the solenoid valves and their ability to close off the passage to the reed valves.

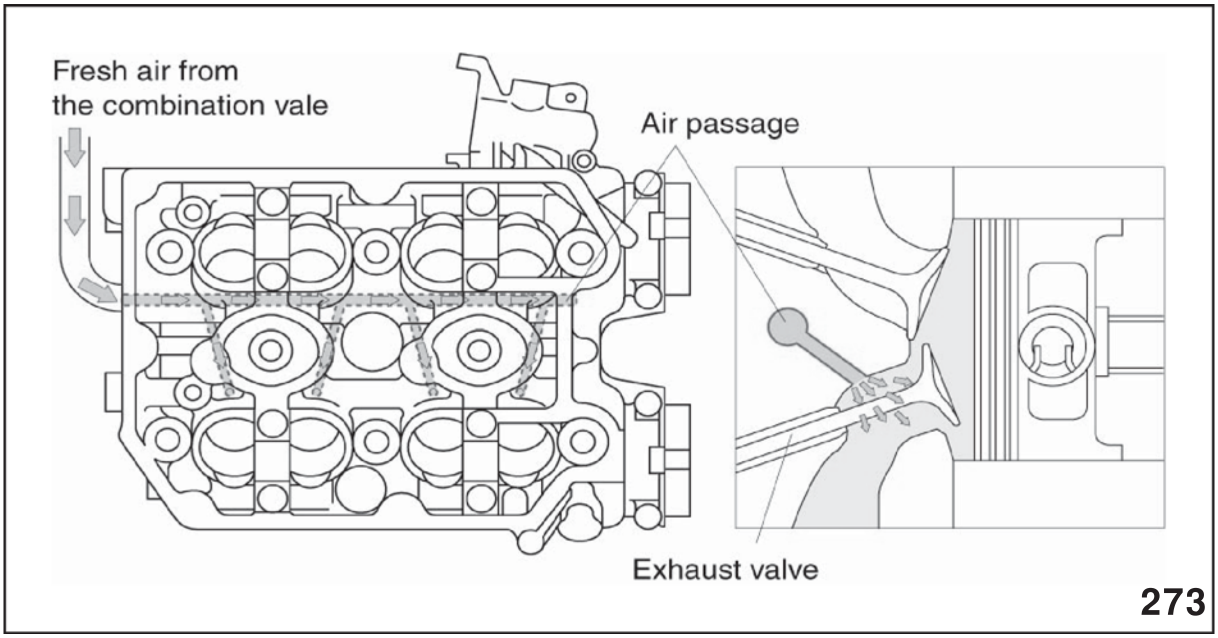


Combination Valve layout

Combination Valve

The Combination valve is composed of a solenoid, air valve and reed valve. The solenoid operates the air valve which allows fresh air from the secondary air pump to flow to the back side of the reed valve. The exhaust pulses of each cylinder control the reed valve. As the exhaust stroke begins the pressure of the exhaust closes the reed valve. As the exhaust pressure reduces, the reed valve opens, as the fresh air pressure is now higher than the exhaust pressure. Fresh air enters the exhaust stream and the ignition of unburned exhaust emissions begins. The reed valve will remain open until the exhaust pressure increases.

Cylinder Head



Air Passage Inside Cylinder Head

Air passages are machined inside the cylinder head as shown below. The air compressed from the combination valve is emitted to the backside of the exhaust valve through the air passages.

Control of ECM

ECM measures engine coolant temperature, starting condition from the starter signal and other signals, and activates air suction pump and combination valve according to the engine coolant temperature.

The ECM will activate the combination valve relays and the pump relay when the engine coolant temperature is below 150 degrees F (70 degrees C)

The system will operate for 90 seconds (varies according to the coolant temperature)

Slide Sequence

Slide Sequence

Slide Sequence

Slide Sequence

Slide Sequence

Tools and Equipment

Special Tools

Tool Number	Description
ST42099AE000	Special Quick Connect Tool
Universal tool OTC 7660	
42099AE000	Fuel Line Tool

State I/M Program Advisories Bulletins

No.	Date	Title	Subject
11-50-97	12/05/97	All Subaru Full-Time AWD Models	State Emission Testing
11-51-97	12/05/97	All Subaru Full-Time AWD Models	Diagnostic Service Cautions
11-52-98	05/22/98	All 1999 Model Subaru AWD Models	State Emission Testing
11-49-97R	09/02/98	1996 MY Legacy, Impreza & SVX	OBD Check During State I/M Program
11-53-98	01/05/99	97-98 Legacy, Impreza and Forester Manual Transmission vehicles with 2.5L & 2.2L engines	Hesitation On Acceleration
11-54-99	03/01/99	All 1996-1999MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-55-99	03/17/99	All 1996-2000MY	On-Board Diagnostic System Check During State Emission Test
11-56-99	09/08/99	All 2000MY	State Emission Testing
11-57-99	09/29/99	All 2000MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-59-00	02/25/00	1999 Legacy, Impreza, Forester	Air Intake Chamber Box Breakage
11-61-00	06/01/00	All Subaru Vehicles	State Emission Test / Fuel Filter or Gas Cap Test
11-62-00	05/08/00	All 2001 Models Subaru Vehicles	On-Board Diagnostic System Check During State Emission Test
11-63-00	11/01/00	1980-1989 MY Subaru Vehicles	Pressure Testing of Fuel Tank system During State Emission Test
11-64-01	02/01/01	All 1996-1999 Legacy Postal Vehicles	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-65-01	02/01/01	All 2002 Model Subaru AWD Vehicles	On-Board Diagnostic System Check During State Emission Test
11-66-01	02/01/01	All 2002 Model Subaru AWD Vehicles	State Emission Testing
11-68-02	03/05/02	All 1996 and Newer Models	On-Board Diagnostic System Check During State Emission Test
11-69-02	11/01/02	All 2003 Models	On-Board Diagnostic System Check During State Emission Test
11-70-02	11/01/02	All 2003 Models	State Emission Testing
11-71-03	09/22/03	All 2004MY Vehicles	State Emission Testing OBD II System Check

Service Bulletins

No.	Date	Title	Subject
09-23-86	10/09/86	Exhaust System Noise Diagnosis	All 1985 and 1986 vehicles except Hatchback and Brat Models
09-24-87	06/25/87	Front Exhaust Pipe (EPF) and Under Cover Complete Modifications	All 1983 and 1984 Turbocharged vehicles
09-25-88	12/27/88	Exhaust "Y" Pipe Identification, Noise Diagnosis, and rebuild Procedure	1985 and 1986 L and XT series Non-Turbo vehicles
09-26-91	01/09/91	Non-Turbo Single Wall "Y" Pipe Cover Sets (EPF)	"L" series and Non-Turbo Loyale
09-27-90	12/10/90	Catalytic Converter Recycling	All catalyst equipped exhaust pipes
09-28-91	04/30/91	Modified Exhaust Cover Sets	"L" series and Non-Turbo Loyales
09-29-91	05/09/91	Exhaust Pipe Joint Rattle	1987 through 1991 Justy vehicles with flex joint style exhaust pipe
09-30-91	11/08/91	Knocking Noise from the Exhaust Flex Joint	Loyale
09-31-93	01/12/93	Fuel-Cut Control Unit	89MY to 93MY L-Series/Loyale
09-32-93	02/05/93	Exhaust Pipe "EPR" Whistling Noise	All Legacy Models, including Turbo
09-33-95	11/09/95	Fuel Injector Removal	All Legacy, Impreza and SVX Vehicles
09-34-96	09/13/96	Fuel Injector Replacement	Legacy, Impreza and SVX with EGR
09-35-02	01/07/02	2000MY Legacy Vehicles	New Spare Part for Variable Capacity Muffler
09-36-03	04/01/03	2002MY Impreza WRX	Fuel Smell in Cold Weather
09-37-03	07/15/03	2002~2003MY Impreza WRX	New WRX Radiator
09-38-03	02/06/04	200~2004MY Legacy H-4 and H-6 Equipped Vehicles	Fuel Pump Assembly Division of Parts
09-39-04	05/07/04	2005MY Legacy & Outback Vehicles	Engine Coolant System Refilling

Tech TIPS

Date	Subject
03/95	Legacy and Impreza engines with no injection pulse #1 cylinder
03/95	Impreza air suction valve noise
04/95	2.2 Impreza AWD fuel senders
05/95	Reformulated gasoline's
06/95	1995 Subaru Legacy DTC P0505 - Idle control system malfunction
06/95	1995 Subaru Legacy DTC P0325 - Knock sensor circuit malfunction
06/95	1995 Subaru Legacy DTC P0130 - Front 02 sensor circuit malfunction
07/95	Loyale water pump Leaks
07/95	Rough idle on MPFI vehicles
07/95	94 Impreza ROM sockets
09/95	DTC P0505 idle control system when solenoid measures 5W or less
12/95	Extreme cold weather engine warm up and OBD ll
07/96	Loose fuel caps and trouble code P0440
09/96	1997 Legacy warranty claims for loose fuel caps
09/96	Legacy (Non Turbo), SVX, and Impreza ISC valves
10/96	Modified fuel injectors
11/96	P0440 and Legacy fuel caps
11/96	Blue vs. Gray connectors during diagnosis
11/96	Extreme cold weather engine warm-up and OBDll
03/97	DTC P1500 radiator fan relay one circuit
03/97	1997 Subaru Impreza Outback Sport
04/97	Understanding P0440
05/97	DTC P0507-Idle control system RPM higher than expected
07/97	Code P0500
07/97	Additional information regarding code P0440
08/97	OBD ll cylinder misfire codes
09/97	Cooling fan operation
10/97	More P0440 information
01/98	Exhaust smell during cold start
01/98 & 05/98	Model Year 1998 changes in P0440 Evap operation
05/98	DTC P0440 Revisited
11/98	P0440 TIP
11/98	DTC P1507
03/99	1999 Legacy excessive crank time
03/99	Vehicle won't take fuel
05/99	DTC P0705 diagnostics
08/99	Freeze frame data

Tech TIPS

Date	Subject
09/99	Evaporative system diagnosis
09/99	Vehicles that won't take fuel
10/99	Fuel system quick connector
11/99	OBD readiness codes
11/99	P0440 1998/1999 Forester
01/00	Don't touch that screw
05/00	Sulfur smell from the exhaust
11/00	WXV-79 engine control module service program
11/00	Use of genuine air cleaner element
01-02/02	H6 Extended crank time
09-10/02	Forester fuel line noise
08/03	WRX STi Driveability
09/03	2004MY Legacy fuel filter replacement
11/03	H6 Driveability
12/04	Fuel Line Tool
03/05	Gas Mileage
04/06	Subaru B9 Tribeca Fuel Line Tool
06/05	Fuel Hose Retainer Clips

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Technicians Reference Booklet

Heating , Ventilation and Air Conditioning (HVAC)

Module 603

AUTOMOTIVE Youth Educational Systems

September 2005

MSA5P0137C

Technical Training

Table of Contents

Introduction

This Technician's Reference Booklet, reviews the Basic Theory and Operating Characteristics of Subaru Heating, Ventilation, and Air Conditioning Systems. The text and illustrations are derived from and follow the classroom lectures and PowerPoint presentations. They are intended to supplement and reinforce classroom instruction, and serve as a home-study reference source.

NOTE: ALWAYS REFER TO THE APPROPRIATE MODEL YEAR SUBARU SERVICE MANUAL AND THE APPLICABLE SERVICE BULLETINS FOR ALL SPECIFICATIONS AND DETAILED SERVICING PROCEDURES.

Pages for Diagnostic Tips and Notes are also provided. Technician worksheets are to be completed during the hands-on lab work segments of the HVAC Module.

General Overview

A/C Label

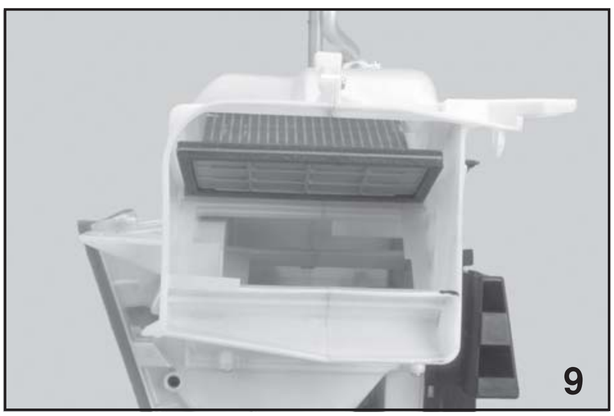
It is very important to first identify the refrigerant type and the manufacturer of the HVAC System. This information, along with refrigerant charge level, lubricating oil type and quantity, can be found on the A/C System Identification Label. The Label is located inside the engine compartment. The information can also be found within the Service Manual.

CAUTION: IT IS VITAL THAT ONLY THE CORRECT COMPONENT FOR THE SYSTEM TYPE BE USED OR SYSTEM PERFORMANCE COULD BE AFFECTED.

Heating

Heater Core

The heat source comes from the heated coolant that is routed through the Heat Exchanger or Heater Core. There is no coolant shut-off valve, so once the engine coolant has reached optimum operating temperature, there is a constant supply of heat available when needed. The air that is forced through the Heater Core by the Blower Motor absorbs the heat provided by the engine coolant.

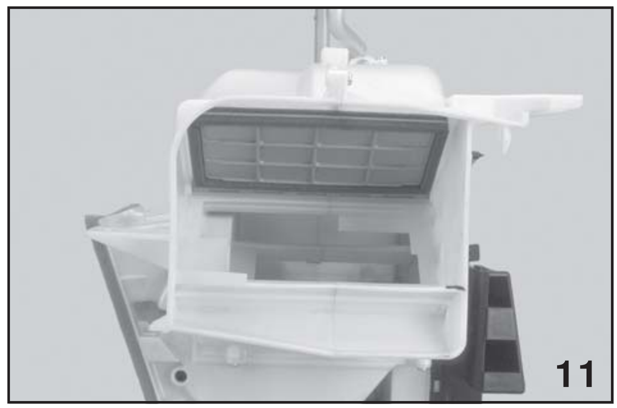


Heater Chamber

This heat is isolated within the Heater Chamber by a door or a series of doors.

Heater Door open

When the heat is not needed, it is very important that the heat source is completely isolated from the airflow, or a Poor A/C Performance complaint might occur.



Heater Door closed

EXAMPLE: AIR-MIX DOORS ARE NOT CLOSING PROPERLY DUE TO INCORRECT ADJUSTMENT OR DAMAGED FOAM SURROUNDING THE DOOR.

NOTE: IF A/C SYSTEM OPERATING PRESSURES ARE WITHIN SPECIFICATIONS AND THE VENT TEMPERATURE IS TOO HIGH, MAKE SURE YOU CHECK TO SEE IF THE HEAT IS ISOLATED WITHIN THE HEATER CHAMBER AND NO HEATED AIR IS MIXING WITH THE AIR EXITING THE EVAPORATOR CORE.

Seat Heaters

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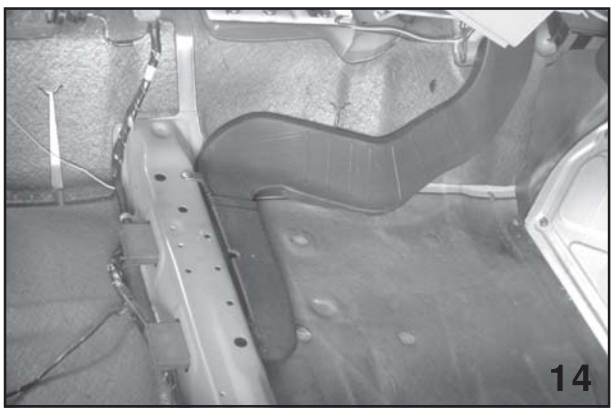
Front Seat Heater

Some later model vehicles offer seat heaters for the driver and front passenger. The seat heaters have internal heating elements with thermostats to control heating.



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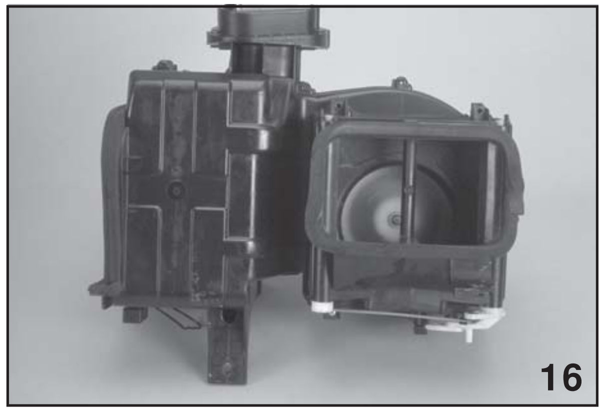
Ducts under Front Seat

Certain model year vehicles have heater ducts routed below the front seats, to offer heating for the passengers seated in the rear seats.

Ventilation

The ventilation system consists of modules that include the blower motor assembly, the evaporator assembly and the heater assembly



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Blower Motor Assembly

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Evaporator Assembly

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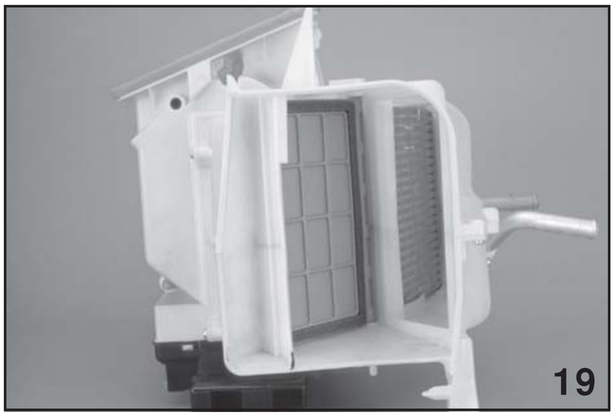
Heater Core



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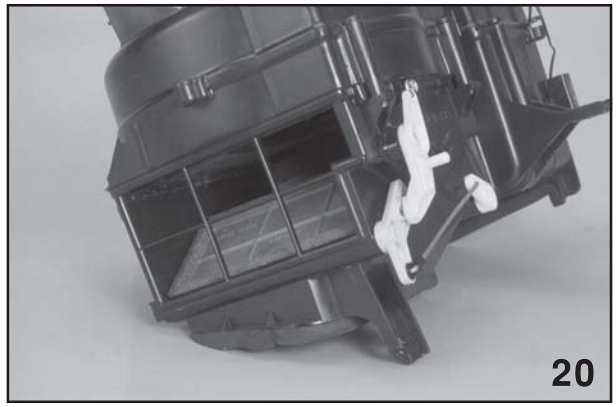
Heater Core installed

NOTE: IF THE VEHICLE IS NOT EQUIPPED WITH AIR CONDITIONING; A TRANSITION DUCT INCLUDING THE BLOWER RESISTOR IS USED TO CARRY THE AIR FROM THE BLOWER MODULE TO THE HEATER MODULE.



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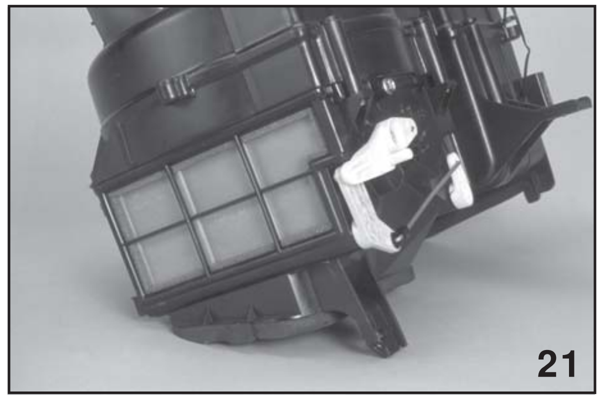
Air Source - Recirculate



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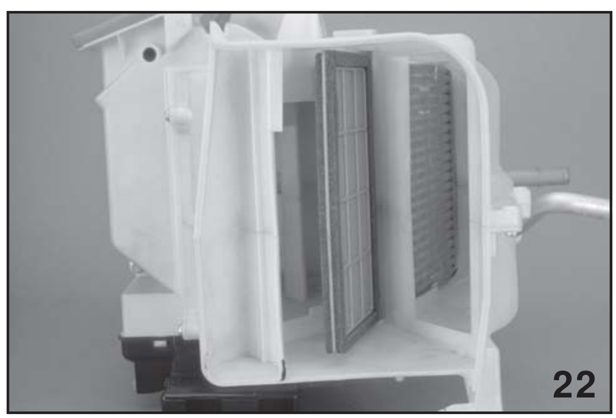
Air Source - Fresh

A door or a series of doors are moved by either a cable or an Actuator Motor to control the air source, the air blend or air-mix doors, and the air direction or mode doors.



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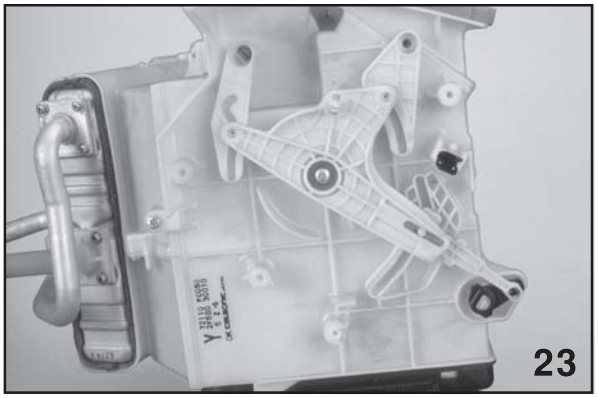
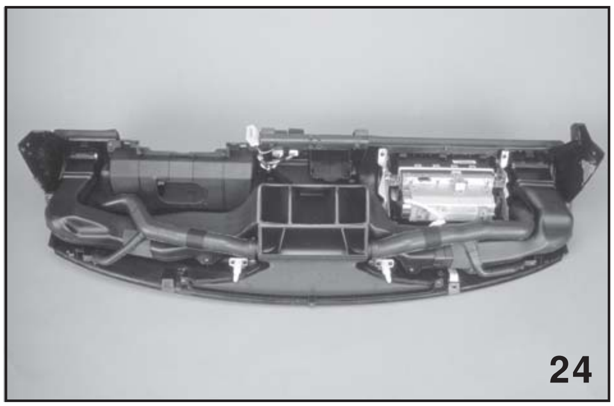
Air Blend or Air - Mix doors



Mode doors



Air Ducts

Air ducts are utilized to direct the airflow from the modules to the outlet vents.

Air Vents

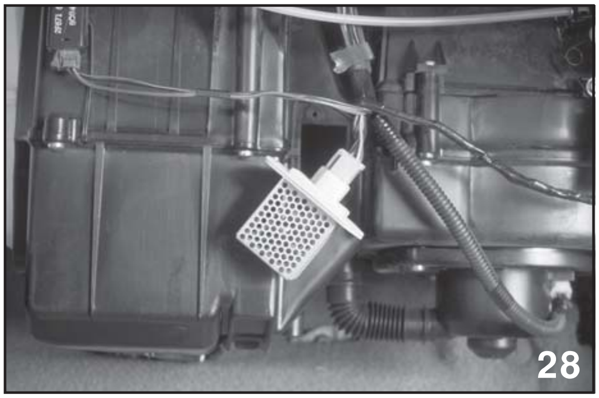
The outlet vents are louvered to direct the airflow as it exits the air ducts. Some model vehicles have outlet vents that can be shut off to stop airflow through the vent.

Blower Motor

The Blower Motor supplies the airflow.

Manual Controls

The Fan Control located on the dash, controls the blower motor speeds.



Resistor Block

A resistor block consisting of three internal resistors is used to control the blower circuit voltage on Manual Systems. For low speed, the negative signal from the control panel passes through three resistors within the resistor block, which lowers the circuit operating voltage. For fan speed number two, the signal is routed through two resistors, offering less resistance and more voltage. For number three-fan speed, the negative signal from the control panel is routed through only one resistor, the voltage supply to the blower circuit is increased, and the fan speed increases. For high fan speed there is no added restriction in the circuit. Due to the high heat that develops as the signal passes through the resistors, a fusible solder is used to protect against the heat. The solder will melt and open the circuit within the resistor block, if the heat is too high.

With Automatic and Semi-Automatic Climate Control Systems, the blower motor circuit signal is routed through a Power Transistor that restricts the circuit in all but high speed. The signal from the control panel is sent to the Automatic Climate Control Module. The signal is processed, and an output signal is sent to the Power Transistor. The base voltage of the Power Transistor changes due to the signal from the Control Module, thereby changing the blower speeds.

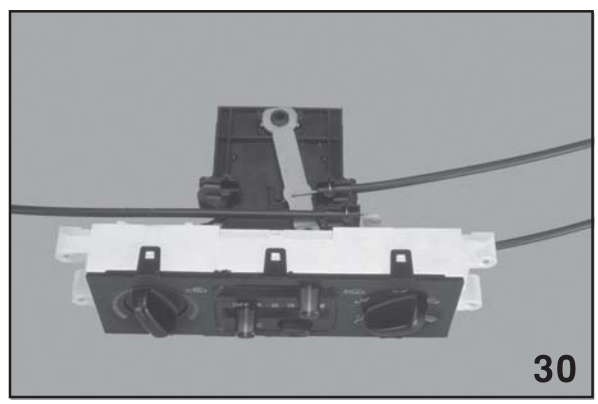
NOTE: BOTH THE RESISTOR BLOCK AND THE POWER TRANSISTOR, CREATE HIGH HEAT DURING OPERATION. A HEAT SINK IS BUILT INTO THE COMPONENT TO ABSORB AND HOLD THE HEAT. THE AIR- FLOW, CREATED BY THE BLOWER FAN, HELPS TO DISSIPATE THE HEAT AS IT PASSES ACROSS THE HEAT SINK. DO NOT OPERATE THE BLOWER MOTOR WITH EITHER COMPONENT REMOVED FROM THE AIR STREAM OR DAMAGE TO THE COMPONENT WILL OCCUR.

Air Conditioning

General Overview

All Subaru Air Conditioning systems are cycling systems. A cycling system prohibits an evaporator freeze condition by cycling the air compressor off when the air off evaporator temperature approaches 32° F. The advantage of a cycling system is a rapid cool down time.

Manual System



Manual Controls

The operator controls the air mode, air blend, air source, air speed, and compressor engagement, by manually setting the controls at the Control Panel. Later models will automatically engage the compressor when the Defrost and Defrost/Heat modes are selected, as well as directing the air source to fresh.

Automatic and Semi-Automatic Climate Control Systems

Auto Control Panel

The operator chooses the temperature setting on an Automatic and Semi Automatic Climate Control System, a series of sensors then send input signals to a Control Module. The Automatic Climate Control Module will then process the signals and send output signals to the Actuators, Blower Motor, and the Engine Control Module. This will control the air mode, air blend, air source, air speed, and compressor engagement. Automatic or Semi Automatic Climate Control Systems can also be operated in a manual mode if the operator so chooses.

Automatic and Semi-Automatic Climate Control Systems also have a self-diagnostic function or "D" Check Mode. This self-diagnostic function will check the sensor circuits, operate the compressor, operate the blower motor, and will also check Actuator operation.

Please consult the appropriate service manual for self-diagnostic mode application.

Control Panel

HVAC Display Panel

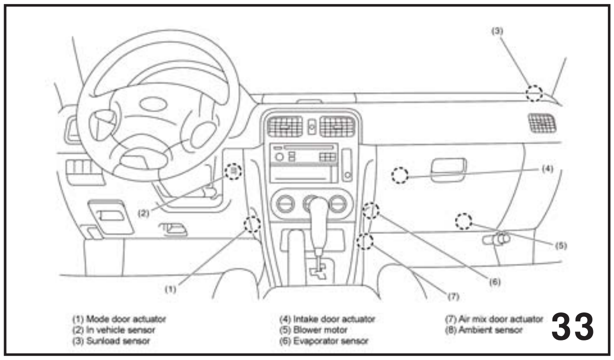
The HVAC Control panel gives the user the opportunity to select temperature output, compressor engagement, air direction and air source. In later model systems, the air compressor will become engaged and the air source moved to fresh, anytime the air direction is in the "Defrost or Defrost/Heat" mode. There is also a delay built into the controls for compressor engagement.

A Zoned Air Control Panel was introduced in limited 2005 Model Year vehicles. This gives the Passenger their own temperature control.

To avoid a "musty" type of smell upon start up, it is recommended to move the air source to Fresh before shutting down the system. This gives the Evaporator Assembly the opportunity to "breath".

Please consult the appropriate Service Manual and/or User's guide for detailed data regarding Control Panel operation.

Sensors



Sensor / Actuator Location

Sensors provide input to the Automatic and Semi Automatic Climate Control Module. The Control Module processes the signals and then sends output signals to the Actuators, Blower Motor, and Engine Control Module (ECM). The Climate Control's Self-Diagnostic Mode will check the Sensor Circuits for an "Open" or "Shorted" condition. The self-diagnostic function will not check for an incorrect sensor signal. If the Sensor is sending an incorrect signal to the Control Module, system performance problems could develop.

Example: If the Cabin Sensor sends a signal that the Control Module interprets as 68 degrees, but the actual cabin temperature is 98 degrees, a poor performance complaint might be reported. Since the sensor input signal to the Control Module directly affects the Control Module output signal. Please consult the appropriate service manual for diagnosing a sensor whose signal is suspect.

Cabin Sensor

Aspirator Intake

The Cabin, or In-Vehicle Sensor, uses an Aspirator Tube to draw cabin air to the sensor. The air stream from the blower motor exiting the center vent outlet acts as a vacuum to draw the air into the aspirator tube. The sensor detects the cabin air temperature as it passes and converts the temperature to a signal that is then input to the Control Module where it is processed. The higher the temperature, the lower the resistance value in the circuit, therefore the higher the voltage signal. Always make sure that the aspirator tube is correctly positioned when servicing the control unit or other dash components.

Ambient Sensor

The Ambient Sensor measures the temperature of the ambient, or outside air, which is input to the Control Module. Due to its construction, the ambient sensor can only measure an average outside temperature and does not respond to sharp temperature changes quickly.

NOTE: REVIEW SERVICE BULLETIN

Number 10-75-04 Date: 09/24/04
15-112-04

APPLICABILITY: 2005MY LEGACY & OUTBACK VEHICLES

SUBJECT: AUDIO AND AUDIO/HVAC DIAGNOSTIC FACEPLATE

Sun Load Sensor

A photosensitive diode is used in the construction of the Sun Load Sensor. The sensor detects changes in the sun's intensity and converts it into a small current, which is then input to the Control Module. This sensor will effect the target location of the air blend actuator.

NOTE: A HIGH INTENSITY INCANDESCENT SHOP LIGHT MUST BE USED WHEN TESTING THE SUN-LOAD SENSOR OR AN "OPEN" CIRCUIT COULD EXIST WHILE CHECKING THE SYSTEM IN THE SELF-DIAGNOSTIC MODE.

Evaporator Sensor

Evaporator Sensor

This sensor is located at the air outlet side of the Evaporator Core. It is positioned on the evaporator core at a location that develops the coldest air off evaporator temperatures. This sensor inputs a value to the ECM, which changes with temperature. If the temperature approaches the freezing level, the ECM will cut the output signal to the Compressor Clutch Circuit.

NOTE: CONSULT THE SERVICE MANUAL FOR THE "CYCLE OFF" TEMPERATURE SETTING OF THE SENSOR.

Refrigerant Temperature Sensor

This sensor is only found on the SVX Automatic Climate Control system. This sensor is installed on the inlet side of the evaporator piping. The refrigerant Temperature sensor inputs a value to the ECM, which changes with temperature.

Coolant Temperature Sensor

This sensor is only found on the SVX and early Legacy Automatic Climate Control systems. It detects the coolant temperature at the heater core then inputs it to the Control Module.

Control Module

Control Module

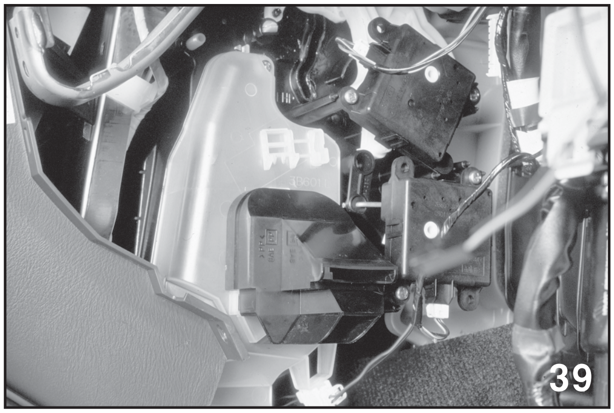
The Automatic and Semi-Automatic Climate Control Module is a microprocessor that receives input from the Controls, Sensors, and Actuators, processes the information and then delivers output signals to the Actuators, Blower Motor, and the ECM.

For 2005 vehicles with CAN Communications, the control module is part of the Low Speed CAN that communicates with the BIU.

NOTE: CONNECTING THE BATTERY IN REVERSE POLARITY COULD DAMAGE THE AUTOMATIC CLIMATE CONTROL UNIT.

WARNING: A SRS WIRING HARNESS IS ROUTED CLOSE TO THE CONTROL MODULE; TAKE CARE NOT TO DAMAGE THE HARNESS WHEN SERVICING THE MODULE.

Actuators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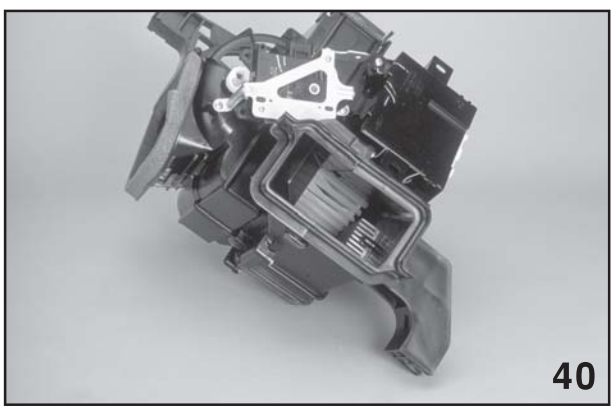
Actuators

Actuators are used to position doors within the HVAC Modules, directing airflow by utilizing bidirectional motors. Actuators are used in Manual, Automatic, and Semi-Automatic Climate Control Systems. Mode and Air Blend Actuators have a signal wire to let the Control Module know the position of the doors.

Air Source Actuator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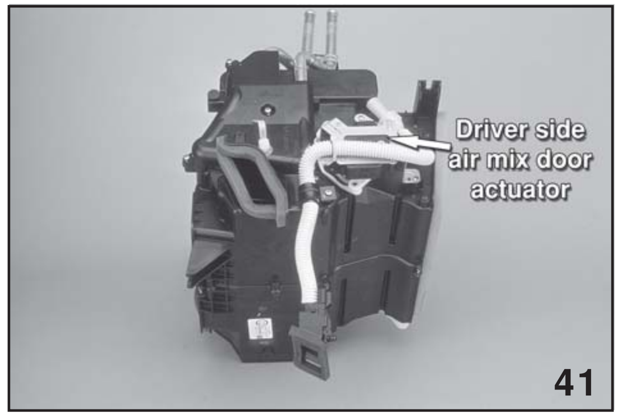
Air Source Actuator

The air source actuator positions a door to introduce either fresh or recirculated air to the HVAC system. The actuator receives its signal from the Control Module on an Automatic System, and from the Control Panel on a Manual and Semi-Automatic System.

On later model vehicles, the actuator will automatically move to the fresh air position when the Defrost and/or Defrost/Heat modes are selected. On early systems, the air source door would only stay in recirculate for a certain time period.

Air Mix Actuator



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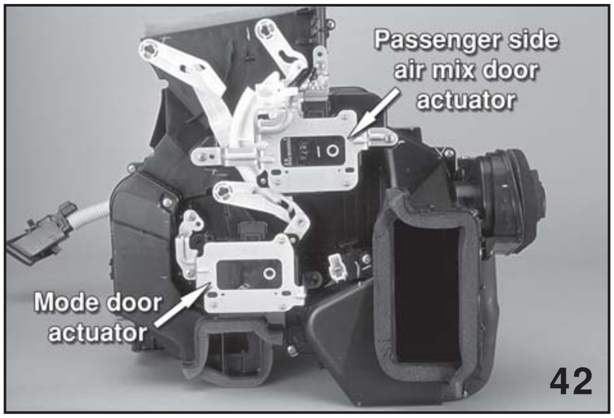
Air Mix Actuator

The air blend or air mix actuator controls the amount of heated air from the heat exchanger introduced to the airflow from the blower motor by moving one or more doors. This actuator is found only on Automatic and Semi-Automatic Climate Control Systems. This actuator provides a signal wire back to the HVAC Control Module indicating its position. For vehicles with Zoned Air, there are two air mix actuators.

Air Mode Actuator



Air Mode Actuator

The air mode actuator controls the direction of the airflow as it enters the cabin area. The actuator is driven to a fixed location by input signals from the Control Module on Automatic Systems and from the Control Panel on Semi-Automatic and Manual systems. The actuator drives a series of doors that are timed with rods and levers to a fixed location depending on the mode setting. This actuator provides a signal back to the HVAC Control Module indicating its position.

The number of modes available change with different model years, please consult the Service Manual or Owner's Operation Guide for mode selections.

System Protection

There have been three devices used for system protection.

A fusible plug:

Equipped on R-12 Systems to protect the system from high refrigerant discharge pressures. The plug was located at the top of the Receiver Drier. Once the pressure / temperature increased to potentially damaging levels, the high temperature would melt the plug and the system charge would then vent to the atmosphere. This is no longer acceptable and is prohibited by law. If this device is left on an R-12 system after retrofitting to R-134a, then problems could develop.

Receiver Drier

A Pressure Switch:

Is used to protect the system from an over or under charged system. If system-operating pressures become too high or too low, problems with lubricating the system as well as damage to components could develop. The system pressure switch can be found on the High or Discharge side of the system. If the pressures are not within specifications, the Compressor Clutch Circuit will be “opened” by the Pressure Switch and the compressor clutch will not engage. The operating parameters of the pressure switch changed considerably when the R-134a systems were introduced. The switches should not be interchanged. Please consult the appropriate service manual for pressure switch operating specifications.

Pressure Switch

Some systems use a pressure switch with a third or medium pressure control. This operates the engine cooling fans at a higher speed when the high side pressure reaches a certain level, and lowers the fan speed when the pressure drops back to a set level. The four-wire connector can identify the triple function pressure switch.

Electronic Thermostat

A Thermo-Amplifier or Electronic Thermostat:

Is used to protect the System from an Evaporator Freeze up condition. There is always moisture in the air. If the temperature is allowed to drop below freezing at the Evaporator, ice can develop restricting the airflow through the evaporator core.

Compressor

Compressor

There have been three types of compressors used since the 1990 model year. The Axial Piston Type, which has pistons located axially around a plate attached to the compressor drive shaft. A Rotary Vane Type, which has vanes located within a rotor assembly fixed to the drive shaft. And new for 2005, a Scroll Type, which has two scrolls, one fixed to the rear plate, and one that is fixed to the Compressor shaft.

Axial Piston Type

There are two types of Axial Piston Compressors found on Subaru vehicles. A Wobble Plate compressor, which is a variable displacement compressor and a Swash plate compressor, which is a fixed displacement compressor. Both Axial Piston Type Compressors will knock if the refrigerant charge is too high or an internal problem develops. The type and amount of lubricating oil is very important. Use the oil with the correct viscosity. Please consult the System Label located within the engine compartment and/or the Service Manual for Oil type and capacity.

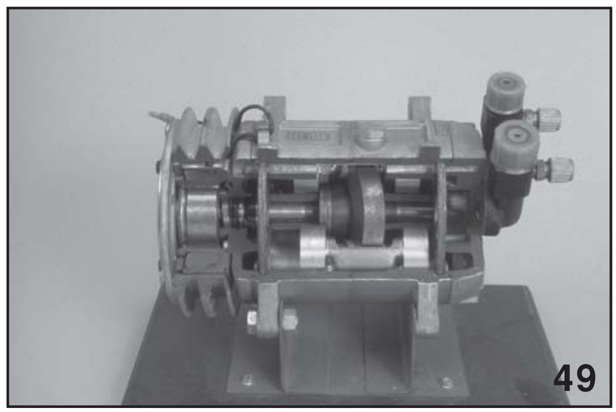
Wobble Plate

Wobble Plate

This compressor is a variable displacement compressor found on early Legacy and all SVX Vehicles. Five pistons are fixed to the front side of a wobble plate attached to the compressor shaft. For the Legacy, the Low Pressure Refrigerant from the Evaporator entering the compressor is monitored. The lower the pressure/temperature, the larger the amount of high-pressure refrigerant supplied to the backside of the wobble plate. The changing of the pressure to the backside of the wobble plate will change the length of the piston stroke, thereby changing the displacement.

The ECM controls the displacement on SVX Compressors, by providing a voltage signal to a valve on the rear of the compressor. The higher the signal, the larger the amount of high-pressure refrigerant supplied to the backside of the wobble plate, limiting its displacement by shortening the piston stroke. The ECM would also control compressor displacement due to engine coolant condition. As the coolant approaches an overheat condition the displacement of the compressor would change from full displacement to 75% displacement, to 50% displacement, to 25% displacement as the coolant continues to overheat. The compressor would then be turned off if the coolant reaches a fully overheated condition.

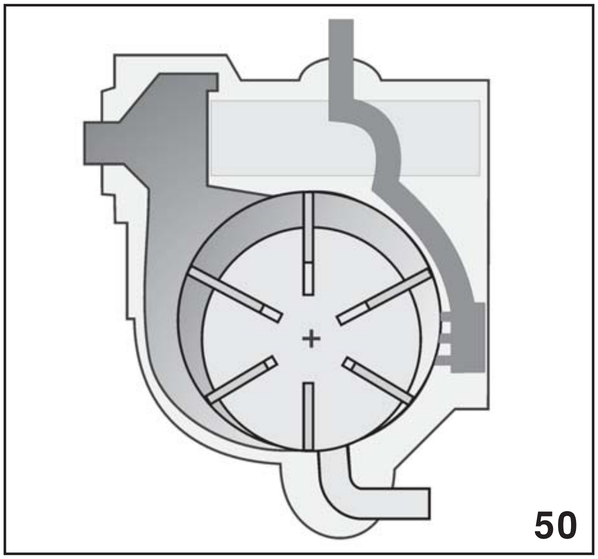
Swash Plate



Swash Plate

Three two sided pistons are arranged around an offset plate fixed to the compressor shaft. As the shaft rotates, each piston will be moved forward and back, drawing in low pressure refrigerant on its back stroke and forcing out high pressure refrigerant on its forward stroke. This compressor is a fixed displacement compressor. It was last used on 1993 Legacy's with a ZEXEL system.

Rotary Vane Type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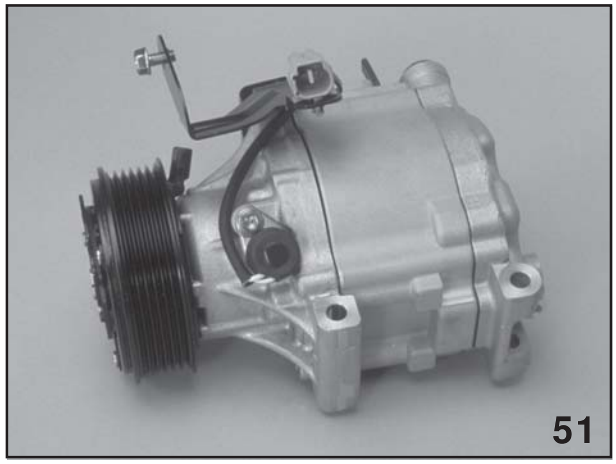
Rotary Vane Compressor

The Rotary Vane Compressor has a rotor fixed to a shaft, which is fitted with six vanes. The rotor and vanes are rotated by the shaft within an elliptical cylinder. As the rotor rotates, the vanes are extended and compress the low-pressure refrigerant as it enters the compressor. A trigger valve is used to route high-pressure refrigerant to the shaft side of the vanes to help them extend during low engine speeds. Due to the trigger valve operation, an intermittent "Buzz" noise sometimes can be detected.

This type of compressor will not "Knock" but will experience a "Chatter" type noise if an internal problem develops. A "Moaning" noise can develop with this type of compressor at extreme operating pressures. The noise should diminish once the pressure drops back down within normal operating conditions.

Scroll Type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Scroll Compressor

This type of compressor was introduced for the 2005 model year.


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Compressor Halves

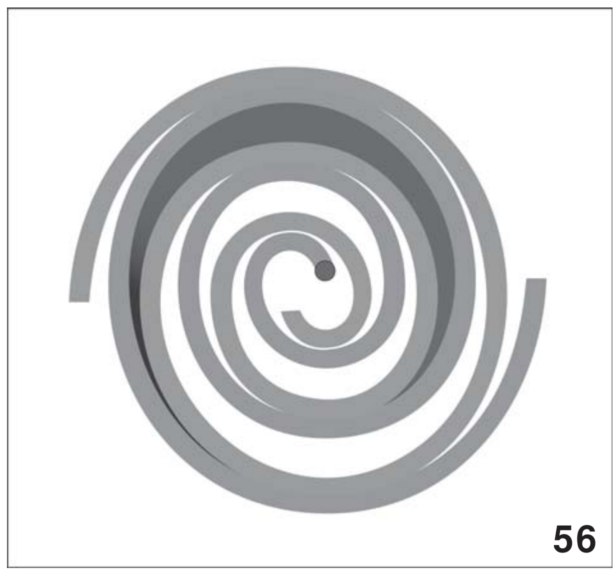
This compressor utilizes two scrolls to pressurize the refrigerant. One scroll is fixed to the shaft and rotates within another scroll fixed to the rear plate of the compressor.

Reed Valves

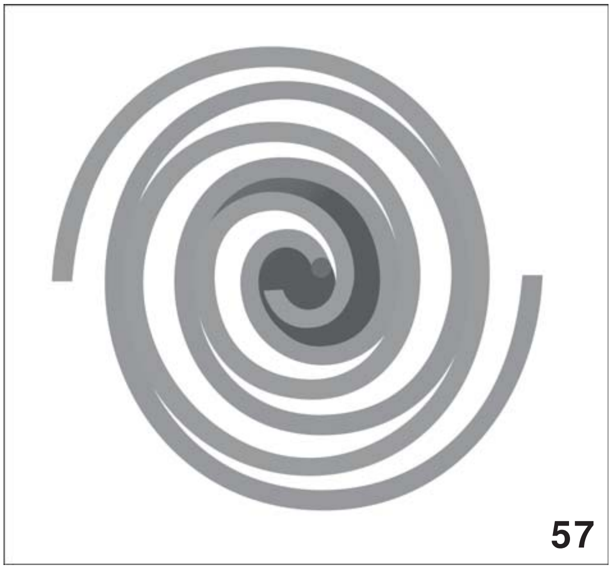
The refrigerant enters into the compressor through two intake valves and exits the Compressor through one exhaust valve.

Operation Intake

Operation Compression



Operation Compression _2



Operation Discharge

As the refrigerant is drawn into the compressor, the area becomes smaller as the scrolls Rotate, thus boosting the pressure of the refrigerant as it is drawn to the center of the Scrolls.

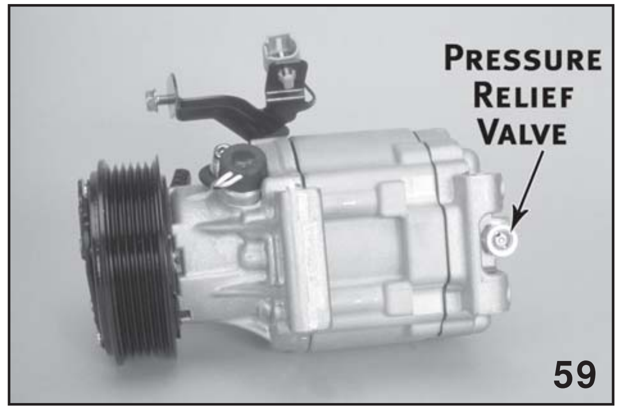
Compressor Protection

There are currently three different types of devices used to protect the compressor.

Check Valve

The check valve is designed to stop high pressure refrigerant flowing to the low-pressure side of the system through the compressor when the compressor has cycled off. It is located on the inlet side access port of the compressor.

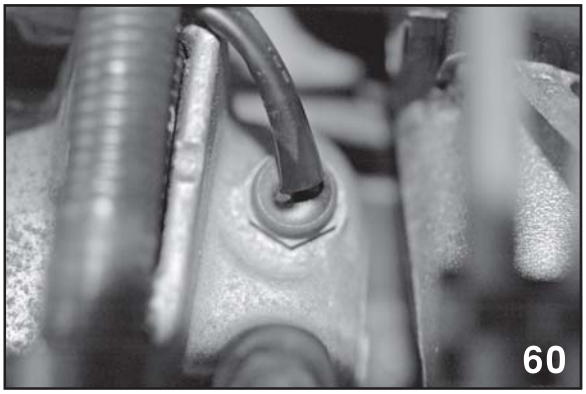
Pressure Relief Valve



Pressure Relief Valve

The PRV is located on the compressor case with access to the high pressure refrigerant within the compressor. It is designed to purge a limited amount of refrigerant when the refrigerant reaches a certain pressure within the compressor. Once the pressure drops to within a specified level the valve is designed to close.

Thermo-Switch



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Thermo-Switch

The thermo-switch is fixed to the case of the compressor and is designed to open the compressor clutch circuit when the surface of the compressor case reaches a specified temperature.

Compressor Replacement

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Scroll Compressor

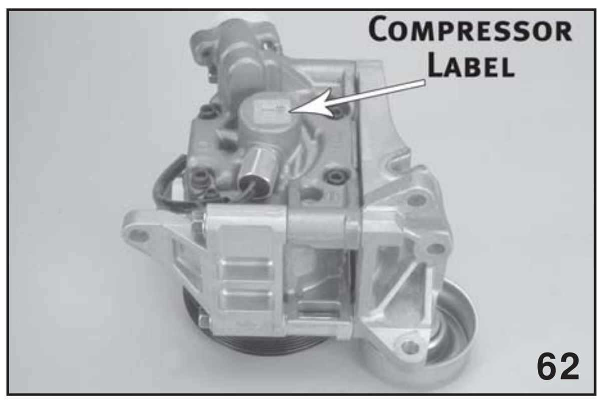
The amount and type of lubricating oil used is very important when servicing the Compressor. Remember that every service compressor comes with a full system charge of oil. If the system becomes saturated with compressor oil, poor cooling performance can develop. Only add the amount of oil that was drained from the compressor being replaced. This means that new oil from the replacement compressor might have to be drained.

Lubricating Oil

R-12 refrigerant systems utilize mineral oil to lubricate the system.

R-134a refrigerant systems utilize a poly alkaline glycol or PAG oil to lubricate the System. The relationship between the PAG oil and R-134a refrigerant is not as compatible as that of R-12 and mineral oil. The PAG oil does not completely immerse with R134a refrigerant, therefore a sight glass cannot be used to verify the system charge level.

PAG oils with different viscosities are used depending on what type of compressor is used. Do not mix PAG oils with different viscosities or the life of the compressor could be affected. PAG oil is highly hygroscopic, which means that it absorbs moisture at a very high rate. PAG oil will turn yellow in color when it becomes contaminated with moisture. Clean all spilled PAG oil immediately from all vehicle surfaces.



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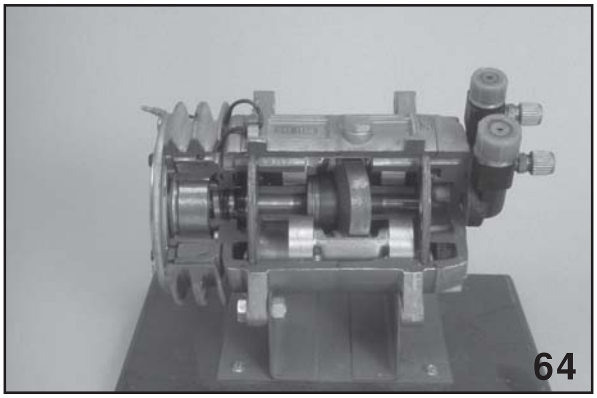
Compressor Label

A label on the back of the compressor, on the system-identifying label within the engine compartment, and the service manual all list the type and system capacity of oil that should be used when adding oil to the system.

Compressor Clutch Assembly

The compressor clutch assembly is made up of three components.



Compressor Clutch Assembly

Field Coil

A 12-volt signal from the compressor clutch relay energizes the field coil. When energized, it becomes a strong electromagnet that pulls in the armature plate against the compressor pulley. The signal must not drop below 10.5 volts for the coil to be effective.

Pulley

The pulley is mounted to the compressor case. A sealed bearing is positioned between the case and the pulley. The engine, through the use of a drive belt, rotates the pulley.

Armature Plate

The armature plate is splined to the compressor shaft. When the coil is energized, the armature pulls in against the pulley, letting the drive belt rotate the compressor. The distance, or air-gap, between the pulley and the armature is very important. If the distance is too large, then a noise can develop as the armature momentarily slips against the pulley when the coil pulls it in. If the distance or air-gap is too small, a noise can develop when the compressor is not engaged.

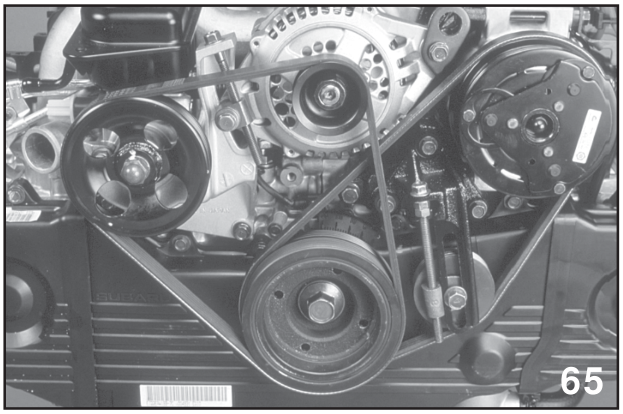
Clutch Engagement

The following conditions have to be met before the compressor clutch will engage and stay engaged:

1) A minimum of 10.5 volts to the clutch coil.
2) A minimum amount of refrigerant in the system to overcome the low system pressure cutout switch.
3) A ground signal from the ECM to the Compressor Clutch Relay, energizing the coil of the relay.
   a) If the engine coolant is in an overheated condition, the ECM will cease to provide the ground signal to the Clutch Relay, thereby disengaging the compressor clutch.
   b) If the throttle is at or over the 90% level, then the ECM will cease to provide the ground signal to the Clutch Relay.
   c) On the 3.0 liter Engine, a compressor speed sensor input must remain within specifications or the compressor clutch will be "Locked Out" and will not engage.
4) The A/C Switch circuit, which includes the Electronic Thermostat circuit, must provide a compressor "ON" request to the ECM.

NOTE: THE "ON" REQUEST FROM THE A/C SWITCH CIRCUIT, THE SIGNAL FROM THE ECM TO THE CLUTCH RELAY, AND THE SPEED SENSOR "LOCK OUT" SIGNAL, CAN ALL BE CHECKED WITH THE SELECT MONITOR.

Drive Belt

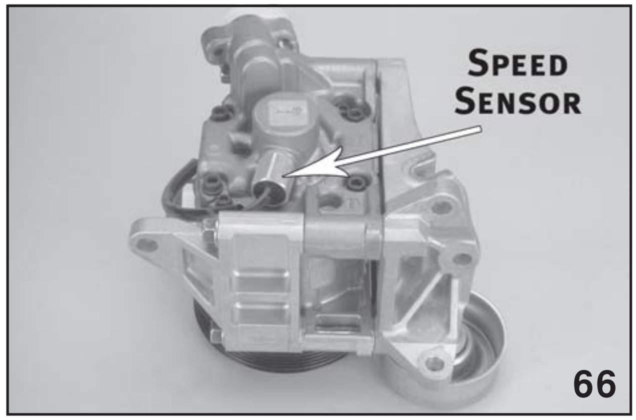


Compressor Drive Belt

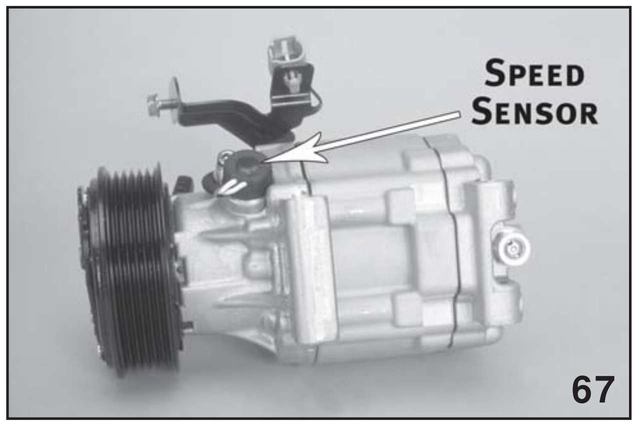
A drive belt, driven by the engine, is used to rotate the compressor pulley. The tension of the drive belt is very critical. If the tension is too loose slippage can occur creating noise and heat. If the tension is too tight, then damage could occur to the compressor pulley bearing. Proper alignment of the compressor pulley is also very critical. The drive belt tension is adjusted by the use of a manually adjustable idler pulley, or by an automatic tensioner. When inspecting for belt tension, also visually inspect the belt for improper wear patterns or frayed edges. Consult the Service Manual for the proper service procedure.

When replacing a new drive belt, remember that the belt might stretch a little after a short run-in time.

Belt Protection



Speed Sensor (newer)



Speed Sensor (older)

A device used to protect against the seizure of the compressor throwing the drive belt off of the pulley is currently being used on the vehicles with the 3.0 liter engine. The speed sensor, monitors the rotational speed of the compressor shaft and sends a sine-wave signal to the ECM. The ECM compares this signal against other engine speed input signals. If the speed signals differ by more than 20 percent, the ECM stops its ground signal to the compressor clutch relay, therefore disengaging the compressor clutch. This “locking out” of the compressor will remain until the ignition key is cycled “off and on”. If there is an interruption in the speed sensor circuit, open or short, the compressor will be “locked out” as well.

Condensers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Condenser

There are four types of condensers that have been used on Subaru vehicles.

Serpentine

As the refrigerant enters the condenser at the top it flows from one side to the other, then down until it reaches the bottom of the condenser. This type of condenser is used primarily with R-12 refrigerant systems.

Parallel Flow

As the refrigerant enters the condenser on one side it drops down and flows through all tubes to the opposite side of the condenser. This type of condenser was used on early R-134a refrigerant systems.

Multi-flow


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Multi-Flow Side View


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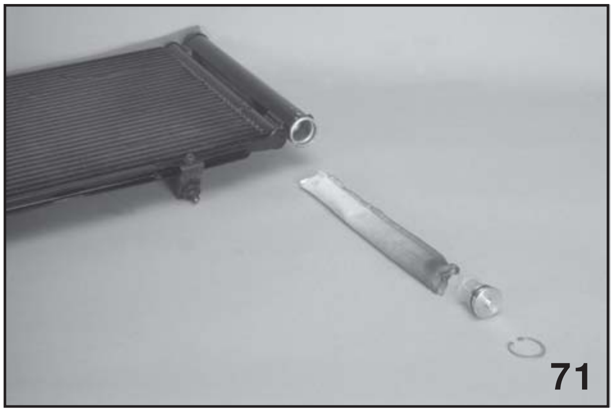
Multi-Flow Front View

As refrigerant in a gas state enters the condenser, it partially drops down one side tank until it reaches a baffle plate. At this point it crosses the condenser, drops down until it reaches another baffle plate, then crosses back across the condenser. The refrigerant will flow through three passes until it reaches the bottom of the condenser where it is now in a liquid state.

Multi-flow with Receiver Drier (Sub-cooling)



Multi-Flow (Sub-cooling) Condenser

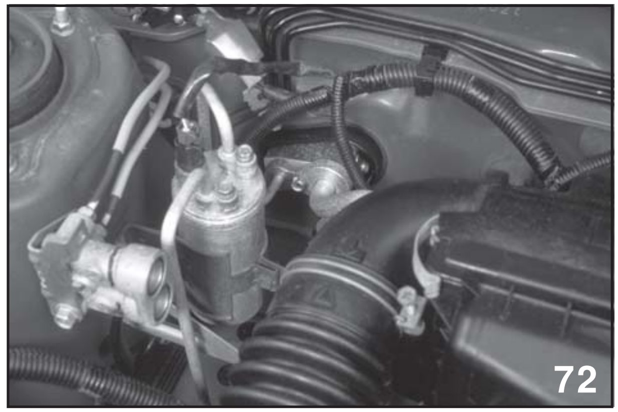
This condenser works the same as the multi-flow condenser, only this condenser has a Receiver Drier built into it at the outlet side of the condenser.

With all condensers it is very important that there is no restriction or partial restriction whether it is internal or external.

If a partial internal restriction develops, then a measurable difference of surface temperature will occur with the lower temperature being found downstream of the restriction. If the condenser has been opened to the atmosphere for a length of time the PAG oil at the bottom of the condenser, can absorb enough moisture from the atmosphere to partially restrict the flow of refrigerant through the condenser.

External restrictions such as bent fins or debris, can affect the heat transfer capabilities of the condenser. A slow increase in high side operating pressures will develop, leading to a poor cooling complaint. If the engine cooling fans are not operating correctly, then the same increase in high side operating pressures will develop. If the restriction to air flow is large enough then the high side operating pressure will increase until the Pressure Switch cycles the system off due to high operating pressures.

Receiver Drier



Receiver Drier

The receiver drier is designed to perform three functions.

Receiver

The R/D is used to receive the refrigerant and store it in a liquid state to pass on to the Expansion Valve. It is very important that the refrigerant reaches the expansion valve in a liquid state so it can readily change state back to a vapor within the evaporator.

Drier

The R/D has a drying agent within it. The drying agent, or desiccant, is used to absorb any moisture within the system. It only takes a small drop of moisture to freeze up and block the refrigerant from entering into the evaporator through the expansion valve. Moisture in the system will displace the refrigerant and can become acidic, affecting the integrity of the system.

Filter

A filter to trap particulates within the system is also found within the R/D. This is to trap any unwanted debris from circulating throughout the system.

If the system has been opened to the atmosphere for a considerable length of time and there is no residual pressure within the system, then the R/D needs to be replaced.

As with any component replacement, make sure that any opened system is isolated from the atmosphere when making repairs.

Thermal Expansion Valve

Evaporator

Three types of thermal expansion valves have been used on Subaru vehicles with A/C. An expansion valve located within the evaporator case with an equalizing tube, an expansion valve within the evaporator case without an equalizing tube, and a block type expansion valve.

Block Type TXV

All valves control the flow of refrigerant into the evaporator core, to deliver the refrigerant in a “misty” or primed state. The expansion valve controls the amount of refrigerant entering the evaporator by monitoring the temperature of the refrigerant as it exits the evaporator.

When the system cycles “off” the expansion valve will open due to the increase in the refrigerant outlet temperature. Due to the opening of the expansion valve when the compressor cycles “off”, an intermittent gurgling noise might develop as refrigerant in a liquid state enters the evaporator.

If the expansion valve looses it’s capability to sense the temperature of the refrigerant as it leaves the evaporator, such as sensing bulb or sensing element failure, then the expansion valve closes and the low side operating pressure drops into negative pressure.

NOTE: IF THERE IS A COMPLETE BLOCKAGE AT THE EXPANSION VALVE INLET, THEN THE LOW SIDE PRESSURE WILL DROP INTO A NEGATIVE PRESSURE, WHICH CAN DAMAGE THE COMPRESSOR DUE TO A LACK OF LUBRICATION. IF THERE IS ONLY A PARTIAL RESTRICTION AT THE EXPANSION VALVE INLET THEN LOWER THAN NORMAL LOW SIDE OPERATING PRESSURES WILL DEVELOP.

Evaporator Assembly

Evaporator Assembly

The evaporator assembly includes the following components:

- Evaporator Core
- Thermal Expansion Valve
- Blower Resistor Assembly
- Case
- Drain Tube
- Thermo-sensor
- Air Filter (If so equipped)

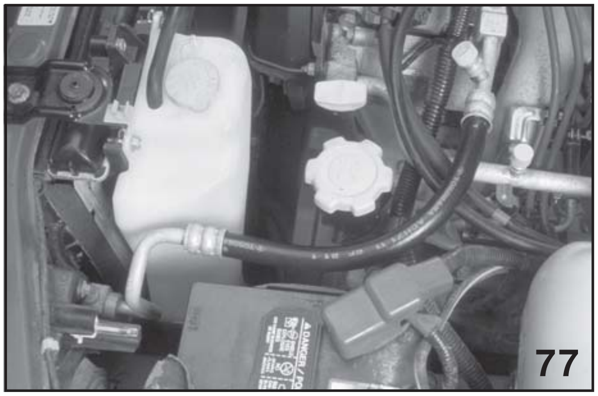
The evaporator core itself is made of aluminum, which provides excellent heat transfer. The refrigerant enters the core through the expansion valve in a misty condition and changes state to a vapor absorbing the heat from the air stream provided by the blower motor. There is always moisture in the air, so the casing is designed to collect the moisture from the core and drain it out of the evaporator assembly through the drain tube.

Air - Filter

Some evaporator assemblies have an air filter in line between the core and the blower motor to catch any organic debris before it collects on the inlet side of the core. The combination of moisture and organic debris at the bottom of the evaporator case can become acidic, causing premature failure of the core. If enough debris collects on the inlet side of the core, then airflow can become restricted. Due partially to the debris and moisture, a musty odor can develop within the evaporator assembly. This smell is common within the industry and there are many aftermarket aerosol and coatings available to temporarily get rid of the smell. Be aware that a musty odor can return. If any treatment is used for the musty smell, avoid coating the resistor attached to the case.

If the system has an Air Filter at the evaporator assembly, then it must be cleaned or replaced periodically or poor airflow from the vents could occur.

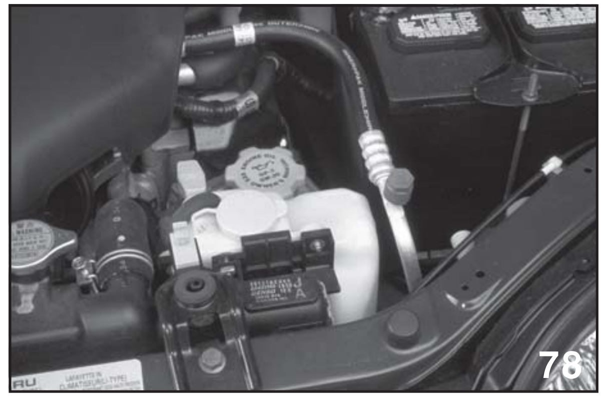
Pipes and Hoses



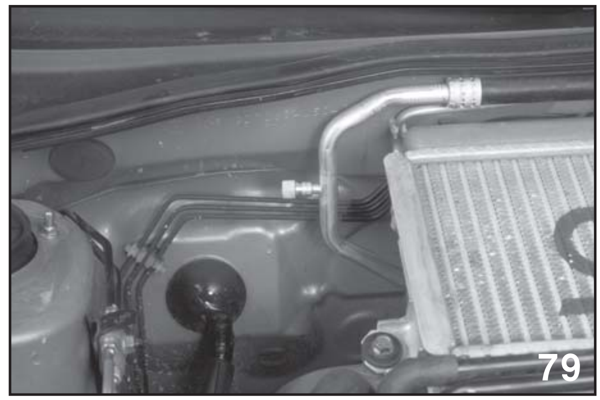
Hose

Throughout the years many different hose and pipe combinations have been used on Subaru A/C Systems. If a replacement hose or pipe is needed, always verify the system manufacturer and refrigerant type first. O-ring sizes have also changed throughout the years and replacing the O-rings with the correct size is vital in maintaining the system charge level. When replacing O-rings always lubricate the new O-ring upon installation and position them properly on the pipe. Take care to clean any residual lubricating oil from the component after completing the repair. If a component is to be replaced, seal off the opening at the hose or pipe from the atmosphere to prevent moisture from entering the system. Remember that both the desiccant within the R/D and the PAG oil (R-134a Systems) absorb moisture from the atmosphere at a very high rate.

Tighten O-ring connections at the proper torque specifications. If the connection is not torqued properly a refrigerant leak could develop.

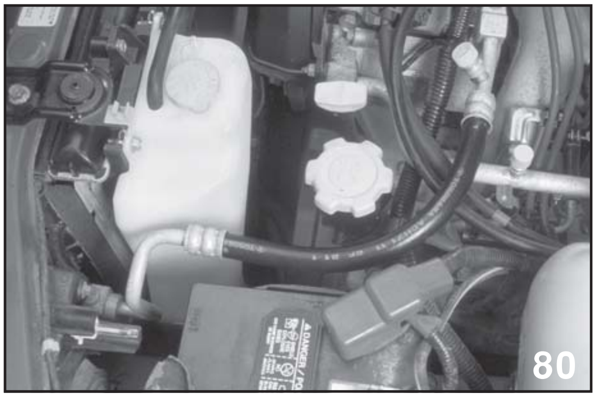


Service Cap, High Pressure



Service Cap, Low Pressure

The service access points of the system are currently located on the pipe/hose assemblies. It is very important that the service valve caps remain on the fittings for two reasons.



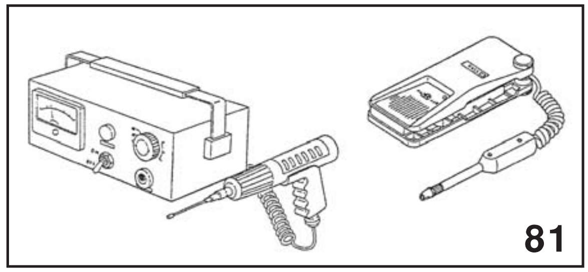
Service Cap

1) The cap keeps debris from entering the service valve opening. This debris can be introduced to the system or to the service equipment when servicing the system.
2) There is a seal positioned within the cap that helps seal the service valve from refrigerant.

If the service valve caps are missing from the system when servicing an A/C System, then new caps need to be installed. When inspecting the valves for damage or leakage concerns, always inspect the seal within the service valve cap. If the seal is damaged then a potential refrigerant leak could develop, and the cap must be replaced.

If an internal partial restriction develops within the hose or pipe, then system performance will be affected. If a partial restriction develops due to a crimped pipe or an internal breakdown of a hose, a temperature difference will occur where the partial restriction is located. This change in temperature can be large enough for frosting or icing to develop on the outlet side of the restriction.

Leak Detection



Leak Detectors

It is vital to conduct the A/C System leak check correctly. If the vehicle comes into the shop with Service Valve Caps on the vehicle, then the leak check procedure must be performed with the caps “ON”. First verify that the system performance is not within specifications and that a low refrigerant charge is the concern:

NOTE: OPERATE LEAK CHECK EQUIPMENT PER FEDERAL GUIDELINES. (J-1028)

1) Visually inspect for any leaks.
2) Isolate the vehicle from the wind or shop fan.
3) Operate the system until it has stabilized.
4) Shut the engine off.
5) Remove the gauges and install the service valve caps.
6) Start your leak detection on the high side of the system at the compressor and then work your way to the expansion valve. By the time you check the low side of the system, the pressures should have equalized.
7) Check the low side of the system starting at the compressor and then work back towards the expansion valve.
8) Remove the resistor block from the Evaporator Case and check for leaks within the case.

If there is no refrigerant within the system, the compressor should not engage. Add enough refrigerant for the system to overcome the low-pressure cutout, which enables compressor clutch engagement. Then perform your leak check procedure.

If a low refrigerant charge is verified, and the leak cannot be found by any other means, then introduce an approved refrigerant dye into the system to isolate the leak. When using dye:

1) Follow the manufacturer's guidelines on how to introduce the dye into the system and for the amount of dye to be introduced.
2) Always clean any residual dye from the system after repairs are made.
3) An overcharge of dye can affect the integrity of the system.

NOTE: BE AWARE THAT THE DYE MUST IMMERSE WITH THE OIL TO WORK CORRECTLY. THE OIL IS MOVED THROUGH THE SYSTEM BY THE REFRIGERANT. SOME R-134A LEAKS DO NOT LEAK PAG OIL; THEREFORE THERE WILL BE NO DYE AT THE LEAK AREA. SOME SMALL HIGH SIDE LEAKS, LEAK PAG OIL IN AN ATOMIZED CONDITION THAT DISSIPATES BEFORE COLLECTING AT THE LEAK AREA.

After the leak has been repaired, another system leak check must be performed to verify that the leak has indeed been repaired, and that no other leaks exist.

When performing the leak check procedure:

1) Remember that there could be more than one leak.
2) Always operate leak detection devices per manufacturer's and federal guidelines.
3) A very small percentage of refrigerant leaks, leak at cold temperatures only. This is due to the contraction of components due to the cold weather, and as the operating pressures/temperatures increase, expansion occurs and the leak seals off.

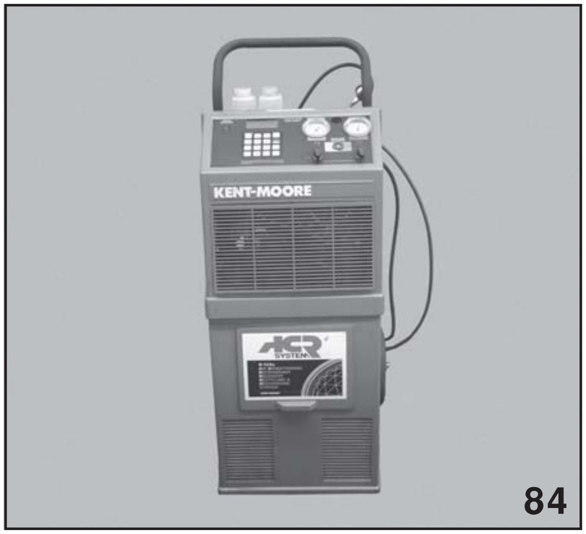
Receiver Drier O-ring

4) Be aware that some combination Condenser/Receiver Drier assemblies have an additional leak check point at the bottom of the condenser.

Retrofit

Please consult the Service Bulletin # 10-68-96R for the retrofit scenario for the vehicle being retrofitted. Remember that an R-12 system is most efficient when charged with R-12 refrigerant. Retrofit only if requested by the customer or if there is no R-12 refrigerant available.

Service Equipment



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Service Equipment

It is very important that the Recovery/Recycle/ Leak Detection equipment be kept calibrated.

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Controls

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Gauges

Most Recovery and Recycle Machines have a Self-Calibration Mode. Check the Operation Manual. You want to be able to dial in a Refrigerant Charge and know that the equipment is indeed charging only the amount of refrigerant indicated.

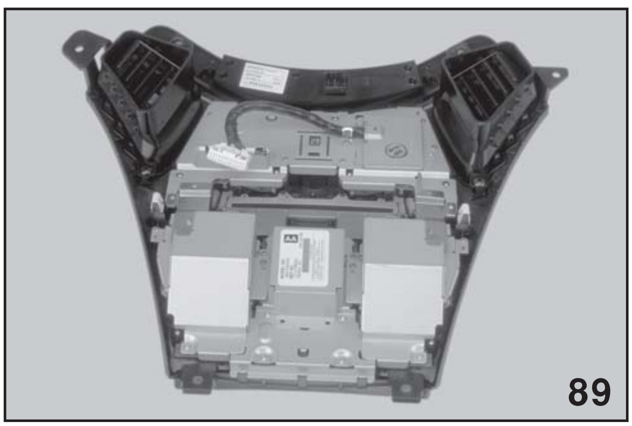
If the system has been opened to the atmosphere for a length of time then a complete vacuum must be performed on the system. The vacuum process, removes any moisture within the system. A two or three minute vacuum is not sufficient to remove all moisture in the system. Remember moisture will degrade system performance and can cause premature failure of components.

Operate all Service Equipment per manufacturer's specifications.

Subaru B9 Tribeca Audio System

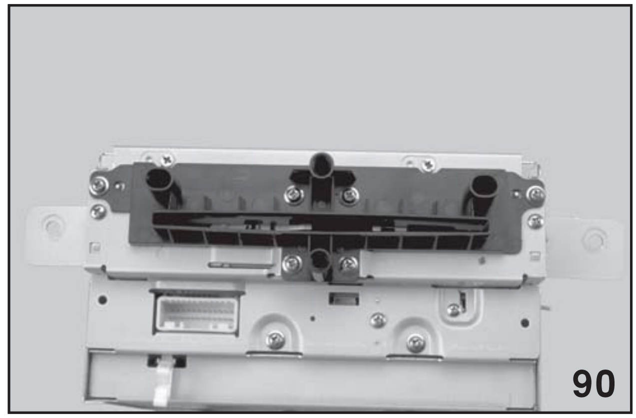
Face Plate Front View

The Audio Unit is controlled by a faceplate which is also used to control the Air Conditioning.



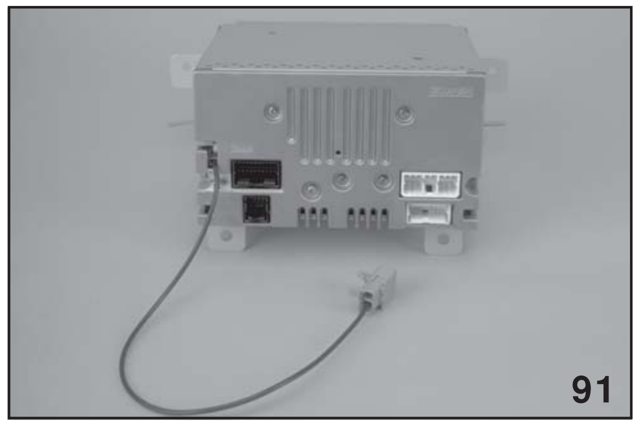
Face Plate Back View

The Audio Unit transfers the control signals from the faceplate through the Audio Unit circuitry to the harness connecting to the radio. This harness then connects to the HVAC wiring and to the HVAC Control Unit.



Audio Unit Front View

The faceplate connects to the audio unit with a single connector.



Audio Unit Rear View

Before diagnostics for the HVAC control system can be performed the faceplate operation must be checked.

NOTE: RADIO AND HVAC MUST BE OFF

- Turn the key to accessory on and wait 2 seconds
- Press and hold the Auto and Mode buttons on while the ignition is turned on.
- Check that all segments of the Vacuum Fluorescent Displays (VFD) are illuminating.
- If Seat Heater equipped, those switches can be checked at this time.
- Press all control buttons and observe if a corresponding indicator light is illuminated.

Audio control check

Multi-Function Display (MFD) or Navigation Display will display mechanical problems and compact disc problems when "MECHA ERROR" or "CHECK DISC" appears on the display.

The audio set can diagnose problems using its face panel buttons so that the face panel and the CD/radio unit can be separated depending on their problems.

By use of this diagnostic function, judgement to one of the following three conditions can be made:

(A) Face Panel failure

(B) CD/radio unit failure

(C) Poor contact between the face panel and CD/radio unit (communication error)

1. To enter the diagnostic mode:

1) Turn the ignition switch to ACC. (Turn off the audio.)

2) Press buttons "TUNE ∆", "SEEK ∇" and "RDM" together for at least **2 seconds.**

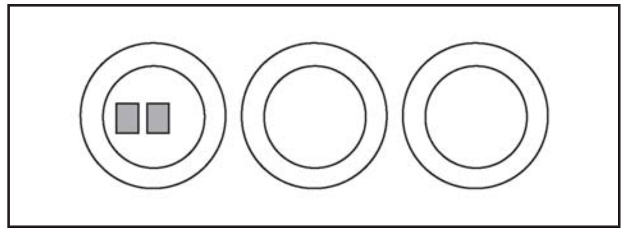
3) You will hear a beep.
(If beep does not sound, try again. If you cannot hear the beep, both face panel and CD/radio unit have a possibility of a problem and/or poor contact between the face panel and CD/radio unit should be considered.)

4) **Within 15 seconds** after the beep sounds, press the preset button "1" to enter the diagnostic mode.

In the diagnostic mode, VDF'S (Vacuum Fluorescent Displays) on the climate control dials illuminate.

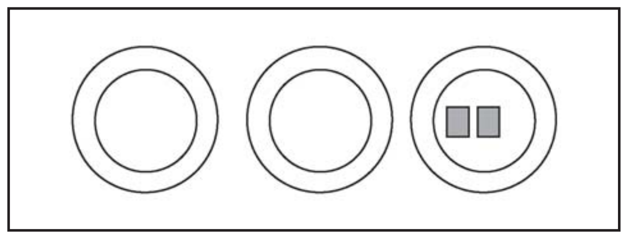
In Diagnostic Mode

If VFD on the Left side dial illuminates



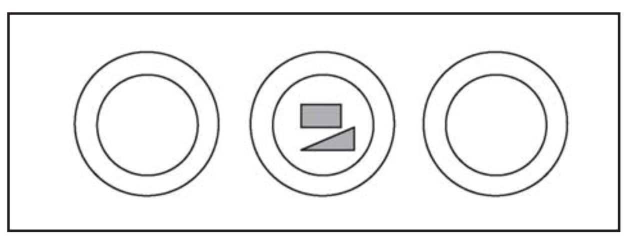
The face panel has NO problem. The CD/radio unit has a possibility of a problem and/or poor contact between the face panel and CD/radio unit is considered.

If VFD on the Right side dial illuminates



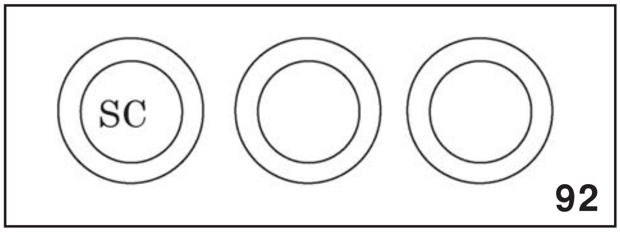
The CD/radio unit has NO problem. The face panel has a possibility of a problem and/or poor contact between the face panel and CD/radio unit should be considered.

If VDF on the Center dial illuminates



Confirm each audio control button's function by pressing the button.

VFD'S will show specific letter symbol corresponding to each button's function. For example, when "SCAN" button is pressed, letter symbol "SC" appears on the VFD.



VFD Chart

(However buttons of “POWER”, “FM”, “AM”, “CD” and “RES/AUX” have no this function.)

If each button is confirmed to be functioning
The CD/radio unit has a possibility of problem.
If any of buttons is confirmed to be malfunctioning
The face panel is faulty.

NOTES:

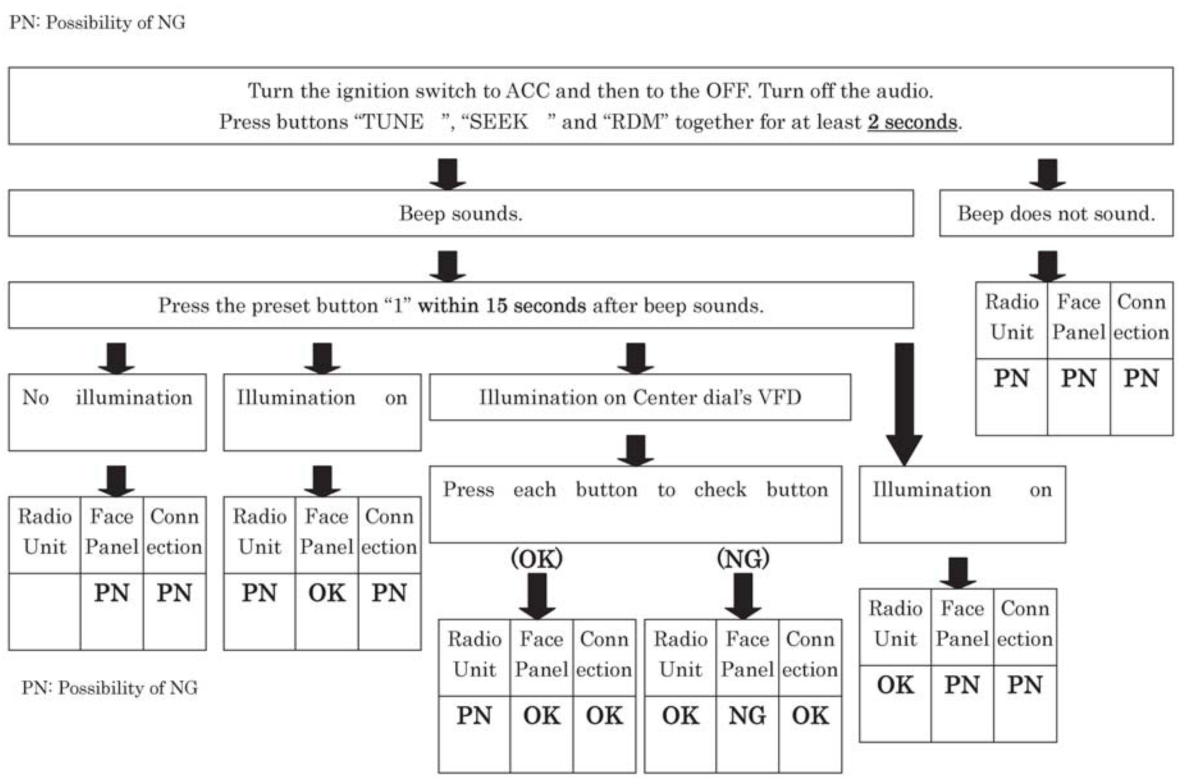
If VFD'S on the 3 dials do not illuminate

Audio set has not been switched to diagnostic mode. Try procedure 1 again.
If you cannot enter the diagnostic mode, both face panel and CD/radio unit have a possibility of a problem and/or poor contact between the face panel and CD/radio unit should be considered.

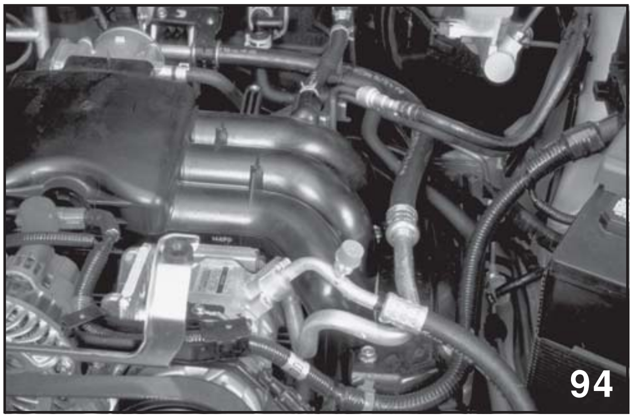
To return from diagnostic mode

Perform any of the following operations.

- Press "POWER" button
- Press "CD", "FM", "AM" or "AUX" button
- Turn ignition switch to OFF



Subaru B9 Tribeca HVAC (Automatic Air)



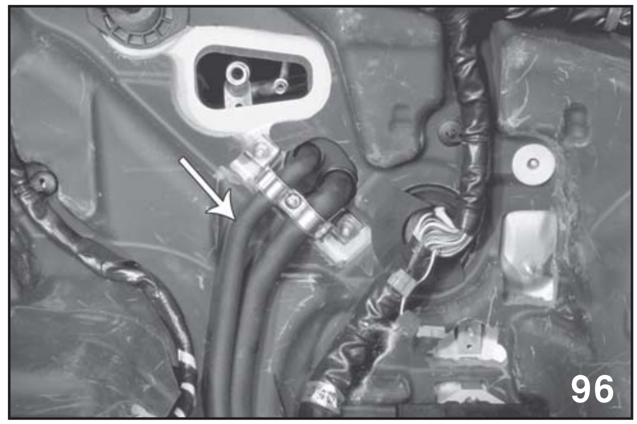
Compressor

Above Engine Compartment

NOTE: FIXED SWASH PLATE COMPRESSOR

The Subaru B9 Tribeca is equipped with Dual Zone climate control and rear air conditioning (7 passenger models). Diagnostics for climate control is provided using the A/C control unit to communicate trouble codes to the control displays. The control unit is located on the blower housing assembly.

The low pressure refrigerant hose is routed from the compressor to the front expansion valve and Ts to the grommet for the rear evaporator hose. The high pressure refrigerant hose is routed from the compressor to the condenser. Then along the frame rail to the trinary switch and above the engine compartment to the front expansion valve and T's to the grommet for the rear evaporator hose.

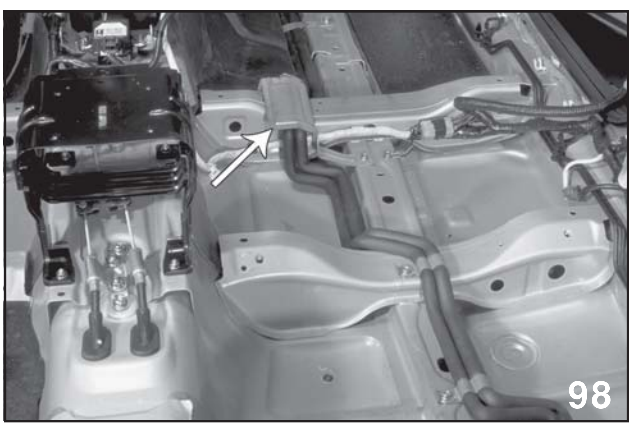


Entering Passenger Compartment

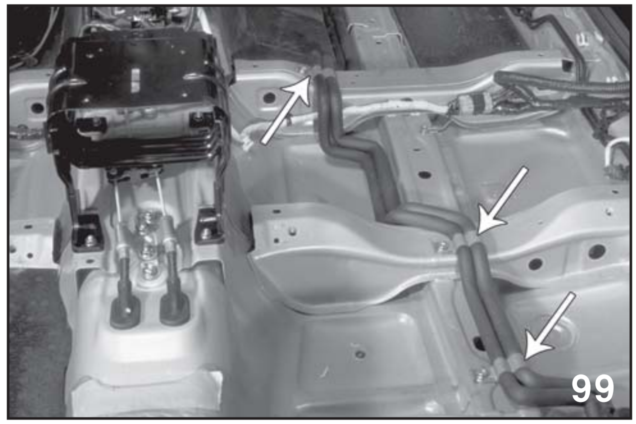
Both the high and low pressure hoses enter the passenger compartment and are clamped in place to the vehicle body behind the dash and above and to the left of the ECM.

Under Passenger Seat

There are three different sections of A/C hoses in the passenger compartment. The front section is routed from the bulkhead to just ahead of the second row seat bottom cushion. The connection between the front section and the rear section of A/C hoses are accessed by removing the lower door jam trim of the right rear passenger side door. Removal of the front section of hoses requires the removal of the dash, steering support beam, blower motor assembly and right front passenger seat.



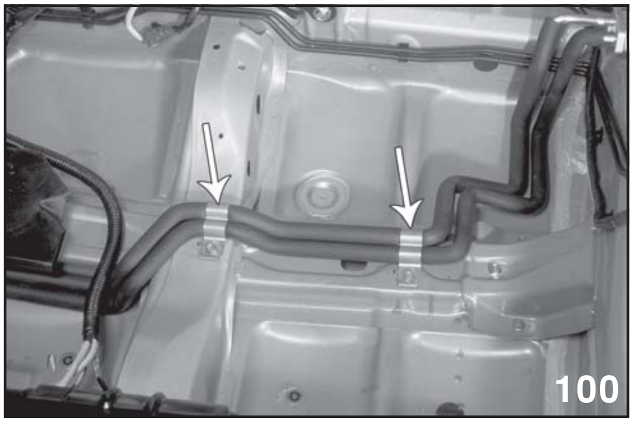
In Front of 2nd Row Seat



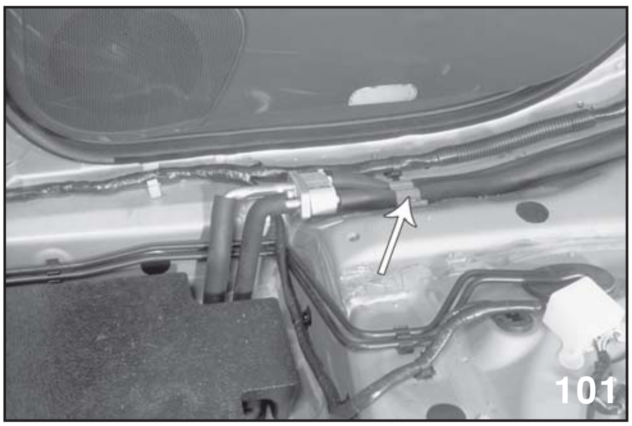
Clamps

From the bulk head the hoses are routed to the right side of the center console and cross over the frame channel that serves as a forward mount for the front seat. The hoses are protected by a shield and are clamped to the frame channel.

The hoses are then routed under the right front seat and cross over the frame channel that serves as the rear mount of the front seat. The shape of the channel and the location of the hoses crossing the frame channel, protect the hoses from damage.

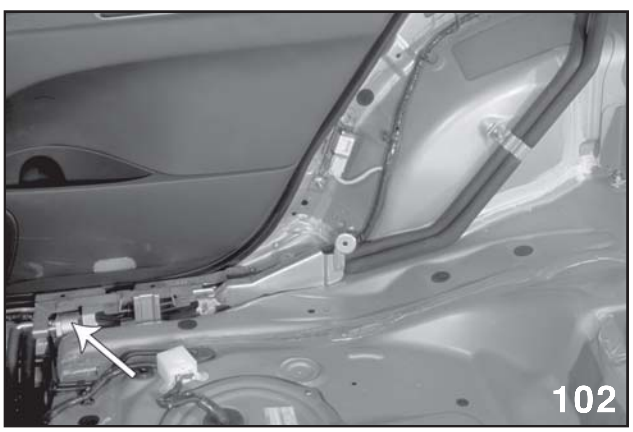


Hose Clamps



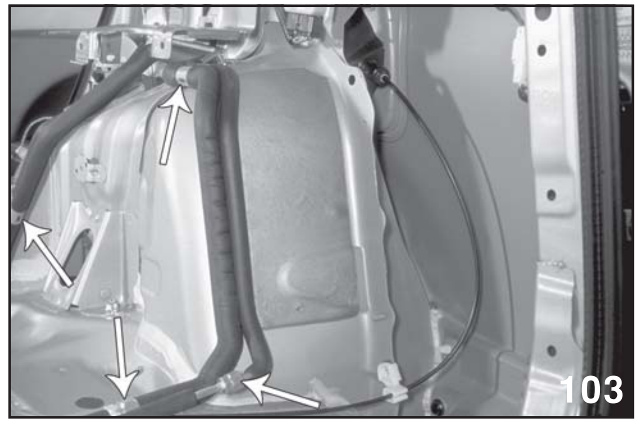
Connection

A polystyrene block protects the hoses as they are routed on to the right rear door jam area.



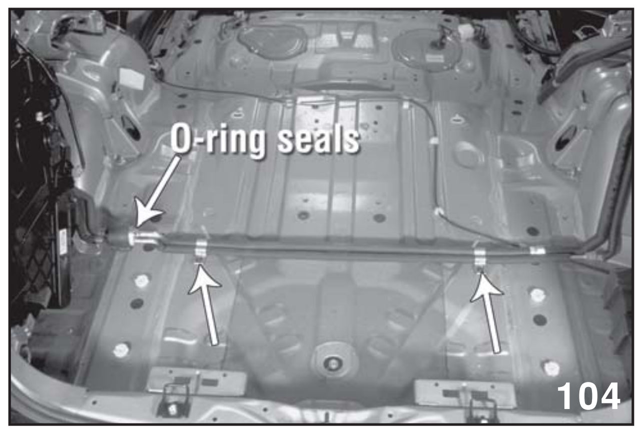
Wheel Well

A metal cover protects the hoses as the front and middle sections meet (O-ring seals). The metal cover provides protection until the hoses are routed to the wheel well area where the inner trim panels provide protection.



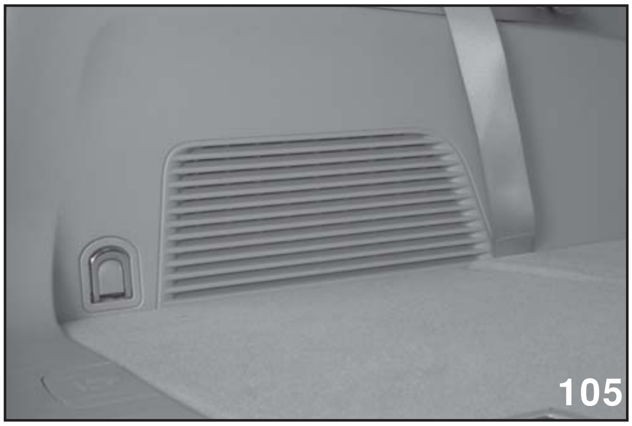
Connection

The hoses are routed over the wheel well and make a turn to the driver side of the vehicle. At this point the middle and the rear section of A/C hoses meet (compression sealed).



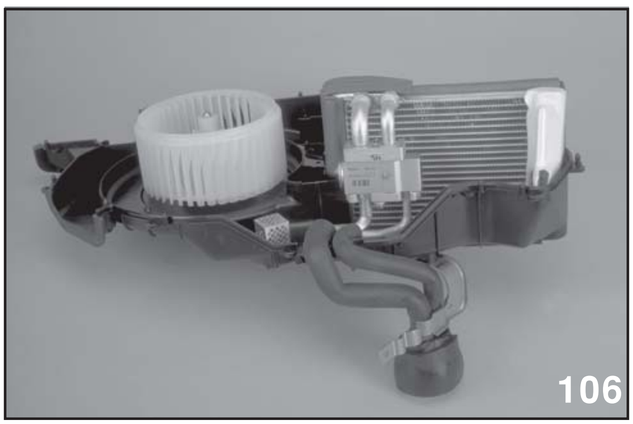
Connection At Rear Evaporator

The hoses are routed across the back of the vehicle just ahead of the tool storage tray, to the rear evaporator.



Air Inlet

Air cooled by the rear evaporator is drawn into rear blower motor through the rear vent in the cargo area.

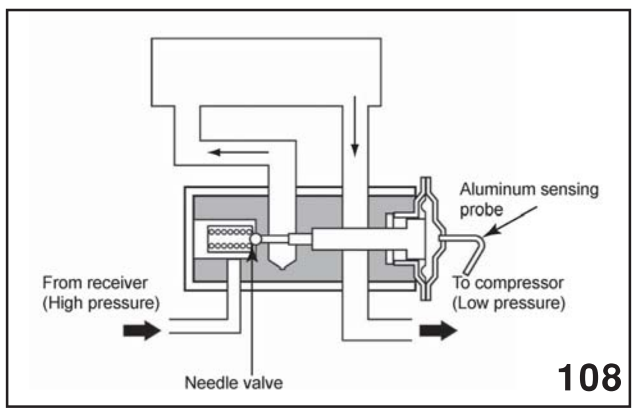


Rear Evaporator Split

The rear blower motor is equipped with a resistor style fan speed controller which is controlled by a single blower motor fan speed switch. In operation the refrigerant flowing through the rear evaporator will decrease as the rear expansion valve senses the decreasing evaporator outlet temperature.

Rear Blower Switch

As the amount of refrigerant flowing through rear evaporator decreases the efficiency of the front evaporator increases due to the reduce heat load placed on the low pressure side. Only one thermistor is used on the Subaru B9 Tribeca A/C system and it is located in the front evaporator.



Rear Expansion Valve

Low temperature at evaporator exit:

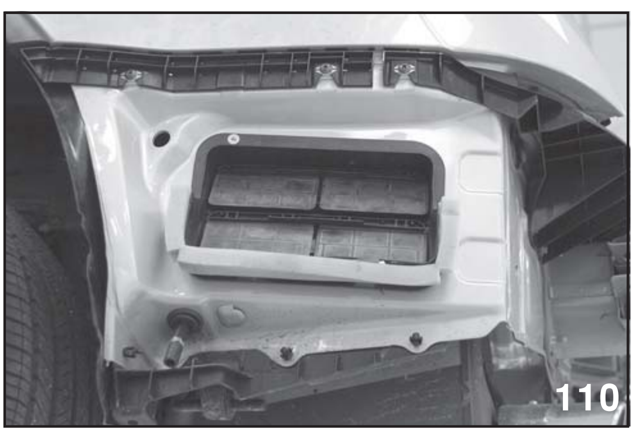
> Gas pressure inside diaphragm decreases, reducing volume, pulling aluminum sensing probe right and throttling the needle valve.

High temperature at evaporator exit:

> Gas pressure inside diaphragm increases, expanding volume, pushing aluminum sensing probe left, opening the needle valve to increase coolant flow.

Rear Evaporator Removed

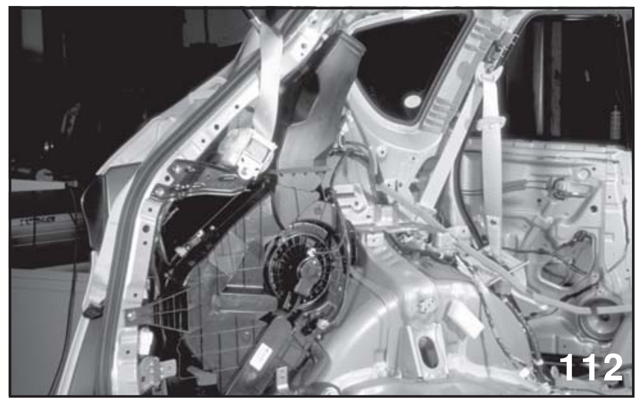
The rear evaporator drain hose is routed from the rear evaporator case to a grommet in the bottom of the left rear cargo area. The drain hose exits the vehicle behind the left rear inner fender and in front of the rear bumper cover. Installation of the hose to the vehicle body is accomplished by depressing the lock tabs of the forced ventilation assemble and pushing the forced ventilation assemble outward slightly. Place the hose into the grommet. Pull the forced ventilation assemble back into place, ensuring the lock tabs engage. Position the rear evaporator assemble in the vehicle, leaving enough room to reach behind the evaporator assemble install the drain hose onto the evaporator case.



Rear Evaporator Drain Hose

Verify the drain hose did not move out of the grommet. Secure the evaporator case to the vehicle.

Head Liner



Rear Blower Motor

Bottom Of Head Liner

The blown air from the rear evaporator case is routed up the D pillar post area through the vent tube made onto the head liner. The air distribution vent tubes are an incorporated portion of the headliner and cannot be serviced separately. Air blown into the passenger compartment can be closed off or redirected by operating the vent levers of the individual headliner vents.

Slide Sequence

Slide Sequence

Slide Sequence

Service Bulletins

No.	Date	Title	Subject
10-61-91	7/2/91	All vehicles equipped with Air Conditioning	Removal & recycling of Refrigerant R-12
10-63-93	4/12/93	All 93MY SVX	A/C systems using R134a Refrigerant handling procedures
10-64-93	11/8/93	93MY Impreza	Heater vent door binding or leaking air
10-65-94	3/8/94	All Subaru Models	Proper oils for Subaru A/C systems
10-66-94	6/17/94	Subaru Vehicle	R-12 & R 134a A/C system handling procedures
10-67-94	11/11/94	92-94 MY Legacy	Clicking noise from the heater mode door actuator
10-68-96	7/12/96	87-'92 Retrofit procedures	A/C Retrofit procedures R-12 to R-134a
10-68-96R	8/15/98	87-'92 Retroit procedures	Adjustable driver's side defroster grill
10-69-96	11/15/96	1995 and later MY Legacy	Adjustable driver's side defroster grill
10-70-00	7/11/00	2001MY Legacy and Outback	A/C Relay disconnection
10-71-00	12/15/00	Some 2000MY Legacy Vehicles	Recirculation door actuator noise
10-73-02	8/12/02	All 2003 Legacy and Baja Vehicles	A/C system relay storage and activation during PDI
10-74-02	9/1/02	2001~2002MY H-6 Legacy Vehicles	Legacy H-6 A/C Compressor revolution sensor
10-72-02R	7/15/03	All 2002~2003MY Impreza Vehicles up to VIN 3*801514	Countermeasure to prevent icing in the evaporator on air conditioned vehicles correction
10-75-04 15-112-04	09/24/04	2005MY Legacy & Outback Vehicles	Audio and Audio/HVAC Diagnostic Faceplate

TechTIPS

Date	Subject
05/00	2000MY Legacy heater control cables
07/00	2001MY A/C disconnect procedure
02/01	Mode control panel change
07/01	2001MY Legacy evaporator thermostat probe location
08/01	Legacy H-6 A/C compressor's cutting out
08/01	Valeo/Zexel A/C TXV fastener torque specification
09/01	H-6 climate control system information
09/01	Change to 2002MY Legacy/Outback A/C information
11/01	2001/2002MY Legacy blower motor noise
08/02	Blower motor noise
01-02/03	Blower motor noise
04/03	H-6 A/C compressors cutting out
07/03	Auto. A/C system aspirator tubes
10/03	Service bulletin 10-72-02R an update

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Technicians Reference Booklet

Manual Transmissions

Module 201

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December 2005

MSA5P0268C

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of December 2005.

This book is revised with material from New Model Updates 912, 913, 914 and 915.

Table of Contents

Manual Transmissions (201)

Manual Transmissions (201)

Introduction

This Technicians Reference Booklet introduces the Subaru Manual Transmission. It reviews the components and operation, diagnosis, component removal, disassembly, inspection, and reassembly of the transmission. The text and illustrations are derived from and follow the classroom instruction with slide presentations.

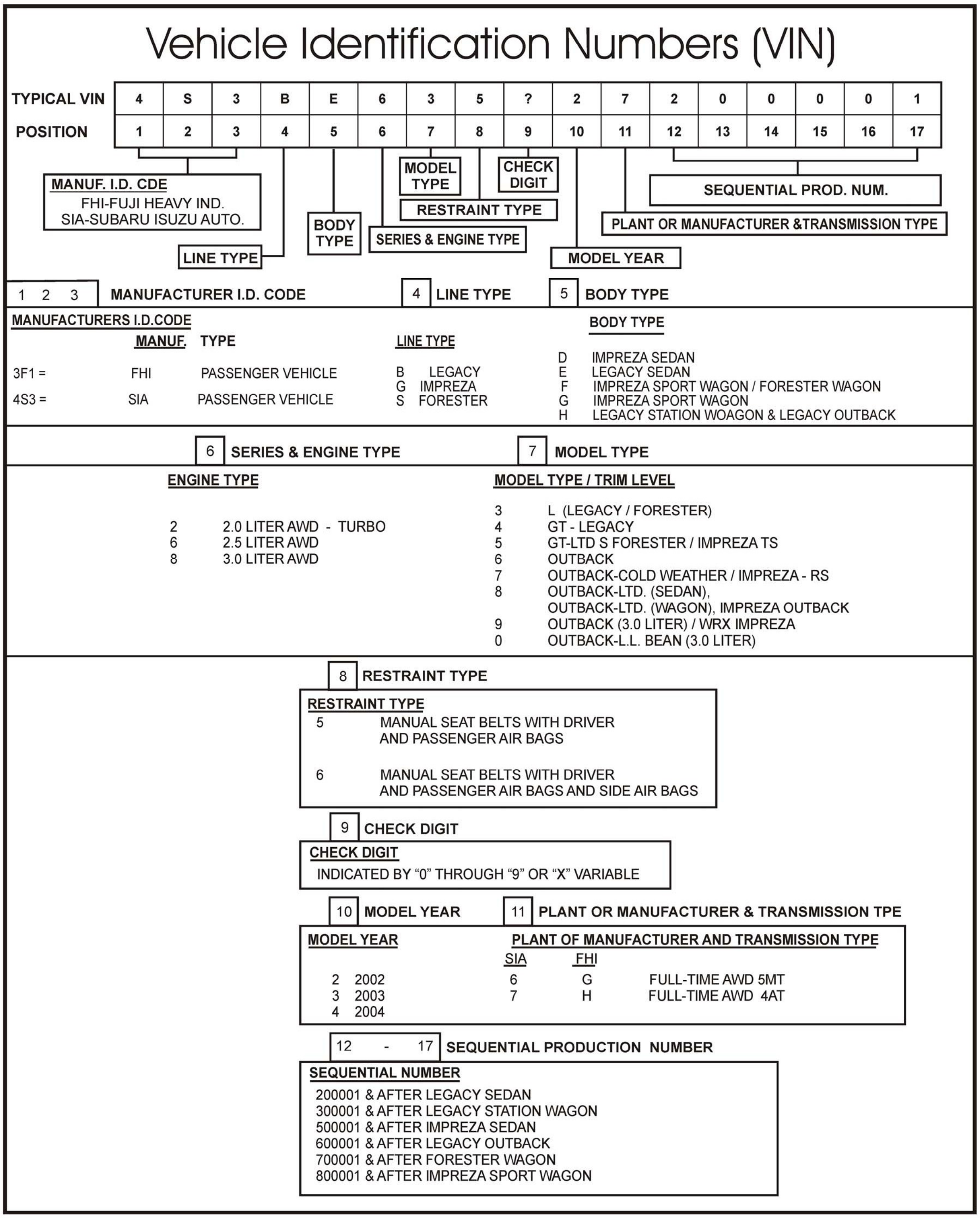
This text should be used as a supplement and reinforce classroom and lab instruction.

A list of applicable Service bulletins, important notes, cautions and special tools are given within this booklet. Pages for diagnostic tips and notes are also provided. Technicians work sheets are to be completed during the hands-on lab work segments of the Manual Transmission Module.

Always refer to the appropriate model year Subaru Service Manual, Service Manual Supplements and applicable Service Bulletins on STIS Web site for all up to date specifications and detailed service procedures.

VIN Chart

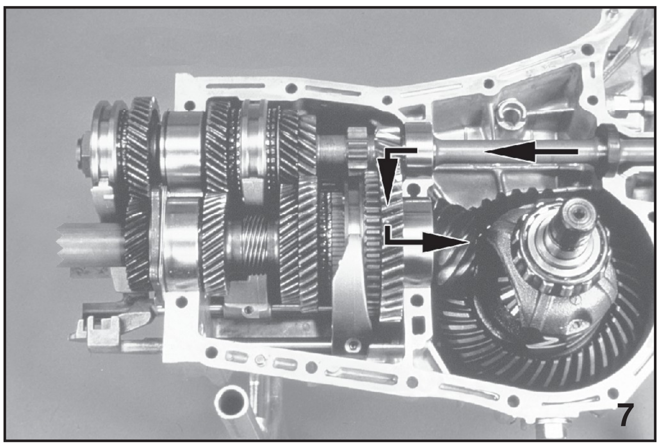
There are several different manual transmissions used in Subaru vehicles. Consult the VIN chart below as well as the appropriate Subaru Service Manual on STIS Web site to determine the transmission type on which you are working. Different model-year transmissions of the same general type may use different replacement parts.



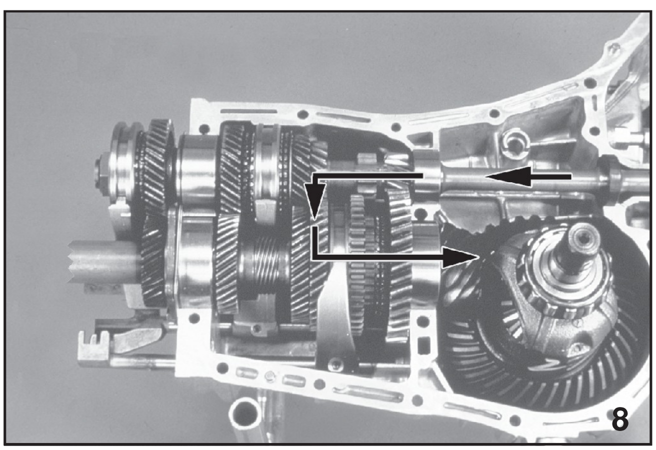
VIN Chart

6

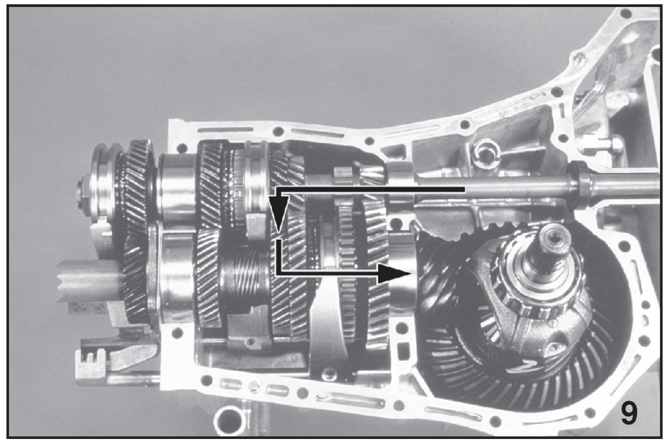
The power passes down the main shaft and across to the output shaft (pinion shaft). This is where the gear selection is made depending on which set of gears are engaged. The center differential compensates for the difference in front and rear axle speeds. It consists of a bevel gear set and a viscous coupling located at the rear of the transmission housing. The center differential, together with a pair of transfer gears, transmits the power from the transmission to the drive pinion shaft (front wheel drive shaft) and the rear drive shaft. The viscous coupling functions as a differential-action-control element.



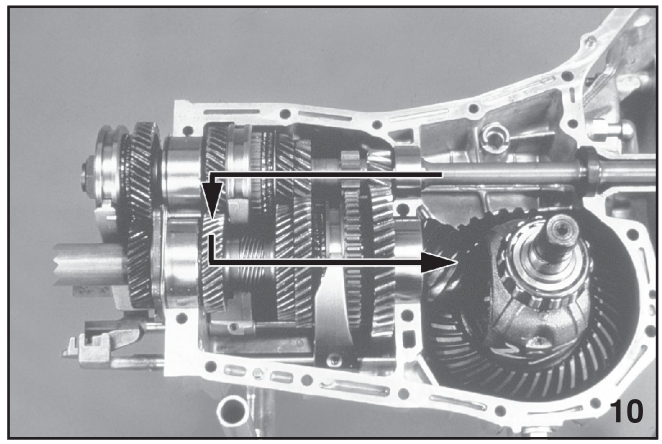
1st Gear



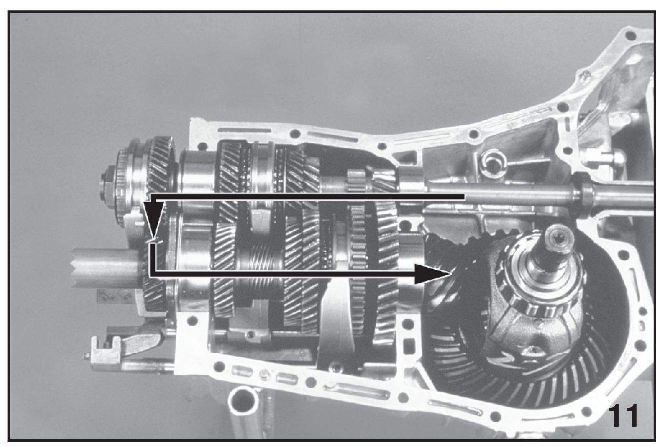
2nd Gear



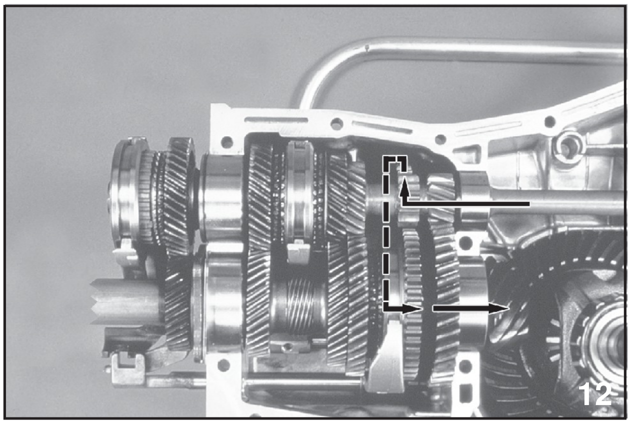
3rd Gear



4th Gear



5th Gear



Reverse

Preliminary Diagnosis

Before removal and disassembly, be sure to verify the customer complaint by making a thorough road test. Identify the probable cause before proceeding.

The following is a partial list of the more common problems that may be encountered in a transmission. For a more complete list, see the troubleshooting chart in the appropriate model year Subaru Service Manual on STIS Web site.

Gears Difficult to Engage

Possible causes: Worn, damaged, or burred spline of synchronizer sleeve; worn or damaged bushings; incorrect contact between synchronizer ring and gear cone.

Grinding Noises When Shifting

Possible causes: Worn or damaged teeth on synchronizer ring or clutch not fully disengaging.

Transmission Jumps Out of Gear

Possible Causes: Loose, worn, or broken engine mounts; worn, damaged, or incorrect shifter fork; worn 1st or 2nd driven gear, needle bearing, or race; worn 3rd or 4th drive gear or bushing; worn reverse idler gear or bushing.

Noises

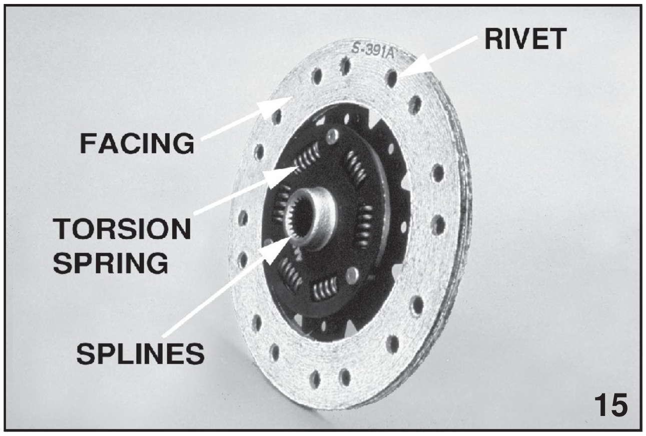
Note when the noise occurs: If it occurs only in one gear, or in all BUT one gear, suspect the components associated with that gear. If the noise occurs only when turning, suspect the differential.

NOTE: IF AN UNUSUAL NOISE IS HEARD WHEN THE VEHICLE IS PARKED WITH ITS ENGINE IDLING AND IF THE NOISE CEASES WHEN THE CLUTCH IS DEPRESSED, IT MAY BE CONSIDERED THAT THE NOISE COMES FROM THE TRANSMISSION.

NOTE: IF THE TROUBLE IS ONLY WEAR OF THE TOOTH SURFACES, MERELY A HIGH ROARING NOISE WILL OCCUR AT HIGH SPEEDS. IF ANY PART IS BROKEN A RHYTHMICAL KNOCKING SOUND WILL BE HEARD EVEN AT LOW SPEEDS.

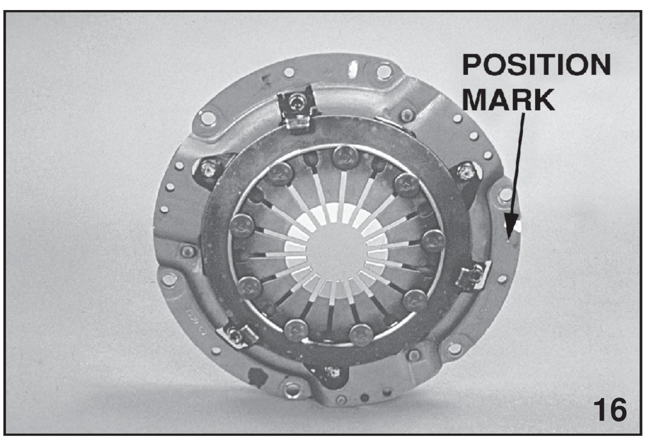
Notes:

Mechanical Operated (Cable Operated Push Type)



Clutch Disc

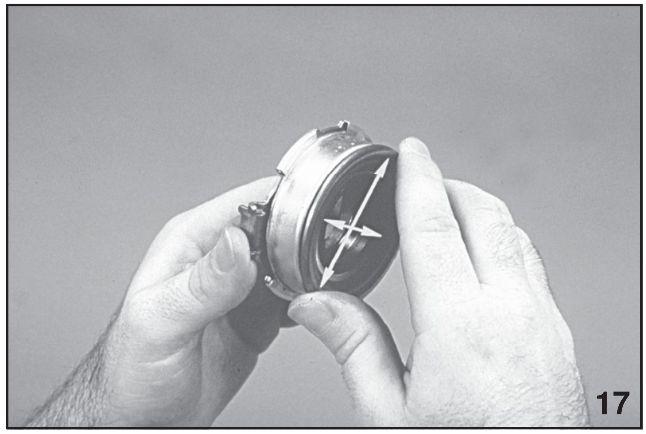
Inspect the disc for hardened or oil-soaked facing material, worn splines, loose rivets, or torsion spring failure. Measure the depth of the rivet heads, replace the disc if not within specifications. Measure the run out or warpage of the disc with a dial indicator and the proper guide. This is measured at the outer circumference of the facing. Refer to the appropriate model year Subaru Service Manual on STIS Web site.



Clutch Cover

Visually check the clutch cover without disassembling it. Look for loose rivets, a damaged or worn throw out bearing contact area or disc surface, a loose plate strap setting bolt, or a worn spring sliding surface.

(Position mark is "0" mark. Used during installation.)



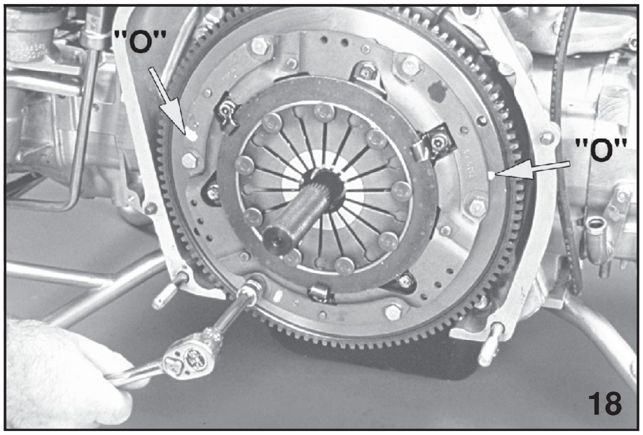
Clutch Release Bearing

Rotate the release bearing while applying pressure in the thrust direction (also radial direction on self- centering bearing). Feel for smoothness of rotation. Also look for wear to the surfaces that contact the release lever and transmission case.

NOTE: THIS IS A SEALED BEARING; DO NOT WASH IT IN SOLVENT. CHECK FOR SIGNS OF LEAKAGE

NOTE: INSURE RELEASE LEVER PIVOT BALL IS LUBRICATED.

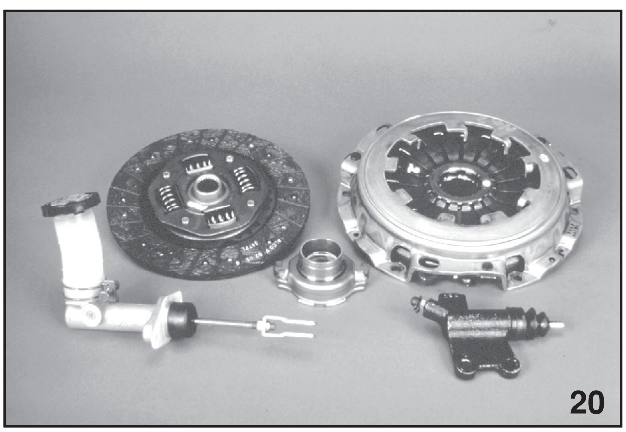
Check the release lever for wear on the pivot or the point of contact with the bearing. Check the contact surface of the flywheel for wear or heat damage. Also check the pilot bearing in the flywheel for smooth rotation. This is also a sealed bearing; do not wash it in solvent.



"O" marks

To install the clutch, place the clutch disc on the disc guide, and position the disc on the flywheel with the word "front" facing the flywheel. Position the cover with the "O" marks on the cover and the flywheel as far apart as possible. Tighten the bolts gradually to draw the cover in evenly. Torque the bolts to specification.

Hydraulic Clutch (Pull Type Legacy and WRX Turbo)



Hydraulic Clutch Components

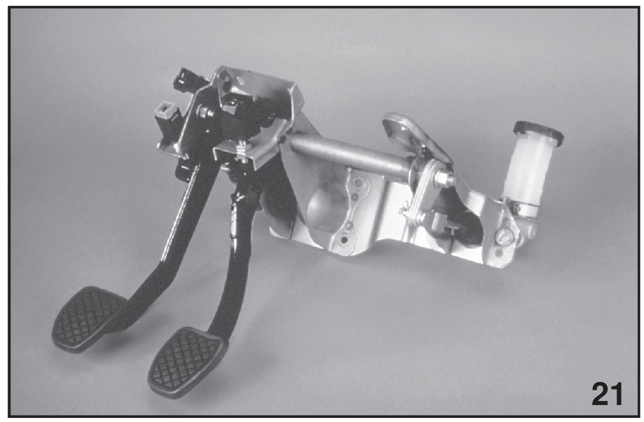
The Subaru hydraulic clutch has been designed for use in our speed/endurance record vehicles and the turbo equipped EJ Series engines. The major advantage, in addition to increased durability and strength, is the self-adjusting feature of the clutch. This eliminates the "free play" adjustment required of the mechanical clutch. The hydraulic clutch, however, does require proper initial linkage adjustment.

Components of the hydraulic clutch are:

- Master cylinder
- Damper assembly
- Operating (slave) cylinder
- Release bearing (pull type)
- Release lever
- Release shaft

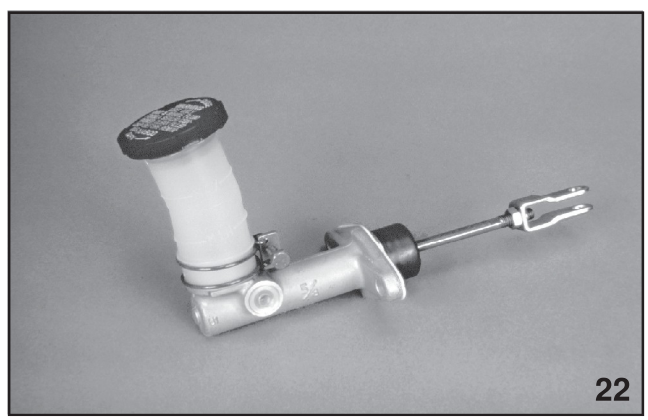
Modified components are:

- Flywheel
- Pressure plate
- Clutch disc
- Pedal mounting platform



Clutch Pedal Assembly

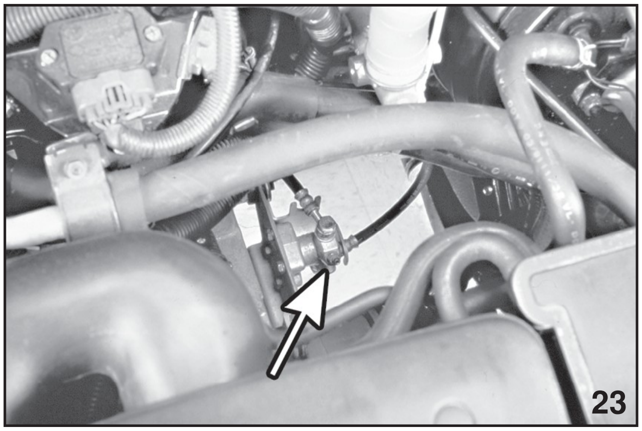
The hydraulic clutch master cylinder operates similar to the brake master cylinder. It is mounted to the right of the clutch pedal. Pedal input is transmitted by a torque rod to the lever at the end of the master cylinder.



Master Cylinder

The aluminum cylinder body has an internal piston which is operated by the push rod. It uses a cup type seal in the bore of the cylinder body. **The master cylinder is not field serviceable.**

Manual Transmissions (201)



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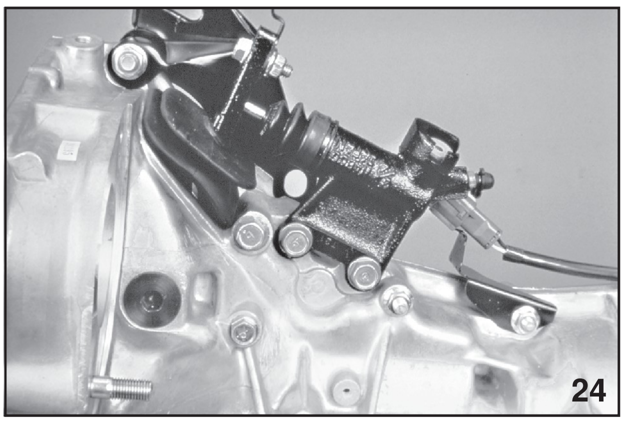
Clutch Damper

A clutch damper is mounted between the master cylinder and the operating cylinder to control the hydraulic noise of the system.



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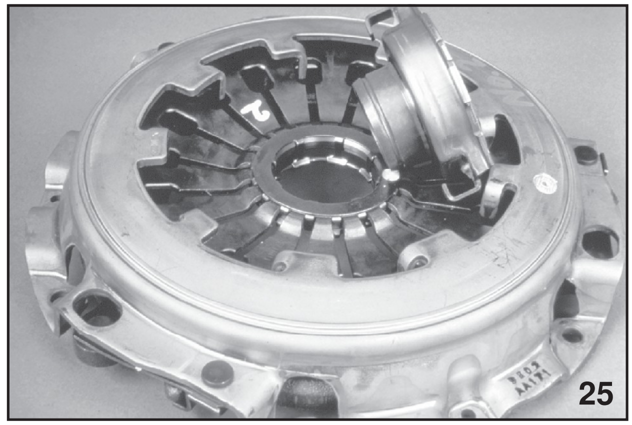
Operating Cylinder

The operating (slave) cylinder is mounted on the transmission. It has a cast iron cylinder body with an internal piston and cup type seal and operates similar to a brake wheel cylinder. It has an air bleed port on top of the cylinder. The bleeding process is similar to a wheel cylinder procedure. The operating cylinder is not field serviceable.



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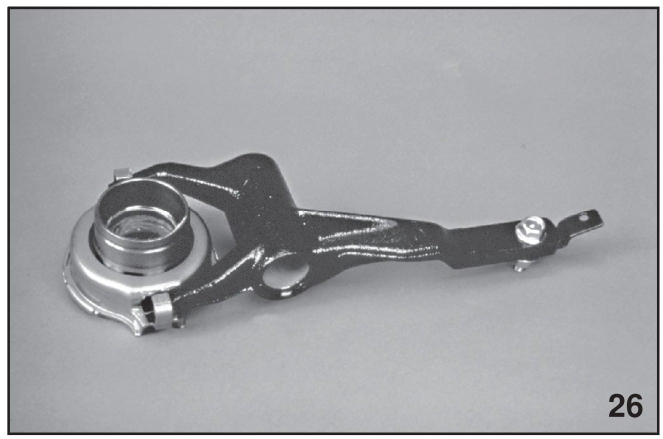
Release Bearing

The constant mesh type release bearing pulls to release the clutch. The release bearing locks into the pressure plate diaphragm springs through the use of a locking wedge collar.



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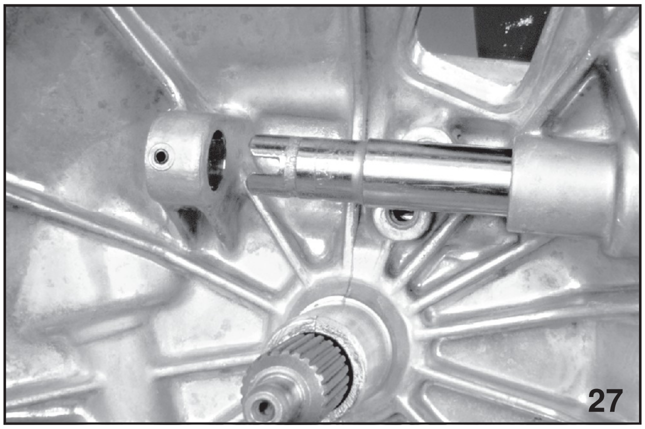
Release Fork (lever)

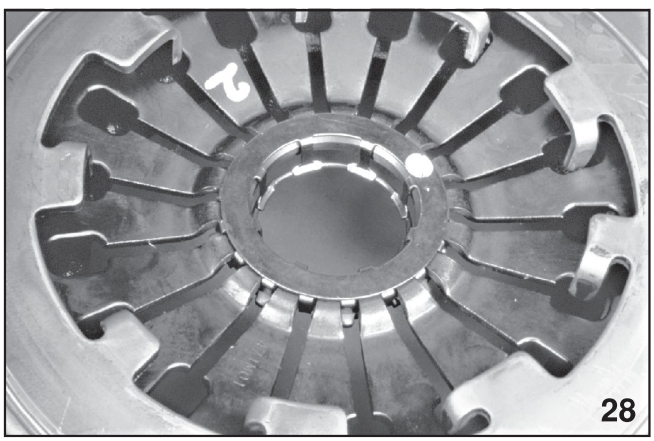
The cast iron release fork (lever) pivots on a shaft. The off-center design of the pivot point provides an increased mechanical advantage which results in less effort required to release the clutch. The release fork pulls the release bearing towards the transaxle to disengage the clutch. The bushing is not field serviceable.



Release Fork Shaft / Spring

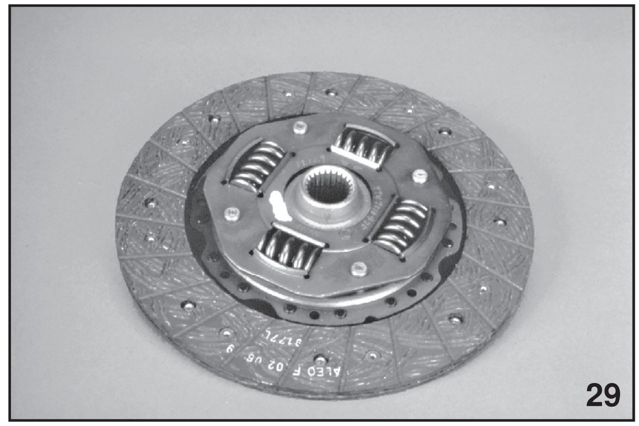
The release fork bushing is mounted to the transmission on a steel shaft. The non-rotating shaft has a split end which aligns with a pin in the transmission case. The shaft is held in place by a plug.

The return assist spring is connected between the transmission case and the release fork.



Clutch Cover (Pressure Plate)

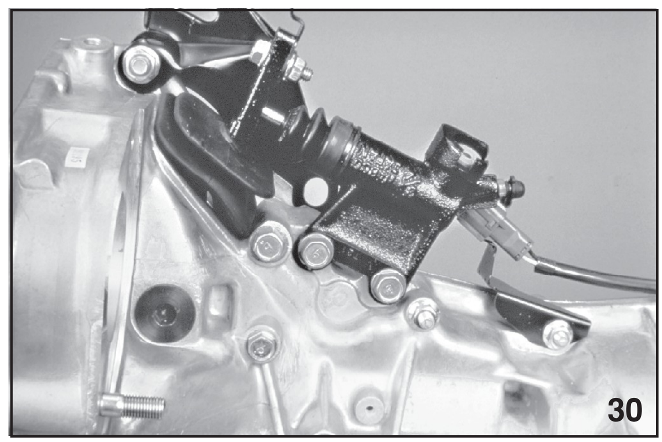
The clutch cover is a diaphragm (Belleville) type spring which is pulled by the release bearing to release pressure from the plate. The cover serves as the fulcrum. A locking wedge collar for the release bearing is an integral part of the clutch cover assembly.



Clutch Disc

The facing is made of non-asbestos material. The hydraulic clutch disc has larger damper springs than the N.A. clutch to withstand the increased turbo engine torque.

The flywheel diameter and thickness have been decreased from the N.A. clutch to provide for cooler operation and faster acceleration.



Clutch Operation

Hydraulic pressure from the master cylinder flows through the damper to extend the operating cylinder piston. The piston pushes on the release fork. As the fork pivots on the shaft it pulls the release bearing which is locked to the pressure plate diaphragm spring. As the diaphragm spring moves outward (away) from the clutch disc, it disengages engine power from the transmission.

Releasing the pressure from the master cylinder allows the operating cylinder piston to retract. This allows the diaphragm spring to move toward the clutch disc, reapplying the pressure to move the pressure plate inward to clamp the clutch disc between the flywheel and the pressure plate. The power flow from the engine through the clutch to the transmission is then restored.

The release fork return spring connected between the fork and the transmission provides constant inward pressure on the fork. This maintains constant outward pressure on the locking wedge collar of the release bearing, preventing release bearing disengagement from the locking wedge collar.

NOTE: WHENEVER THE HYDRAULIC CLUTCH PARTS ARE SERVICED AND/OR REPLACED, PRECISE LINKAGE ADJUSTMENTS MUST BE PERFORMED IN THE PROPER SEQUENCE TO INSURE PROPER CLUTCH OPERATION AND TO AVOID POSSIBLE DAMAGE TO THE CLUTCH COMPONENTS.

Release Bearing / Noise Diagnosis

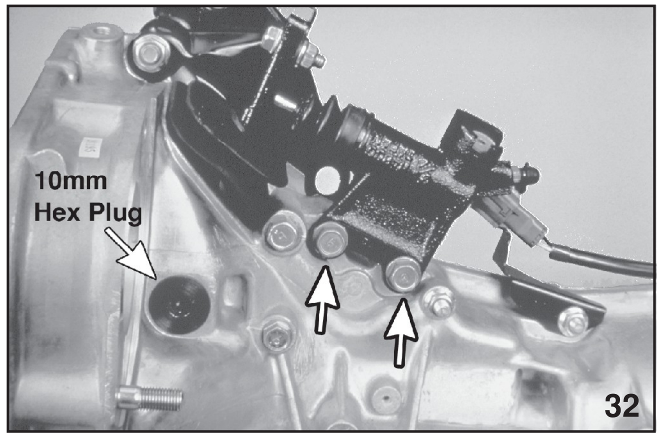
1. Grinding or "Howling"
   - Release Bearing
2. Clutch Pedal Depressed
   - Noise disappears
     - Trans. Bearing
   - Noise increases
     - Pilot Bearing

The fork return spring maintains the release bearing under constant outward pressure against the pressure plate diaphragm spring. And, unlike conventional clutch systems, the bearing always rotates. Thus, a defective release bearing will make a grinding or "howling" noise. The noise will change when the clutch pedal is depressed, and the noise may or may not stop.

If the noise completely stops when the clutch pedal is depressed and the transmission is in "gear" the problem is most likely a transmission bearing. If the noise becomes louder when the clutch pedal is depressed and the transmission is in "gear" it is most likely a defective pilot bearing.

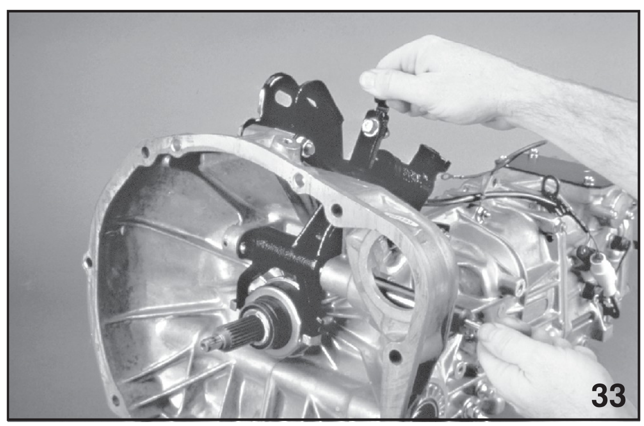
Transmission Removal

<u>NOTE:</u> ALWAYS REFER TO THE APPROPRIATE MY SUBARU SERVICE MANUAL ON STIS WEB SITE FOR DETAILED REMOVAL STEPS. THE FOLLOWING STEPS MUST BE PERFORMED <u>PRIOR</u> TO THE REMOVAL OF A HYDRAULIC CLUTCH EQUIPPED TRANSMISSION (PULL TYPE) FROM THE ENGINE AND VEHICLE OR DAMAGE WILL OCCUR TO CLUTCH ASSEMBLY.



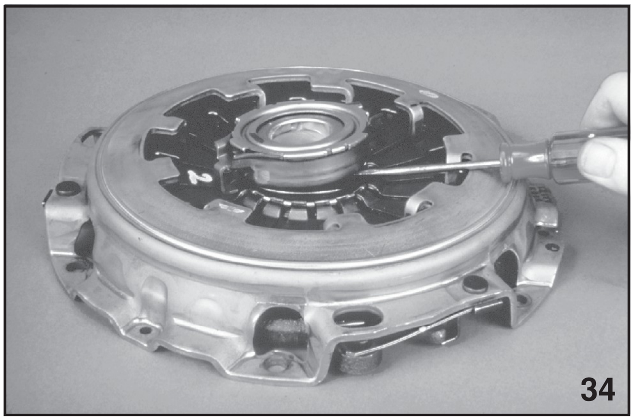
Operating Cylinder Removal

Remove the operating cylinder mounting bolts. Do not disconnect the hydraulic line from the operating cylinder.



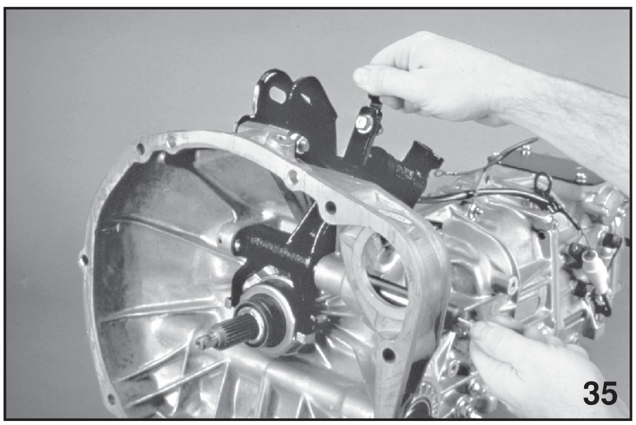
Release Fork Shaft Removal

Use a 10mm hex wrench to remove the plug from the side of the transmission case to access the release fork shaft. Then insert a 6 mm bolt into the release fork shaft and remove the shaft. Pull the release fork up and away from the transmission. This will allow the transmission to be separated from the engine.



Release Bearing Removal

Prior to installing the clutch to the transmission you must remove the release bearing from the pressure plate. Gently pry between the locking wedge collar and the face of the release bearing.



Release Bearing Installation

Install the release bearing over the transmission input shaft bearing retainer. Install the release fork into the release bearing retaining ears. Insert the release fork shaft through the transmission case (slotted end first) through the fork bushing into the transmission case mount. The shaft slot must align with the pin in the case mount. Then use a 10mm hex wrench to install the case plug to lock the fork into the case.

Be sure that the locking wedge collar is properly installed in the pressure plate.

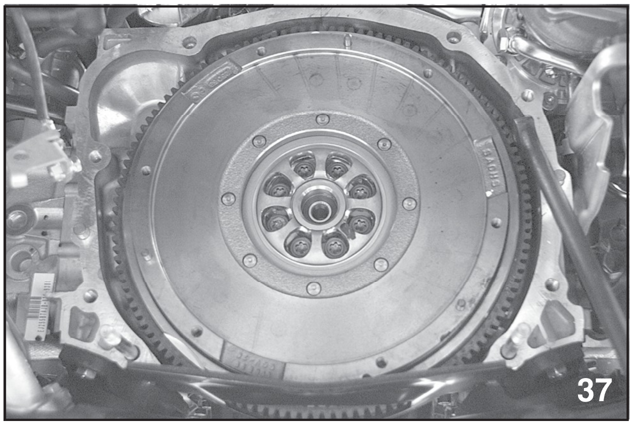
NOTE: ALWAYS REFER TO THE APPROPRIATE MY SERVICE MANUAL ON STIS WEB SITE, FOR THE DETAILED TRANSMISSION INSTALLATION STEPS.

Upon completion of the installation of the transmission to the engine, manually push the fork toward the operating cylinder until a "click" is heard. This forces the release bearing to lock into the wedge collar.

Verify that the bearing is locked into the wedge collar by manually pushing the fork towards the transmission clutch housing. The clutch should operate.

NOTE: THE FORK SHOULD NOT TOUCH THE TRANSMISSION CASE CLUTCH HOUSING AS THIS INDICATES THAT THE BEARING IS NOT LOCKED TO THE PRESSURE PLATE.

Flywheel



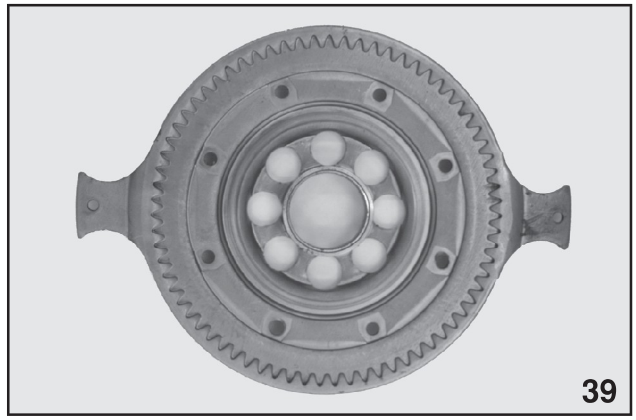
Flywheel Installed

2005MY and later Legacy Turbo vehicles with manual transmission are equipped with a Dual Mass Flywheel. A special tool is required to remove flywheel bolts (J-41510). This flywheel is non serviceable and should not be resurfaced.

The clutch contact surface of the flywheel can move slightly in either direction while the inner mass of the flywheel is stationary.

Cutaway view with springs installed on one side only

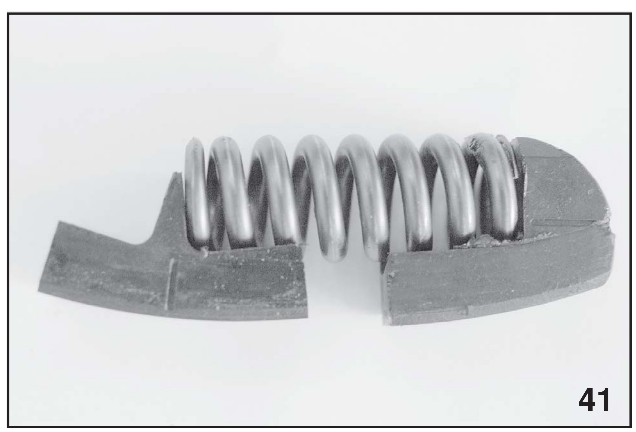
The Dual Mass Flywheel provides a smoother transfer of power from the engine to the clutch assembly by absorbing vibration and shock through a series of springs that are arranged along the circumference of the flywheel.



Actuator

First Mass and Gears

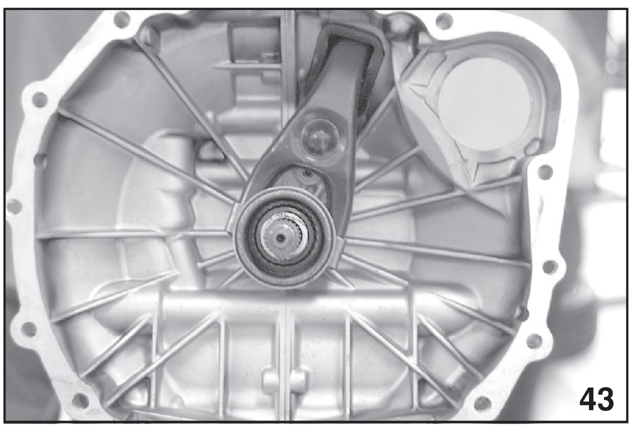
The first mass of the flywheel is connected to the crankshaft and delivers power to the second mass which acts as the contact surface for the clutch plate. The second mass is riveted to an actuator that is supported internally by a set of gears that ride along an internal cut gear of the actuator.



Spring and Spring Carrier

Actuator in contact with Spring Carrier

The actuator power input points will engage with the spring carriers on acceleration or deceleration. The springs will compress as the force to them is increased (On acceleration) and deliver the power to the actuator and finally to the clutch plate.



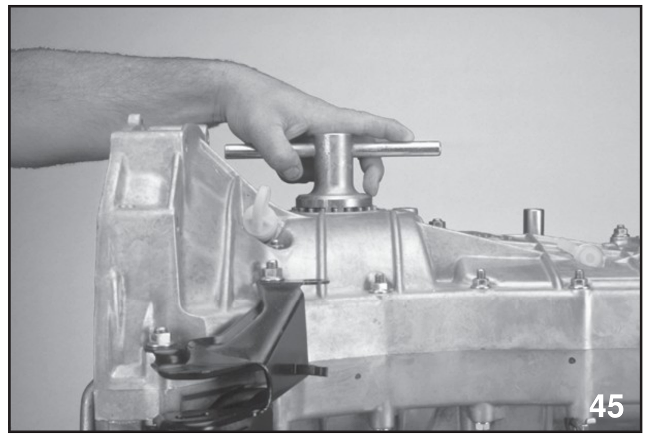
Release Bearing

The release bearing is a push type. Consult the Subaru Service Manual on STIS Web site for proper servicing of the release bearing and removal / installation of the transmission.

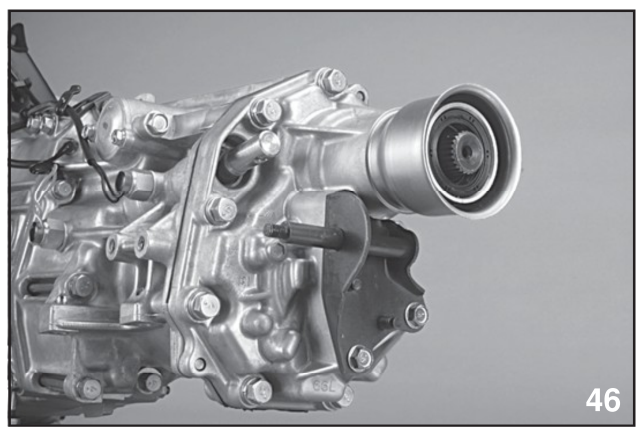
Component Removal

Attach the transmission case to the appropriate special tool stand set (499937100), right-hand side up (nuts on case bolts facing up).

Precautions
- Reduce preload
- Do not lose detent balls
- Remove all case bolts

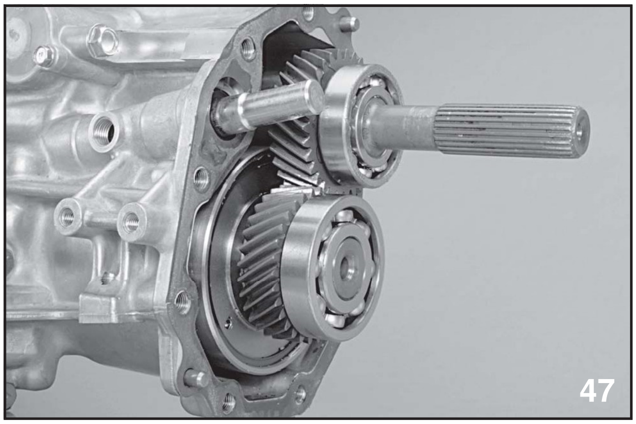


Reducing Preload



Extension Housing

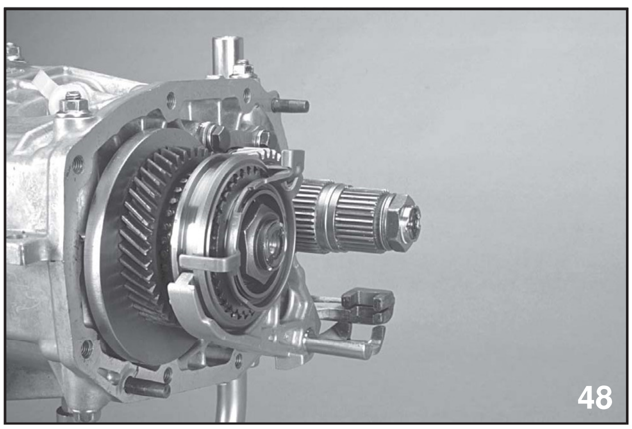
Remove
- Extension housing
- Transfer housing, then split cases
- Drive pinion shaft
- Transmission main shaft
- Differential



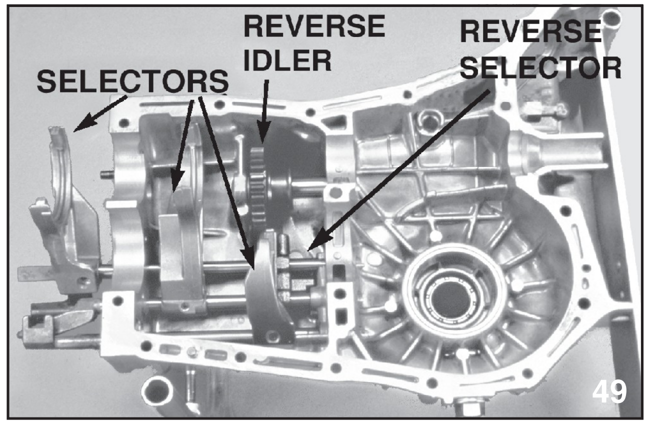
Transfer Gears

Transfer Case Removal

Disconnect the backup light and neutral switch connectors. Remove the transfer case cover bolts and transfer case cover. Then remove the selector arm set screw and the reverse check mechanism.

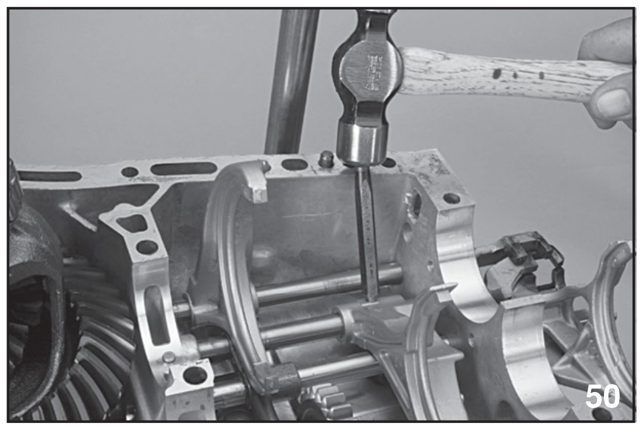


5th / Reverse Synchronizers

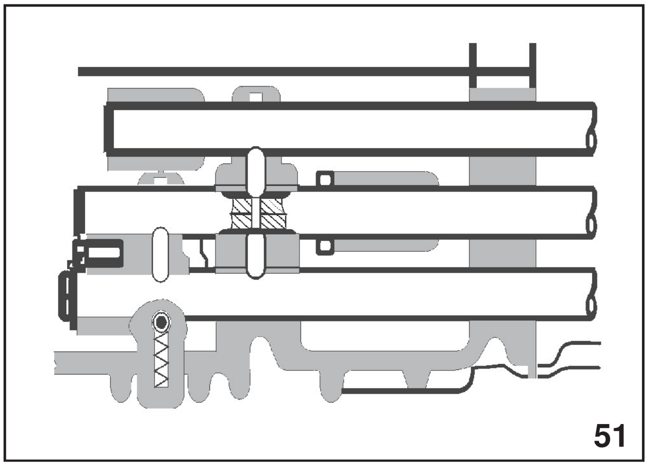


Shifter Forks and Rails

The shifter forks are retained by set screws (bolts) or spring pins. Drive out the pins with the 1-2 shift rail in first gear and the 3-4 rod in neutral; there are recesses in the case that allow room for the pins to come out in these positions.

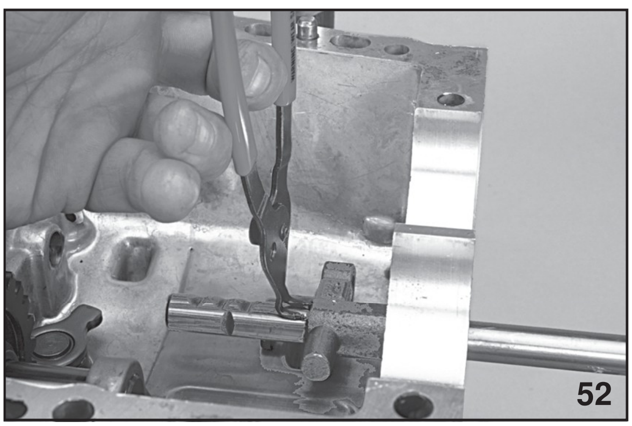


Shift Fork Pin Removal



Shift Rail Interlock Mechanism

When removing a shift rail, keep the remaining rails in the neutral position. The interlock mechanism prevents more than one rail being out of neutral position at a time. Remove the reverse idler gear and washer, pulling out the straight pin. Remove the reverse shifter arm and rod.



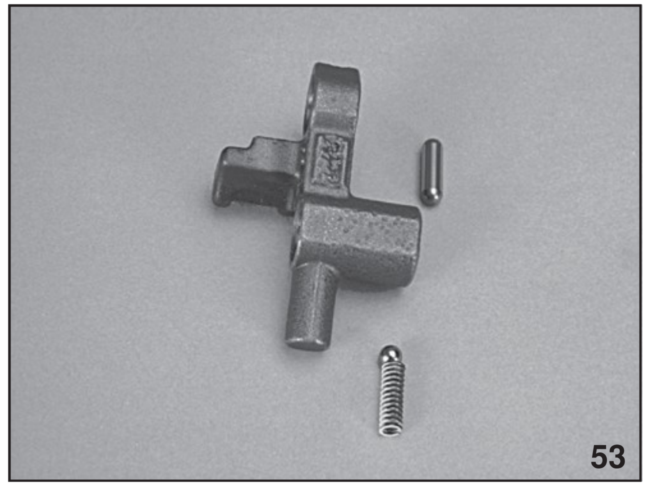
Reverse Shifter Rod

Remove outer snap ring, and pull out reverse shifter rod arm from the reverse fork rod. Then take out the ball, spring and interlock plunger from the rod.

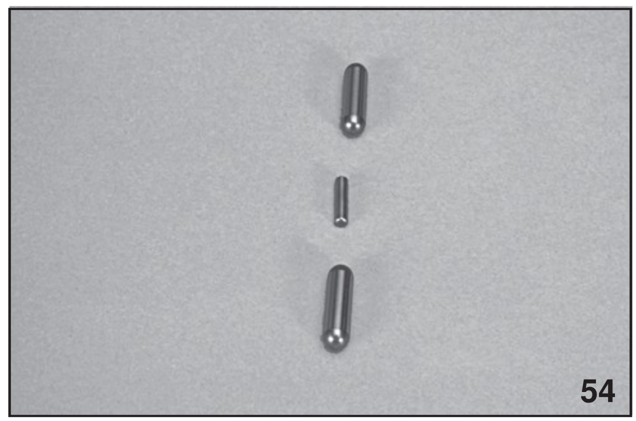
And then remove rod.

When pulling out the reverse shifter rod arm, be careful not to let the ball pop out of the arm.

NOTE: SNAP RING IS DIRECTIONAL. BEVEL SIDE MUST BE TOWARDS INTERLOCK.

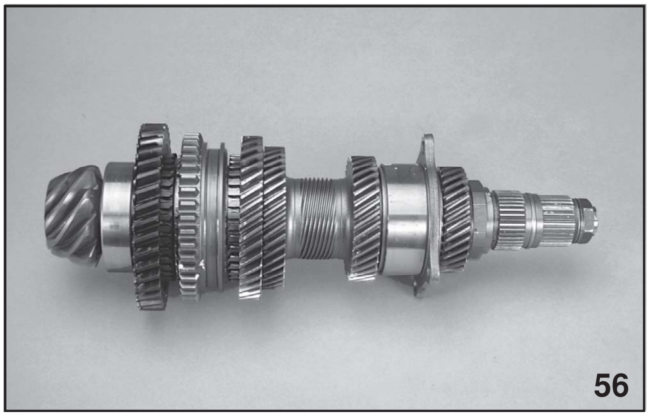


Reverse Fork Rod Arm, Pin ,Ball and Spring

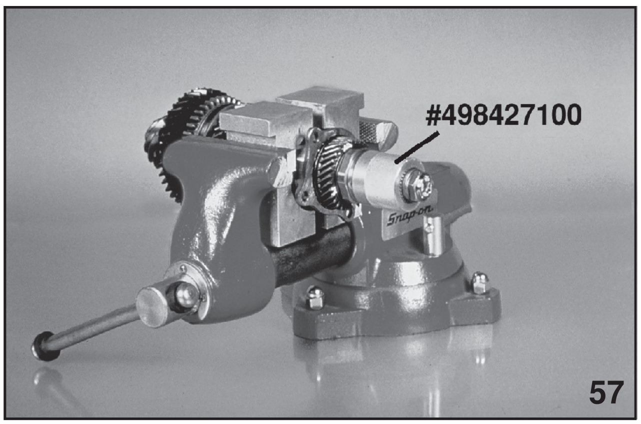


Interlock Plungers and Pin

Drive Pinion Shaft Disassembly

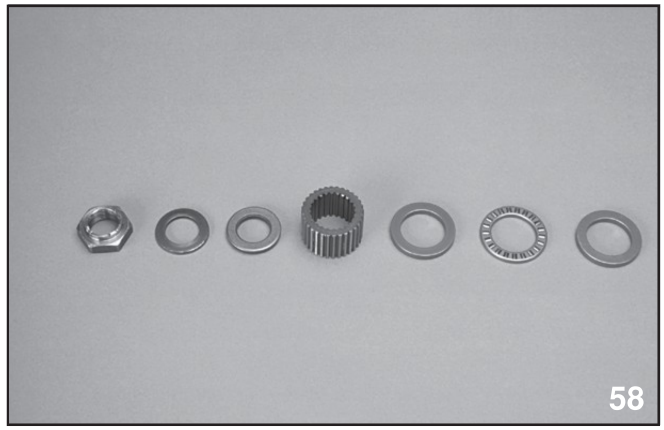


Drive Pinion Shaft Assembly



Remove Pinion Shaft Lock Nut

Remove the lock nut after installing holder **899884100** stopper **498427100** and socket **899988608**.

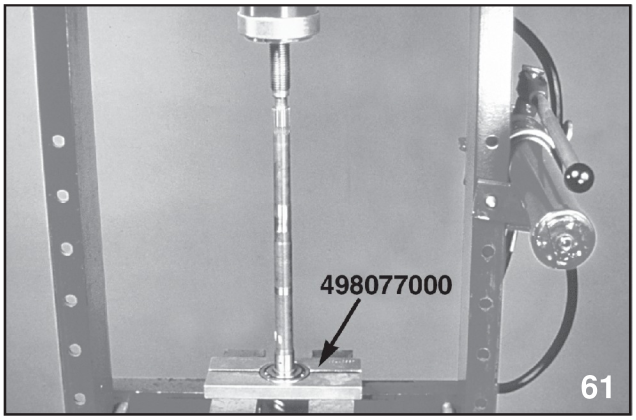


Differential Bevel Gear Sleeve Parts

Withdraw drive pinion from driven shaft. Remove differential bevel gear sleeve, adjusting washer No. 1, adjusting washer No. 2, thrust bearing, needle bearing, drive pinion collar, needle bearing and thrust bearing.

Drive Pinion and Driven Shaft Assembly

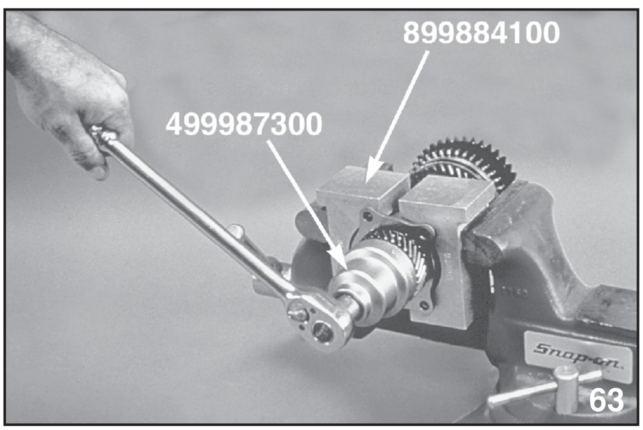
Pinion Shaft Disassembly



Press Pinion Shaft Bearing and Washer

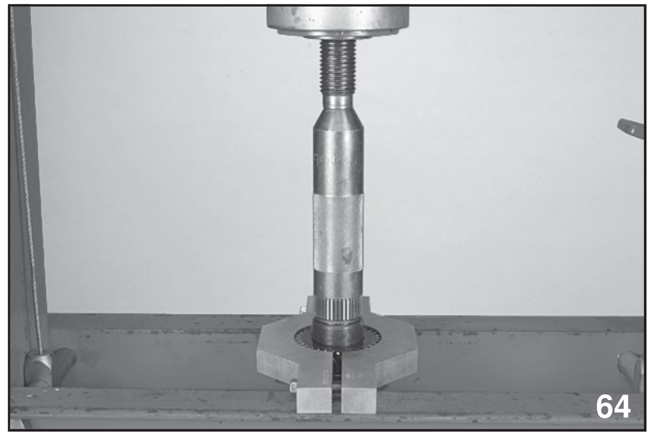
Use the remover 498077000, press the pinion shaft bearing and washer from the pinion shaft.

Driven Shaft Disassembly



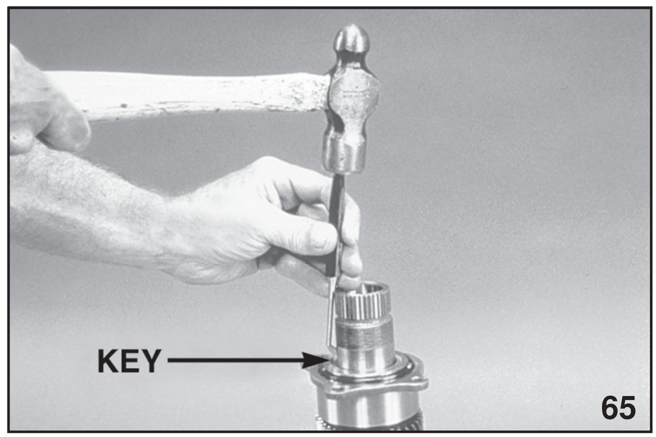
Driven Shaft Lock Nut Removal

Unstake the lock nut, and use the holder **899884100** and the socket wrench **499987300** to remove the lock nut from the driven shaft assembly.



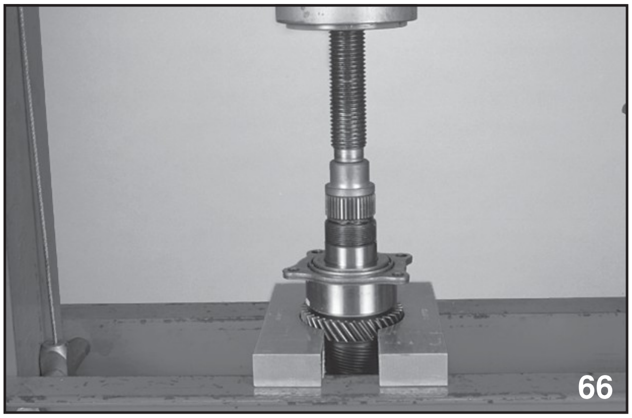
Press 5th Driven Gear

Press 5th driven gear from the driven shaft assembly using the remover **499857000** and press **499757002**.



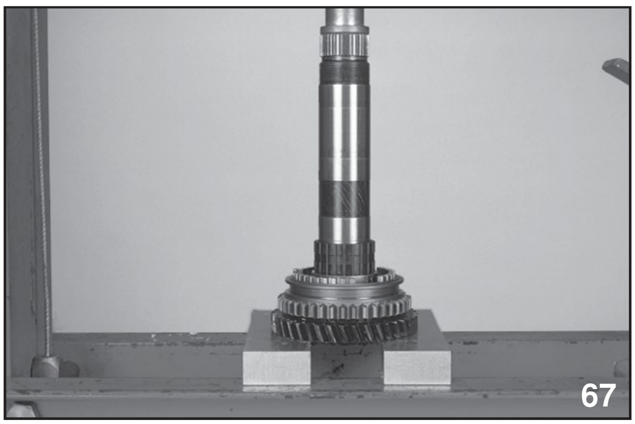
Woodruff Key Removal

Remove the Woodruff key prior to removing the roller bearing and the 3rd-4th gear assembly. Use a drift and a hammer to remove the key. Be careful not to damage the gears, shaft, or bearing.



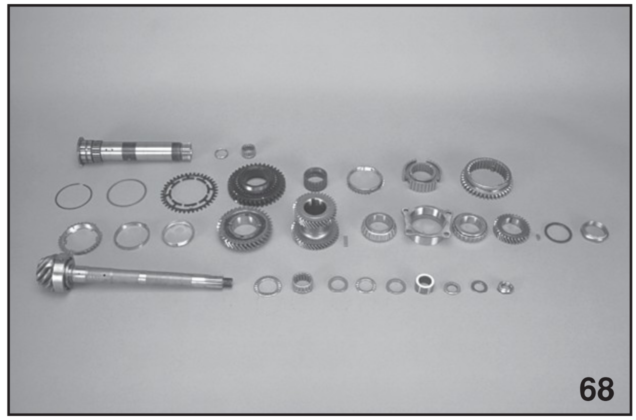
Press Roller Bearing and 3rd-4th Gear Assembly

Press the roller bearing and the 3rd-4th gear assembly using the remover **899714110** and press **499757002**.



Press 1st and Rev Gear Assembly

Prior to removing any of the other driven gear assembly components, the driven shaft key must be removed. Use a hammer and a drift to remove the key. Lift off the 2nd gear assembly, and then press the 1st driven gear, the 2nd gear bushing, the reverse gear, and the 1st-2nd gear synchronizer hub using the remover **899714110** and press **499757002**.



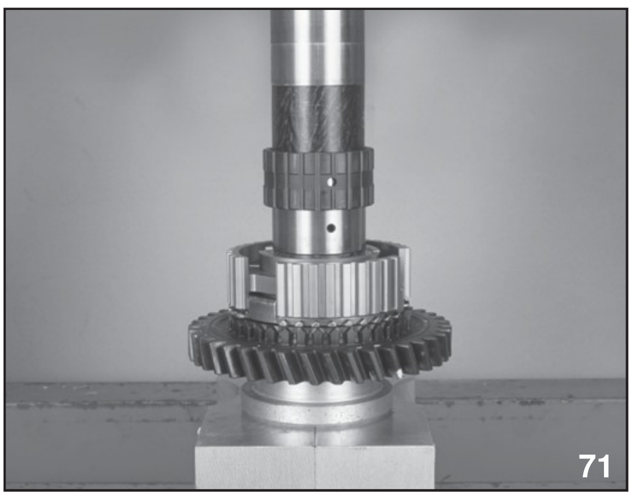
Drive Pinion and Driven Shaft Components

Notes:

Driven Shaft Reassembly

1st Driven Gear Bushing

The driven shaft is placed on top of the installer **499587000** to make sure that 1st driven gear is pressed flush to the driven shaft.



2nd Driven Gear Bushing

Install washer, snap ring and sub gear (if equipped) to 1st driven gear.
Install 1st driven gear, 1st baulk ring, gear and hub assembly onto driven shaft.

NOTE:

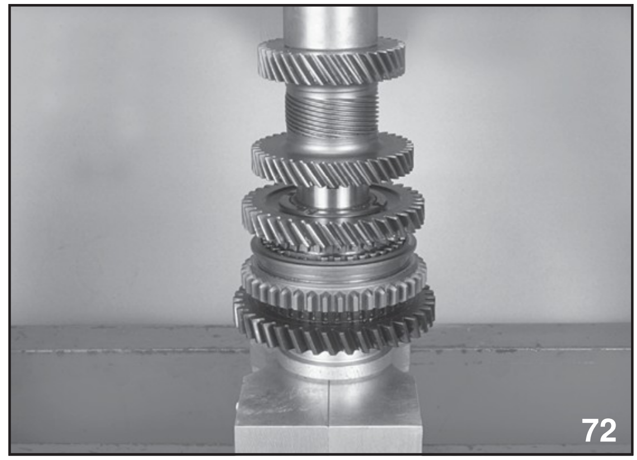
- Take care to install gear and hub assembly in proper direction.
- Align baulk ring and gear & hub assembly with key groove.

Install 2nd driven gear bushing onto driven shaft using **499277200** Installer and **499587000** Installer.

Install 2nd driven gear, inner baulk ring, synchro cone, outer baulk ring and insert onto driven shaft.

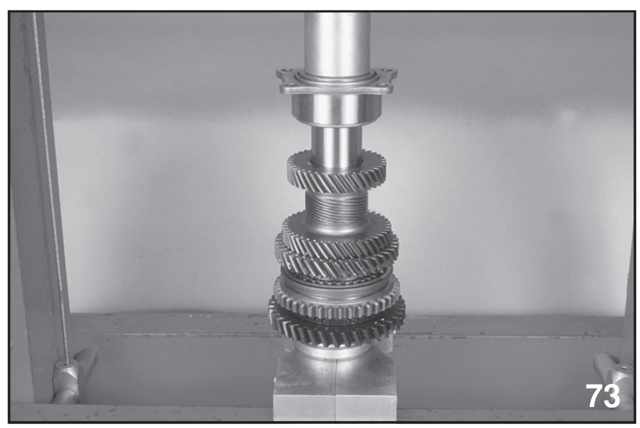
NOTE:

- Place a suitable spacer between the installer 499587000 and the driven shaft to provide clearance between the 1st gear and installer
- When press fitting, align oil holes of shaft and bushing.



3rd-4th Driven Gears

After installing woodruff key on driven shaft, install 3rd-4th driven gear using **499277200** installer.



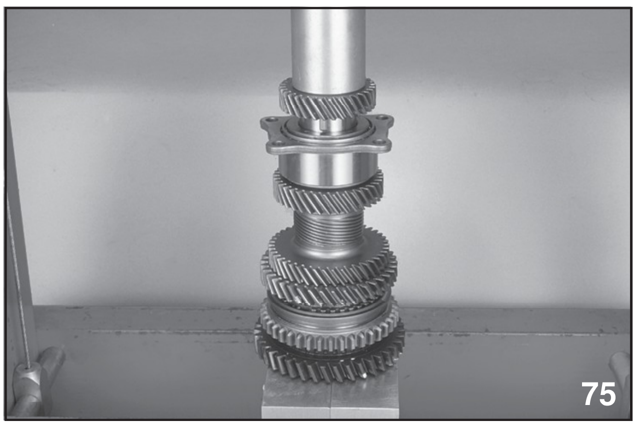
Pinion Shaft Roller Bearing

Install the roller bearings and bearing retainer onto driven shaft using **499277200** installer.

Install the lower bearing first. Then place the bearing retainer on the lower bearing. **Finally press on the upper bearing.**

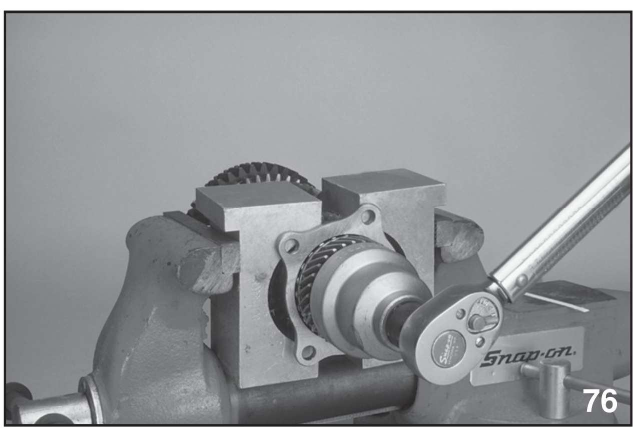
Woodruff Key

Position 5th gear woodruff key in groove on the rear of driven shaft.



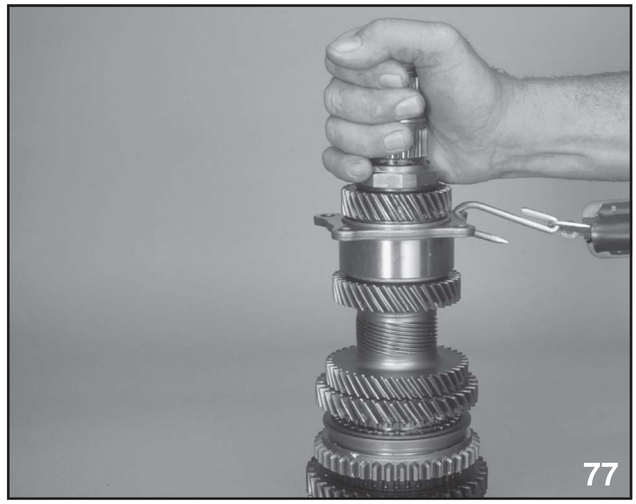
5th Driven Gear

Install and press 5th gear onto driven shaft.



Install Driven Shaft Washer and Lock Nut

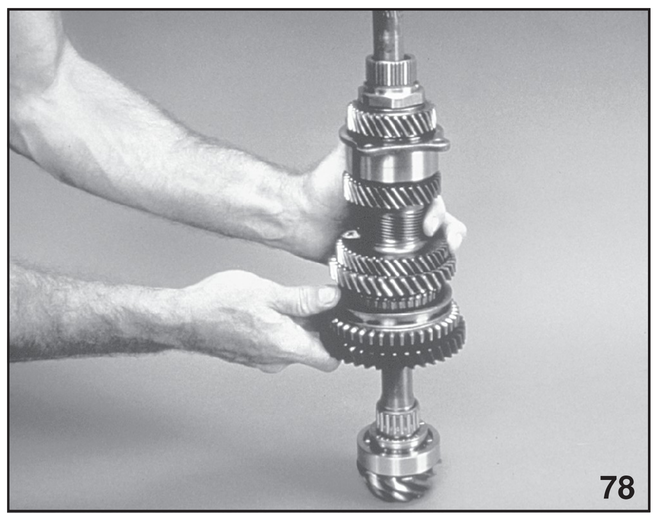
Install a new driven shaft washer and lock nut, and then use the holder **899884100** and the socket wrench **499987300** to torque the lock nut to specification. Stake the lock nut at two points.



Roller Bearing Starting Torque

Use a spring gauge to measure the starting torque of the roller bearing.

NOTE: IF NOT WITHIN SPECS, REPLACE THE ROLLER BEARINGS.

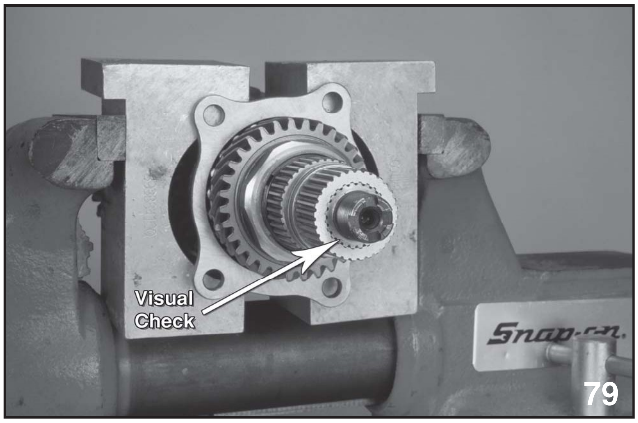


Install Driven Shaft Assembly

Install the bearing on the pinion shaft, and press the washer using the installers and press.

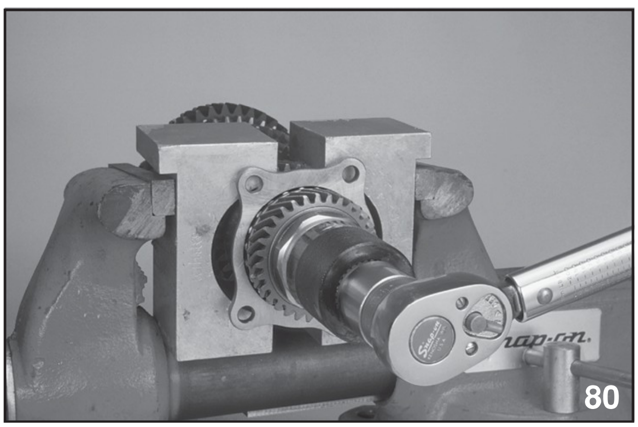
NOTE: THE BEARING IS DIRECTIONAL AND MUST BE INSTALLED WITH THE KNOCK PIN HOLE AWAY FROM THE PINION GEAR.

Then place the thrust bearing on the pinion shaft, and carefully install the driven shaft assembly onto the pinion shaft.



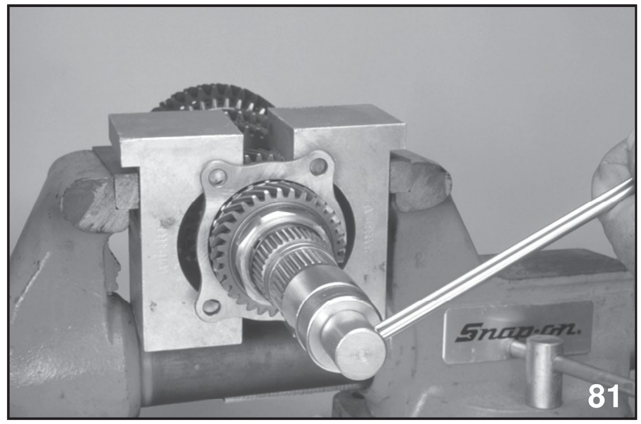
Visual Check / Bearing Preload

With a visual check confirm that the end of the pinion shaft and the differential bevel gear sleeve are flush. If they are not flush, select a adjusting washer No. 2 so that they are flush with a visual check. Install the washer, a new lock washer and new lock nut.



Torque Lock Nut

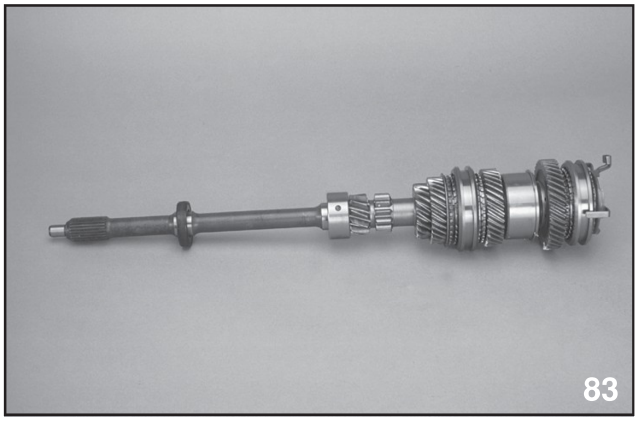
Torque lock nut using **899884100** holder, **498427100** stopper and **899988608** socket tighten lock nut to specified torque.



Lock Nut Starting Torque

After removing the **498427100** stopper, measure the starting torque using a torque wrench. If starting torque is not within specified limit, select a new adjusting washer No. 1 and recheck. If specified torque range cannot be obtained when No. 1 adjusting washer is used, then select a suitable No. 2 adjusting washer. These washers are selective: See appropriate model year Subaru Service Manual on STIS Web site for procedure and tables. Stake lock nut at four places.

Transmission Main Shaft Disassembly

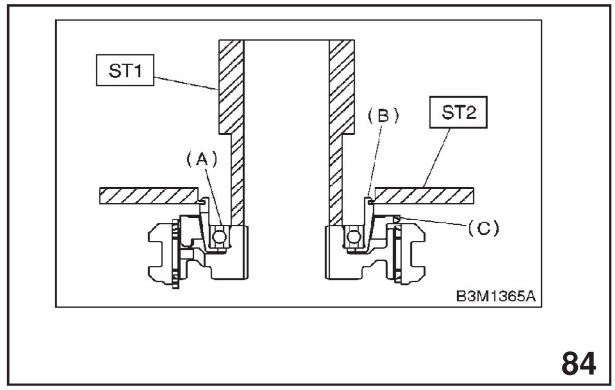


Main Shaft Assembly

Remove lock nut from main shaft assembly using **498937000** holder and **899984103** socket.

Remove 5th-rev. sleeve and hub assembly, baulk ring, 5th drive gear and needle bearing. The following steps apply to 1999 MY and newer. You only need to do this if you are servicing 5th Rev. gear components. Remove snap ring and synchro cone stopper from 5th-rev sleeve and hub assembly.

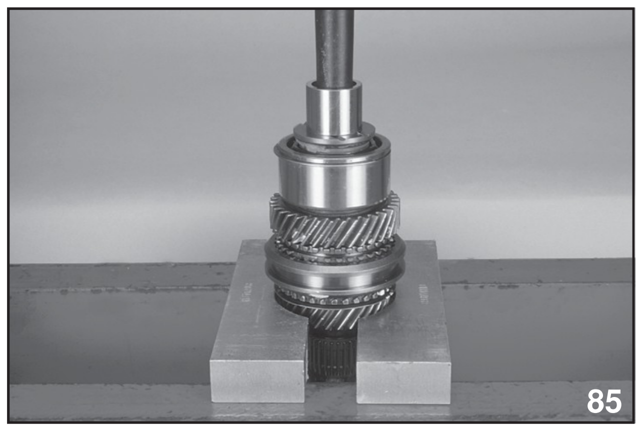
ST1	499757002	SNAP RING PRESS
ST2	498077400	SYNCHRO CONE REMOVER



Removing Synchro Cone and Baulk Ring

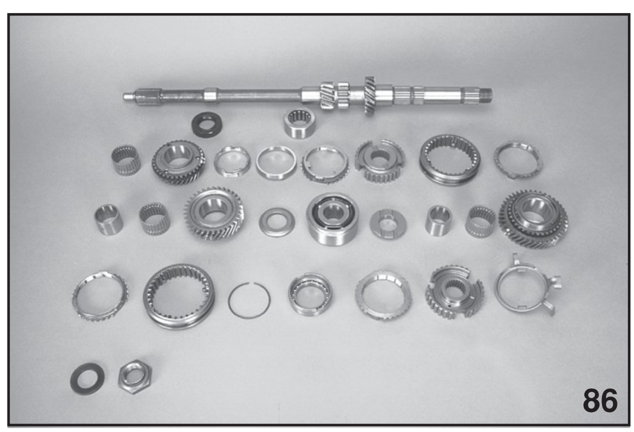
(A) Ball bearing
(B) Synchro cone
(C) Baulk ring

Using ST1, ST2 and a press, remove ball bearing, synchro cone and baulk ring (Rev.)



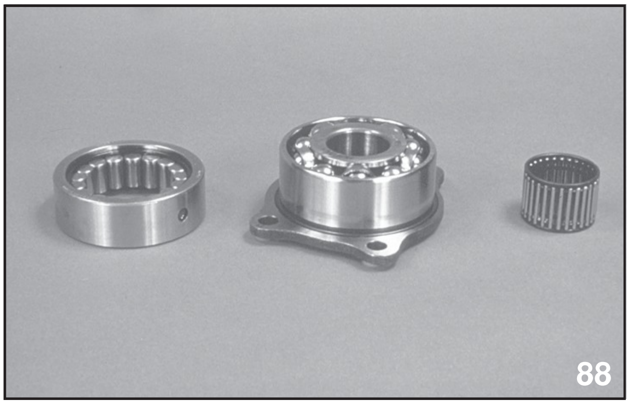
Press Off Components

Press off the components at the 3rd drive gear using retainer **899714110**, and **899864100** Remover.



Main Shaft Components

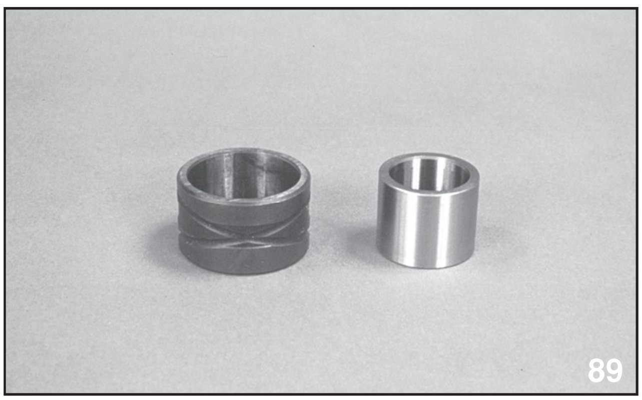
Disassembly & Inspection of Components



Bearings

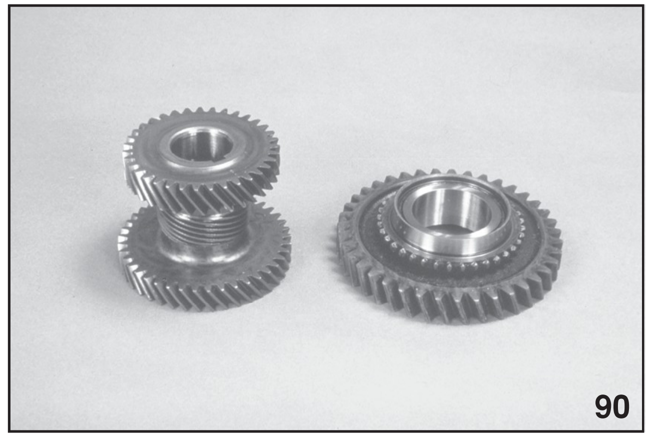
Inspect the parts during the disassembly procedure. Replace or repair as indicated.

Replace the bearings if they are worn, damaged, or do not turn smoothly.



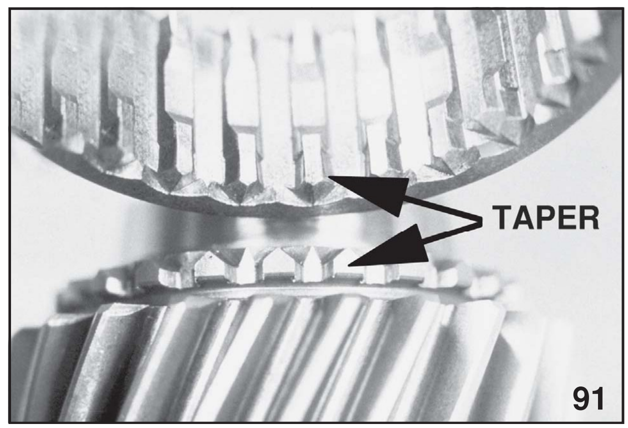
Bushings

Replace the bushings when the sliding surfaces are damaged or abnormally worn.



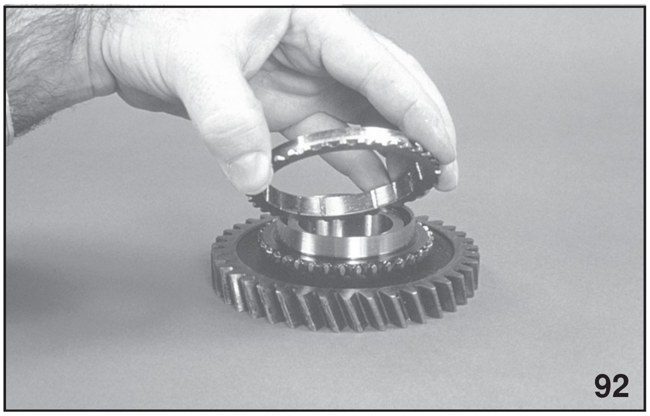
Gears

Replace the gears if the tooth surfaces are damaged or excessively worn. Replace if the cone is rough or damaged or if the inner bearing surface is damaged. The 3rd and 4th gears must be replaced as a set.



Inspect Gear Teeth & Couplers

Replace the couplers (sleeves) or gears if the tapers are worn; they help prevent popping out of gear.



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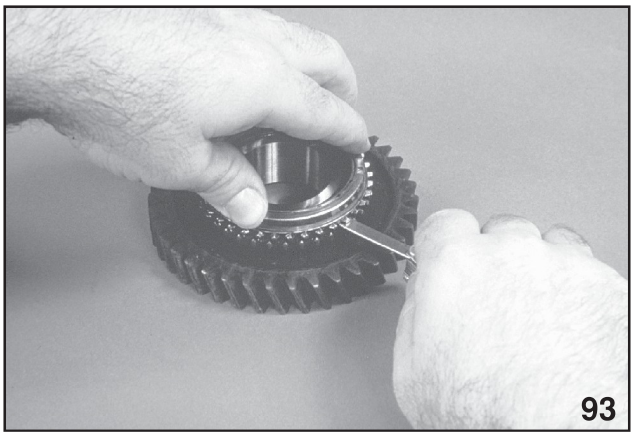
Synchronizer Ring



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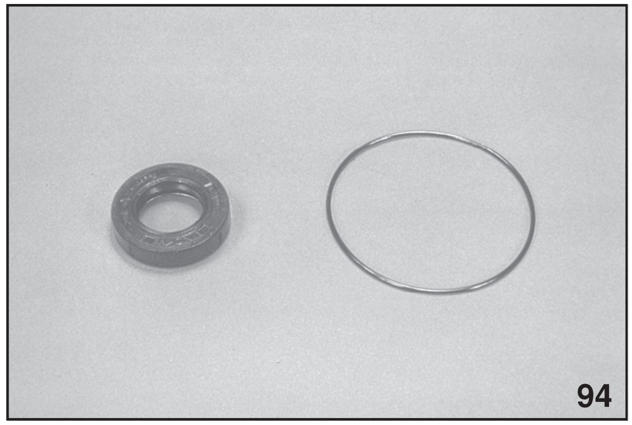
Synchronizer Ring Wear

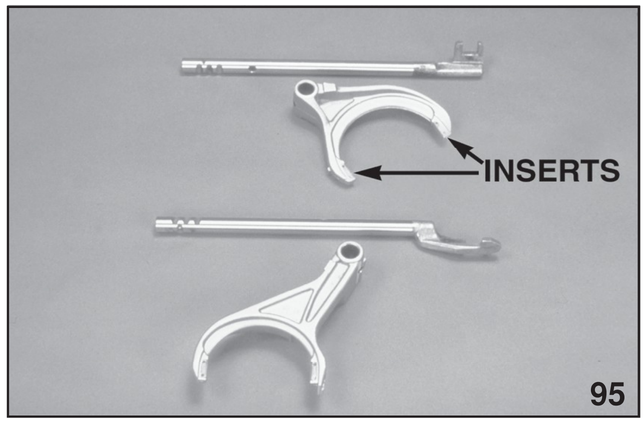
Replace the synchronizer ring when the inner surface is worn, the contact surface of the synchronizer insert is scored or abnormally worn, or if the gap between the faces of the ring and gear is less than specification when the ring is pressed against the cone. (Minimum clearance .020")



94

Oil Seals & O-rings

Replace all Oil Seals and O-rings.

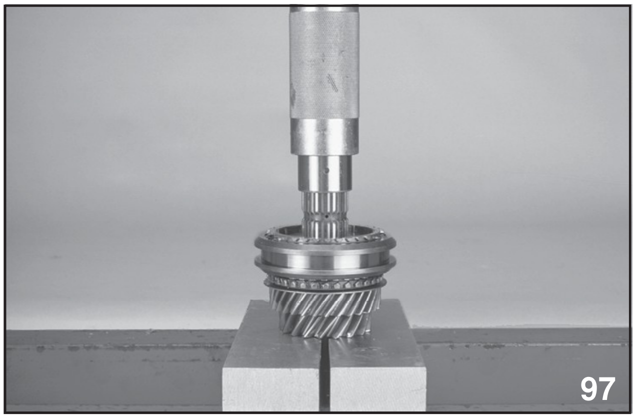


95

Shift Forks and Rails

Replace the shift forks and rails when they are damaged or if the nylon inserts on the forks are worn or missing.

Transmission Main Shaft Reassembly

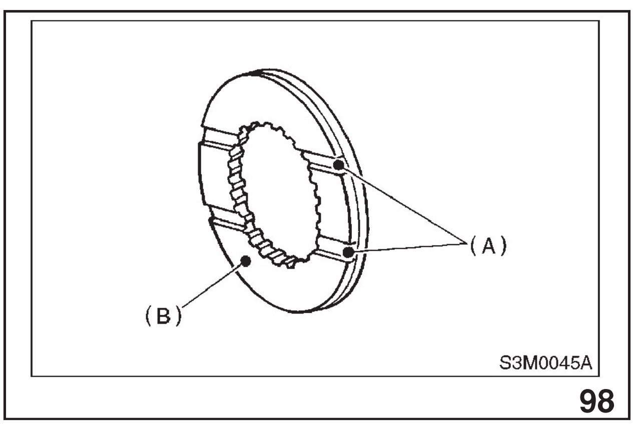


4th Gear Bearing Race

Install 3rd drive gear, outer baulk ring, synchro cone, inner baulk ring, sleeve and hub assembly for 3rd gear needle bearing on transmission main shaft.

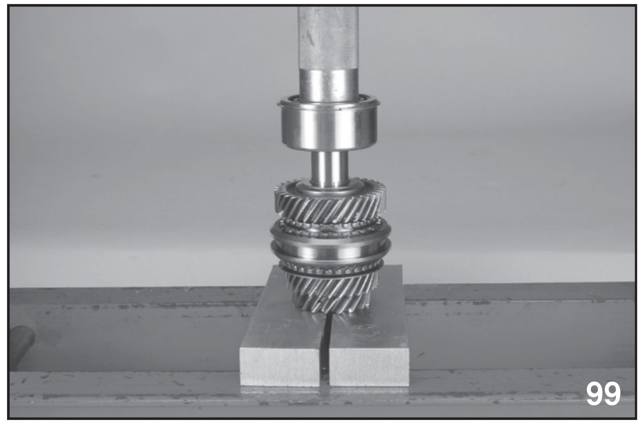
NOTE: ALIGN GROOVE IN BAULK RING WITH SHIFTING INSERT. SLEEVE HAS LUBRICATION HOLE. PROPERLY ALIGN WITH PASSAGE IN SHAFT.

Install 4th needle bearing race onto transmission main shaft using **899714110** remover and **499877000** installer and press.



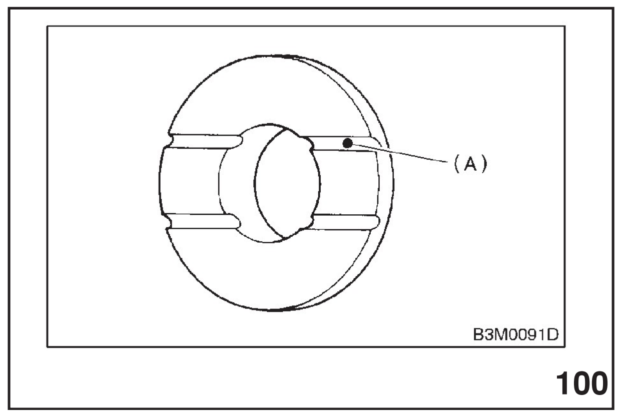
4th Gear Thrust Washer

(A) Groove
(B) 4th gear side



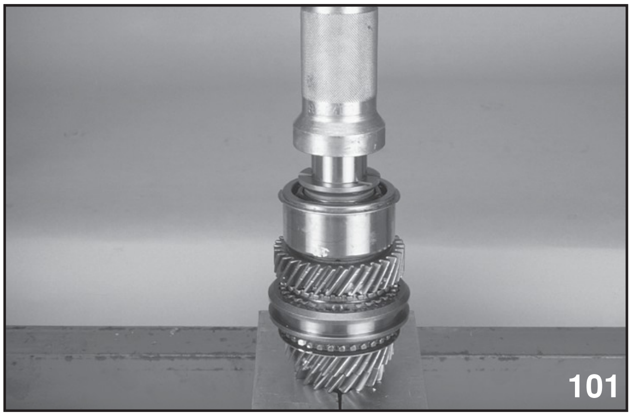
Ball Bearing Pressing

Install baulk ring, needle bearing, 4th drive gear and 4th gear thrust washer on main shaft. Install ball bearing onto rear section of main shaft and press.



5th Gear Thrust Washer Detail

(A) Face this surface to 5th gear side.

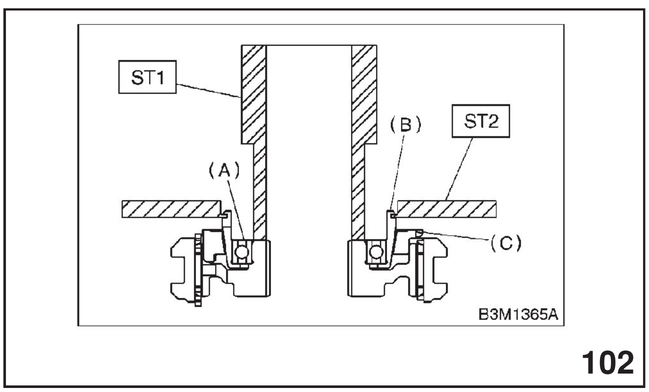


5th Gear Thrust Washer

Install 5th gear thrust washer and 5th needle bearing race on main shaft and press.

NOTE: THE FOLLOWING STEPS ONLY APPLY TO REASSEMBLY OF 1999 MY AND NEWER REVERSE BAULK RING AND SYNCHRO CONE.

ST 499757002 INSTALLER



Installing Reverse Baulk Ring and Synchro Cone

(A) Baulk ring
(B) Synchro cone
(C) Ball bearing

Install bearing onto synchro cone.

Install baulk ring and synchro cone onto 5th-Rev sleeve and hub assembly using ST and a press.

NOTE:

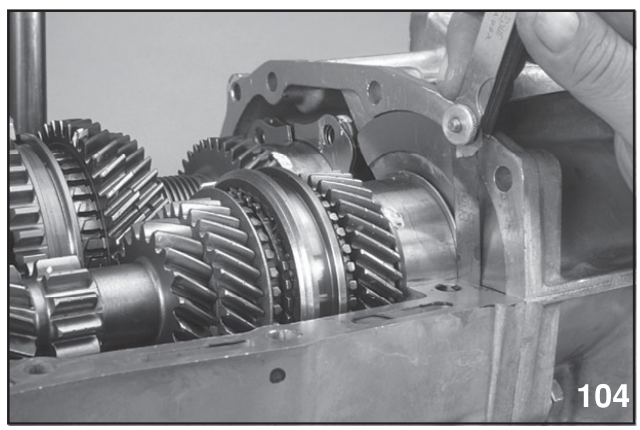
- Use new ball bearing.
- After press fitting, make sure synchro cone rotates freely.

Install synchro cone stopper and snap ring to 5th-Rev sleeve and hub assembly.

Main Shaft

Install the remaining parts to the rear section of transmission main shaft including a new washer and nut.

Mount the shaft in a vise using transmission main shaft holder **498937000**. Torque the nut to specification using socket wrench **499987003**. Stake the nut at two places.

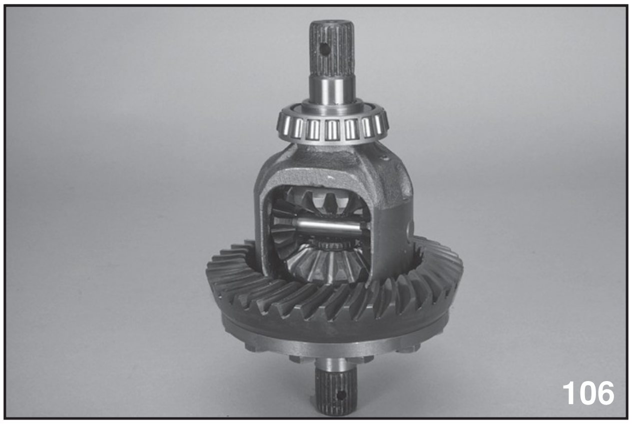


Main shaft End Play Clearance

With a feeler gauge, measure the clearance by placing the feeler blade between the snap ring and the main case. This dimension should be 0-.008 in (0-0.2mm).

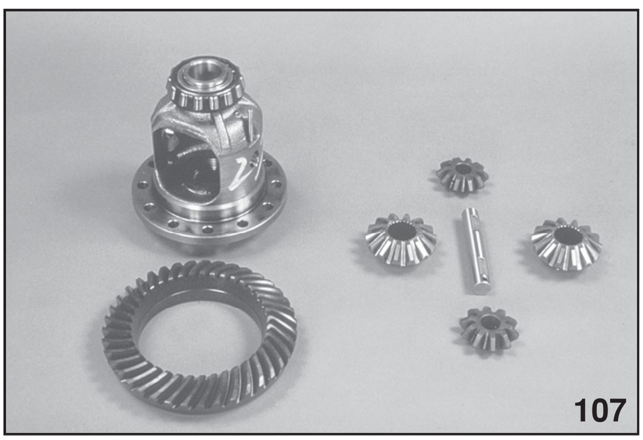
NOTE: THIS PROCEDURE DIFFERS FROM THE METHOD SHOWN IN THE SUBARU SERVICE MANUAL ON STIS WEB SITE.

Differential Disassembly and Reassembly



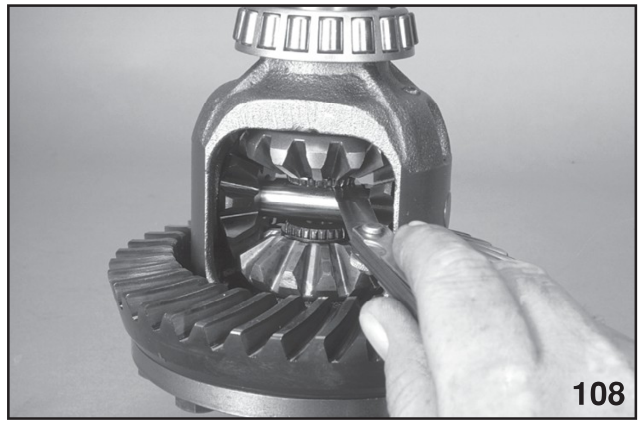
Differential Assembly

Mark the axle shafts for reassembly in the same location, remove the snap rings, and then remove the axle shafts. Unbolt the crown (ring) gear and remove it. Drive out the pinion shaft pin toward the crown gear side, and remove the pinion shaft, pinion gears, and washers.



Differential Components

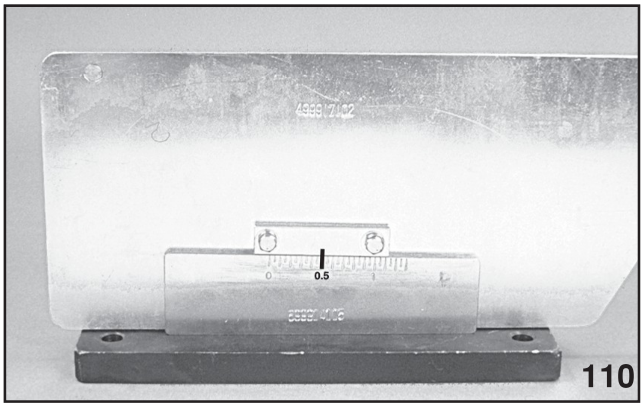
Inspect the parts for wear or damage. After reassembly, make sure that both washers are the same thickness. Align the hole in the pinion shaft with the hole in the differential case, and then install the pin from the crown gear side. Measure the backlash between the bevel side gears and pinion gears, and choose the proper selective washers to adjust the backlash to specification.



Axle Shaft Clearance

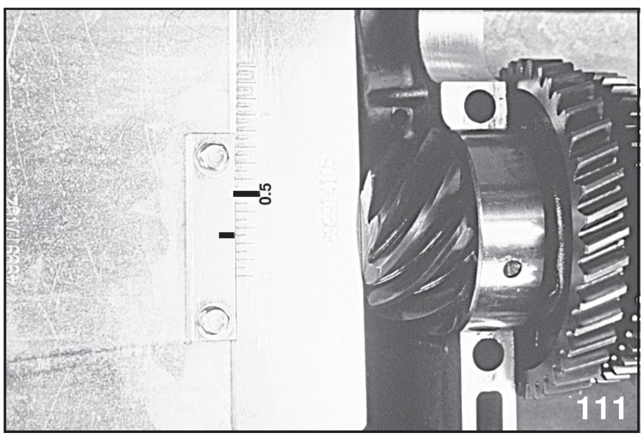
Measure the end play of the axle shafts. Replace the selective snap ring(s) if not with in specifications. (0 to .008")

Pinion Depth Shim Selection



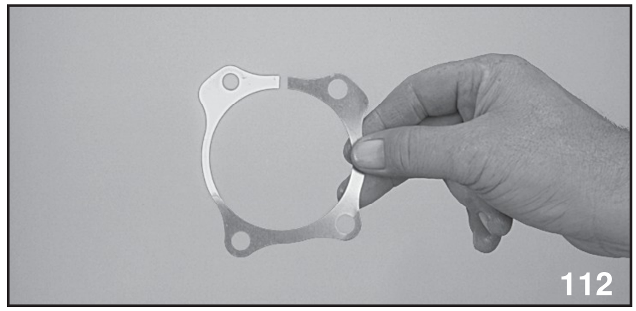
Adjustment of Drive Pinion Shim Gauge

To calibrate gauge assembly: Loosen the two bolts, place the gauge on a flat surface, align the red centering marks, and tighten the bolts.



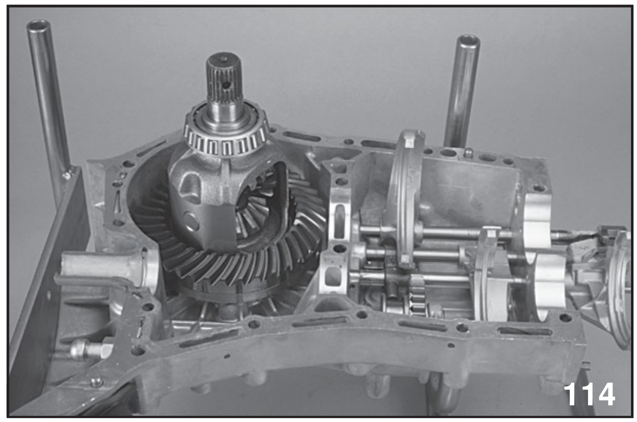
Using Pinion Setting Gauge Assembly

Place the assembled drive pinion without shims into the right-hand transmission case, and tighten the bearing holder bolts to specifications. Put the gauge assembly in place, and slide the plate until it is snug between the gauge and the pinion. Read the measurement from the lines that line up, and add or subtract the number on the end of the pinion to get the thickness of the shim required. If there are no marks on shaft, then read directly off gauge.



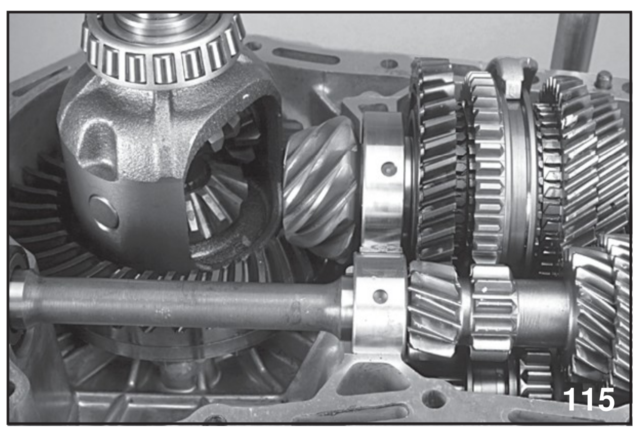
Drive Pinion Shim

Transmission Reassembly

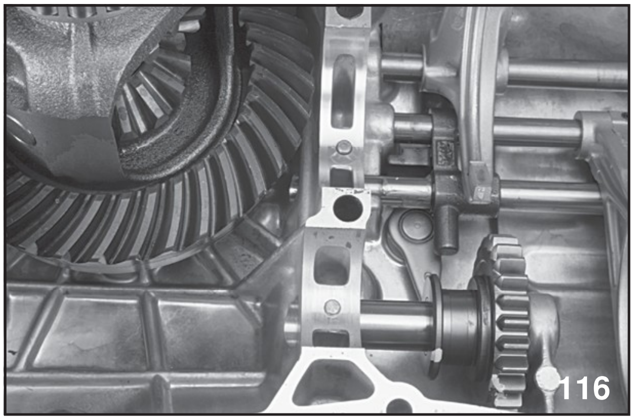


Install Differential Assembly

Install the shifter forks and rods. Coat the interlock plungers with grease if necessary to prevent their falling out. Set each rod to neutral while installing the next rod. Install the shifter detent balls, springs, and plugs. Install the differential assembly.

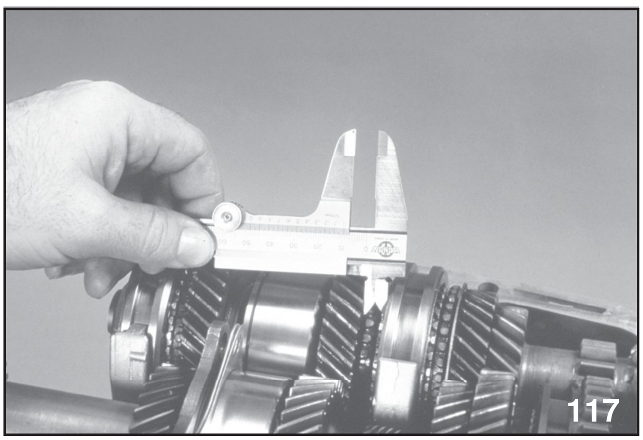


Knock Pin Bearing Holes



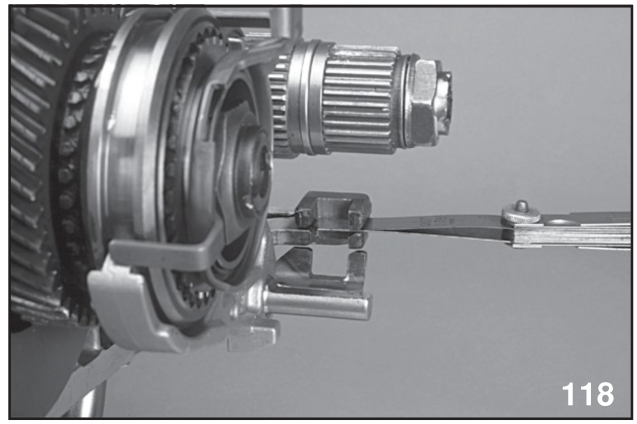
Knock Pins

Install the drive pinion shaft with shims and main shaft into the case. Make sure that the pinion bearing and main shaft bearing are correctly fitted to the knock pin in the case.



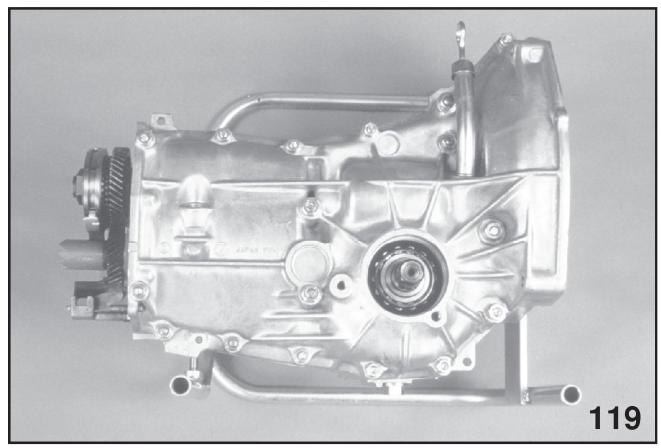
Measure Shifter Fork Centering

The shifter forks are selective. Measure between the coupler (sleeve) and each gear face. Use the table in the appropriate model year Subaru Service Manual on STIS Web site to select the proper forks.



Measure Shift Rod End Clearance

Measure the clearance between the rod ends. Replace the forks or rods if they are not within specification.

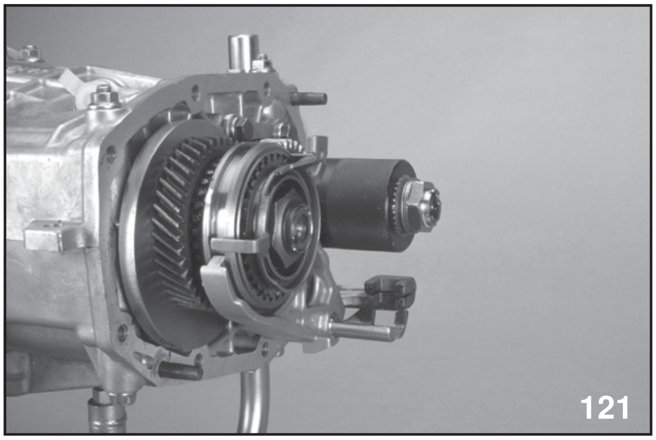


Transmission Case Reassembled

Apply a light coat of Prussian Blue to several of the crown gear teeth.

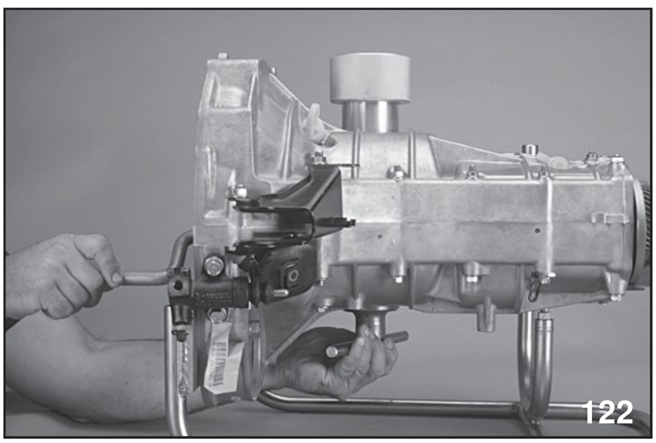
Reassemble the transmission case using a non-hardening sealer. Insert the bolts from the bottom, and torque the bolts in the proper sequence. Torque the bolts for the drive pinion bearing retainer to proper specification.

Hypoid Gear Adjustments



Locking the Driven Shaft

Install 498427100 Stopper onto the end of the drive pinion shaft.



Hypoid Gear Clearance Adjustment

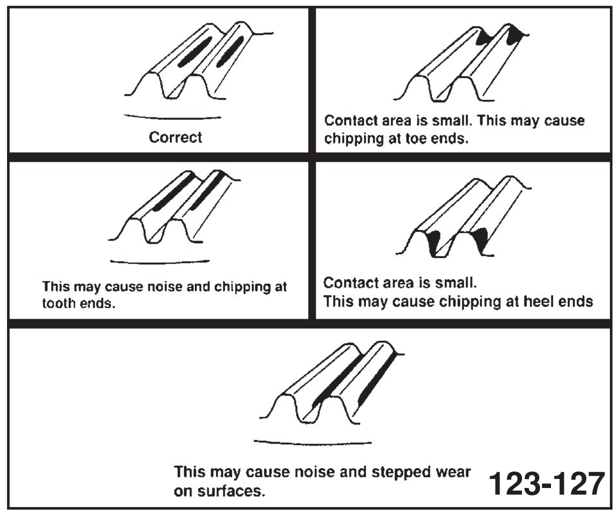
Adjust the backlash with weight **399780104**, wrench **499787000**, and handle **499927100**. Place the transmission right-hand-side up, and place the weight on the top bearing cup. Shift into 5th gear. Screw in the bottom retainer assembly, without an O-ring, while turning the input shaft with the handle. Stop when you feel a slight resistance. Do this procedure several times to be sure the setting is correct.

Remove the weight, and then screw in the upper retainer, without an O-ring, stopping when a slight resistance is felt.

NOTE: AT THIS POINT, THE BACKLASH BETWEEN THE HYPOID GEAR AND DRIVE PINION SHAFT IS ZERO STATE. (LASH)

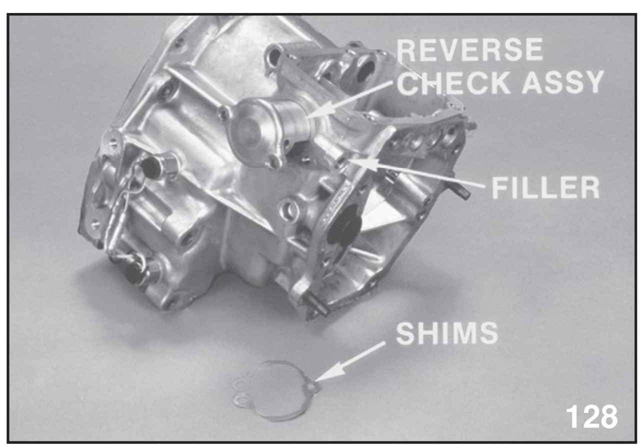
Back off the bottom retainer by 1 and 1/2 notches of the lock plate. Next, turn in the top retainer the same amount plus an additional 1/2 to 1 notch. Temporarily tighten the lock plates. Turn the handle several dozen times, tapping lightly around the retainer with a plastic mallet.

Check the backlash with a dial gauge, inserting the probe through the drain plug hole and placing stem of dial indicator on drive side of ring gear. Repeat the above procedure if backlash is out of specification.



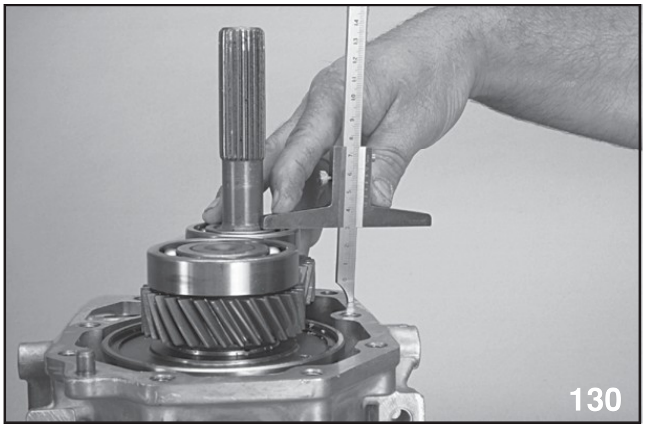
Hypoid Gear Tooth Contact Patterns

Check the Prussian Blue tooth contact pattern. With the backlash and contact pattern correct, mark the positions of the axle shaft oil seal retainers. Back off one retainer at a time (counting turns) until oil ring groove is exposed. Install a new O-ring, and then bring the retainer back to original position.



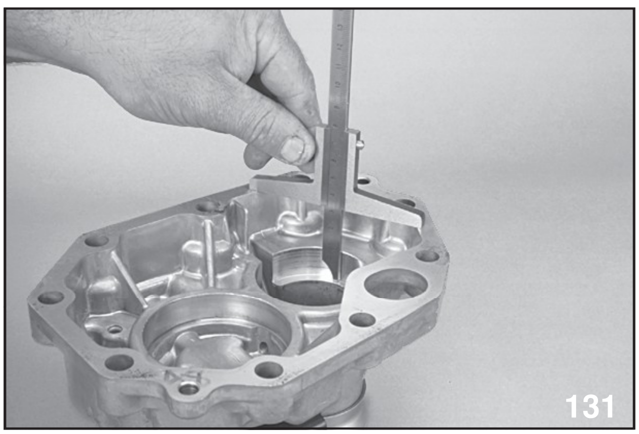
Install Transfer Case & Extension Assembly

Transfer Case and Extension Case Assembly



Height "W"

Measure height "W" between transfer case and ball bearing on the transfer driven gear.



Depth "X"

Measure depth "X".

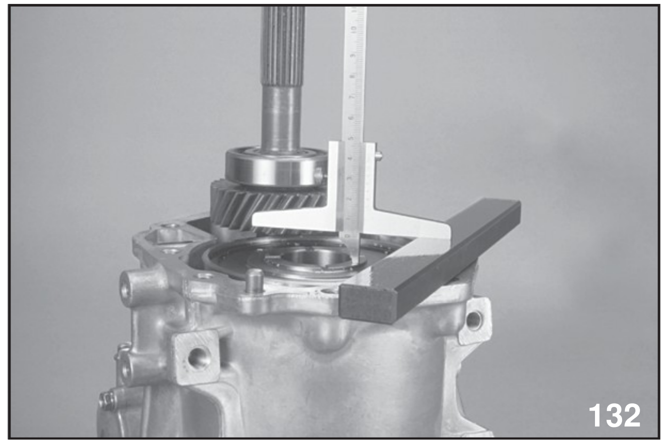
NOTE: MEASURE WITH BEARING CONE AND THRUST WASHER REMOVED.

Calculate space "t" using the following equation: t = X - W - (0.2 to 0.3 mm) (0.008 to 0.012 in)

Standard clearance between thrust washer and roller bearing:

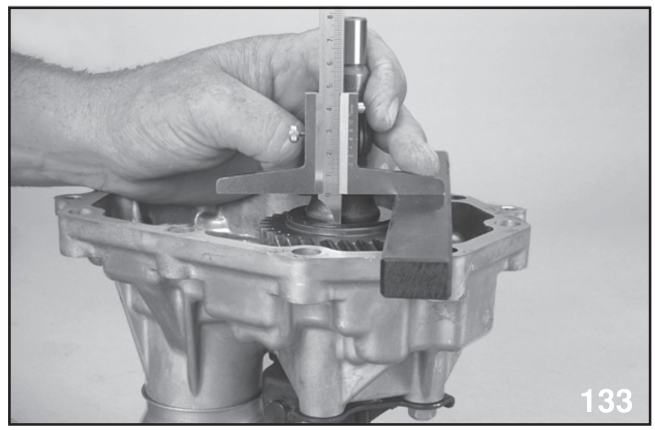
0.2 - 0.3 mm T (0.008 - 0.012 in T)

Select suitable thrust washer.



Depth "S"

Fit thrust washers on transfer drive shaft. Measure depth "S' between transfer case and center differential.



Depth "T"

Measure depth "T" between extension case and transfer drive gear.

Calculate space "U" using the following equation: U = S - T - (.15 to .35 mm)

Select suitable thrust washer

Standard clearance:

0.15 - 0.35 mm (0.0059 - 0.0138 in)

Fit thrust washer on center differential.

Apply proper amount of liquid gasket to the transfer case mating surface.

Install extension assembly into transfer case.

Center Differential

The center differential operation is unchanged and is now non-serviceable, except for the supporting bearings.

1999 and Later Center Differential Assembly

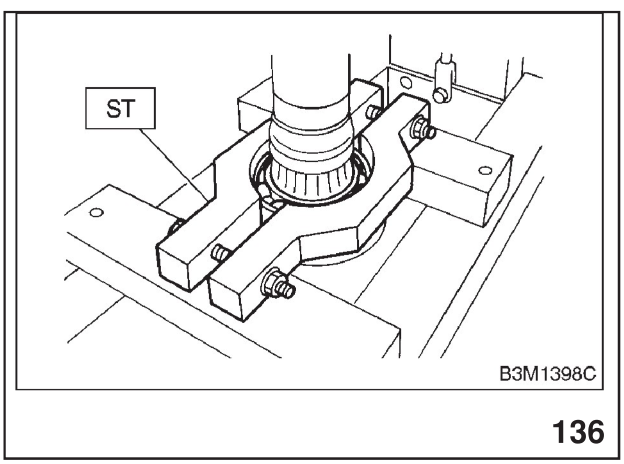
DISASSEMBLY

NOTE: DO NOT DISASSEMBLE CENTER DIFFERENTIAL BECAUSE IT IS A NON- SERVICEABLE PART.

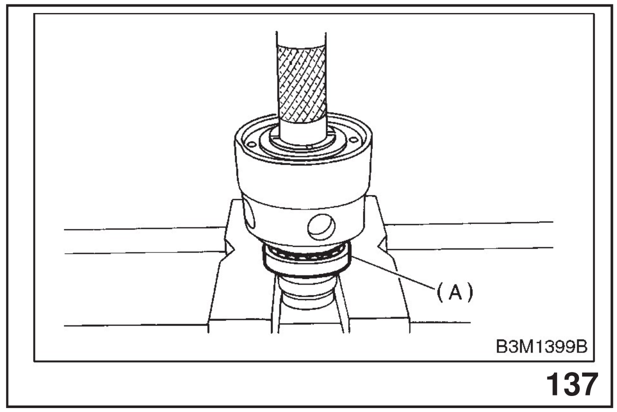
Remove ball bearing using ST.

NOTE:
Do not reuse ball bearing. Prepare a new ball bearing.

ST 498077300 Center Differential bearing remover



Removing Ball Bearing



Installing Ball Bearing

(A) Ball bearing

Assembly

Install ball bearing to center differential assembly.

Inspection

1) Bearings

Replace bearings in the following cases:

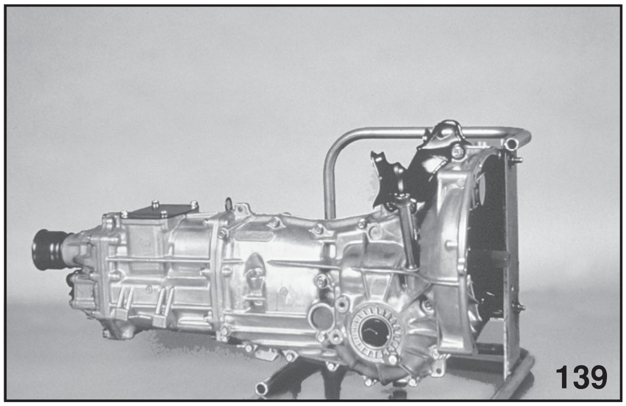
- Broken or rusty bearings
- Worn or damaged
- Bearings that fail to turn smoothly or make abnormal noise when turned after gear oil lubrication.
- Bearings having other defects

2) Center differential

Replace center differential assembly in the following case:

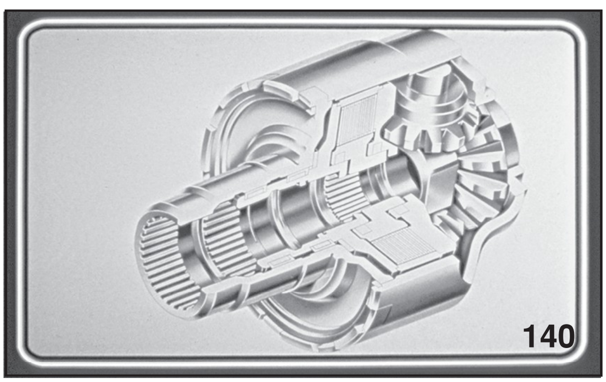
- Worn or damaged

Viscous Full-time 4WD Transmission



Viscous Full-time 4WD Transmission

The length and size of the transmission have been increased to match the 2.2L engine. The gears/synchronizers have also been increased in size to improve shift characteristics for the Legacy. This transmission uses the FT4WD design center differential, with a viscous coupling used in place of the center differential locking mechanism.



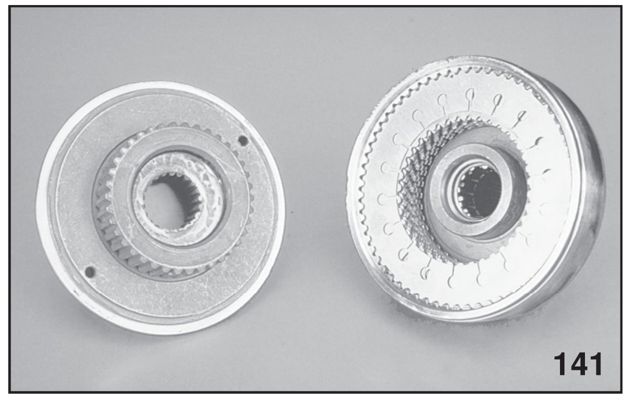
Viscous Coupling

The viscous coupling provides improved driving stability on slick driving surfaces by automatically optimizing the drive torque from the front to the rear wheels.

Operating similar to a limited slip differential, the coupling transfers torque to the non-spinning front or rear wheels. It also absorbs the difference in rotating speeds between the front and rear wheels during turning which prevents torque bind.

An additional advantage of the viscous coupling is the removal of the DIFF LOCK switch (found on XT, XT6 and L-Series models) which is not required because the viscous coupling replaces the function of the DIFF LOCK. The viscous coupling automatically distributes torque to the wheels with the most traction.

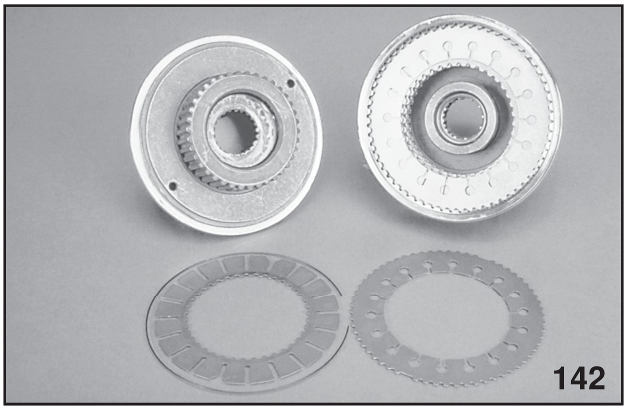
NOTES: WHEN TOWING A VEHICLE WITH A VISCOUS COUPLING, ALL FOUR WHEELS MUST CONTACT THE GROUND OR THE VEHICLE MUST BE HAULED ON A FLAT BED TRUCK (ALL WHEELS OFF THE GROUND).



Viscous Coupling Components

The two main components of the viscous coupling. The housing and the hub. They are designed similar to an AT clutch pack. The inner plates are splined internally to the hub and provide output to the rear wheels. The outer plates are splined to the housing and provide output to the front wheels.

A spacer ring maintains the proper spacing between the outer plates while allowing axial movement of the inner plates. The sealed unit uses silicone oil to transmit torque from the housing to the hub through the plates.



Viscous Coupling Plates

Viscous coupling operation

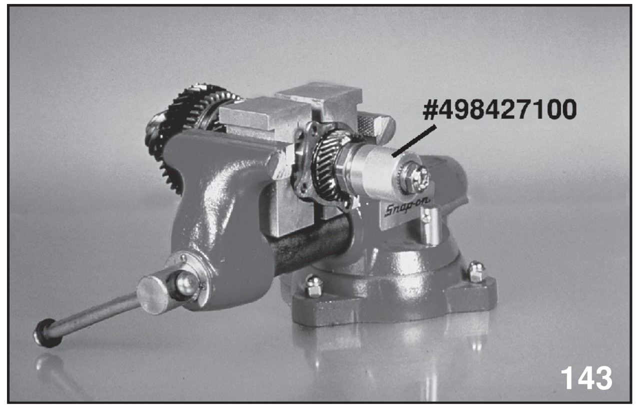
The plates shear (cut) through the silicone oil as they rotate. This causes increased oil temperature which expands the oil. As the oil expands, it creates a shearing force which is transmitted to the plates. This causes torque to be transmitted between the hub and the housing.

NOTE: THE GREATER THE DIFFERENCE OF THE ROTATIONAL SPEED BETWEEN THE HOUSING AND THE HUB, THE GREATER THE TORQUE TRANSFER.

During normal driving conditions when there is no speed difference between the front and the rear wheels, the center differential **delivers a 50/50 torque ratio** (F/R). The viscous coupling does not control the action of the differential because the inner and the outer plates are rotating at the same speed.

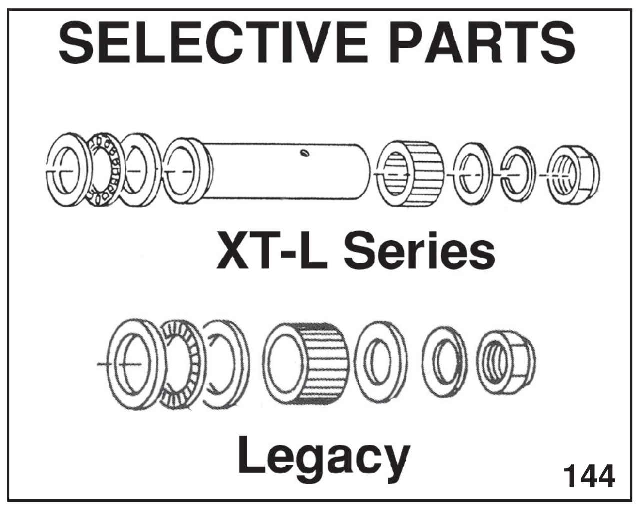
During limited traction driving conditions when there is a rotational difference between one or more wheels there is a different rotating speed between the housing and the hub. Thus the inner and outer plates are rotating at different speeds. This produces the viscous shearing force between the inner and the outer plates. At this time, the torque is proportionately delivered to the non-spinning wheels.

The viscous coupling is non-serviceable and must be replaced as a unit.



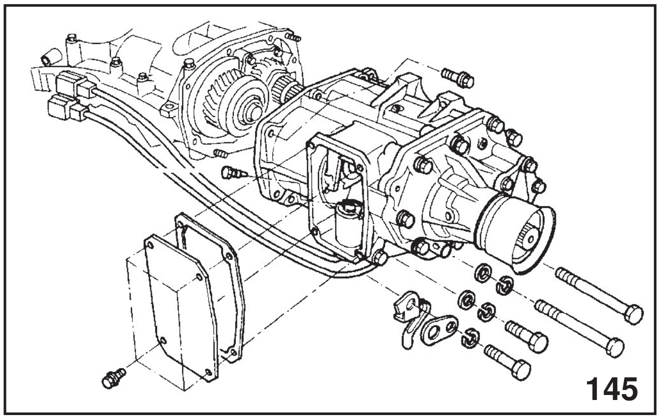
Legacy Pinion Shaft

Disassembly/reassembly procedures for the main case are similar to the previous MY full-time 4WD transmission. The transfer case procedures have been revised due to the viscous coupling center differential. Although disassembly of the drive pinion assembly is similar to the previous MY transmission, you must use stopper **498427100** to remove the pinion shaft lock nut.



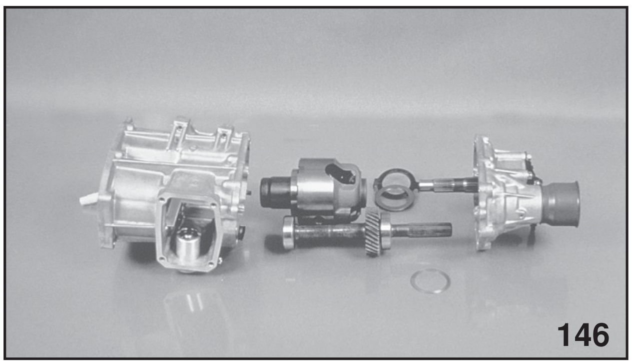
Thrust Bearing Preload / Selective Parts

The selective parts for the drive pinion shaft are different from the previous MY full-time 4WD transmission. See Subaru Service Manual on STIS Web site for selective parts charts and information.



Transfer Case Removal

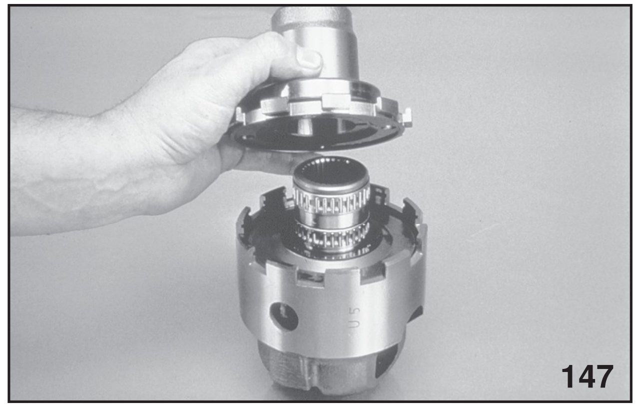
Disconnect the backup light and neutral switch connectors. Remove the transfer case cover bolts and transfer case cover. Then remove the selector arm set screw and the reverse check mechanism.



Transfer Case and Extension Housing

Remove the extension housing bolts and separate the extension housing from the transfer case. Remove the center differential and transfer driven shaft from the transfer case. Then remove the transfer drive shaft from the extension housing. Be sure to remove the thrust washers from the extension housing.

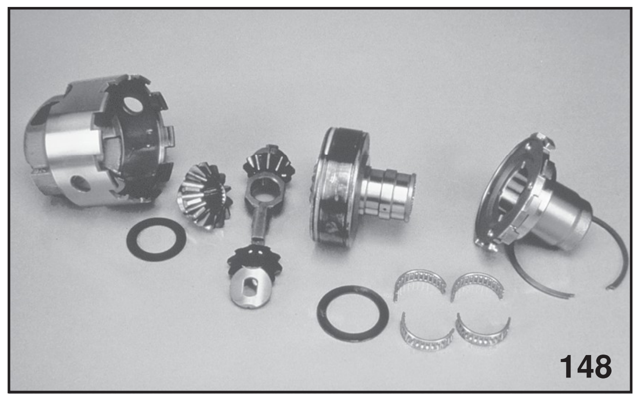
NOTE: THE TRANSFER CASE AND EXTENSION HOUSING CAN BE REMOVED FROM THE MAIN CASE WITHOUT DISASSEMBLY OF THE MAIN CASE COMPONENTS.



Center Differential Disassembly

Remove the snap ring, the differential cover with ball bearing, and the split needle bearings.

NOTE: THE SPLIT NEEDLE BEARINGS MUST BE INSTALLED IN EXACTLY THE SAME POSITIONS WHEN THE CENTER DIFFERENTIAL IS REASSEMBLED.

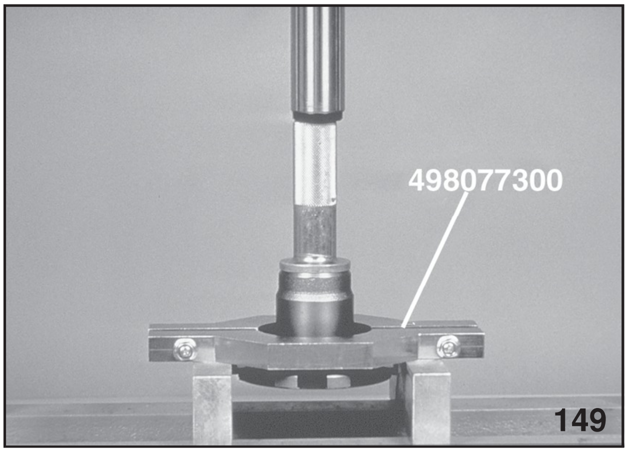


Viscous Coupling Removal

Carefully remove the viscous coupling from the differential case.

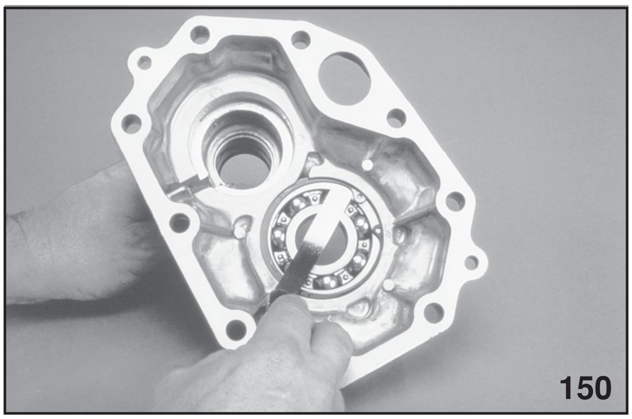
NOTE: ADJUSTING WASHER ON VISCOUS COUPLING IS DIRECTIONAL.

Remove the pinion shaft, pinion bevel gears and retainers, bevel gear, and thrust washer.



Ball Bearing Removal

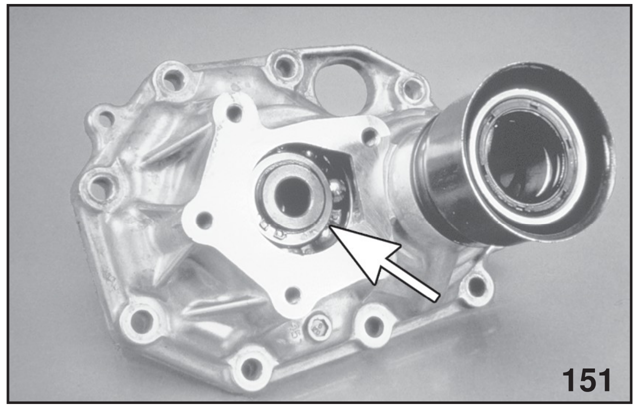
Use remover 498077300 and a press to remove the center differential cover ball bearing. Do not reuse the ball bearing.



Measuring Bearing End-Play

The transfer drive shaft bearing end-play is determined by a selective snap ring which is available in three sizes. Refer to model year Subaru Service Manual on STIS web site. Snap Ring (Inner 72) chart.

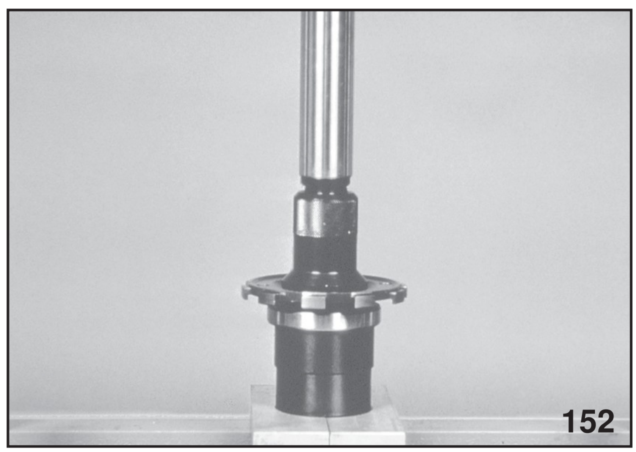
Install the inner ball bearing into the extension housing and then install the selective snap ring (72 mm). Use a feeler gauge to measure the clearance between the snap ring and the bearing outer race. The desired clearance is 0.0 - 0.15 mm (0.0 -0.0059 in).



Measuring Outer Snap Ring Clearance

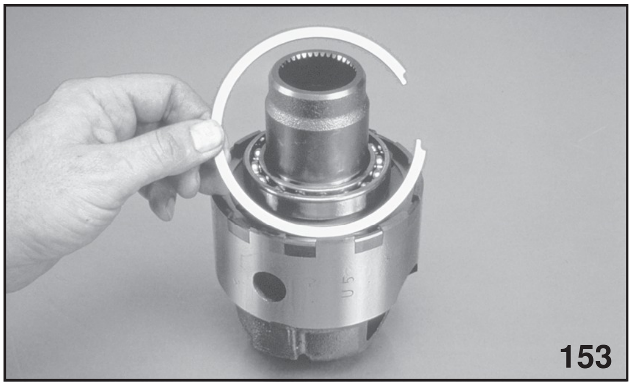
Press the transfer drive shaft into the ball bearing and install the outer selective snap ring to the transfer drive shaft. Refer to model year Subaru Service Manual on STIS web site. Snap Ring (Outer - 30) chart for choice of three sizes of snap rings.

Use a feeler gauge to measure the clearance between the snap ring and the bearing inner race. The desired clearance is: 0.0 - 0.15 mm (0.0 -0.0059 in).



Install Center Differential Ball Bearing

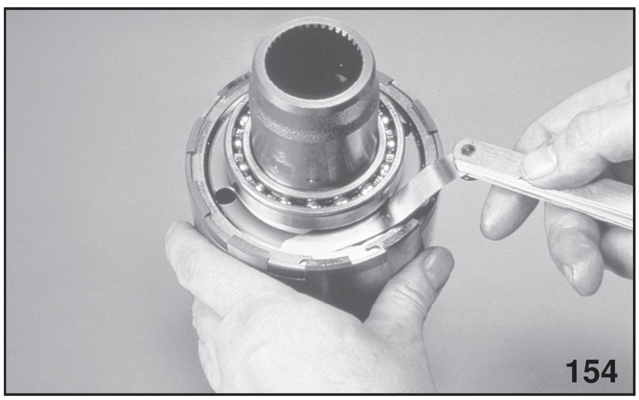
Use a press and an appropriate press tools to install the center differential cover ball bearing. Always press against the inner bearing race when installing the center differential ball bearing.



Center Differential Housing Snap Ring Clearance

NOTE: IT IS EASIER TO PERFORM THIS PROCEDURE BEFORE REASSEMBLY OF THE CENTER DIFFERENTIAL COMPONENTS.

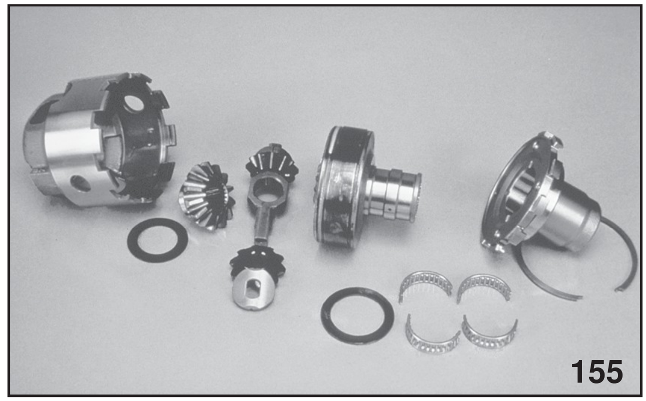
The clearance is determined by a selective snap ring which is available in three sizes. Refer to Model Year Subaru Service Manual on STIS web site. Snap Ring (Inner 110) chart. Always install a new selective snap ring.



Measuring Snap Ring Clearance

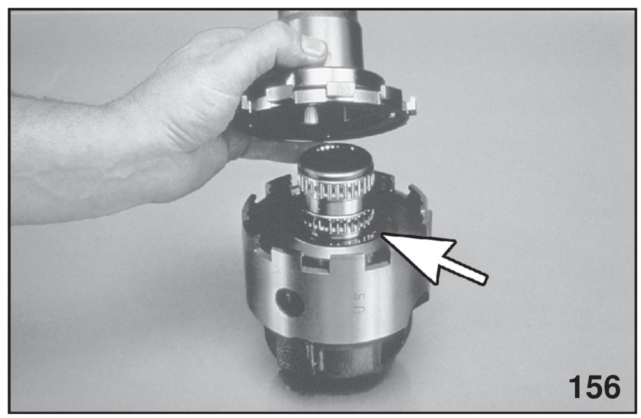
Use a feeler gauge to measure the clearance between the snap ring and the center differential cover. The desired clearance is: 0.0 - 0.15 mm (0.0 - 0.0059 in).

NOTE: INSTALL THE THICKEST SNAP RING POSSIBLE WHICH ALLOWS THE DESIRED CLEARANCE.



Reassemble Center Differential

Install the center differential components into the case in the reverse order of disassembly. Install the bevel gear thrust washer (nonselective). This washer is directional, the chamfered edge faces the bevel gear. Then install the bevel gear, pinion shaft, pinion gears and retainers (no adjustment), and the viscous coupling.

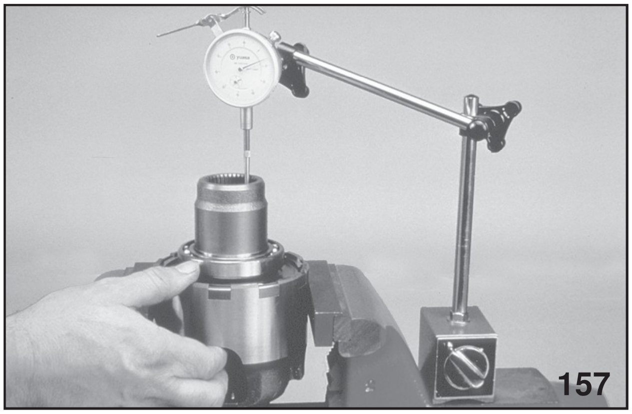


Reassemble Center Differential
Adjusting Washer

Then install the original backlash adjusting washer (selective), split needle bearings, center differential cover, and a new selective snap ring (110 mm).

NOTE: THE ORIGINAL BACKLASH WASHER MUST BE INSTALLED DRY TO OBTAIN AN ACCURATE BACKLASH MEASUREMENT. THE WASHER IS ALSO DIRECTIONAL. THE CHAMFERED SIDE MUST FACE THE VISCOUS COUPLING.

NOTE: THE SPLIT NEEDLE BEARINGS MUST BE REINSTALLED TO THE EXACT SAME POSITIONS AS WHEN THE CENTER DIFFERENTIAL WAS DISASSEMBLED. THE NEEDLE BEARINGS ARE A MATCHED SET AND MUST BE REPLACED AS A SET.

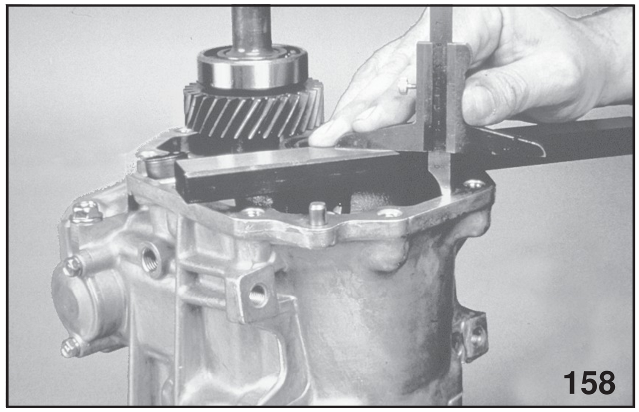


Backlash Adjustment

Support the center differential in a vise or press blocks. Set up a dial indicator and measure the axial backlash (up and down movement of the pinion shaft). The desired clearance is: 0.62 - 0.86 mm (0.024 - 0.034 in).

Be sure to measure the backlash at three points as you rotate the center differential assembly. Use the largest reading to select the proper backlash adjusting washer. A thinner washer will increase the backlash, a thicker washer will decrease the backlash. Refer to model year, Subaru Service Manual on STIS Web site. Adjusting washer (45 x 62 x t) chart. Be sure to re-measure the backlash after installing a new adjusting washer.

NOTE: THE BEVEL GEAR PROTRUDES FROM THE DIFFERENTIAL CASE. BE CAREFUL TO SUPPORT THE DIFFERENTIAL CASE SO THAT THE BEVEL GEAR CAN HANG FREELY AND IS FREE TO ROTATE.

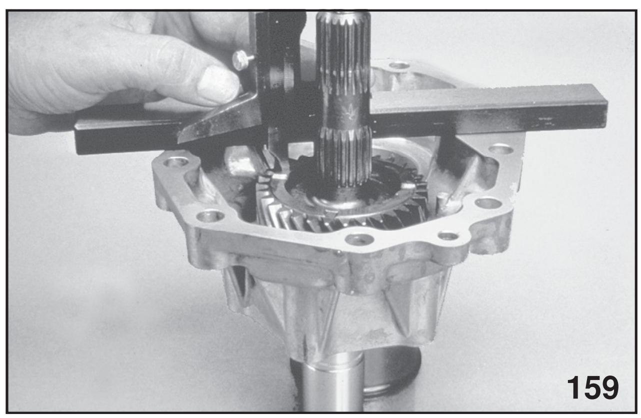


Measuring Height “A”

To measure the center differential end-play, first install the center differential and the transfer driven shaft into the transfer case.

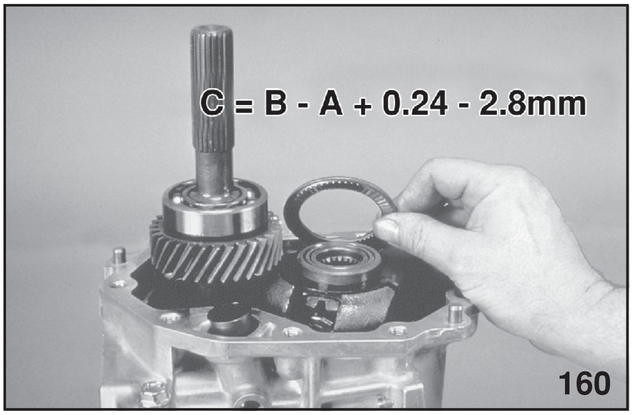
TIP: ALIGN THE SPLINES OF THE CENTER DIFFERENTIAL WITH THE PINION SHAFT AND THE TRANSFER DRIVEN SHAFT BEFORE INSTALLATION OF THE CENTER DIFFERENTIAL TO THE TRANSFER CASE. THIS WILL EASE THE FINAL ASSEMBLY OF THE TRANSFER CASE AND EXTENSION HOUSING.

Measure height “A” from the differential thrust surface to the transfer case mating surface. The washer and bearing should not be installed.



Measuring Depth “B”

Measure depth “B” from the extension housing mating surface to transfer drive shaft gear face.



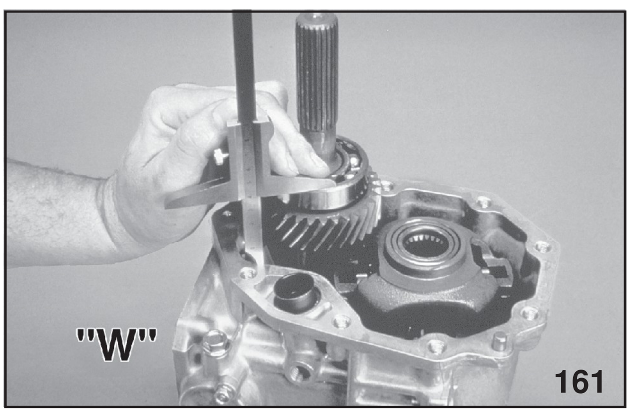
Calculate End-Play "C"

Use the formula:

C = B - A + 0.24 mm (0.010 in) - 2.8 mm (0.110 in)

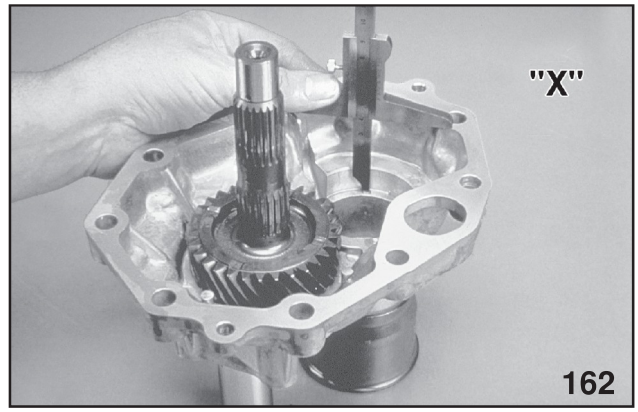
Standard gasket thickness = 0.24 mm (0.010 in)
Standard thrust bearing thickness = 2.8 mm (0.110 in)

The desired clearance is: 0.35 - 0.55 mm (0.014 0.022 in). Refer to model year, Subaru Service Manual on STIS Web site. Space "C" Center differential washer chart. Select and install the proper selective washer from the five available sizes. Be sure to position the washer with the tabs as shown in the Subaru Service Manual.



Measuring Height "W"

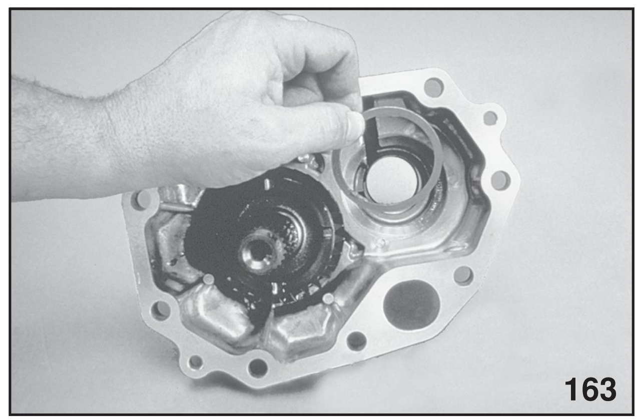
The transfer driven gear thrust clearance is height "W". Measure from the transfer case mating surface to the transfer driven gear outer bearing race.



Measuring Depth "X"

Measure depth "X" from the extension housing mating surface to the transfer driven gear bearing seat.

NOTE: SELECTIVE SHIM SHOULD BE REMOVED WHEN PERFORMING THE ABOVE MEASUREMENT.



Calculate Clearance "Y"

Use the formula:

Y = X - W + 0.24 mm (0.010 in)

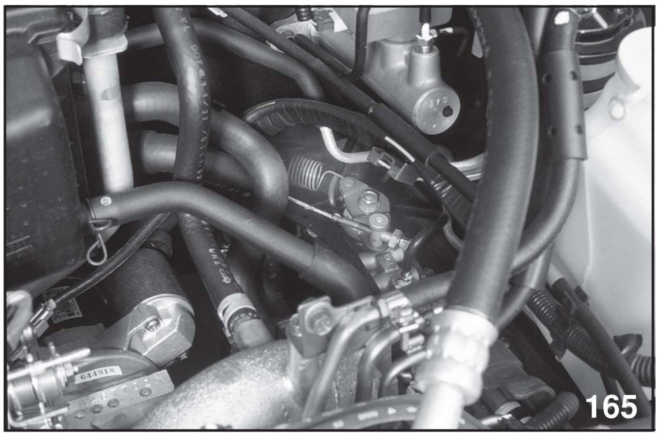
Standard gasket thickness = 0.24 mm (0.010 in)

The desired clearance is: 0.05 - 0.30 mm (0.002 0.012 in). Refer to model year, Subaru Service Manual on STIS Web site. Space "Y" Thrust washer (52 x 61 x t) chart. Select and install the proper selective shim in the transfer driven shaft bearing seat. Use petroleum jelly to hold the shim in position.

Install the thrust bearing with the roller side surface facing the differential washer. Carefully install the extension housing to the transfer case. Torque the bolts, install the selector arm set screw, and reinstall the transfer case in the reverse order of disassembly.

Forester Hill Holder

Starting with the 2003MY Forester 5 speed manual transmission model is equipped with a hill holder. The hill holder activates with the clutch and brake pedal pushed when the vehicle is at about a 3 degree incline. Releasing the brake and holding the clutch will trap the brake pressure in the left front and right rear wheels.



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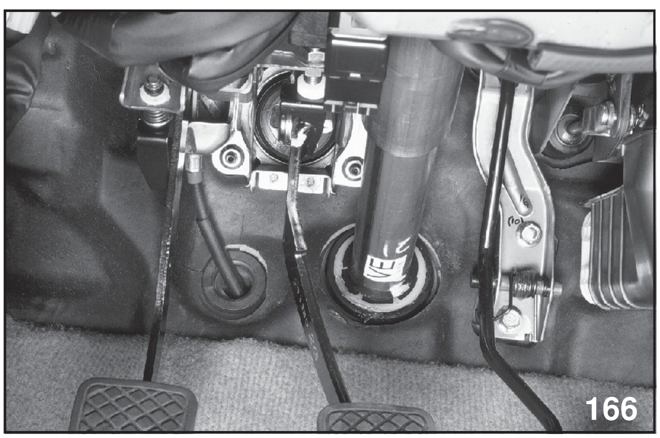
PHV (Pressure Hold Valve)



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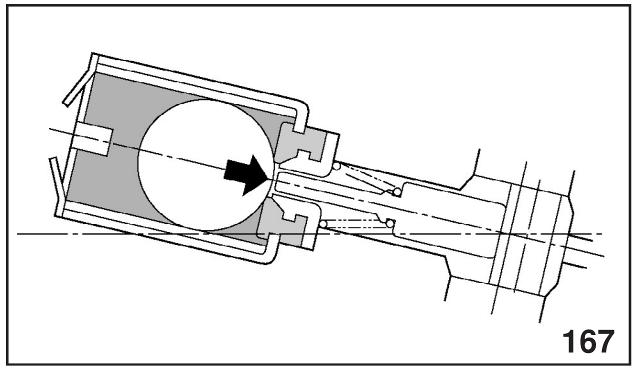
Clutch Pedal

Operation of the pressure control valve (PHV) is accomplished by means of a cable connected to the clutch pedal and routed through the bulk head to the PHV. The end of the cable at the PHV is adjustable.

If the vehicle does not hold on the described incline tighten the adjustment. If the hill holder releases later than the clutch loosen the adjustment. If the hill holder releases too soon tighten the adjustment.



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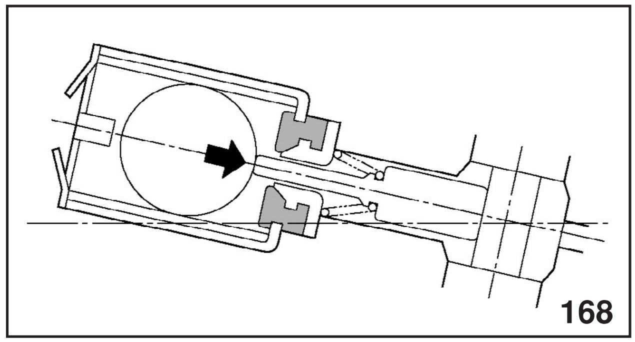
Clutch Pedal In



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Clutch Pedal Out

Notes and Cautions

Disassembly

Reduce the preload on the carrier bearings before splitting the case.

Be sure all 17 bolts are removed before attempting to split the case.

Wrap vinyl tape around the axle drive shaft splines before removing the shafts, to protect the oil seals.

Mark the right and left differential roller bearing outer races for reinstallation on the same side.

Shift Rails

Late model 4WD and turbo 5-speed FWD have pins holding the shift forks. Others have set screws (bolts).

When removing or installing a shift rail, keep all others in the neutral position.

Inspection

A deep blue color and a burnt smell indicates overheating and a lack of lubrication.

All gears but 1st and 2nd must be bought in sets. 3rd and 4th gears must be bought in a set.

If the main shaft is replaced, 3rd gear must also be replaced.

Replace all O-rings and seals.

Components

Use a press and the proper holders to remove and replace parts on shafts.

If a roller bearing is pressed off a shaft, replace it.

Position the open ends of synchronizer springs 120 degrees apart on reassembly.

Align the ring grooves on the synchronizer coupling sleeve with the inserts.

Differential

Measure the backlash between the bevel gears and the pinion on reassembly.

Measure the clearance between the axle shafts and case.

Torque the ring gear bolts in opposite pairs.

Do not fold the oil seal lips when installing the differential assembly.

Reassembly & Adjustments

Apply gear oil to the nylon inserts on the shifter forks.

Select the proper shifter fork to center the coupling sleeves in the synchronizer mechanism (late model only).

Use liquid gasket on mating surfaces of the case halves.

Insert the case bolts from the left hand side of the case, tighten in the prescribed sequence.

Adjust the hypoid gear backlash with oil seal retainers without O-rings; then replace the O-rings.

Check the backlash with a dial gauge.

Check the tooth contact pattern with Prussian Blue.

Adjust the neutral position with shims and plate in the reverse check mechanism.

Assemble the clutch to the flywheel with the “O” marks as far apart as possible.

Full-time 4WD Disassembly

Do not damage the needle or thrust bearings during removal of the pinion shaft.

Prior to pressing the roller bearing and the 3rd-4th gear assembly, you must remove the woodruff key. Use a drift and a hammer to knock out the key. Be careful to not damage the gears, shaft, or bearing.

Prior to removing 1st and reverse gears from the driven gear assembly, the driven shaft key must be removed. Use a hammer and a drift to remove the key.

Full-time 4WD Reassembly and Adjustments

Assembly of the pinion shaft is the reverse process of disassembly. Be sure to follow all of the steps and special cautions as listed in the Subaru Service Manual on STIS Web site.

Place a cloth between the press base and the driven shaft assembly to avoid damage to the driven shaft while pressing driven shaft components.

Stake the driven shaft lock nut at two points. Use a spring balance to measure the starting torque of the roller bearing.

The pinion shaft bearing is directional and must be installed with the knock pin hole away from the pinion.

Carefully install the driven shaft assembly onto the pinion shaft to avoid damage to the needle bearings.

Be careful to install the drive pinion spacer in the proper direction.

Measure starting torque after tightening the pinion shaft lock nut to the specified torque. If the starting torque is not within specifications, select a new spacer and/or sleeve and repeat the procedure.

Refer to the Subaru Service Manual on STIS Web site, charts for selection of the proper spacer and/or sleeve. There are seven sleeves and three spacers.

Stake the pinion shaft lock nut at four points.

Full-time 4WD Center Differential

Use stopper **498427000** to rotate the pinion shaft when adjusting the differential bearing preload and backlash .

The split needle bearings must be installed in exactly the same position when the center differential is assembled.

Use a dial gauge to measure the differential backlash. Refer to the Subaru Service Manual on STIS Web site differential bevel washer chart to select the proper bevel washer. Always consult the appropriate Subaru Service Manual on STIS Web site for proper adjustment of the differential lock cable.

Viscous Full-time 4WD Transmission

When towing a vehicle with a viscous coupling, **all** four wheels must contact the ground or the vehicle must be hauled on a flat bed truck (**all** wheels off the ground).

The transfer case and extension housing can be removed from the main case without disassembly of the main case components.

The split needle bearings must be installed in exactly the same positions when the center differential is reassembled.

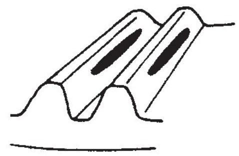
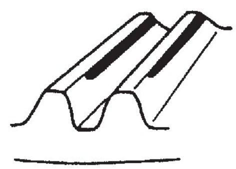
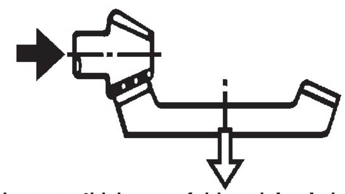
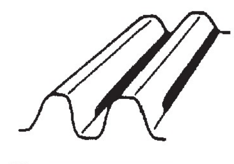
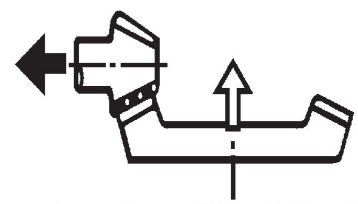
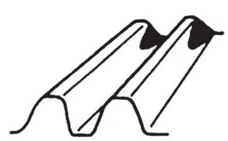
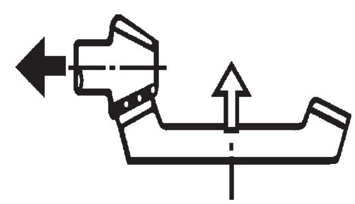
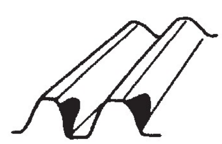
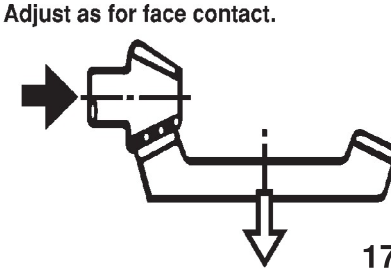
It is easier to determine the center differential snap ring clearance before reassembly of the center differential components.

Install the thickest snap ring possible which allows the desired clearance for the center differential cover. Always install a new selective Snap Ring (110 mm).

The original backlash washer must be installed dry to obtain an accurate backlash measurement. The washer is also directional. The chamfered side must face the viscous coupling.

The split needle bearings must be reinstalled to the exact same positions as when the center differential was disassembled. The needle bearings are a matched set and must be replaced as a set.

Chart for tooth contact

Checking item	Contact pattern	Corrective action
Correct tooth contact Tooth contact pattern slightly shifted toward toe under no-load rotation. (When loaded, contact pattern moves toward heel.)	 Correct	
Face contact Backlash is too large.	 This may cause noise and chipping at tooth ends.	 Increase thickness of drive pinion height adjusting shim in order to bring drive pinion close to crown gear.
Flank contact Backlash is too small.	 This may cause noise and stepped wear on surfaces.	 Reduce thickness of drive pinion height adjusting shim in order to move drive pinion away from crown gear.
Toe contact (Inside end contact)	 Contact area is small. This may cause chipping at toe ends.	Adjust as for flank contact. 
Heel contact (Outside end contact)	Contact area is small. This may cause chipping at heel ends 	Adjust as for face contact.  171

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Tool List

Tool Number	Description
398527700	Oil Seal Bearing Race Pin
399780104	Preload Weight
498077000	Bearing Press Blocks
498077300	Center Differential Bearing Remover
498077400	Synchronizer Cone Remover
498247001	Magnetic Base for Dial Indicator
498255400	Magnet Base Plate
498427100	Stopper
498447100	Differential Side Seal Installer
498517000	Drive Pinion Bearing Replacer
498787100	Main Shaft Stopper
498937000	Transmission Main Shaft Holder
499277200	Bushing Installer
499747100	Clutch Disc Guide
499757002	Snap Ring Press
499785500	Backlash Wrench
499787000	Differential Side Bearing Retainer Wrench
499827000	Speedometer oil Seal Press
499857000	5th Driven Gear Remover
499877000	4-5 Race Installer
499917500	Drive Pinion Gauge Assembly
499927100	Trans Hand Crank
499937100	Trans Stand Set
499987003	Socket
499987300	Pinion Nut Socket
898938600	Main Shaft Holder
899524100	Differential Bearing Puller Set
899580100	Bearing Installer
899714110	Retainer
899754110	Main Shaft Press Tool
899858600	Retainer
899874100	Bushing Installer
899884100	Pinion Shaft Holder
899904100	Straight Pin Remover
899988608	Pinion Shaft Socket

Continued on next page

Tool List

Tool Number	Description
J-25070	Heat Gun
J-26900-7	Dial Caliper
SOA626215	Accent Ball Installer
SOA629389	Drive Pinion Installer
J-41510	Bell Housing Bolt Torx Bit

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03-46-90	04-03-90	First gear disengagement	
03-47-91	05-15-91	Clutch pedal assist spring falling off	
01-143-96	12-23-96	Recommended sealants and adhesives	
03-48-99	07-14-99	First gear popping out	
03-49-02	11-01-02	Popping out of reverse	
03-51-02R	05-01-03	Cold clutch judder (Revised bulletin)	
03-52-03R	07-15-03	Clutch pedal sticking (Revised)	
03-53-04	08-20-04	Transmission rear cross member	

Tech TIPS

Date	Subject
07/95	Inspection of clutch free play during PDI
05/96	Outback gear ratios
10/96	Where's the hill holder?
11/96	Inspection of clutch free play during PDI
01/97	97 Legacy rear differential crossmember bracket noise and vibration
04/97	Rear differential modifications
07/97	All Subaru models with stepped and flat flywheels
07/97	Additional parts information on differential modifications
07/97	Identifying 1997 Subaru Legacy propeller shafts
10/97	'97 Legacy rear differential crossmember bracket noise & vibration
04/98	Rear differential vent oil leakage
09/98	M/T case boss wear
10/98	5MT popping out of first gear
02/99	Shifter rattle
03/99	All 1999 manual transmission vehicles
06/99	Transmission/rear differential gear ratios
01/00	Popping out of fifth gear
04/00	1999/2000MY manual transmission popping out of 1st gear
11/00	2001MY Outback H6-3.0 VDC precautions
8/02	Use of correct fluids
9-10/02	Parts supersession 2002MY Outback & Impreza first driven gear
05/03	Transmission popping out of 3rd gear

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Module 407

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Technical Training

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On Board Diagnostics-II (407)

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Introduction

On Board Diagnostics II was introduced to the Subaru line with the 1995 Legacy. This system combines engine and automatic transmission “Diagnostic Trouble Codes “ or DTCs that have an affect on vehicle emissions. The number of codes and the diagnostics for codes is always changing due to the introduction of new components and newer operating logic for them. But the key to diagnosing OBDII remains the same. That is firstly understanding the systems that are being checked. Then apply that understanding to the logic provided to the OBDII system.

OBDII checks a component and it's system for the ability to function (circuitry tests) and the result while functioning (Performance tests) for key systems.

Enabling Criteria

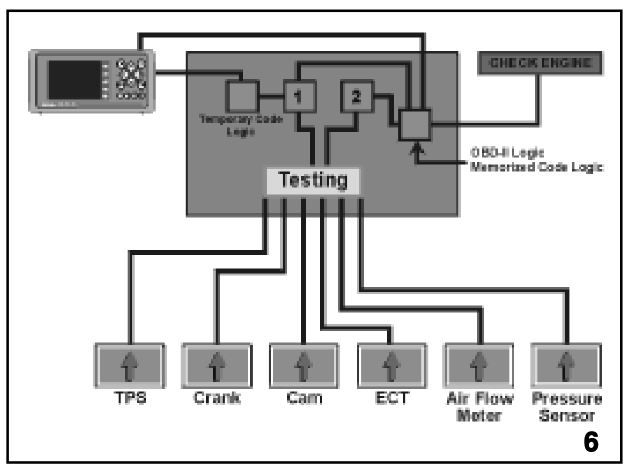
Before OBDII can begin to work the vehicle must meet the “Enabling Criteria”. This is the vehicle operating condition that must exist for the Engine Control Module (ECM) to begin diagnostics. “Enabling Criteria” will not be the same for all diagnostics. For example; the ECM checks an EGR solenoid as soon as the ignition is turned on.

The performance of the EGR system is checked after these conditions are met;

- Engine has been operating for at least 190 seconds
- EGR Solenoid has been energized
- Engine coolant temperature is equal to or Greater than 158°F (70°C)
- Engine speed is 2000-2600 RPM
- Injection duration is 4.1-6.92 ms
- Throttle angle is 5.76-24.96 degrees
- Throttle angle fluctuation during 100 Milliseconds is less than 0.96 degrees.
- Barometric pressure is greater than 507mm HG

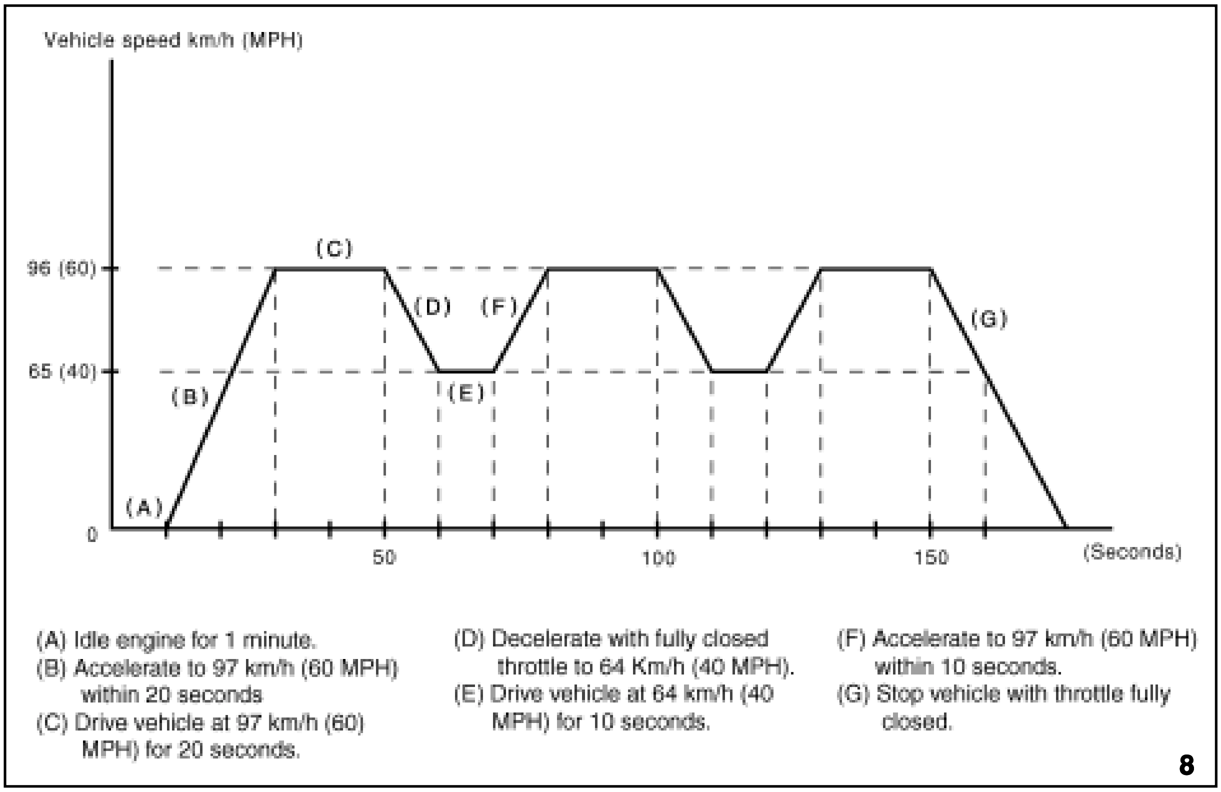
• **There can be no failures in the Following components or circuits;**

- Air Flow Sensor
- Crank Angle Sensor
- Cam Angle Sensor
- Throttle Position Sensor
- Coolant Temp Sensor, EGR SOL



OBD II Logic

Confirmation Driving Pattern



Confirmation Driving Pattern

Generally the "Enabling Criteria" is not published for all DTCs or the logic that the ECM uses to determine if a DTC should exist. What is published is the "Confirmation Driving Pattern" This is the description of the exact way a vehicle is to be driven for the "Enabling Criteria" to be met. Driving a vehicle on a lift will not substitute for actual on the road driving. A slight deviation in the confirmation-driving pattern will usually cancel the diagnostics until the right conditions can be duplicated.

OBDII checks or monitors in two methods. The first method is called Continuous Monitoring. This process will monitor for misfire, fuel system, and electrical output devices any time the vehicle is operating. The second type is non-continuous monitoring. This process will check the condition of the catalyst, heated catalyst, evaporative system, secondary air system, a/c system refrigerant, oxygen sensor, oxygen sensor heater and egr system once per "Trip"

A "Trip" is the operating of the vehicle where the Enabling Criteria is reached and the ECM has powered down.

Notes:

Readiness Codes

Readiness codes report the availability and status of the monitors through the Select Monitor. While viewing the OBD II section from the engine main menu the first 8 items will indicate no support, complete or incomplete. No Support indicates that the vehicle is not equipped with that system. Incomplete indicates that the vehicle has this system but has not diagnosed this system but will once the Enabling Criteria has been met. Complete indicates that the diagnostics have been performed for that system. These values will not default to incomplete once they are complete unless the memory has been cleared or battery power has been removed for more than 10 minutes. (1996 vehicles default to incomplete when the ignition is turned off.) See State I/M Program Advisory Bulletin 11-49-97R. (Located in back of booklet.)

MI(MIL)	OFF
Misfire monitoring	complete
Fuel system monitoring	complete
Component monitoring	complete
Catalyst Diagnosis	incomplete
Heated catalyst	no support
Evaporative purge system	incomplete
Secondary air system	no support
A/C system refrigerant	no support
Oxygen sensor	incomplete
O2 Heater Diagnosis	incomplete
EGR system	no support

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Readiness codes after memory has been cleared

MI(MIL)	OFF
Misfire monitoring	complete
Fuel system monitoring	complete
Component monitoring	complete
Catalyst Diagnosis	complete
Heated catalyst	no support
Evaporative purge system	complete
Secondary air system	no support
A/C system refrigerant	no support
Oxygen sensor	complete
O2 Heater Diagnosis	complete
EGR system	no support

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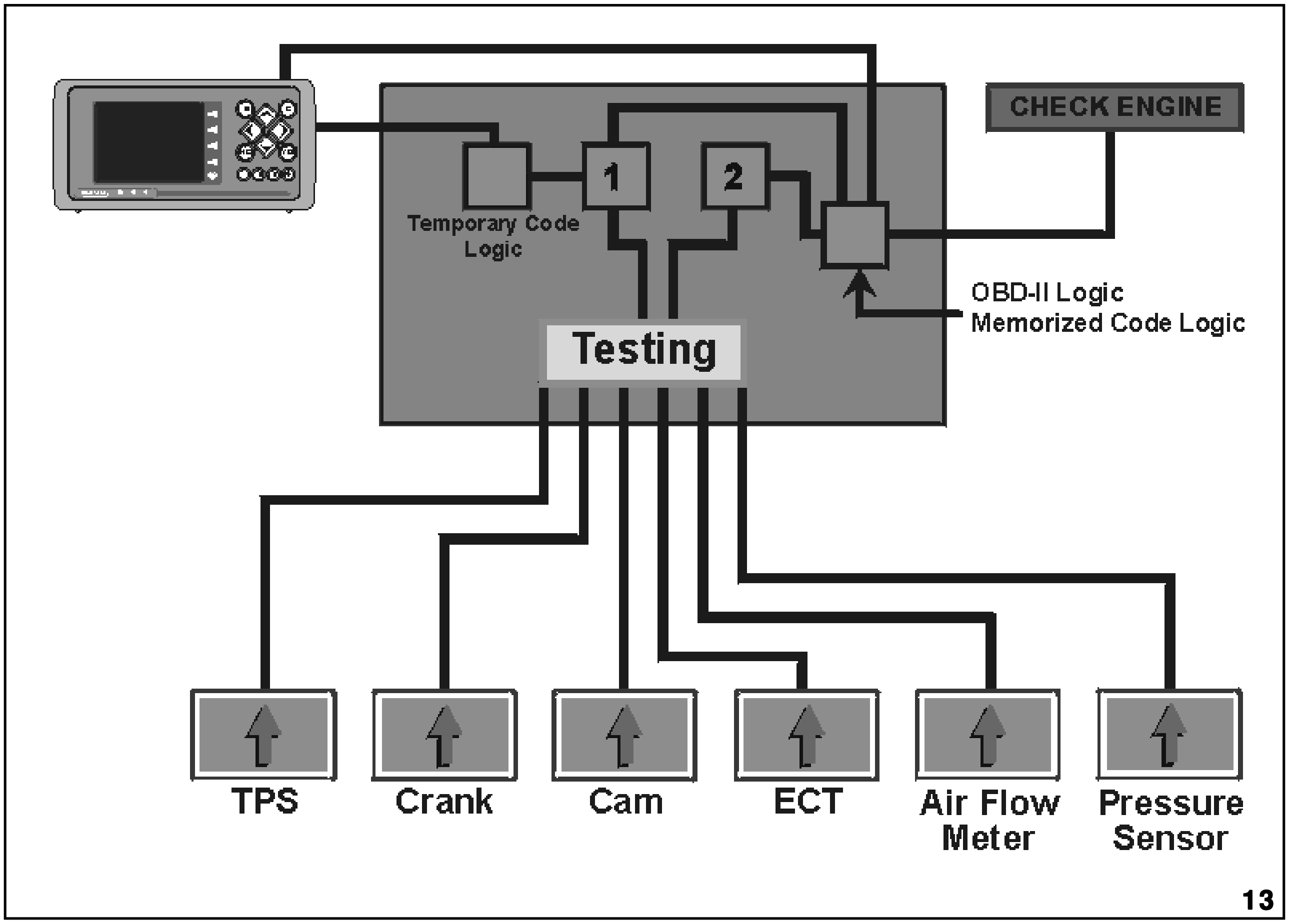
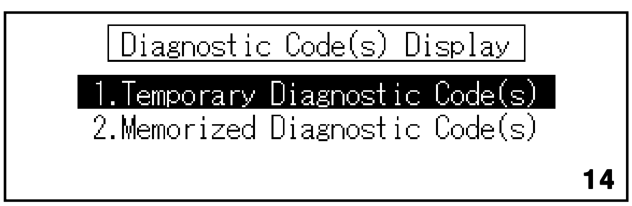
Readiness codes after meeting Enabling Criteria

Notes

OBD II Logic



OBD II Logic

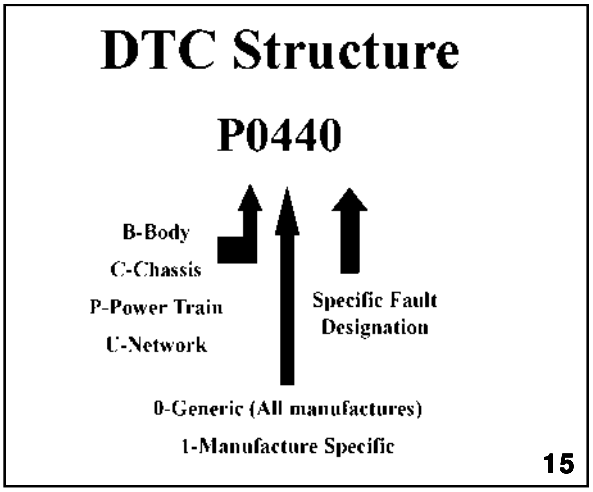


Accessing DTC's

During the actual testing or diagnostics performed by the ECM, vehicle sensors send information to a testing area of the ECM. The information is evaluated to determine if the vehicle has met the Enabling Criteria and the results of the forced testing of systems diagnosed.

Each system is assigned to trigger the illumination of the Check Engine Light in either a single fault or double fault occurrence (Trip). The single fault Trip DTCs will store a memorized code and record the vehicle operating conditions (Freeze Frame Data) when the ECM determines a fault exists. Illuminating the check engine light. The double fault Trip DTCs will not illuminate the Check Engine Light when the first fault is detected. It will register the DTC as a temporary code and wait for the second consecutive failed trip to occur before illuminating the Check Engine Light.

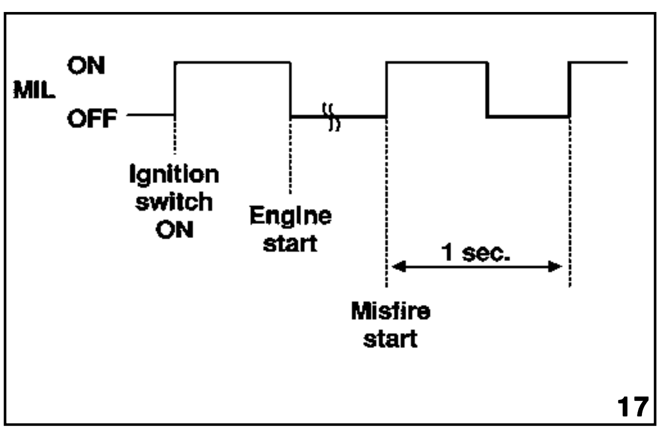
The exception to the second fault rule is any DTC that is related to Fuel Trim or Misfire. The second fault trip for these items must occur within 375 RPMs and 20% of the engine load of the first fault. At that point the Check Engine Light will illuminate and the DTC and Freeze Frame data will be memorized.



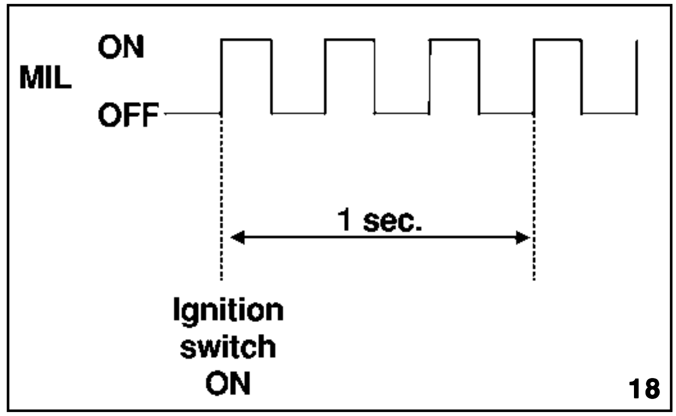
DTC Structure

OBDII requirements state that all manufactures standardize code assignments. Each code will consist of 5 characters.

Malfunction Indicator Lamp Operation



1 Hz



3 Hz

The Check Engine Light, now called the MIL, Malfunction indicator Lamp, provides communication to the driver and the Technician. The steady illumination to the driver with the engine running indicates an existing problem. Flashing at 1 Hzindicates that a misfire that can cause catalyst damage presently exists (Immediate dealer attention to the vehicle is recommended).

Technician communications include three messages. The first is a 3 Hz flash-The inspection mode connectors are connected. The second is a 1 Hz flash-Misfire that causes catalyst damage exits. And the third, Steady illumination-Indicates a problem exists or has recently occurred and a DTC has been set.

DTC Memory

Memory of a DTC (as it relates to illuminating the MIL) is maintained until 3 consecutive passing trips have been made. (The Enabling Criteria was reached 3 times in a row and the tests were performed with good results). The MIL will turn off at this point.

The DTC will remain available for viewing with the select monitor and the freeze frame information associated with it for 40 warm up cycles.

The exception to this rule is if the code is associated to misfire or fuel trim which will require 80 warm up cycles for full erasure.

Warm Up Cycle

A warm up cycle is the operating conditions of the vehicle where the coolant temperature rises to at least 40°F (22.2´°C) above the temperature at start up, and reaches a minimum of 160°F(71.1)

Freeze Frame

Freeze Frame is the vehicle operating conditions that exist when a DTC has been set.

Freeze frame data	P0108
Fuel system for Bank 1	Op_init.
Calculated load value	1.2 %
Coolant Temp.	+133 °F
Short term fuel trim B1	+0.0 %
Long term fuel trim B1	+0.0 %
Mani. Absolute Pressure	75.5 inHg
Engine Speed	0 rpm
Vehicle Speed	0 MPH

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Freeze Frame

Engine RPM

Engine Load

Fuel Pressure

Fuel Trim Values

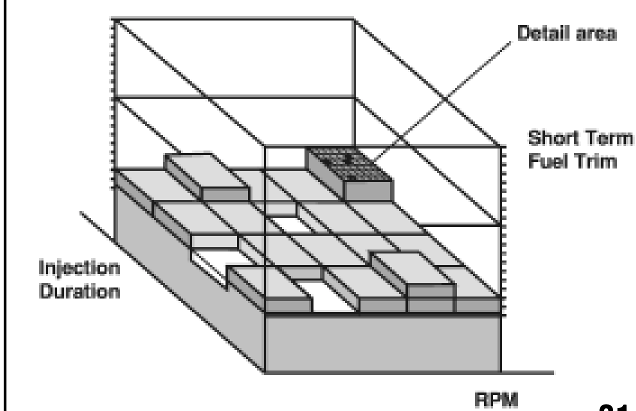
Coolant Temperature

Intake Manifold Pressure

Loop Status

DTC causing the MIL to illuminate

A DTC associated with misfire of fuel trim will over write the freeze frame data from all other DTCs.



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Fuel Trim Map

Short term and long-term fuel trim are visual interpretations on the current (short term) and historical (Long term) corrections to the air fuel mixture required to give the vehicle the best drivability and lowest emission output.

The ECM continuously monitors the amount of fuel injected and places the information recorded into memory. The ECM places the memorized information into a position that is referenced by engine load and engine rpm. The next time the vehicle is in those same conditions the memorized information is compared to the amount currently being injected. A DTC will be registered if the difference between the two is too much.

Notes:

Notes:

ATTENTION:
GENERAL MANAGER ❑ PARTS MANAGER ❑
CLAIMS PERSONNEL ❑ SERVICE MANAGER ❑

IMPORTANT - All Service Personnel Should Read and Initial

SUBARU®

NUMBER 11-49-97R

STATE I/M PROGRAM ADVISORY BULLETIN

APPLICABILITY **1996 Model Year Legacy, Impreza & SVX** **DATE** 9/2/98

SUBJECT **OBD Check During State I/M Program**

This bulletin is a reprint of Bulletin 11-49-97 dated 3/24/97, and serves as advisory information for state Inspection/Maintenance (I/M) programs.

Both the California Air Resources Board and the U.S. Environmental Protection Agency (EPA) have issued regulations requiring manufacturers of passenger cars, light-duty trucks, and medium-duty vehicles to install an enhanced On-Board Diagnostic (OBD) system for emission control systems on 1994 and later model year vehicles with exemption provisions. Our 1995 model year vehicles with a 2.2 liter engine and all 1996 and later model year Subaru vehicles are equipped with this type of OBD system.

The U.S. EPA has published regulations requiring state I/M programs to perform OBD testing on all 1996 and newer model year vehicles beginning January 1, 1998. At this time, the U.S. EPA has not provided I/M programs with their OBD testing guidance procedures.

This notice is to advise you that our 1996 model year vehicles may experience a “not ready” condition during the readiness code check of the OBD test, since our 1996 model readiness code is reset at each engine key-off or engine stall event. This condition may result in 1996 Subaru vehicles being rejected by state I/M facility inspectors. In our approved 1996 model year OBD systems, when the system detects a malfunction, it stores the identified diagnostic trouble code(s) and illuminates the malfunction indicator light (MIL) regardless of the readiness code status. Any malfunction can be confirmed by the existence of a trouble code and MIL illumination. Even if the readiness code is observed in a “not ready” condition, our vehicles will meet the I/M emissions standard.

The U.S. EPA has been informed of the 1996 model year Subaru vehicle readiness code issue and plans to release I/M OBD guidance procedures to the states in the future. **Until publication of the agency’s guidance document, we request that state I/M facility inspectors not notify the affected 1996 model year Subaru vehicle owners/drivers of the readiness code condition nor refer these owners to an authorized Subaru dealer because it will only lead to unnecessary confusion.**

State I/M Program Advisories Bulletins

No.	Date	Title	Subject
11-47-95	10/11/95	1995 Legacy & Impreza 2.2L engines Equipped with an automatic Trans.	OBD II System trouble codes P)105 & P0106
11-49-97R	09/02/98	1996 MY Legacy, Impreza & SVX	OBD Check During State I/M Program
11-54-99	03/01/99	All 1996-1999MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-55-99	03/17/99	All 1996-2000MY	On-Board Diagnostic System Check During State Emission Test
11-57-99	09/29/99	All 2000 MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-62-00	05/08/00	All 2001 Models Subaru Vehicles	On-Board Diagnostic System Check During State Emission Test
11-64-01	02/01/01	All 1996-1999 Legacy Postal Vehicles	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location

Service Bulletins

No.	Date	Title	Subject

406 Module Service Help-Line Updates

Date	Subject
11/94	OBD II - DTC P0441 "Evaporative emission control system incorrect purge flow"
11/94	OBD II Test Drives
06/95	1995 Subaru Legacy DTC P0505 - Idle control system malfunction
06/95	1995 Subaru Legacy DTC P0325 - Knock sensor circuit malfunction
06/95	1995 Subaru Legacy DTC P0130 Front 02 sensor circuit malfunction
09/95	DTC P0505 Idle control system when solenoid measures 5Ω or less
12/95	Extreme cold weather engine warm up and OBD II
11/96	Extreme cold weather engine warm up and OBD II
03/97	DTC P1500 Radiator fan relay one circuit
04/97	Understanding P0440
05/97	DTC P0507-Idle control system RPM higher than expected
07/97	Code P0500
07/97	Additional information regarding code P0440
08/97	OBD II cylinder misfire codes
10/97	More P0440 information
01/98	Model Year 1998 changes in P0449 operation
05/98	Model Year 1998 changes in P0449 operation
05/98	DTC P0440 revisited
11/98	P0440 TIP
11/98	DTC P1507

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Technicians Reference Booklet

Steering Systems Module

Module 502

AUTOMOTIVE Youth Educational Systems®

November 2004

MSA5P0271C

Technical Training

Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of November 2004.

Table of Contents

Slide Sequence

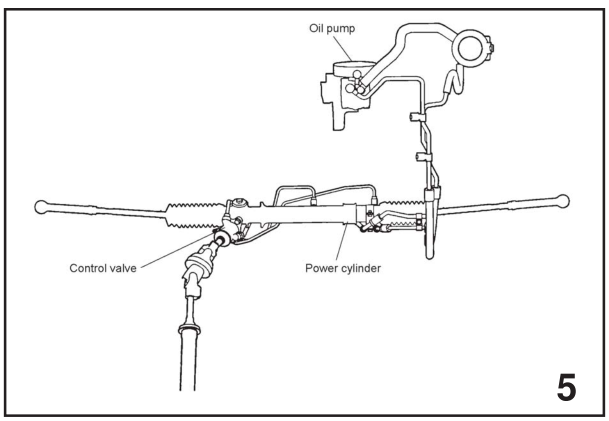
Slide Sequence

Introduction and Operation

Subaru Steering Systems utilize a rack and pinion steering mechanism. As the pinion gear rotates, the rack moves left or right. Rack and pinion steering gives the driver precise control over the wheels. The simple, compact design is easy to service.

Power Steering

A large force is required to operate the steering when a vehicle is stopped. As the vehicle speed increases, a smaller force is required to operate the steering. In other words, a very large force is required to operate the steering wheel when the steering wheel is turned while the vehicle is stopped. Power steering provides an extra force making it possible to steer the vehicle with the same force regardless of the vehicle speed.



Pump and Rack

Outline of the Steering System

The three main elements of the vehicle are driving, turning and stopping. Steering controls the element of turning.

Normally, vehicle are designed to drive straight ahead when the steering is not operated. When turning a corner or changing lanes, the direction of the tires must change and the vehicle must turn. Using a rack and pinion, the steering converts the force exerted by the driver on the steering wheel to a laterally directed force, and at the same time it boosts the force so that the vehicle can turn.

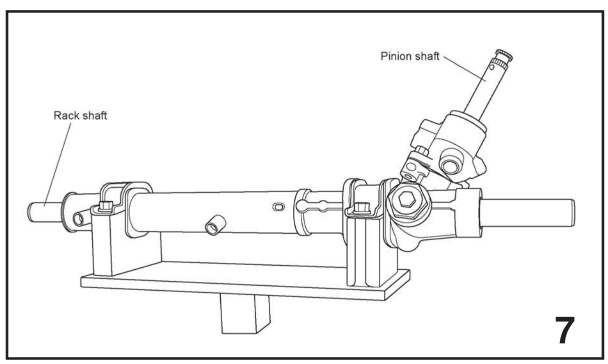
Overview

Pinion shaft

The function of the pinion shaft is to transmit the steering wheel turning force to the rack, causing it to operate.

Rack shaft

The rack shaft converts the rotational force of the pinion shaft to the lateral force, changing the direction of the wheel. It also functions to boost the steering force according to the ratio between steering wheel diameter and pinion diameter.

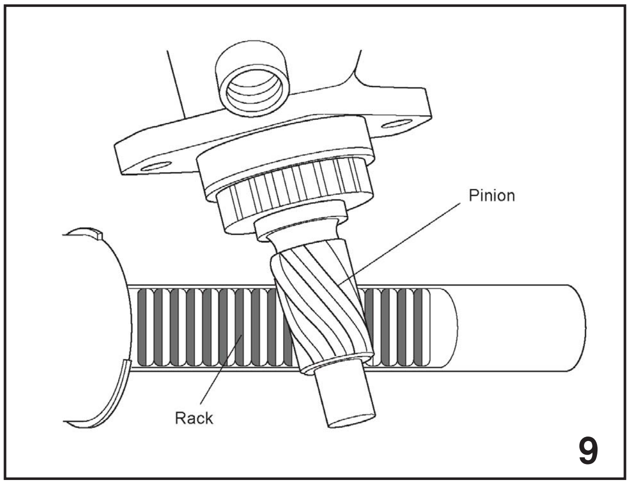


Rack mounted on holding tool

Steering Construction

Rack and Pinion

A rack-and-Pinion steering gear has a pinion installed on the end of the steering shaft. The pinion is meshed with a rack therefore the rotation of the pinion is converted to lateral movement of the rack, which moves the left and right wheels.



Pinion and Rack Gears

Steering Gear Ratio

NOTE: IN THE RACK-AND-PINION STEERING SYSTEM, THE GEAR RATIO CANNOT BE CALCULATED WITH THE RACK TREATED AS A STRAIGHT LINE (BECAUSE THE GEAR RATIO WOULD BE INFINITELY LARGE). ACCORDINGLY, THE STEERING ANGLE RATIO IS FROM THIS POINT FORWARD DESCRIBED AS THE GEAR RATIO.

THE STEERING GEAR RATIO INDICATES THE ANGLE OF THE TIRES WHEN THE STEERING WHEEL IS TURNED. FOR EXAMPLE, IF ONE ROTATION OF THE STEERING WHEEL (360°) CORRESPONDS TO A TIRE ANGLE OF 20°, THEN 360 ÷ 20 = 18,

THE NUMBER IN THIS EXAMPLE 18 REPRESENTS THE STEERING GEAR RATIO.

AS THE STEERING GEAR RATIO INCREASES, THE STEERING EFFORT DIMINISHES, AS DOES THE SHOCK IMPARTED TO THE STEERING WHEEL FROM THE WHEELS, BUT THE WHEEL RESPONSE DETERIORATES. AS THE STEERING GEAR RATIO DECREASES, CONVERSELY, THE STEERING EFFORT INCREASES, BUT THE WHEEL RESPONSE IMPROVES, POSSIBLY MAKING A HIGHLY SENSITIVE STEERING OPERATION.

Variable Gear Ratio (VGR) Power Steering

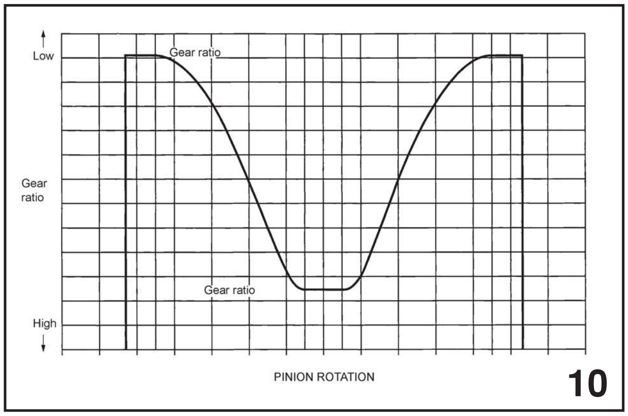
Certain vehicle models use a VGR type rack and pinion. With the VGR system, the gear ratio is varied depend on steering wheel turning angle.

While driving straight ahead:

A larger gear ratio is used to alleviate kickback and other adverse effects that occur while the vehicle is in motion. Road handling characteristics are also improved because the driver's body movements are not readily imparted to the steering.

While turning:

Steering response is improved because the gear ratio becomes smaller as the turning angle increases.



Pinion Rotation Chart

In the VGR system the angle of the gear equipped on the rack is varied, causing the pinion and gear contact point to vary. The gear is set on the rack so that the gear thickness increases as the gear moves away from the center of the rack. As the steering wheel is turned to the left or right, therefore, the gear ratio becomes correspondingly lower.

This means that the rack moving speed at both ends is larger than that of the center part.

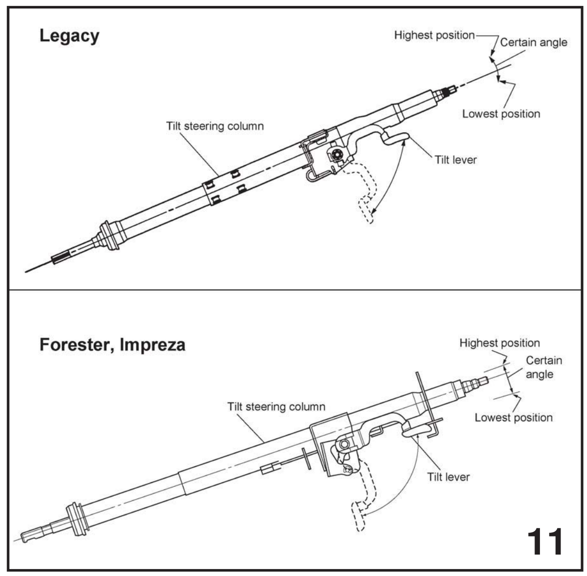
Accordingly, the gear ratio at both ends becomes smaller than that of the center part.

Steering Column

Tilt Steering

Tilt steering is an aid to safe driving, for it allows the driver to adjust the steering wheel position to suit his or her height and physique.

The steering wheel position is adjusted by moving the tilt lever downward, thereby releasing the steering wheel and allowing it to be raised or lowered within a certain range. The steering wheel can then be locked in position by operating the tilt lever again.



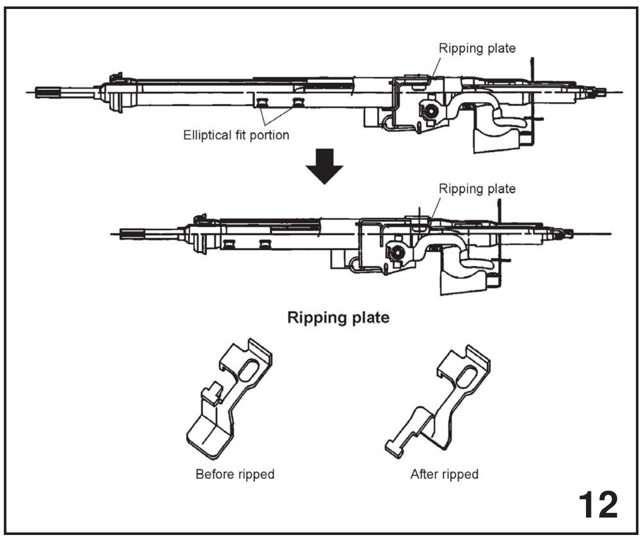
Steering Columns

Energy-absorbing Mechanism

An energy-absorbing mechanism is provided to protect the driver during a collision when his or her body comes into contact with the steering wheel because of inertia.

Ripping Plate System

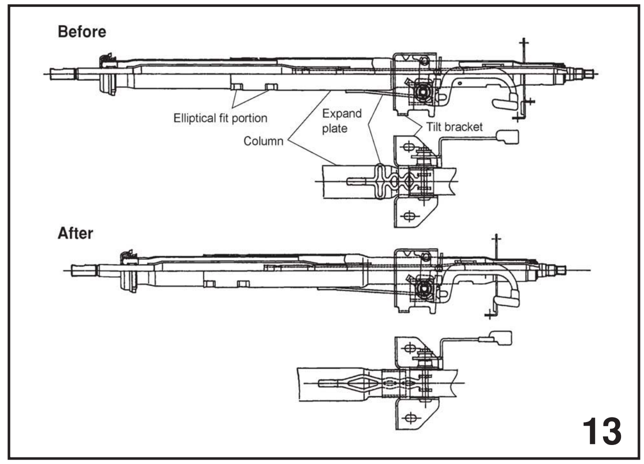
In the ripping plate system, the plate is set on a part of the tilt lever. When a collision occurs and the driver comes into contact with the steering wheel, the ripping plate breaks, causing the steering shaft to shorten, protecting the driver.



Ripping Plate System

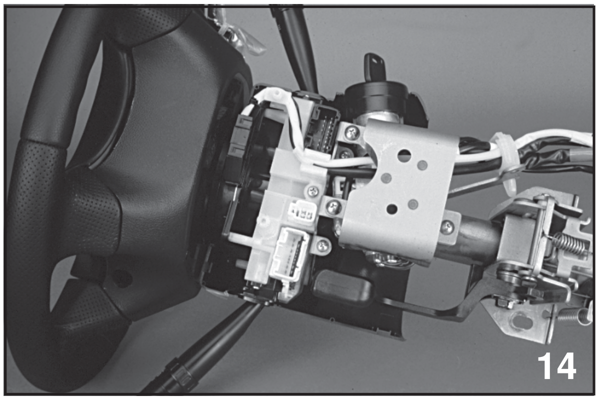
Expand Plate System

In the expand-plate system, the plate expands when the driver comes into contact with the steering wheel during a collision. This causes the steering shaft to shorten, protecting the driver.

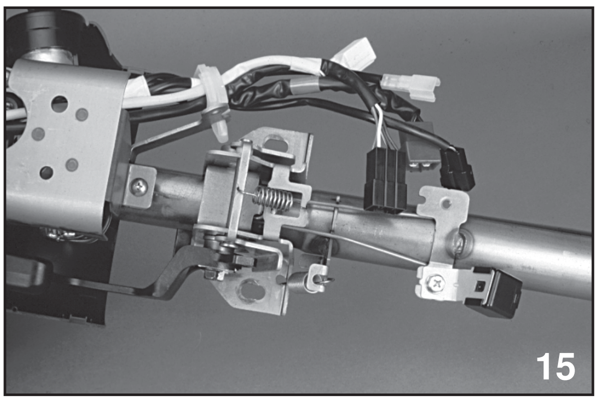


Expand Plate System

Impreza



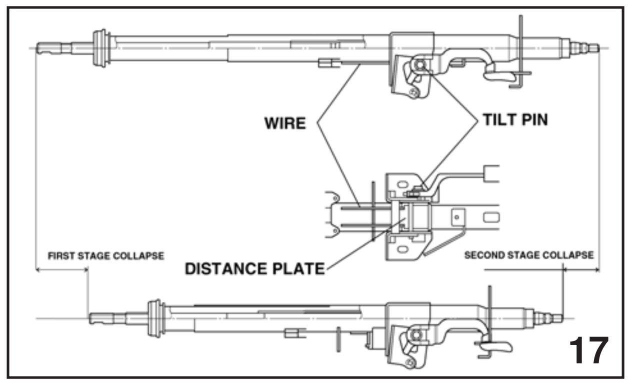
Impreza Steering Column



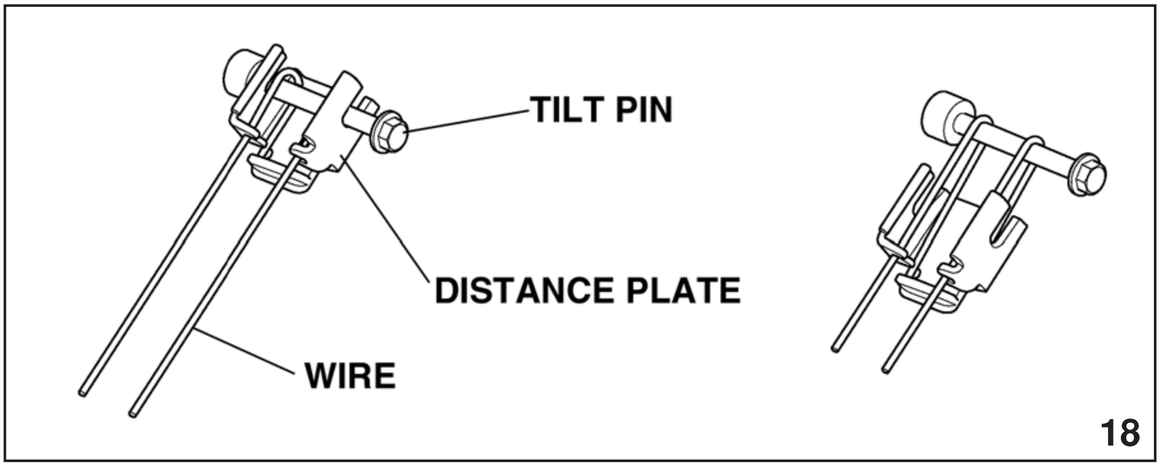
Energy absorbing wire

All 2002 and newer Impreza vehicles are equipped with a 2-stage energy absorbing steering column. The 2nd stage action is possible because of the use of an energy absorbing wire and mount. During the first stage collapse the lower section of the column slides into the outer section or jacket of the column. If a secondary force is applied to the upper part of the column, the energy absorbing wire will begin to stretch allowing the column and the steering wheel to move toward the dash.

Collapsible Steering Column



Before and after collapse



Energy absorbing wire operation

While this secondary collapse is occurring the column moves away from the mount and is supported only by the energy absorbing wire. The amount of secondary collapse will be in proportion to the energy contained in the secondary force.

Power Steering

Power Steering System Overview

The power steering is comprised of the oil pump, the control valve, and the power cylinder.

Oil Pump

Driven by the engine, the oil pump generates the oil pressure that operates the power cylinder, while the flow control valve built in the pump controls the oil flow rate.

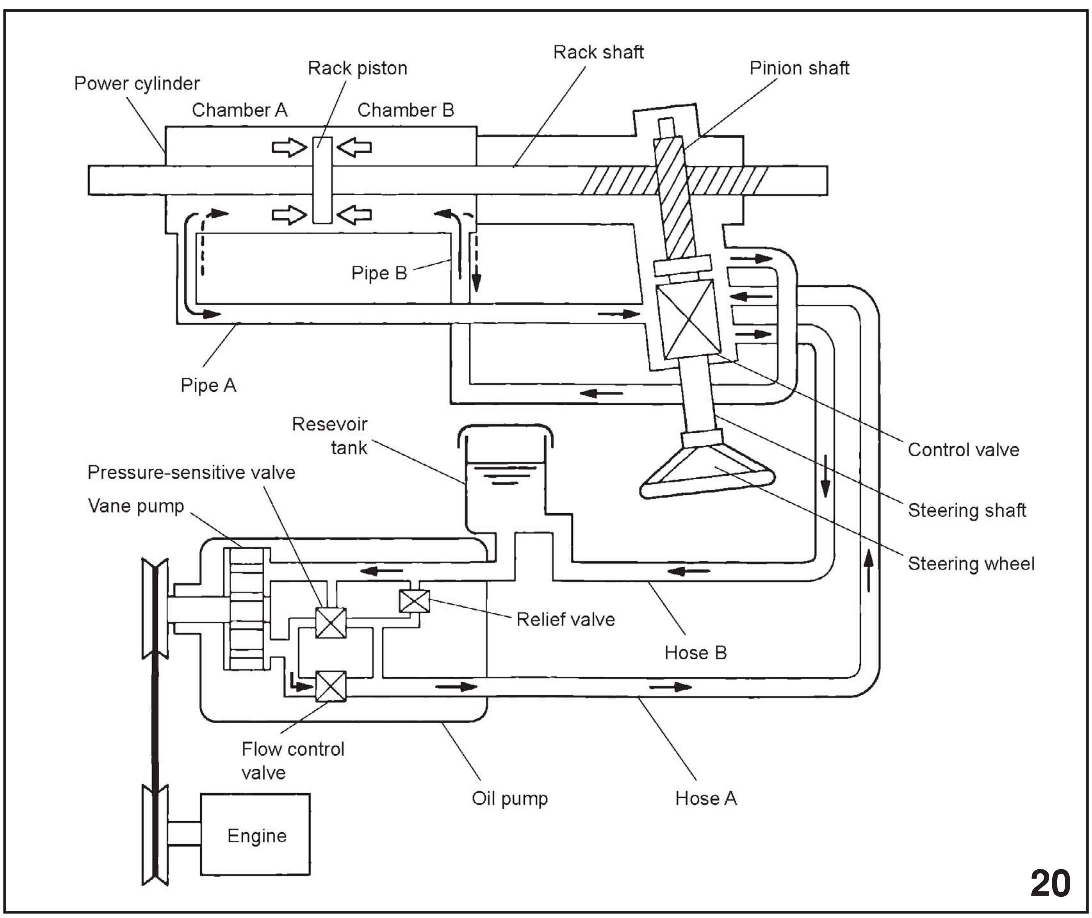
Control Valve

The control valve directs the oil to the left or right power cylinder.

Power Cylinder

The power cylinder is comprised of a piston installed on a rack shaft and cylinder, and it is operated by the oil pressurized by the oil pump.

The oil pressurized by the oil pump is fed through the flow control valve to the steering gearbox, and afterwards it is returned to the reservoir tank.

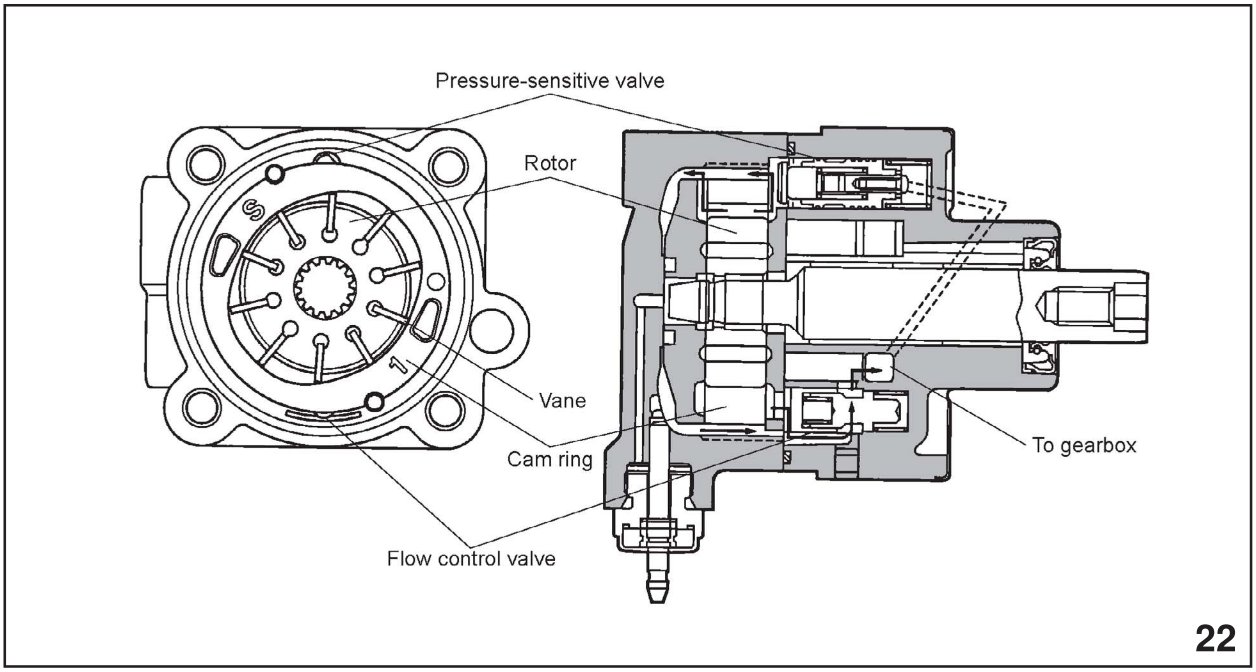


Hydraulic Layout

Oil Pump

The oil pump is driven by the engine by means of a belt. It is a vane-type pump comprised of a rotor, cam ring, and 10 vanes.

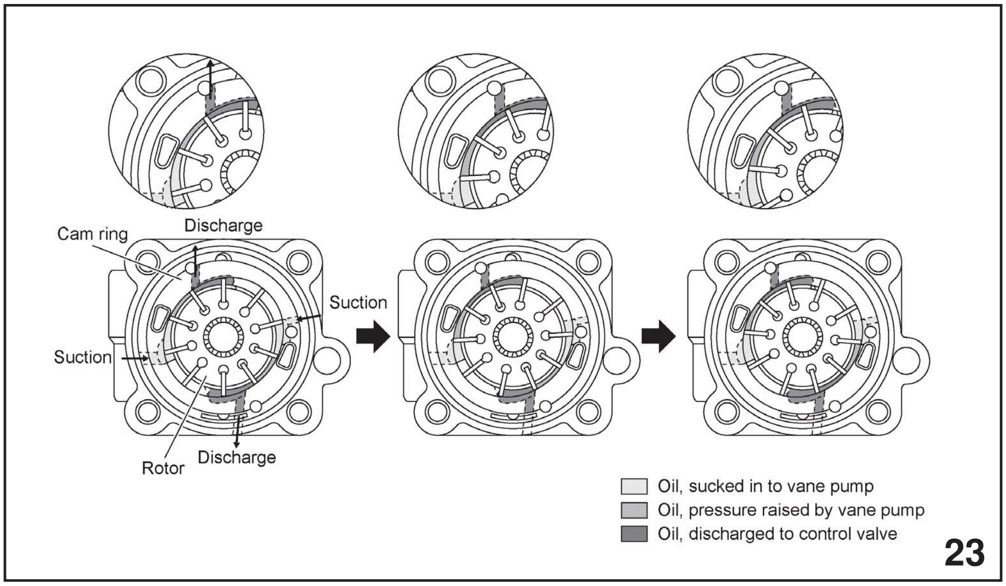
In addition, a flow control valve, pressure-sensitive valve, and relief valve are provided to control the oil pressure.



Power Steering Pump

Oil Pump Operation

When the oil pump rotor is turned by the engine, the vanes which fit into each groove of the rotor are pushed outward by the centrifugal force of the rotor and press against the cam ring. Because the cam ring is shaped oval to the rotor, a negative pressure is created in the pump suction port that draws in oil, and a pressurized oil is created on the discharge side that is forced out of the discharge port.

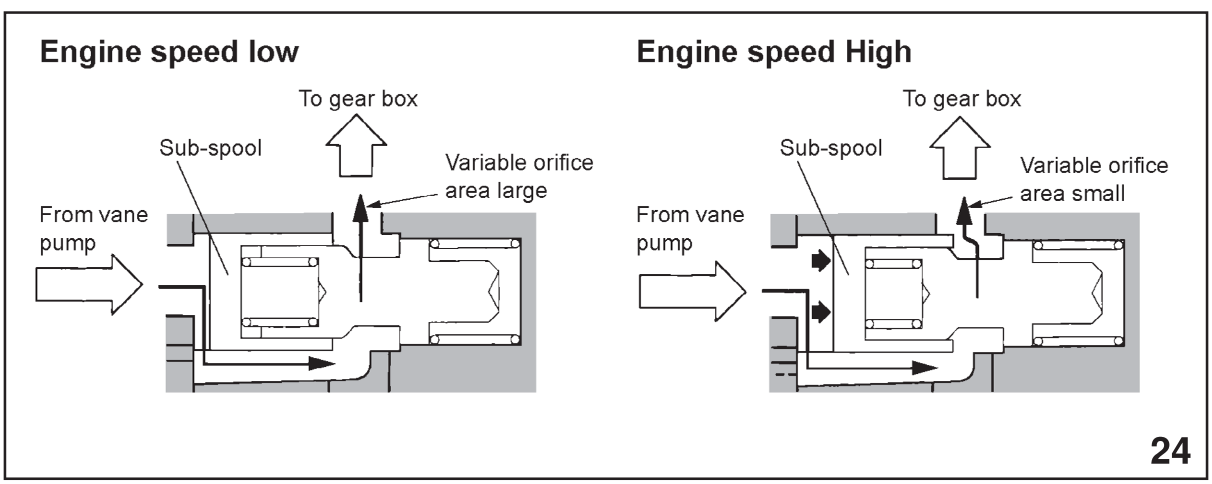


Power Steering Pump Operation

Flow Control Valve Operation

In order to obtain a small steering effort at low speeds and obtain a large steering effort at high speeds, this valve suitably controls the flow rate of working fluid to the gear box out of the pump discharge port which increases in proportion to the pump speed.

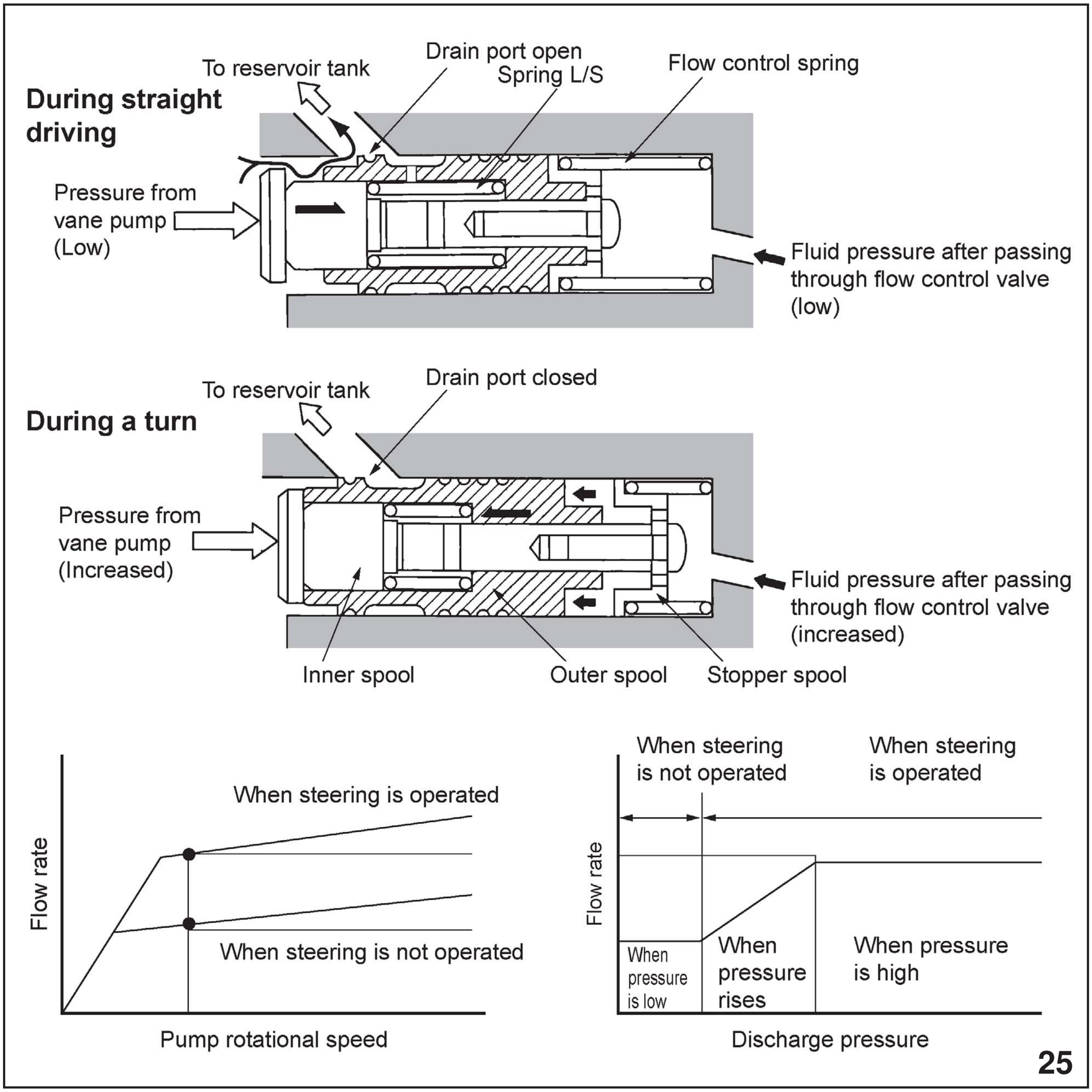
A sub spool is installed inside the flow control valve. When the oil pump discharge rate, overcomes the force of a spring in the sub spool, the sub spool moves to the right, reducing the width of the oil channel to the gearbox, controlling the oil flow rate.



Flow Control Valve Operation

Pressure-Sensitive Valve

This valve prevents energy loss by reducing the oil flow rate to the control valve and lowering the pressure losses in the system (piping, gearbox, and pump) when the steering is not operated (during low-pressure conditions).



Pressure-Sensitive Valve Operation

	Steering		Drain port	Oil flow rate	Pump power consumption
When pressure is low	When steering is not operated		Large	Low	Small
When pressure increases	When steering is not operated	Valve opearation starts	Medium	Medium	Medium
When pressure is high		Valve opearation ends	Small	High	Large

1. When pressure is low (steering is not operated)

When the steering is not operated, the oil pressurized by the oil pump simply passes through the control valve, so the oil pressure does not rise. At the same time, the drain port is widely opened because the pressure sensitive valve outer spool is pushed against the stopper spool by the spring L/S.

Since the flow control spring set load is low, this causes the oil pressure produced by the vane pump is drained away, reducing the pressure difference at the front and rear of the spool assembly and the discharge flow rate to the control valve.

2. When pressure increases

When the steering wheel is turned to the left or right, the control valve is also turned and passage to the reservoir tank is closed. Therefore, oil pump discharge pressure increases.

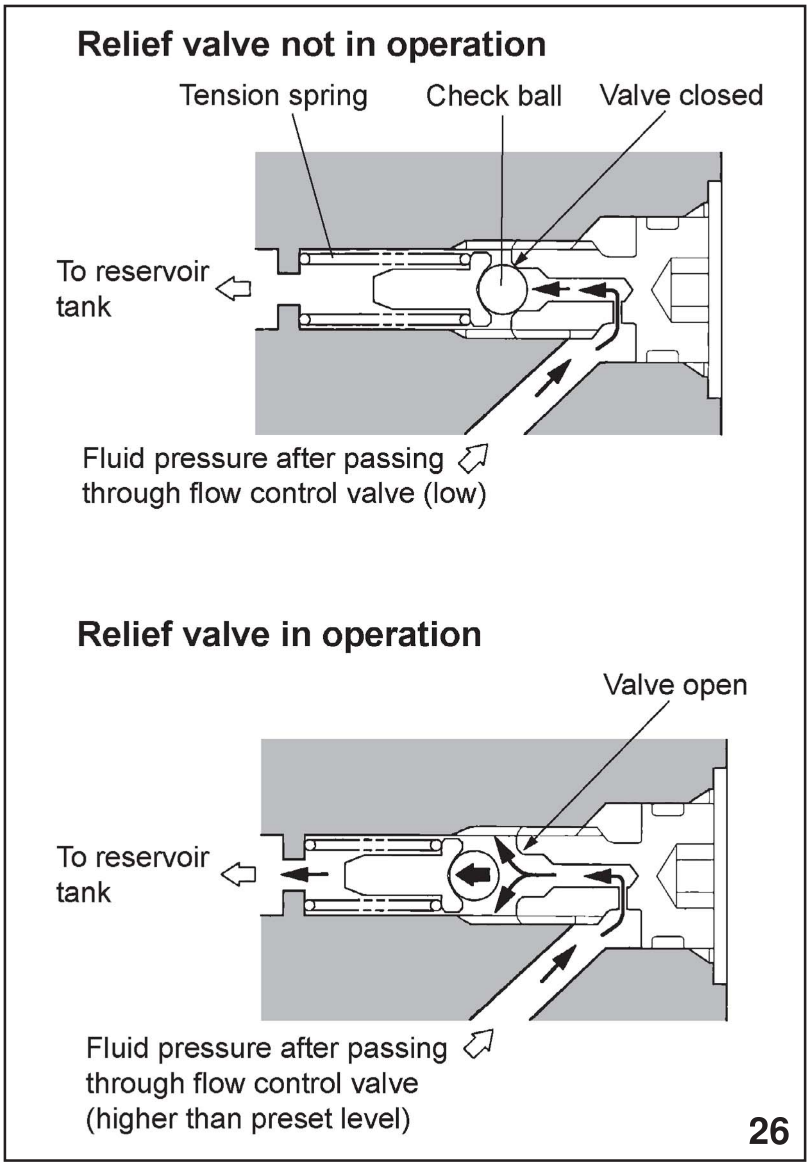
3. When pressure is high

At high pressure conditions the outer spool contacts the inner spool front end and the two parts work in unison, keeping the oil flow rate at maximum.

Relief Valve

The relief valve is comprised of a tension spring and check ball. Oil pressure from the flow control valve is applied to the right side of the relief valve, and the left side is connected to the oil reservoir tank.

During normal operation, the check ball inside the valve is pushed to the right side by the spring force, and the valve is closed. When the oil pressure from the flow control valve rises abnormally (when the steering wheel stays locked, for example), the oil pressure overcomes the spring force and moves the check ball to the left, opening the valve and allowing the oil pressure to escape into the reservoir tank preventing the pressure from being excessive. When the oil pressure from the flow control valve drops afterwards, the spring force closes the valve again.

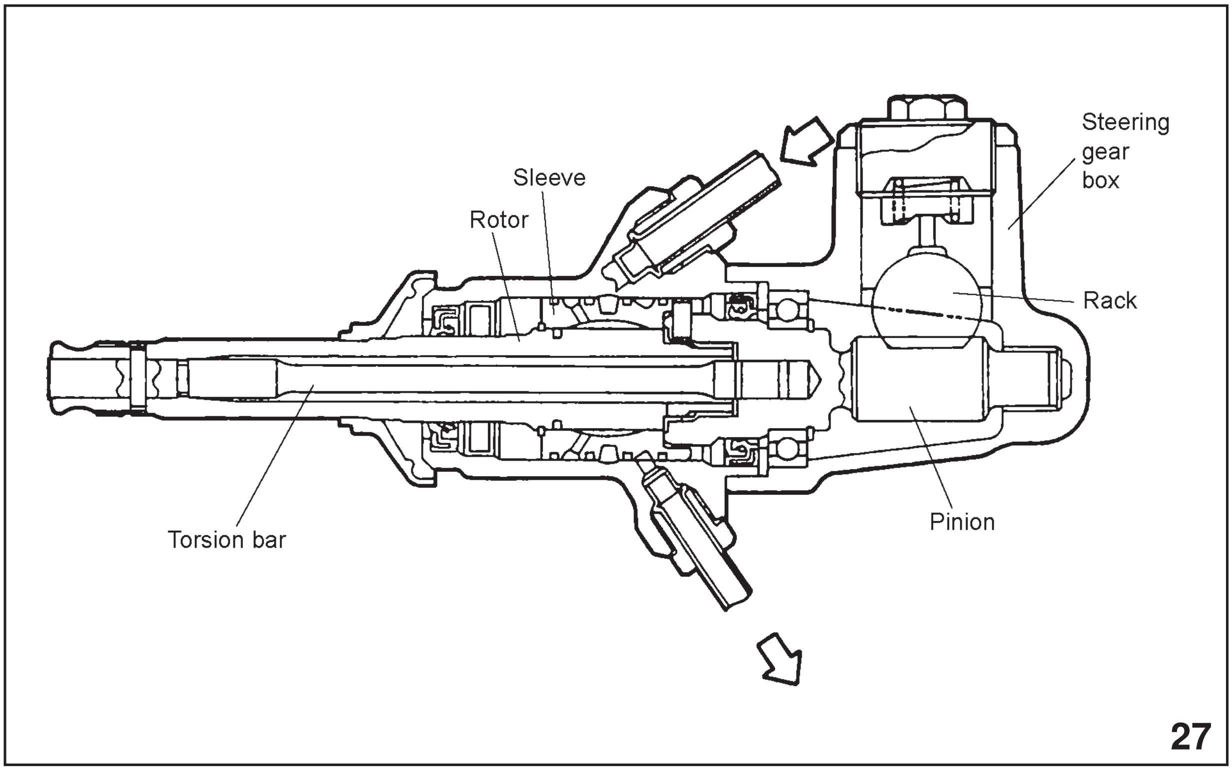


Relief Valve Operations

Control Valve

The control valve consists of a rotor, which rotates together with the steering shaft, and a pinion that rotates together with the sleeve and the torsion bar. The pinion and rotor are loosely engaged with a spline, and the torsion bar which is twisted by the turning force applied to the steering wheel connects them. This generates a relative displacement of the rotor and sleeve and thereby increases or decreases the oil channel cross-sectional area and controls both the change over of the working fluid channel and the working pressure.

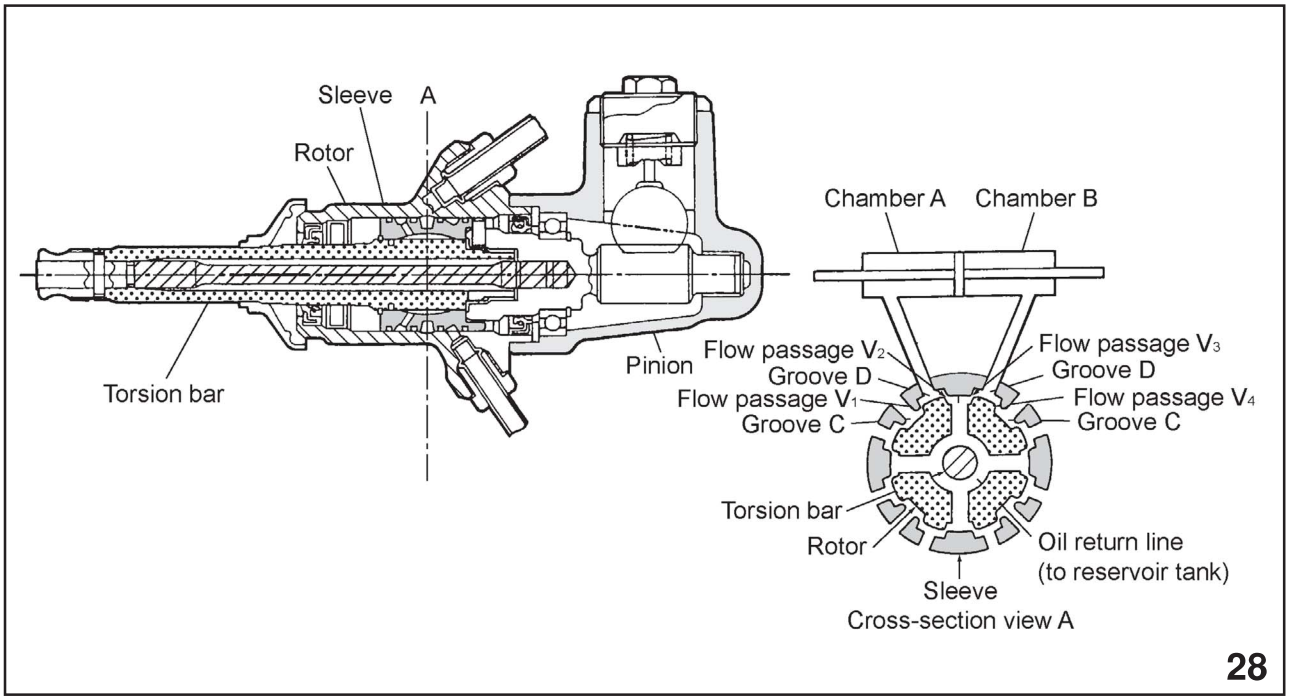
When oil pressure is not produced due to oil pump breakdown, drive belt damage, or other cause, torque is directly transmitted from the valve rotor through the spline to the pinion.



Control Valve

Control Valve Operation

When the steering wheel is turned to the left or right and the torsion bar twists due to resistance with the road surface, the rotor connected to the steering shaft turns, simultaneously switching between the oil channels to chambers A and B and those from chambers A and B to the reservoir tank.

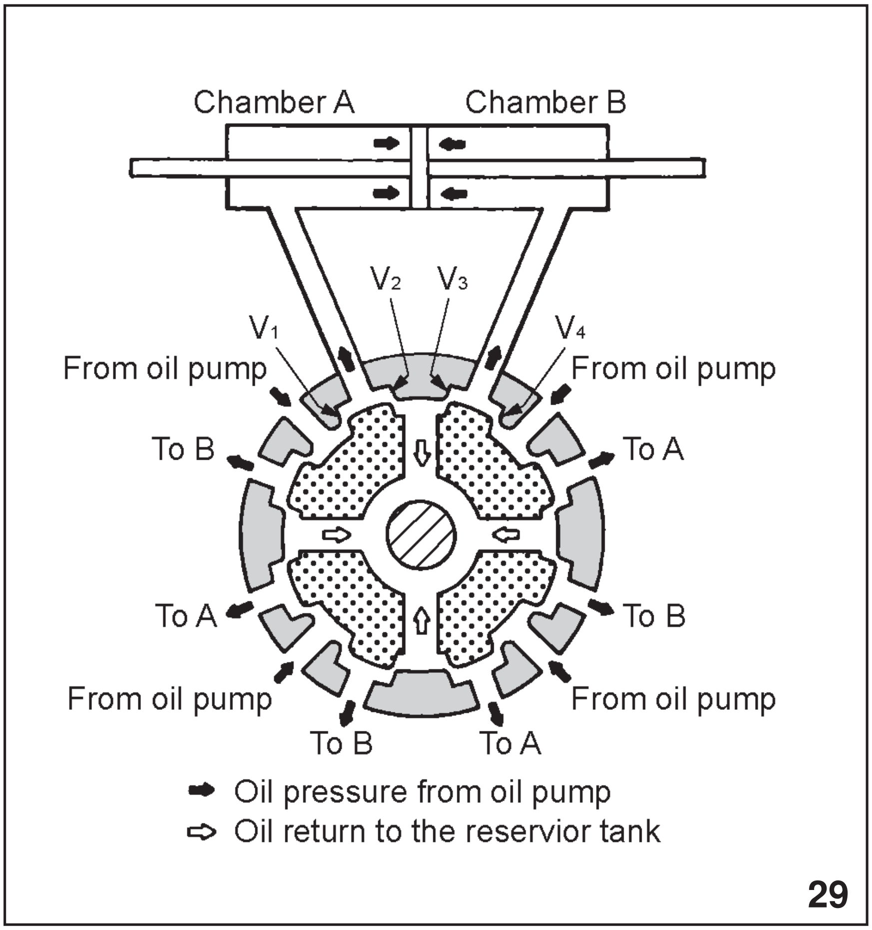


Control Valve Operation

When the steering wheel is in the center position

The torsion bar is not twisted since the steering wheel is in the center position. The rotor and sleeve are in their center positions and oil channels V_1, V_2, V_3, and V_4 have a uniform width. The oil pressure applied to chambers A and B is equal and the steering maintains straight-ahead travel; afterwards, the oil is returned to the reservoir tank.

In this situation, the channel V_1, V_2, V_3, and V_4 are opened widely and oil from the oil pump is drained to the reservoir, keeping oil pressure at a low level.

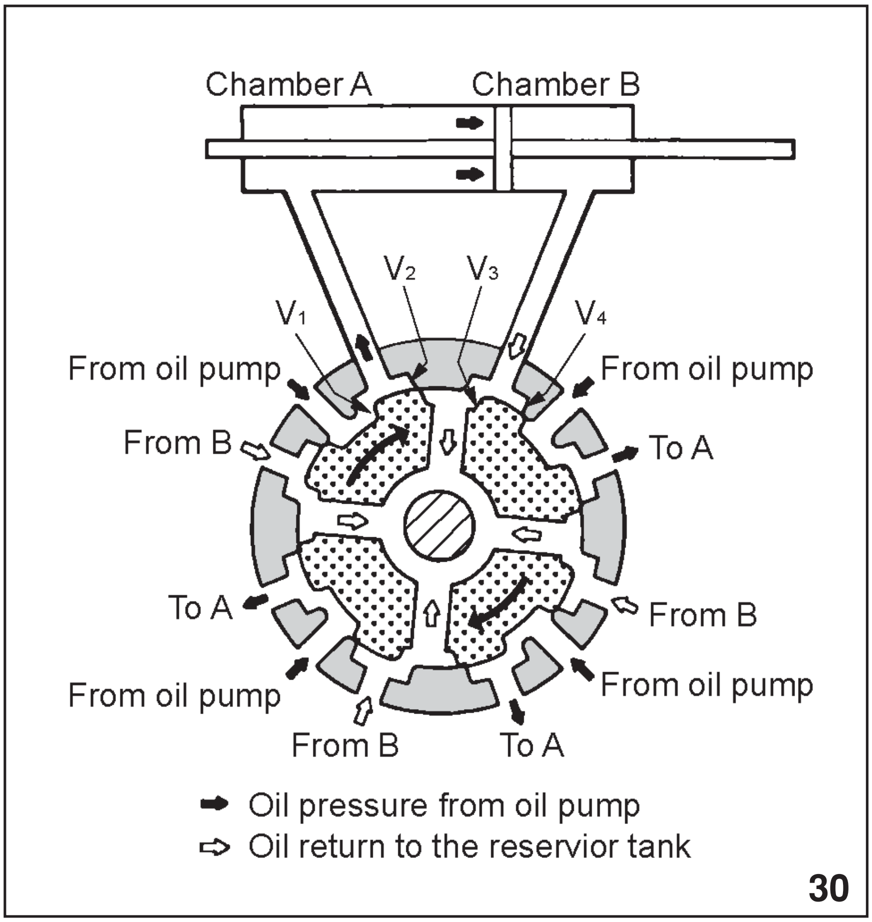


Center Position

When the steering wheel is turned to the right

As the steering wheel is turned to the right, the twisting of the torsion bar causes the rotor to move, closing off oil channels V_1, V_2, V_3, and V_4 and increasing the width of channels V1, and V_3.

The oil pressurized by the oil pump then enters chamber A, passing through oil channel V_1, while the oil in chamber B is pushed by the piston and returned to the reservoir tank via oil channel V_3. This reduces the steering effort and makes it easier to turn the steering wheel to the right. As is evident from the figure, the channels V_2 and V_4 are closed and there is no way that oil from the oil pump return to the reservoir tank, therefore oil pressure from the oil pump increases to the necessary level to move the rack piston.



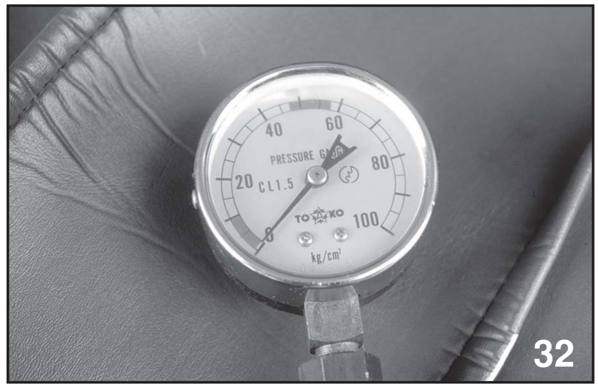
Turning to the right

Airbag Steering Column Installation

Review the roll connector phasing procedures listed in the appropriate MY Service Manual.

The roll connector must be phased to the steering system only when the front wheels are centered.

Power Steering System Pressure Testing

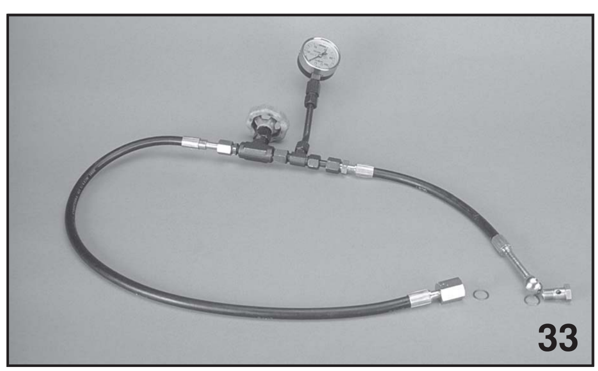


Pressure Gauge

If the troubleshooting procedures leads you to suspect a fault in the power steering system, perform a pressure test. Ensure that the vehicle is equipped with the specified tires and rims and that the tires are properly inflated. Then, bring the engine up to operating temperature before performing the test. Keep the following precautions in mind as well:

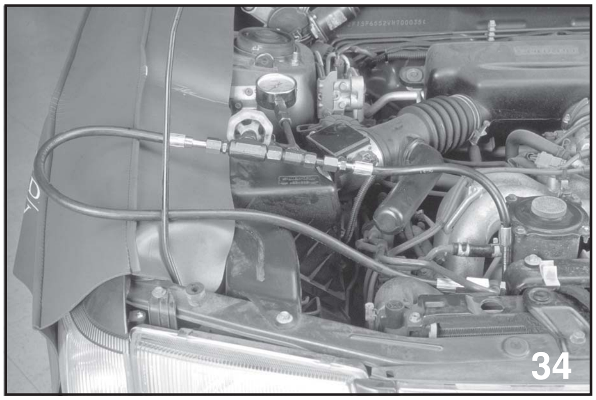
Always wear eye protection

1. Do not leave the pressure gauge valve closed for more than 5 seconds; doing so may damage the pump.
2. Do not hold the steering wheel in the full lock position for longer than 5 seconds; this may damage the pump.
3. Keep the engine speed at idle.
4. Handle ATF fluid carefully; catch spilled fluid with shop cloths to prevent damage to the vehicle's finish.



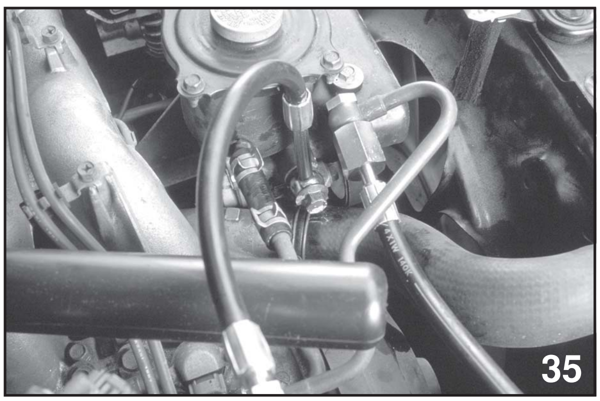
Pressure Gauge with Adapters

Power Steering Pressure Test

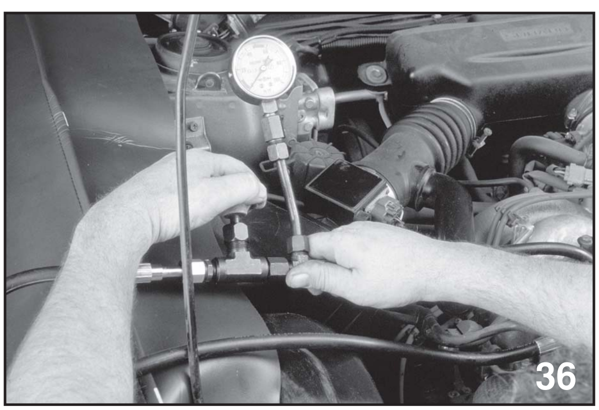


Gauge in place

Attach pressure gauge using the correct hoses to the discharge port of the pump.



Connections at Pump



Opening/closing valve

Then perform the three pressure tests listed.

Step 1: Regular pressure
Engine idling,
valve open:

↓

OK Not OK → Crimped Fluid line → Replace
→ Leaking fluid line → Tighten or replace
→ Clogged fluid line → Drain or replace

↓

Go to step 2

↓

Step 2: Relief pressure

Engine idling,
valve closed

↓

OK Not OK → Faulty relief valve
→ Oil pump leak → Replace
→ Worn pump

↓

Go to step 3

Step 3: Working Pressure

Engine idling,
valve open,

steering wheel
turned stop to stop:

↓

OK Not OK → Faulty control valve → Replace

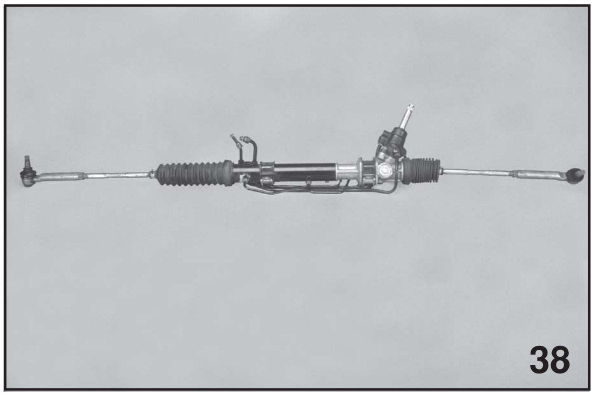
↓

Yes

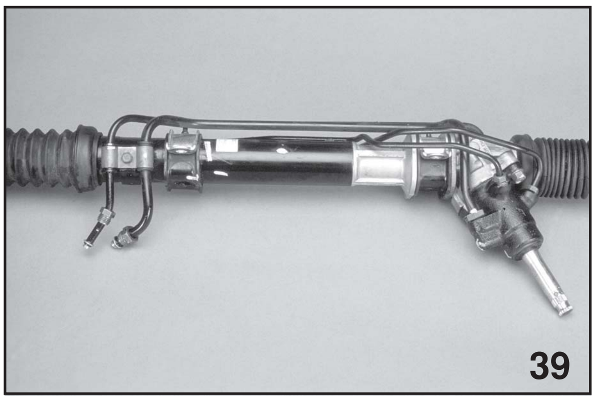
↓

System OK

Steering Rack Overhaul



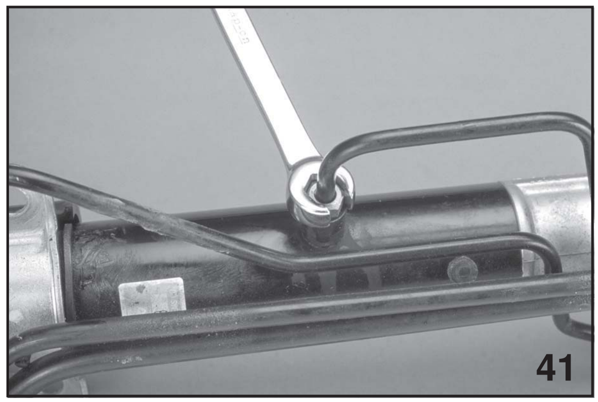
Rack



Pipe Routing

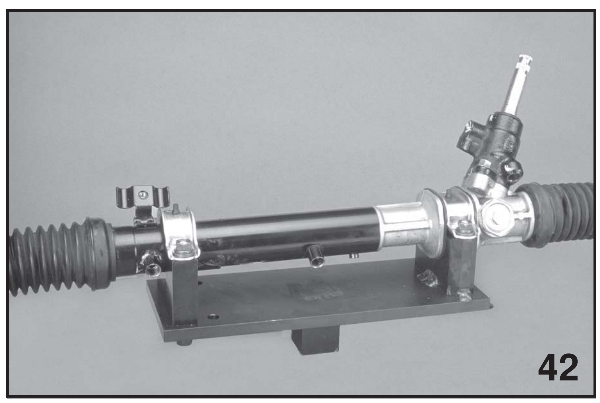
1. 2002 Legacy rack and pinion

Control Valve Connections



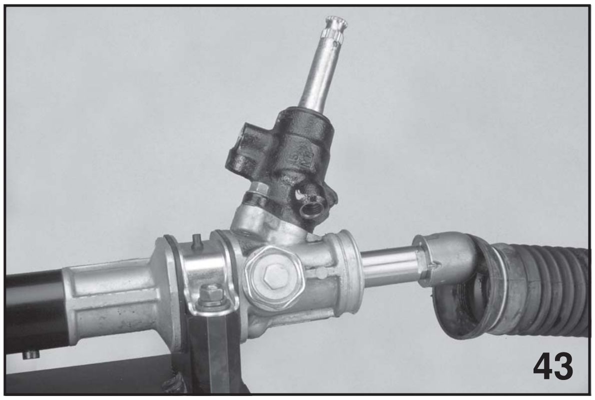
Rack Connections

2. Remove hydraulic lines from rack and pinion



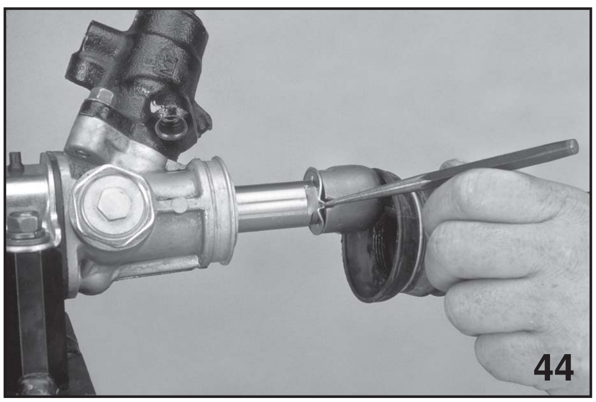
Rack in Holding Tool

3. Mount rack onto rack and pinion fixture. ST 926200000



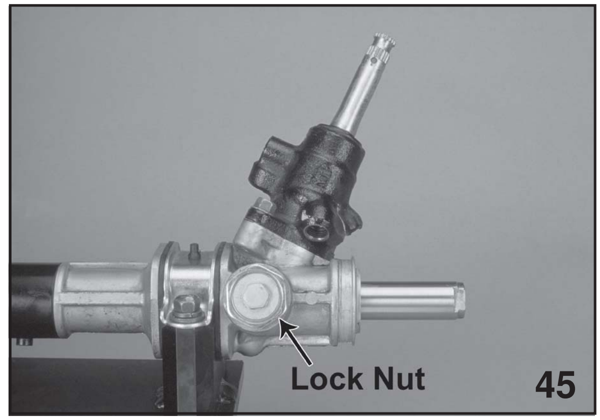
Removing Bellows

4. Remove tie-rod bellows from both sides of rack



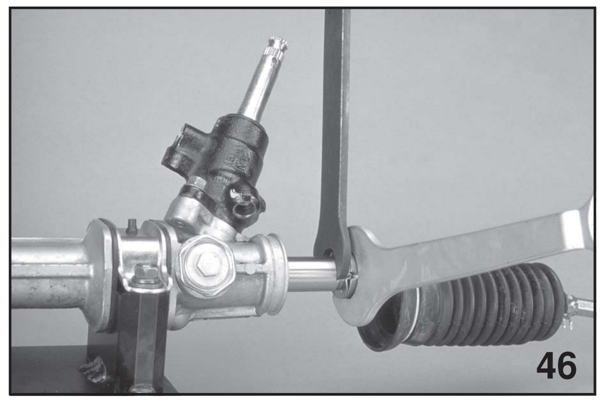
Unstaking Locking Washer

5. Using a hammer and cold chisel, remove stakes from locking washers.



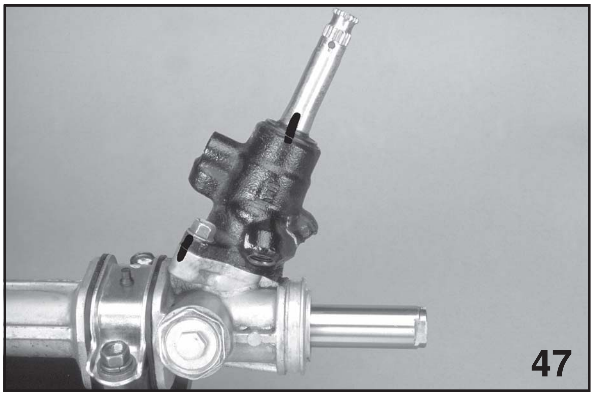
Lock Nut

6. Tighten adjusting nut to assist with holding the rack stationary.



Removing Inner Tie Rods

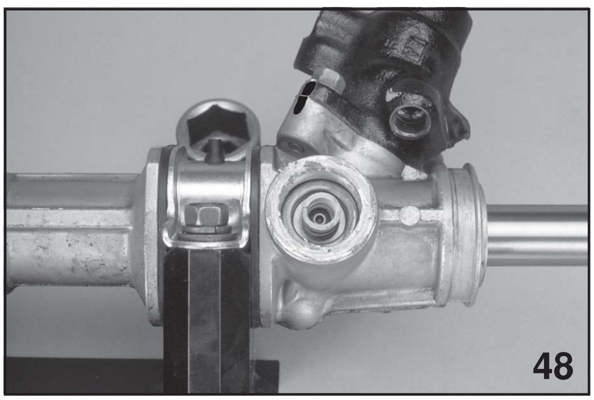
7. Remove inner tie-rods with a 32mm wrench.



Protruding Rack

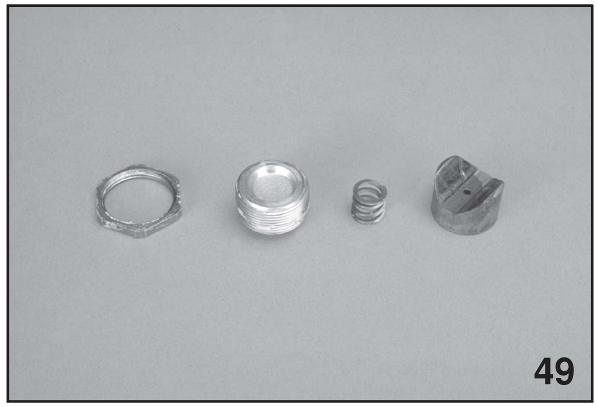
8. Loosen adjusting screw and position drivers side of rack so it protrudes 2.6 inches from rack housing.

   Using paint, mark the relationship of the stubshaft to valve housing and valve housing and rack housing.



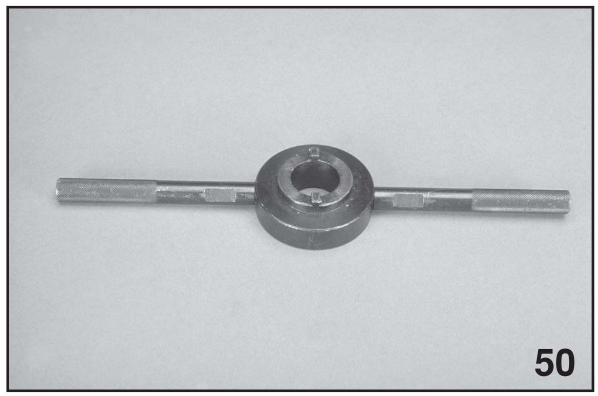
Lock Nut and Adjusting Screw removed

9. Loosen lock nut using ST 926230000



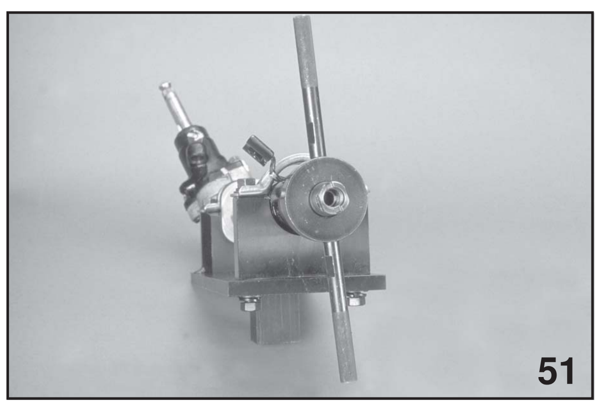
Lock Nut, Adjusting Nut, Spring and Sleeve

10. Remove adjusting nut and sleeve.



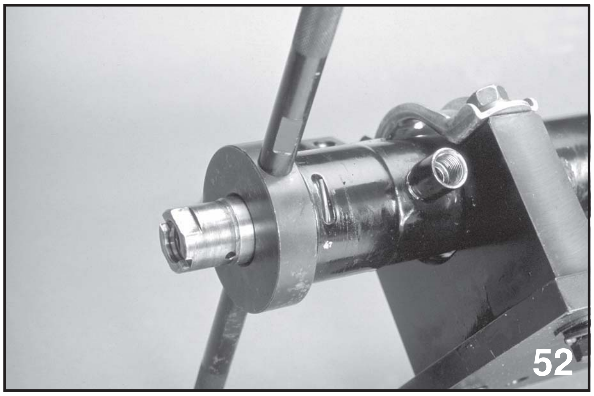
Special Tool

NOTE: TOOL NUMBER VARIES BY MODEL YEAR

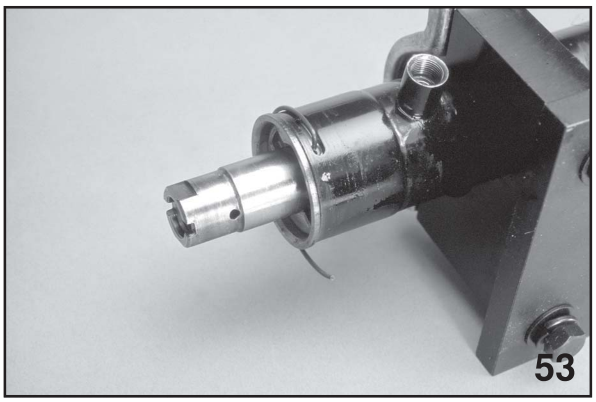


Special Tool usage

11. Using snap ring pliers or special tool, rotate stopper until circlip comes out of stopper.

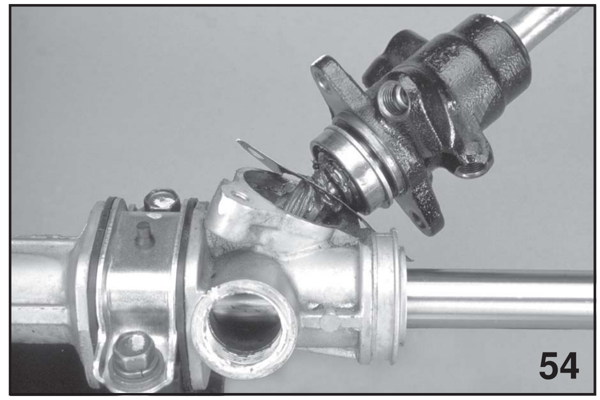


Locate end of Circlip

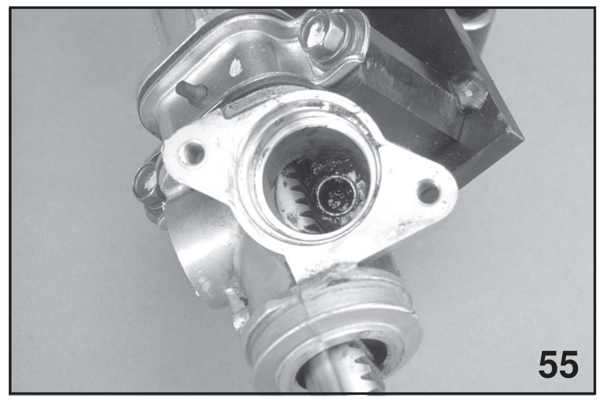


Removing Circlip

12. Rotate circlip in opposite direction and remove it from stopper.

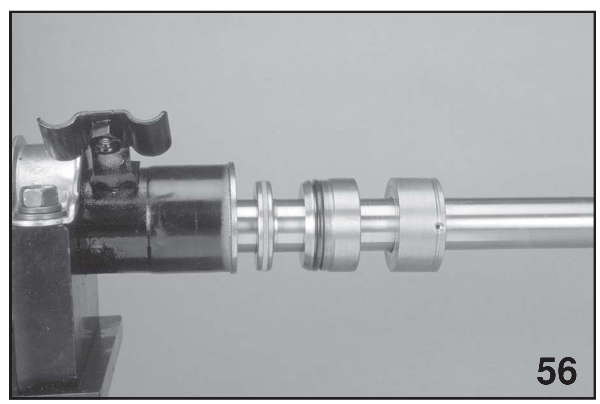


Removing Control Valve



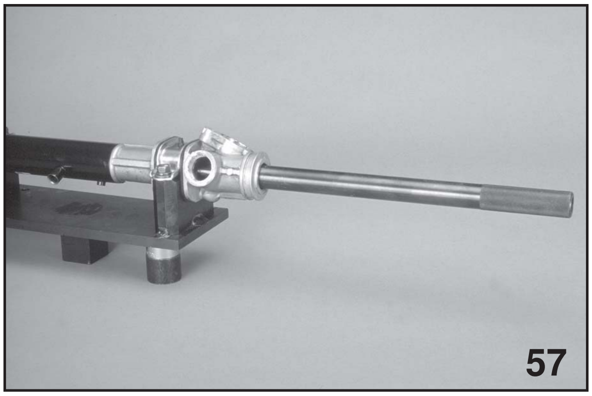
Control Valve Removed

13. Remove two bolts holding valve assembly to rack housing.
14. Remove valve housing from rack.

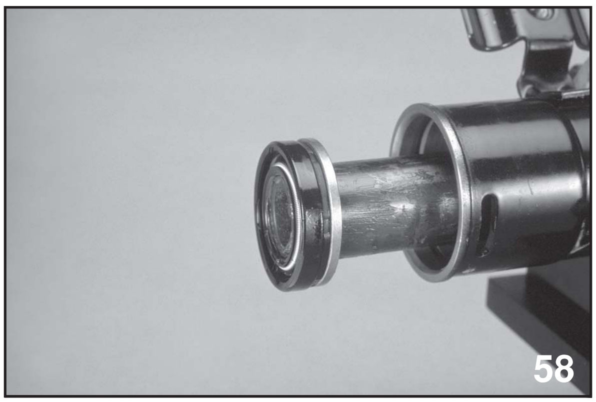


Removing outer Rack Seal

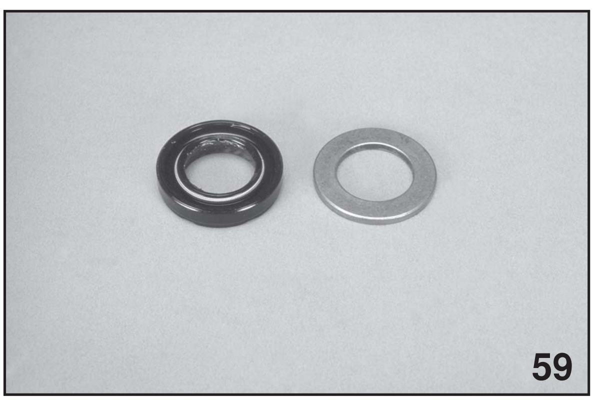
15. Carefully remove rack piston, rack stopper, and rack bushing from rack housing.



Removing Inner Rack Seal

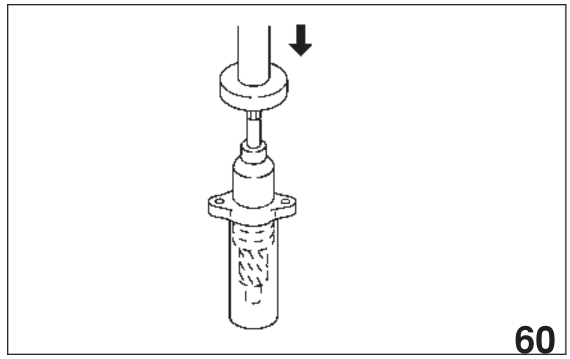


Inner Seal and Backing Washer on tool



Inner Seal and Backing Washer

16. Using ST 34199AE050 remove inner rack seal from rack housing.



Removing Rotary Control Valve

17. Using a press, remove rotary control valve from control valve housing.

Dust Seal

18. Pry dust seal from valve housing.

Snap Ring and Upper Seal

19. Remove snap ring from top of valve housing and pry out upper seal with a screwdriver.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Removing Lower Bearing

20. Using a press, remove lower bearing and backing washer from rotary control valve. This is necessary to replace the lower seal on the rotary control.


64

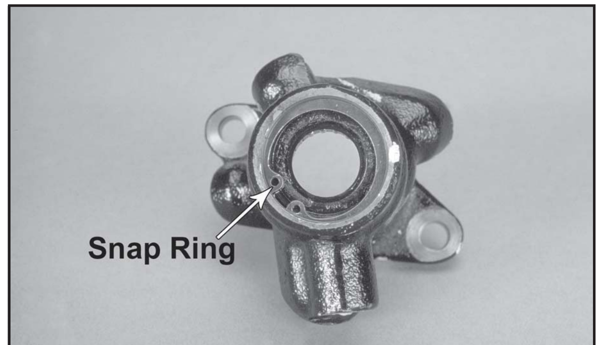
Lower Seal and Bearing

21. Remove lower seal from rotary control valve.


65

Upper Seal

22. Using ST 927610000, install new upper seal in rotary control valve housing. Coat seal with Dexron III before installation.



66

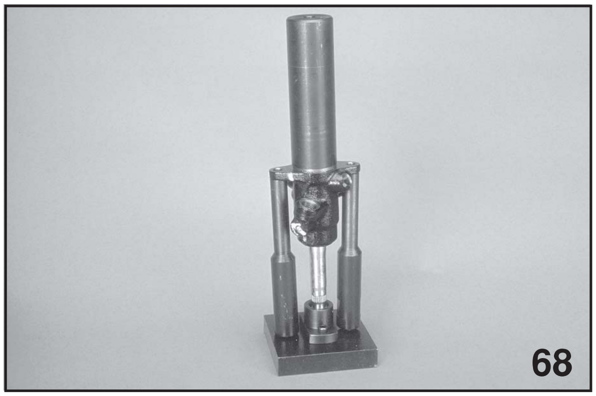
Snap Ring

23. Install snap ring to retain new seal.
24. Wrap splines of stub with electrical tape.


67

Installing Rotary Control Valve

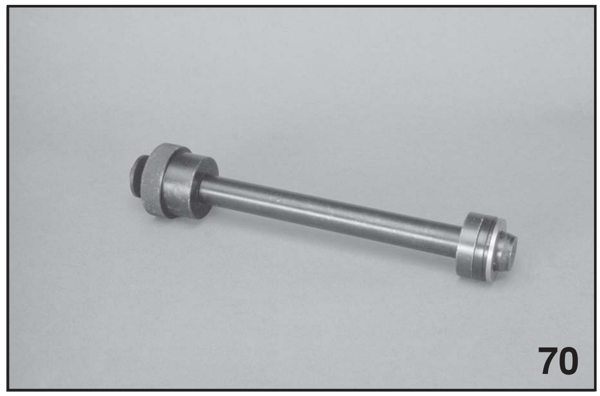
25. Install rotary control valve into housing.



Installing Lower Seal

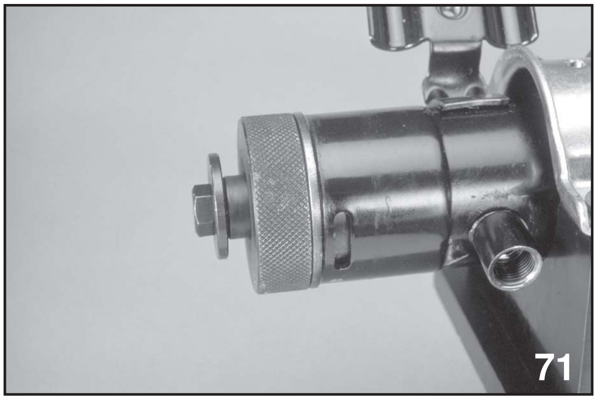
26. Using ST 926370000, 927630000, 927620000 to install new lower seal in rotary control valve housing.
27. While housing is still installed in fixture, install new backing washer and new ball bearing onto rotary control valve using ST 927640000.
28. Lubricate pinion and bearing with Moly grease included in kit.

Inner Seal Tool

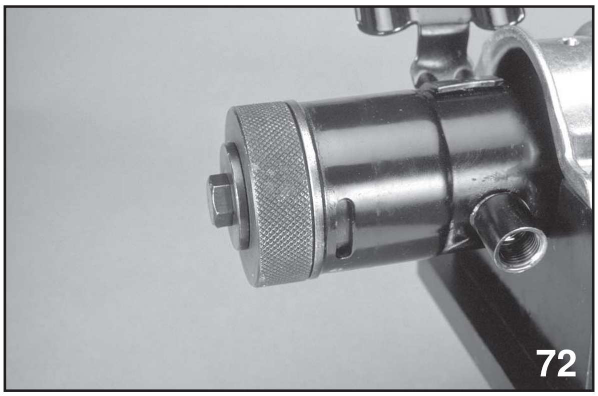


Inner Seal and Backing Washer on tool

29. Install new rack housing inner seal onto ST 34199AE050. Lubricate with Dexron III before installation.

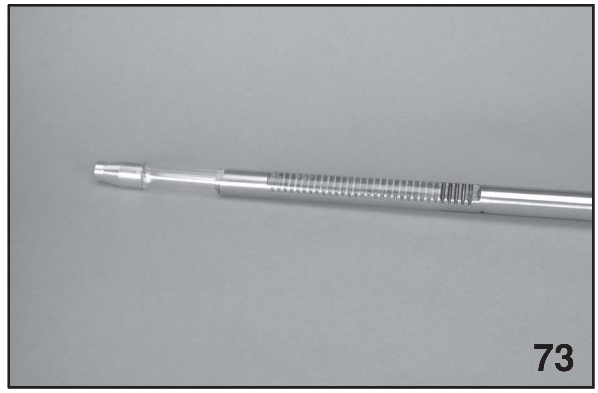


Inner Seal Tool in Rack Housing



Inner Seal Installed

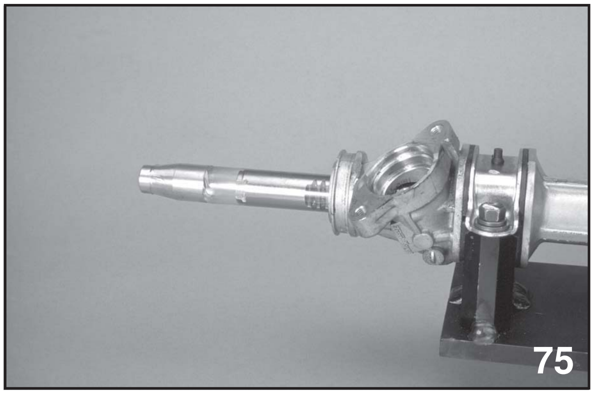
30. Install inner seal into rack housing.



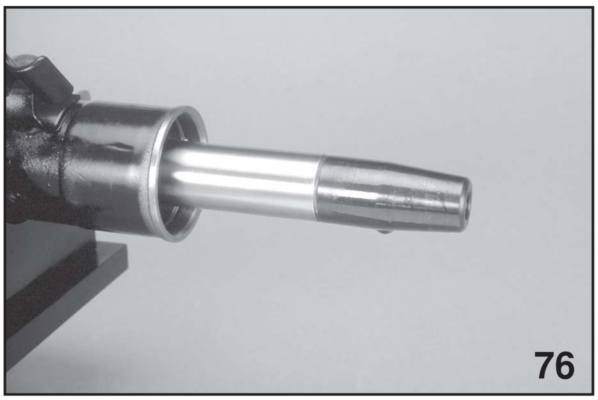
Rack Cover

Rack Cover installed

31. Cover rack teeth with ST 926390001.

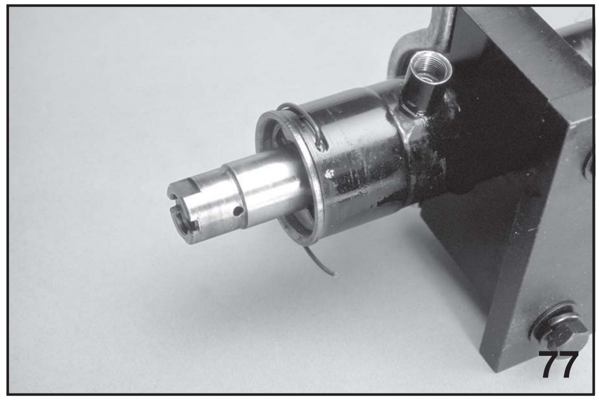


Installing Rack into Rack Housing



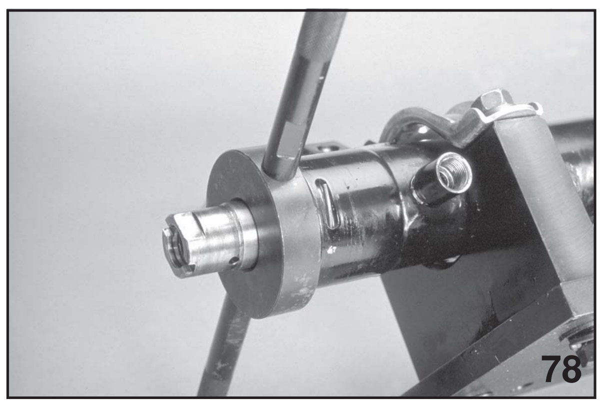
Remove Rack Cover

32. Carefully install rack piston into rack housing sliding it through inner seal.
33. Pack rack teeth with moly grease included in kit.
34. Adjust rack piston so it protrudes from drivers side of rack housing 2.6 inches. Install rotary control valve and housing. Before installation line up marks on valve with those on housing. After installation, insure all marks line up.



Circlip installation

35. Using ST 926400000, and 927660000 install new rack bushing and stopper into rack housing. Install stopper in to housing until inner groove on housing lines up with outer groove on stopper. Lubricate rack bushing with Dexron III before installation.

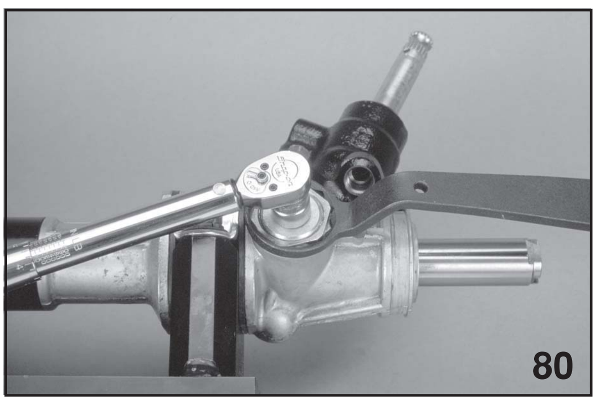


Circlip Tool

36. Install new circlip wire into rack stopper.

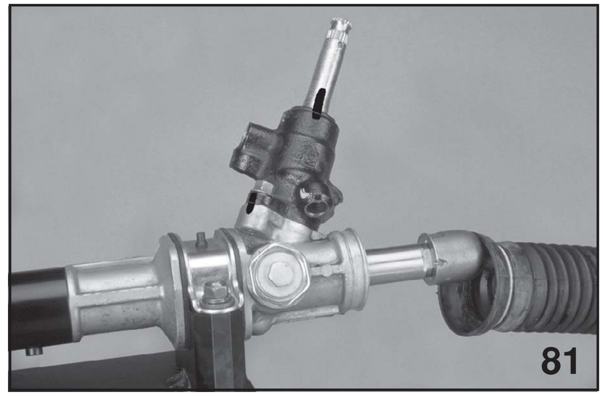
Circlip installation complete

37. Using snap ring pliers rotate stopper to draw in circlip wire. Rotate stopper 90 degrees after circlip wire has drawn in.
38. Lubricate adjusting sleeve with moly grease and install sleeve, spring and adjusting screw into rack housing.
39. Coat threads of adjusting screw with Three bond 1141.



Torquing Adjusting Nut

40. Torque adjusting nut to 65 in. lbs. Repeat this process several times to insure proper contact.
41. After torquing adjusting nut, back off 25° degrees.
42. Install locknut and torque to 29 ft. lbs.



Installing Inner Tie Rods

43. Using new stake washers, reinstall tie rod ends and stake washers down with chisel.
44. Remove rack from holding fixture and reinstall hydraulic lines. Use new O-rings on lines before installation.

Special Tools

926400000-Guide
927660000-Guide
925700000-Wrench
926200000-Stand
926230000-Spanner
926250000-Guide
926340001-Wrench
9276100000-Installer
927620000-Installer
927630000-Installer base
927640000-Installer
927650000-Installer
926390001-Cover
34199AE060-Installer (seal)

Copper gaskets for Power Steering Adaptor hose-PN 34621AC021

Materials

34099PA110 Sealant
004403004 Fuji Bond

Props

Power steering racks
Power steering equipped vehicle(s)
power steering fluid
Tire pressure gauge

Reference Materials

Subaru Service Manuals
Technicians Reference Booklet
Technicians Worksheets

Notes and Cautions

Steering Column Removal

Always refer to the appropriate MY Subaru Service Manual and follow the procedures for removal of the SRS "Airbag" Module prior to any repair and servicing or removal of the steering wheel and steering column from all "Airbag" equipped Subaru vehicles.

Always disconnect the U-bolts before loosening the column mounting bolts.

Disconnect the wiring harness connectors before removing the column.

Remove the XT column carefully to avoid damaging the meter and instrument panel.

Steering Gearbox Overhaul

Do not crimp the pipes.

Do not scratch the rack or the cylinder.

Do not clog the air passages with grease.

Coat the seal and bushings with ATF fluid before installing them.

Install the seals with their lips toward the pressure area.

Use the correct special tools.

Service Bulletins

No.	Date	Title	Subject
04-11-04	01/15/04	2000-2002MY Legacy Sedan, Wagon and Outback Vehicles w/ 2.5L Engines	Power Steering Hose-New style

Tech TIPS

Date	Subject
01/97	Steering Rack Noise
03/97	Power Steering Pump Replacement
10/03	2004MY Impreza and Forester Steering Column Cover
10/03	Parts Ordering Update for VSC Steering Angle Sensor

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Technicians Reference Booklet

Supplemental Restraint System (SRS)

Module SRS-604

AUTOMOTIVE YES Youth Educational Systems®

December 2005

MSA5P0136C

Technical Training

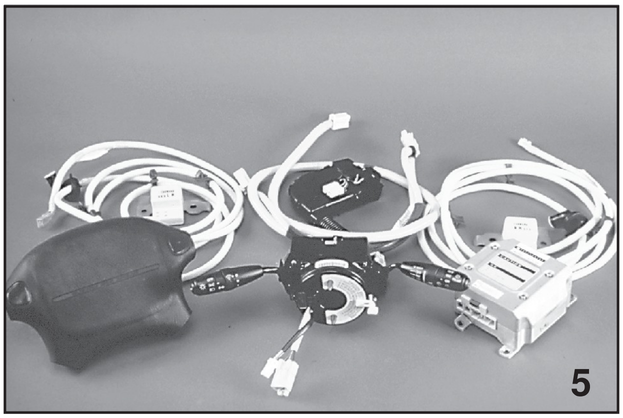
Subaru of America, Inc. reserves the right at any time to make changes or modifications to systems, procedures, descriptions, and illustrations contained in this book without necessarily updating this document. Information contained herein is considered current as of December 2005.

Table of Contents

NOTES

SVX System Overview

The SRS Airbag System is a safety device designed to function in conjunction with a knee bolster, seat belts, and shoulder belts. Similar to other manufacturers, it deploys in frontal collisions only. It is an electrically operated system which uses a chemical deployment device.



SRS Components

The SRS System features built-in Self-Diagnostics and a redundant Safety Design built into all of the circuits.

The system safeguards include double locking connectors with Diagnostic Sensors, a self-shorting inflator SRS Airbag Module connector to prevent accidental deployment during servicing, and a Steering Roll Connector. A capacitor supplies backup power.

Finally, for redundancy, there are two front Inertia Sensors and two Safety Sensor Circuits.

NOTE: THE SRS AIRBAG SYSTEM IS THOROUGHLY DESIGNED TO PREVENT ACCIDENTAL DEPLOYMENT, HOWEVER, CAUTION SHOULD ALWAYS BE USED WHEN SERVICING OR DIAGNOSING THE SYSTEM. THE SRS SYSTEM, WHEN HANDLED PROPERLY, IS LESS HAZARDOUS TO SERVICE THAN A CAR BATTERY OR FUEL SYSTEM.

SRS System Precautions

1. Whenever serving the SRS System disconnect the battery and wait at least 10 minutes before proceeding.
2. Always store the SRS Airbag Module (steering wheel pad) facing up.
3. All of the SRS components are sealed - DO NOT DISASSEMBLE.
4. All of the SRS wiring is enclosed in a yellow housing for quick identification. Use care whenever working near a yellow housing. These wires may not be repaired if they are damaged. They MUST be replaced.
5. Do not drop any of the components. This could alter their sensitivity.
6. The SRS Module must avoid extreme heat exposure (200 degrees F. or greater).

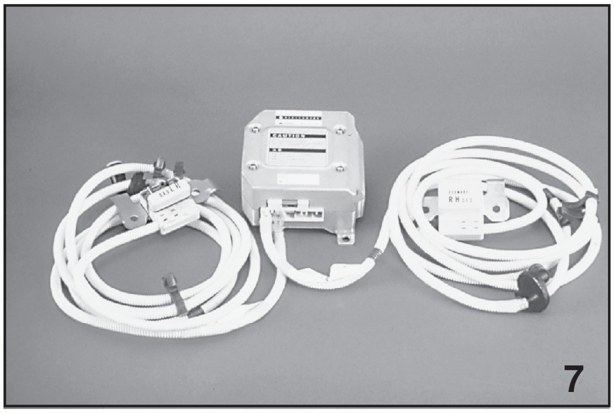
NOTE: EXPOSURE TO TEMPERATURES OF 300 DEGREES F. OR GREATER WILL CAUSE DEPLOYMENT.

7. Wear protective clothing when handling deployed Airbag components. Always use gloves and eye protection. Although the residue is NON toxic, it may cause minor eye and skin irritation.
8. Never place yourself or test equipment between the Airbag Module and seat when serving the Airbag System.

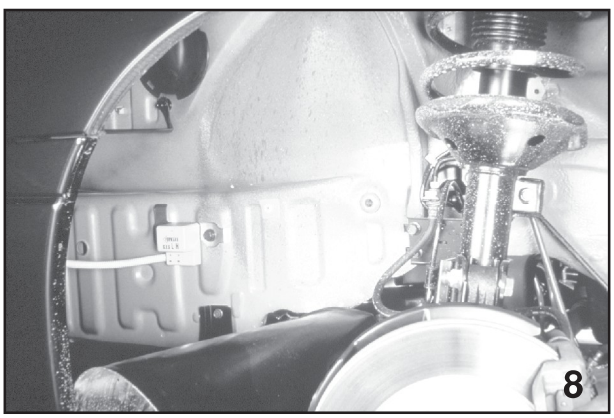
NOTE: REVIEW ALL CAUTIONS OUTLINED IN THE SERVICE MANUAL REGARDING SKIN AND EYE EXPOSURE TO DEPLOYED AIRBAG RESIDUES.

Component Overview

The Airbag and Inflator Module is attached to the steering wheel and covered by the steering wheel pad. It contains the Deployment module, Airbag and cover pad.

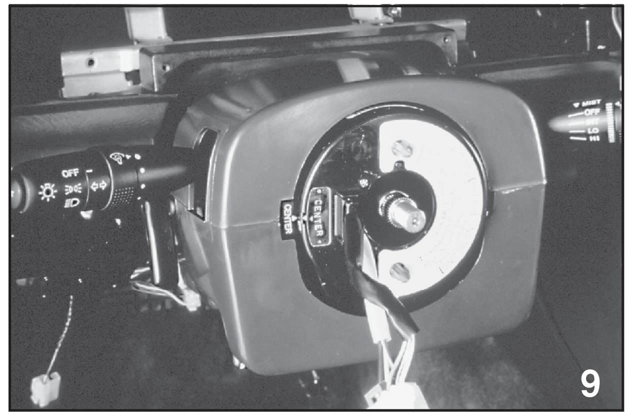


Front Sensors and ECM



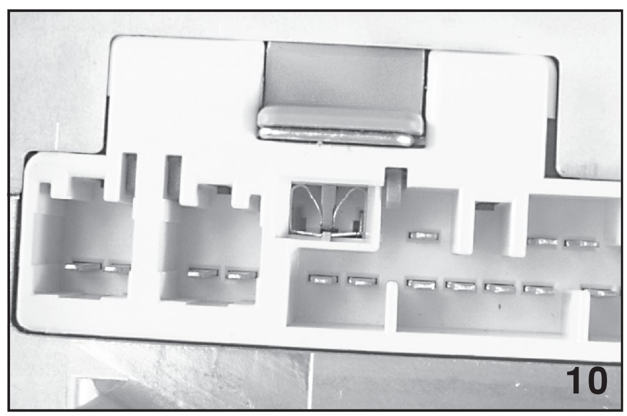
Front Sensor

There are two (2) front sensors located inside the front fenders behind each inner fender liner. In addition, there are two Safety Sensors located inside the ECM.



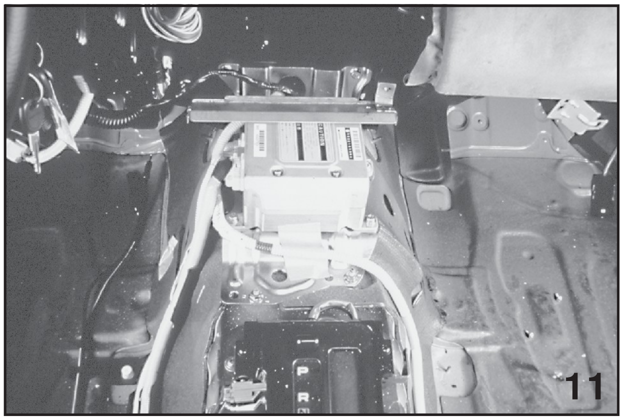
Steering Roll Connector

The steering roll connector is mounted between the steering wheel and the combination switch. It is an integral part of the combination switch assembly. The design of this assembly allows for steering wheel rotation. It also provides the hard wire connection between the Airbag module and the SRS system harness.



Double Lock Connector

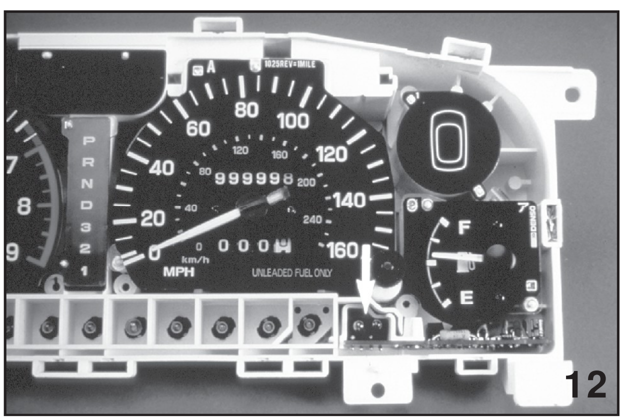
All SRS connectors are equipped with double locks and sensors. The sensors are used to indicate that the connector is not double-locked. For identification purposes, they are green in color.



SRS ECM Location

The ECM is located under the center console. It receives sensor input signals in the event of a frontal impact. It then sends a signal to trigger Airbag deployment. The ECM has self-diagnostic capabilities, incorporating long term memory.

The ECM sends a continuous low voltage signal to monitor the sensors, the harness, the deployment module, and to check for connector integrity.

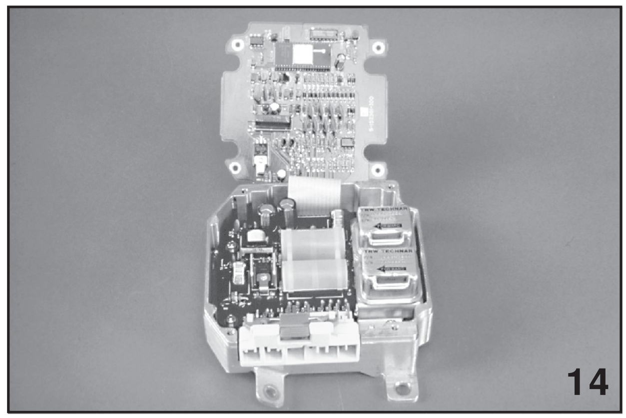


Combination Meter

There are two (2) Airbag warning lamps located in the combination meter. For safety purposes, there are also two (2) independent drive circuits. Only one lamp should illuminate at time.

Component Operation

The ECM controls the SRS Airbag System by constantly monitoring the input signals from the front sensors, the Safety Sensors and the double lock circuit. It also generates output signals to the warning lamps and to the inflator module.



Open ECM

The ECM contains two Safety Sensors which provide input signals, and two capacitors which supplement low battery voltage.

The capacitors also provide backup voltage in the event of a total loss of battery voltage. They are triggered by an internal voltage regulator.

NOTE: THE CAPACITORS CAN ACTIVATE THE SRS AIRBAG UP TO 10 MINUTES AFTER A TOTAL LOSS OF BATTERY VOLTAGE. THE REGULATOR MONITORS BATTERY VOLTAGE AND CAN SUPPLEMENT BATTERY VOLTAGE AS NEEDED IN THE EVENT OF A COLLISION.

Front Sensor Cut-Away

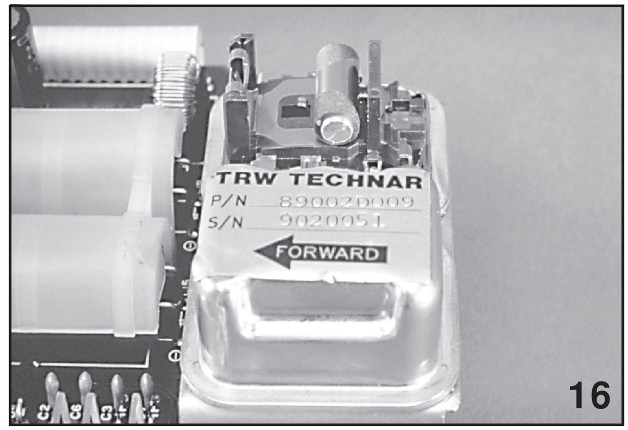
Redundancy is provided by the front left hand and right hand sensors. The hollow roller design provides a movable mass. The roller is mounted on a flat surface and held in place by a flat roller spring. The roller spring allows forward roller movement during frontal impacts of 12.5 MPH or greater. In this case, the roller and spring assembly makes contact with the circuit terminal.

When the roller makes contact with the circuit terminal, it sends a collision signal to the ECM. This completes the sensor circuit and provides a ground circuit to the inflator.

The metal housing of the front sensors are surrounded by resin and filled with inert gas to prevent moisture damage.

CAUTION: DO NOT OPEN THE SENSOR HOUSING. THE INTERNAL COMPONENTS ARE NOT SERVICEABLE.

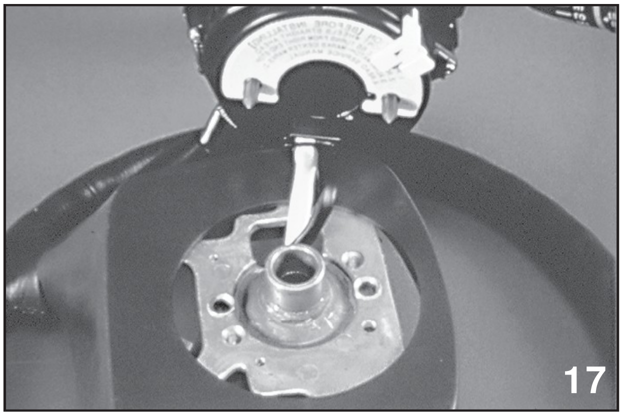
The continuous sensor harness is molded directly into the sensor body. The harness has only one sensor connector, which is located at the ECM. This provides a one-piece circuit path to the ECM. A damaged harness or sensor must be replaced as an assembly.



Safety Sensor

Two Safety Sensors located inside the ECM provide redundancy. They operate similar to the Front Sensors in that they provide a B+ circuit to the Inflator. Although they are similar in construction and operation to the Front Sensors, the Safety Sensors are more sensitive.

Weight added to the center of the roller makes it heavier, which in turn, makes the sensor more sensitive to impact. The ECM must be replaced if one of the Safety Sensors fail.



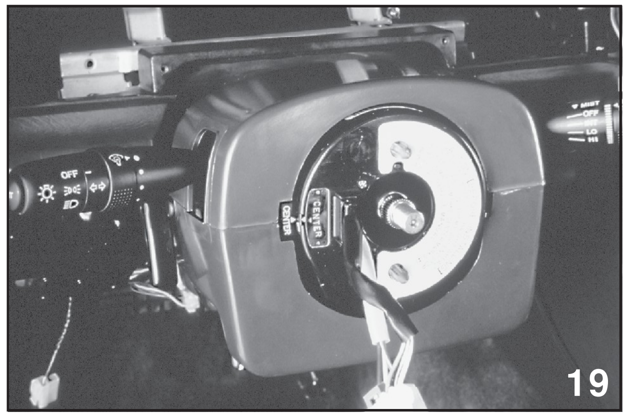
Steering Roll Connector

The Steering Roll Connector is a continuous flat ribbon-type cable. The cable coils around the hub which allows 2.65 turns (either direction) from the center steering position. This provides a direct hard wire connection between the SRS Airbag Module and the ECM harness. It also includes the Horn Circuit. This eliminates the potential circuit interruption inherent to sliding contact-type connectors, which also prevents false trouble codes.

Two guide pins are used to align the roll connector with the steering wheel.

Roll Connector Phasing

The roll connector MUST be phased to the steering system. With the front wheels centered, align the inner "center" indicator located behind the window in the roll connector, with the "center" indicator located on the rotating cover next to the window. There is also an alignment arrow on the connector case.



Roll Connector Indicator

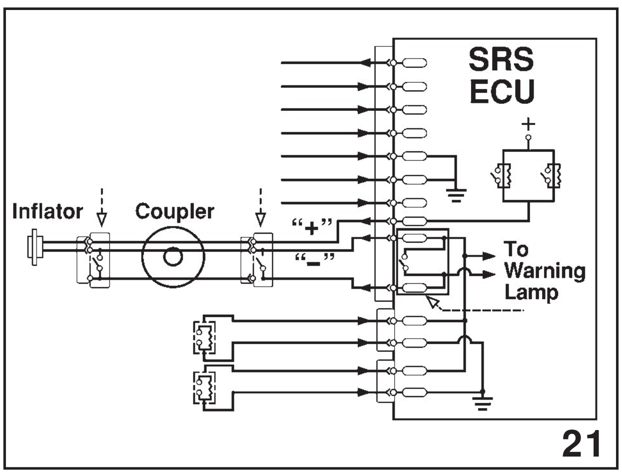
If the inner indicator shows "1R" in the window, rotate the cover one full rotation to the right. If the inner indicator shows "2R" in the window, rotate the cover two full rotations to the right. Similarly, if the indicator shows either "1L" or "2L", rotate the cover one or two left hand rotations.

NOTE: TO MAINTAIN PROPER STEERING WHEEL ALIGNMENT, CENTER THE FRONT WHEELS AND SCRIBE AN ALIGNMENT MARK BETWEEN THE STEERING WHEEL HUB AND THE SHAFT, PRIOR TO DISASSEMBLY.

Connector Double Lock Sensors

Double lock sensor mechanisms are identified by a green color. They are used on all SRS electrical connectors. The system uses four 4 double lock sensors between:

1. The main ECM connection
2. The system power supply and the warning light.
3. The ECM harness and the roll connector at the combination switch.
4. The roll connector and the Airbag module located behind the steering wheel pad.

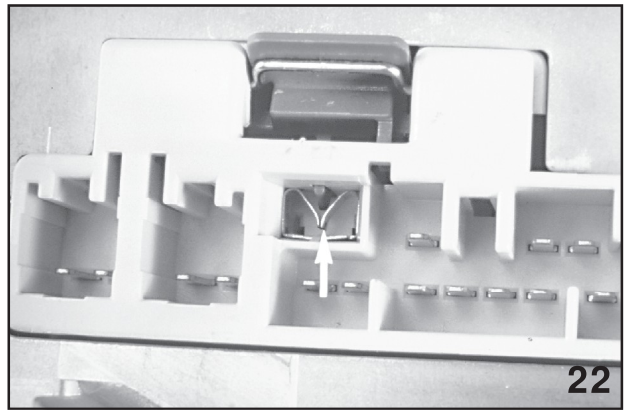


Schematic (Artwork)

These sensors connect the double lock detecting circuit to the negative side of the igniter circuit. This provides a ground signal circuit for the warning light system.

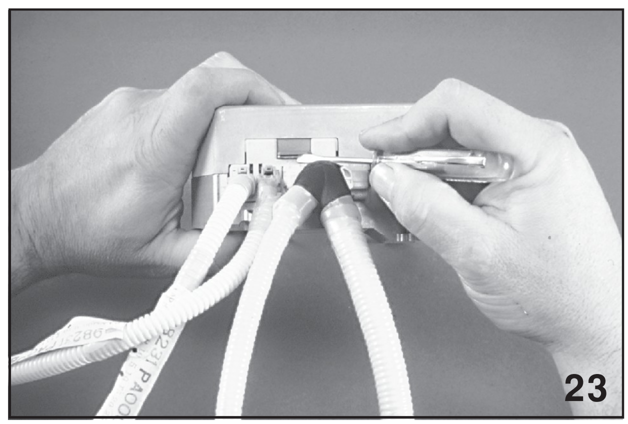
If any green double-lock lever is not properly latched, the SRS warning lamp will be illuminated and a Trouble Code will be displayed (Code 14).

The primary double lock at the ECM secures the main harness connector as well as the two front sensor harness connectors.



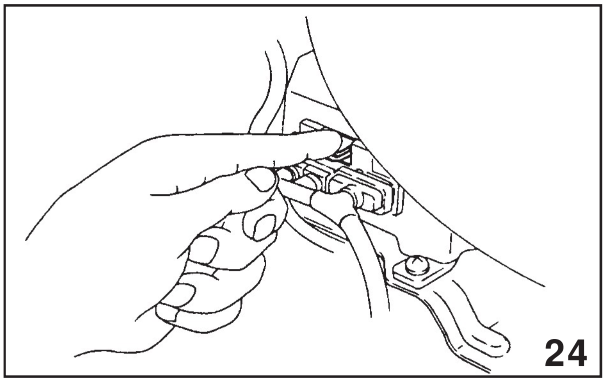
Primary Double Lock Connector (unlocked)

Double lock sensor terminals make contact when they are unlocked and they separate when they are locked. The green tabs mechanically prevent the connector from being removed. The primary double lock will not latch unless the connectors are completely inserted.



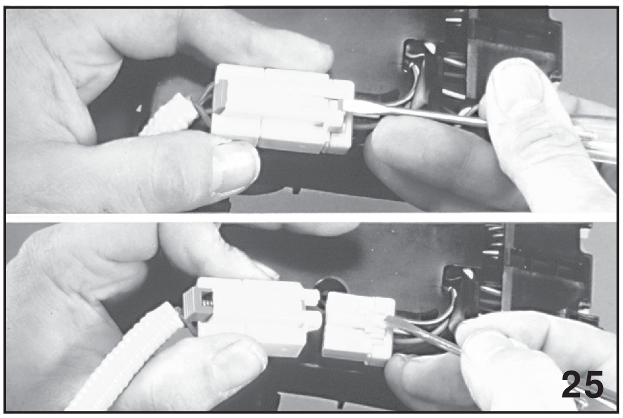
Releasing Primary Double Lock

In order to release the primary double lock, use a small screw driver. Press in on the metal loop and simultaneously raise the green latch. Then to remove the individual connectors, press down on the primary connector locks.



Connector Lock Operation

Secure the primary double lock by pressing the green latch down until a click is heard.



Two Step Lock

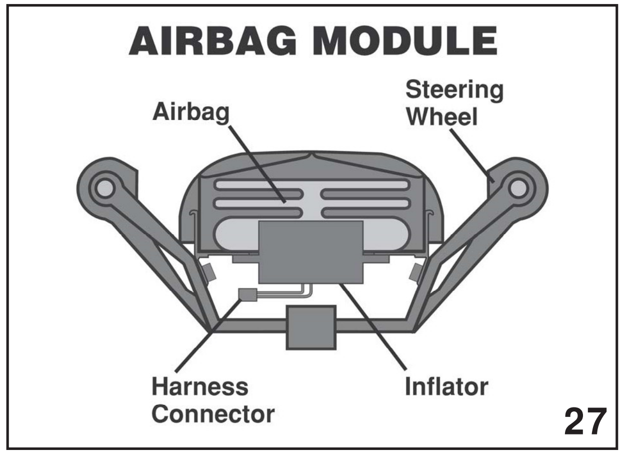
The procedure for locks #2 and #3 are similar to the primary double lock, except that they are released at the primary lock in two steps. First, press down once on the spring-loaded green latch and it will pop out. Then press it down a second time in order to remove the connector. To secure the double lock, push in the green latch until a click is heard.

Double lock locations:

1. The main ECM connection
2. The system power supply and the warning light.
3. The ECM harness and the roll connector at the combination switch.
4. The roll connector and the Airbag module located behind the steering wheel pad.

Airbag Module

The Airbag module comes as a one piece assembly with the horn buttons. It is mounted to the steering wheel with four #30 tamper-proof torx bolts.



Airbag Module (Artwork)

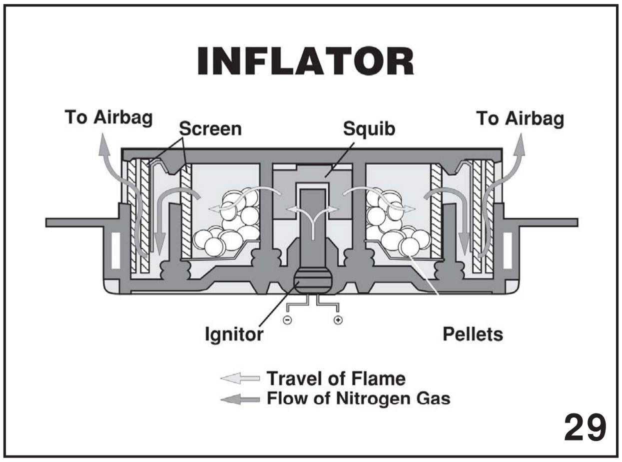
The Airbag module consists of three subcomponents:

1. Inflator
2. Airbag
3. Inflator harness with connector

NOTE: THE AIRBAG MODULE IS SERVICED ONLY AS AN ASSEMBLY. DO NOT ATTEMPT TO DISASSEMBLE OR REPACK THE AIRBAG.

Inflator Igniter

The inflator igniter is designed to ignite a squib after it receives an input from the ECM. The igniter is an electrically heated device which generates temperatures in excess of 300 degrees F. to ignite the squib.



Squib (Artwork)

The squib consists of fire transmissive material used to ignite nitrogen pellets. The nitrogen pellets generate nitrogen gas (N2) during combustion. This creates rapid gas expansion which, in turn, inflates the Airbag.

The built-in screen cools and removes hot cinders from the N2 before the N2 enters the Airbag.

NOTE: FOR MORE SPECIFIC CHEMICAL CONTENT, PLEASE REFER TO THE SUBARU SVX SERVICE MANUAL.

Airbag

The Airbag itself is located behind the steering wheel center pad. It is made out of nylon material which expands to a diameter of approximately 30 inches (762mm) when inflated.

The bag is coated on the inside with silicone and is coated on the outside with talcum powder or cornstarch. This provides lubrication for deployment. These inner and outer coatings produce the majority of the residue found after deployment.

Airbag Deployment

In order to activate the system, a frontal force of 12.5 MPH or greater is required. This force overcomes the inertia and the tension of the roller springs of the rollers in the front sensors and the Safety Sensors. The rollers then make contact with the circuit terminals. The front sensors provide a ground circuit while the Safety Sensors provide a positive circuit.

In order for the ECM to activate the inflator, it must receive at least one collision signal from the front sensors and at least one collision signal from the Safety Sensors.

After receiving a signal from the ECM, the igniter instantly heats up to 300 degrees F., igniting the squib which burns the nitrogen pellets to create nitrogen gas. The generated N2 goes through the screen into the Airbag. The outer skin (steering wheel pad) of the inflator Airbag module then ruptures as the Airbag deploys. The drivers forward movement is absorbed by the Airbag as it vents the N2 through two 1.58 inch (40mm) holes.

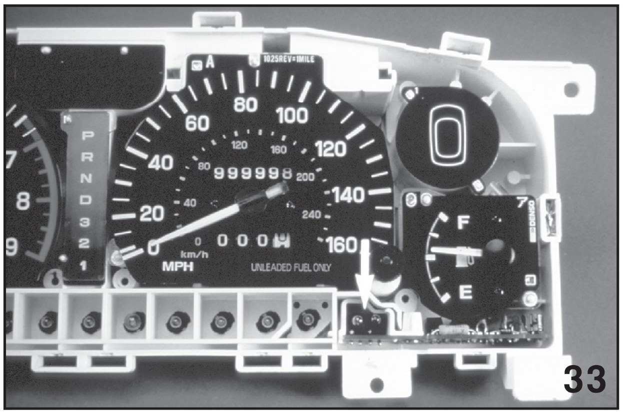
The Operational Time Sequence is almost instantaneous:

1. Collision: Zero seconds
2. Operation of the inflator: 30 millisecond
3. Discharge of the N2: About 60 millisecond
4. Completion: About 110 milliseconds

NOTE: A VEHICLE WITH A DEPLOYED AIRBAG MUST BE TOWED TO THE DEALER FOR SERVICE.

Airbag Warning Lamps

Two (2) Airbag warning lamps are located on the lower right-hand corner of the combination meter. Two bulbs are used with independent drive circuits for redundancy. The assembly is replaced as one unit.



Airbag Warning Lamps

The lamp illuminates for 8 seconds after the key is turned to the "ON" position. It communicates to the operator when service is required and it communicates trouble codes to the technician.

Diagnostics and Servicing

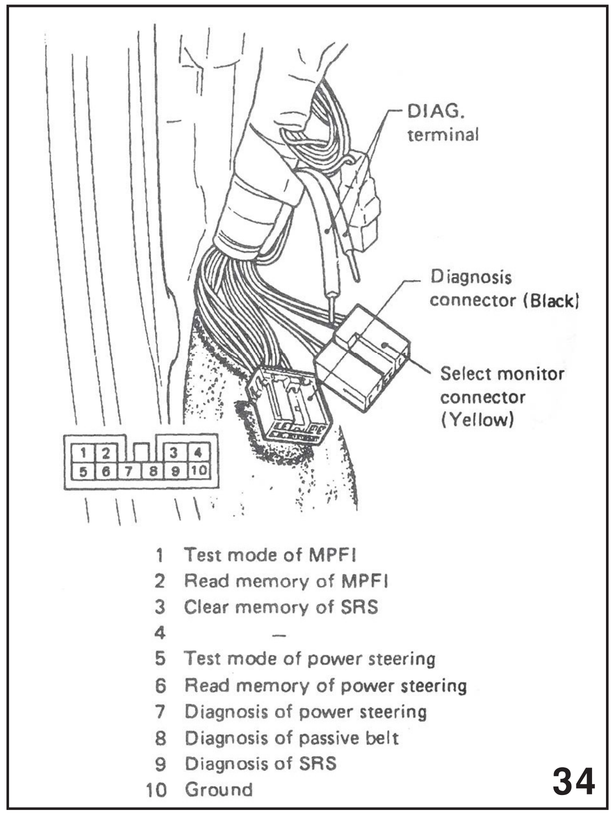
The self-diagnostic system employs three modes similar to the fuel system self-diagnostics:

1. U-Check (User Check)
2. D-Check (Dealer Check)
3. Read Memory

The U-Check Mode warns the driver of a system fault by illumination of the "AIRBAG" light on the dash. The light will turn off if the trouble source corrects itself.

Trouble codes are stored in long term memory and displayed similar to the fuel system codes. They are indicated by the "AIRBAG" light with the following values:

1. 1.2 Second (Long) Flash = 10
2. 0.3 Second (Short) Flash = 1
3. Continuous 0.6 Second Flashes = no trouble



Diagnostic Connector

There is also an additional factory long-term memory which can only be accessed by the factory. The purpose of this is for the ECM to maintain a vehicle trouble code history. The long term memory cannot be cleared in the field.

NOTE: THE DIAGNOSTIC PROCEDURES ARE FOUND IN THE SUBARU SVX SERVICE MANUAL ON THE STIS WEB SITE.

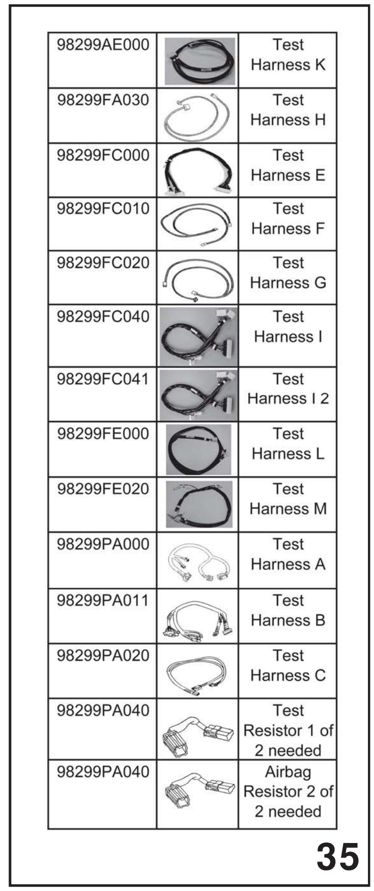
CAUTION: DO NOT UNLOCK "DOUBLE LOCK" CONNECTORS OR DISCONNECT SYSTEM CONNECTORS WITH THE IGNITION "ON". THE ECM WILL SET A TROUBLE CODE IMMEDIATELY. THESE CODES WILL ALSO BE SET IN HIDDEN MEMORY AND CANNOT BE CLEARED.

SRS System Servicing

An SRS inspection is required every ten (10) years. Perform the Self-Diagnostic Checks and verify that the Airbag warning lights are functioning. Also verify that there are no codes in memory and no current codes existing.

NOTE: REFER TO THE SUBARU SVX SERVICE MANUAL ON THE STIS WEB SITE. TO REVIEW THE TEN YEAR SERVICE PROCEDURES.

NOTE: REFER TO THE SUBARU SVX SERVICE MANUAL ON THE STIS WEB SITE. TO IDENTIFY THE TEST HARNESSES AND THE CONNECTOR NUMBERS.



98299AE000		Test Harness K
98299FA030		Test Harness H
98299FC000		Test Harness E
98299FC010		Test Harness F
98299FC020		Test Harness G
98299FC040		Test Harness I
98299FC041		Test Harness I 2
98299FE000		Test Harness L
98299FE020		Test Harness M
98299PA000		Test Harness A
98299PA011		Test Harness B
98299PA020		Test Harness C
98299PA040		Test Resistor 1 of 2 needed
98299PA040		Airbag Resistor 2 of 2 needed

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Sample List of Test Harnesses

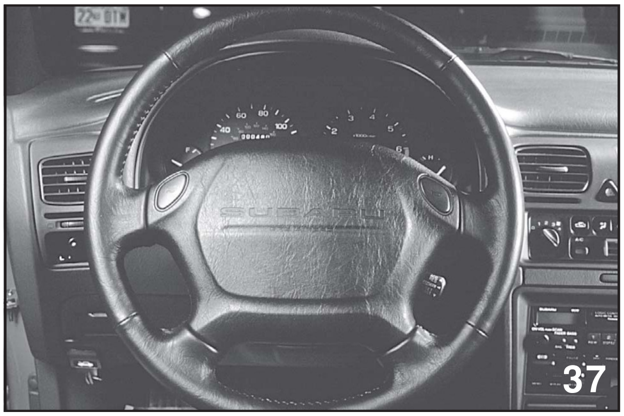
NOTE: REFER TO THE APPROPRIATE MODEL YEAR SUBARU SERVICE MANUAL ON THE STIS WEB SITE FOR COMPLETE TEST HARNESS LIST.

CAUTION: NEVER USE TEST HARNESS "C" TO CHECK THE RESISTANCE OF THE AIRBAG MODULE.

CAUTION: THE DEPLOYMENT HARNESS SHOULD NEVER BE CONNECTED TO THE AIRBAG MODULE WHILE THE MODULE IS IN THE VEHICLE.

CAUTION: ALWAYS US A DIGITAL TYPE OHM METER WITH AN OUTPUT SPECIFICATION OF 100 MILLI-AMPS OR LESS WHEN TESTING THE AIRBAG SRS CIRCUITS. USE OF THE INCORRECT TYPE OF METER MAY CAUSE ACCIDENTAL DEPLOYMENT. IF YOU ARE NOT SURE ABOUT THE SPECIFICATION OF YOUR METER, DO NOT USE IT UNTIL THE SPECIFICATIONS CAN BE VERIFIED.

1995 Model Legacy



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Steering Wheel

Dual Supplemental Restraint System Airbags will be standard equipment on all 1995MY Legacys and functions are similar to previous Model Year Legacys.

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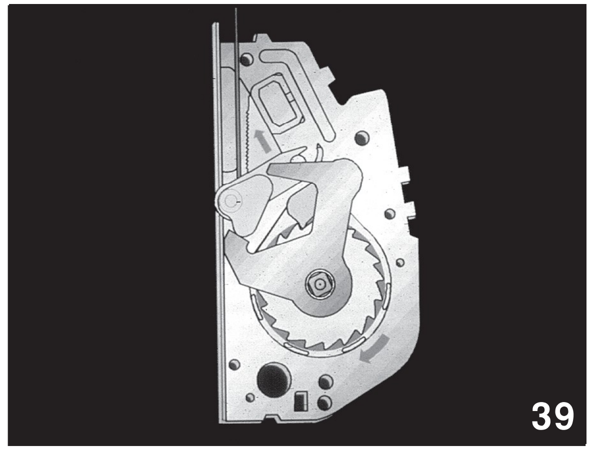
Dash Board Airbag

The passenger front Airbag Module is wired in parallel with the driver's side. Both sides will deploy in the event of a frontal collision of 12.5 mph or greater.



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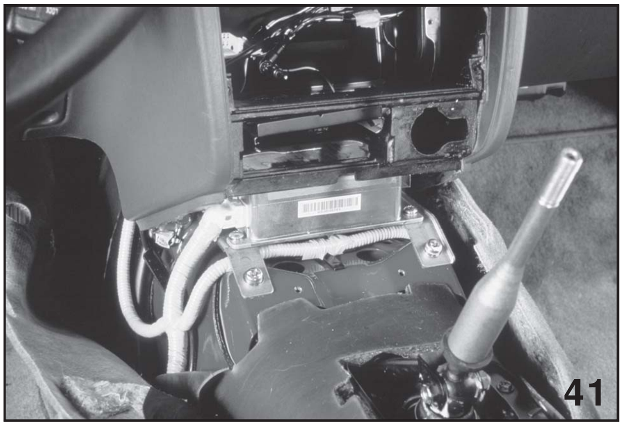
Seat belt

Four (4) position, three (3) point seat belts with ELRS are used in the front seats. The outer rear seat positions use a three (3) point seat belt with ALR assemblies. The center rear seat position uses a two (2) point seat belt.

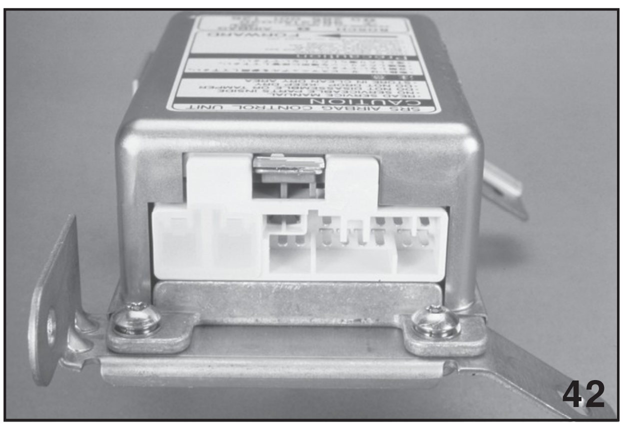
CAUTION: BEFORE SERVICING ANY SRS COMPONENT, DISCONNECT THE BATTERY AND WAIT 30 SECONDS FOR THE CAPACITORS TO DISCHARGE.

1996 Model Legacy and Outback



ECM Location

All 1996MY Legacy and Outback vehicles have dual Airbags. However, the electrical systems operating them will differ.



ECM on Bench

The Outback utilizes the same system as was used on the 1995MY Legacy which have front sensors and Safety Sensors incorporated in the SRS control unit.

The 1996MY Legacy vehicles no longer have separate front sensors. A "G" sensor located in the control unit performs all impact sensing.

Steering Wheel

Steering Wheel Side View

Both models use a floating type SRS Airbag module. The 1996MY Legacy steering wheel will no longer have horn buttons. To use the horn, press on the SRS Airbag module, which activates a switch plate.

1998 Model Forester

Dash

The SRS Airbag system for the 1998MY Forester employs both a driver and passenger Airbag. Please observe all warning precautions listed on the appropriate service publications and warning labels of the vehicle.

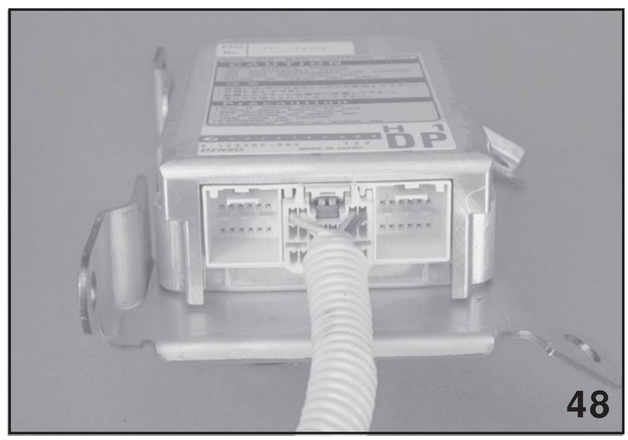
The driver side Airbag is unchanged from that of the 1997 Impreza. Dashboard configuration for the passenger side requires a new Airbag design. The Airbag module can be removed or installed with the instrument panel in place.

The inflator of the passenger side Airbag is a new design. During deployment, a liquid fuel (Alcohol 10 milliliters) is ignited. The expansion of gasses during the burning of the fuel inflates the Airbag.

Gasses produced during burning include Argon and Helium.

Control Unit Location

Control unit location is just forward of the shifter assembly.



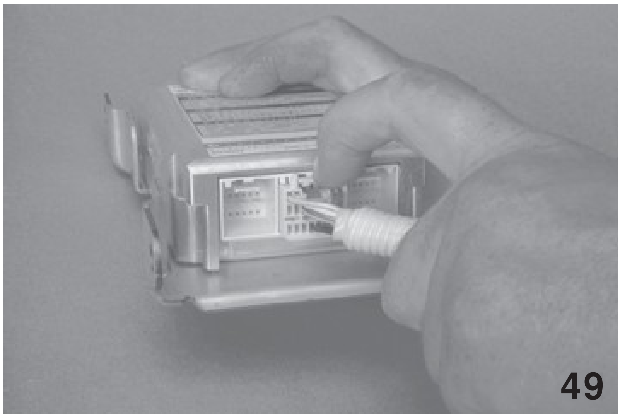
Control Unit on Bench

The connector appearance and double lock feature have changed.

The control unit connector plate is designed for use with other Subaru SRS systems as well as the North American models. The connector is yellow with 20 pins.

The connector is disengaged by pushing down on the top tab and gently pulling, applying force to the tab and the connector.

A plastic tab inside the connector area separates the contacts that monitor the circuit for loose connections (Code 14).



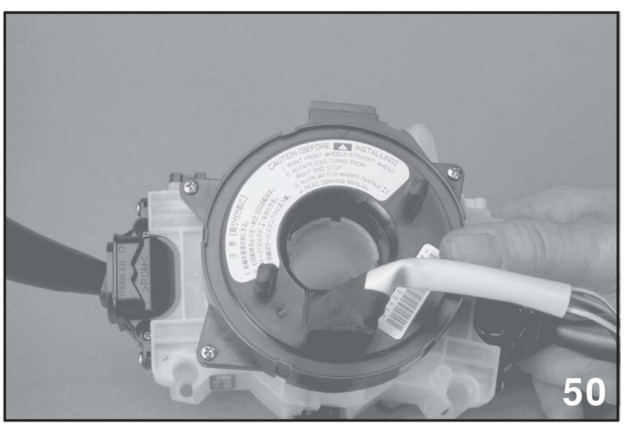
Double Lock

The connector "double-locks" for the driver side and passenger side Airbag modules have also changed.

To disengage, push down on the yellow tab and slide the green tab in the direction of the arrow on the connector. Next, release the tab and pull gently on the connector. Failure to release the tab before attempting separation will result in the connector remaining engaged.

The new test harnesses are labeled, respectfully: **E, F, and G.**

The same test resistor is used when checking driver or passenger Airbag module integrity.



Steering Roll Connector

The window of the Steering Roll Connector has been deleted. Follow the direction on the Steering Roll Connector and the service manual when working with an area that will change the wheel to Steering Roll Connector phasing.

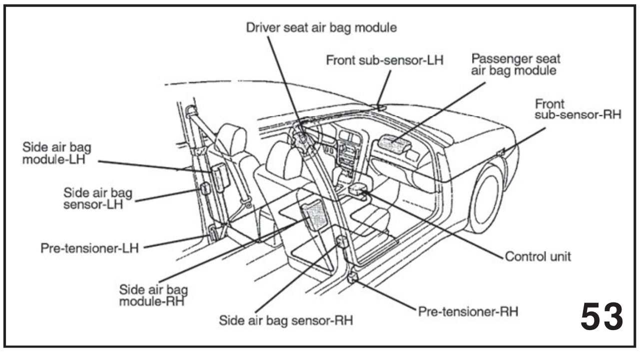
Side Airbag

The Legacy SRS Airbag system utilizes the same type of control unit and connectors with the addition of two (2) front sub-sensors mounted just forward of the wheel arch area. Their input to the SRS ECM influences deployment, however, deployment is not dependent on the front sensors switches closing. The ECM makes the final determination to deploy or not using logic that contains preset values.

Side SRS Airbags are equipped on GT Limited and Outback Limited models. They are designed to deploy on impact to the side of the vehicle. The severity of the impact is determined by the side Airbag sensor located in the B-Pillar.

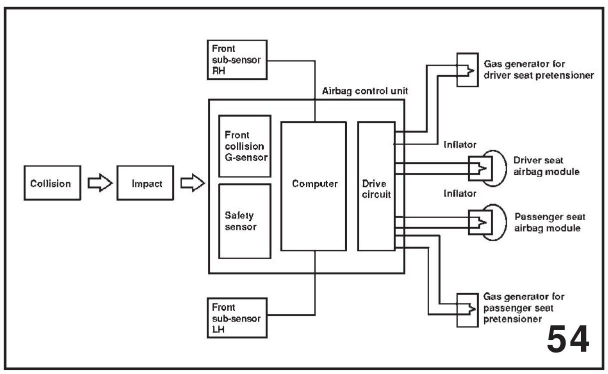
Side impacts to the rear door of the vehicle are absorbed by the door and body of the vehicle as well as to the shield under the rear passenger seat. The transferred force is then distributed through the shield and back to the body of the vehicle.

2000 Model Legacy and Outback



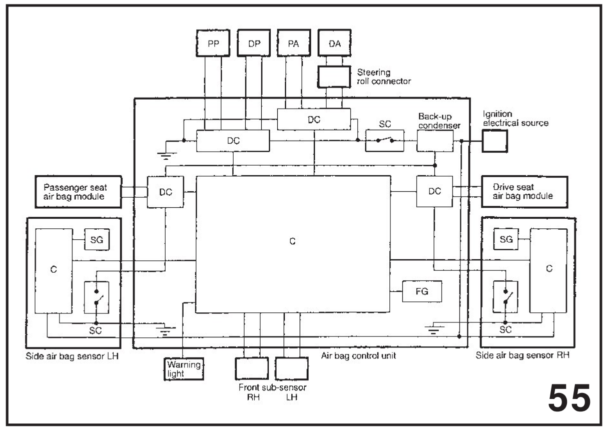
Vehicle Electrical (Artwork)

The SRS Airbag control unit has been changed to include the addition of inputs and provide the output necessary for side Airbag and seat belt pretensioner operation.



Pretensioner Schematic (Artwork)

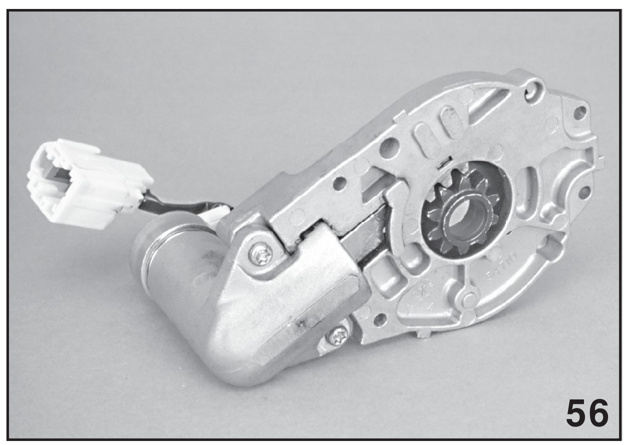
This diagram illustrates the electrical layout of the SRS Airbag system without side Airbags. The front sub-sensors are located in the front bumper area. The seat belt pretensioners will activate at the same time the front Airbags activate.



System Schematic (Artwork)

This diagram illustrates the total SRS Airbag system electrical layout. During a frontal impact, the front sub-sensors and sensors contained in the SRS control unit determine the severity of impact. If the impact exceeds preestablished parameters, the front Airbags, driver and passenger side, as well as both front seat belt pretensioners activate.

Seat belt pretensioner operation winds the belt to restrain the occupant.

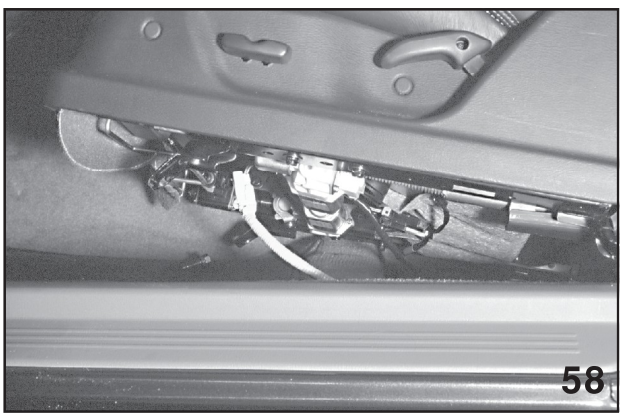


Pretensioner

The gas generator, when activated, pushes a piston which is made onto a rack-type gear. This gear rotates the winding gear creating the motion and force necessary to wind the belt inward. When the force of the belt reaches a fixed value, the force limiter contained in the seat belt assembly operates to control the restraint force so it does not increase further.

Front Seat

The GT and Outback models have a 6-way power driver seat. When servicing this seat, disconnect the side SRS Airbag connector after positioning the seat for mounting bolt removal and disconnecting the battery. (Wait 30 seconds before proceeding).

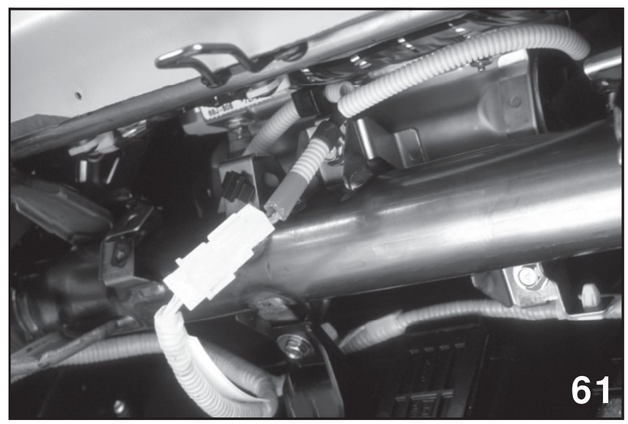


Side Airbag Harness

2001 Model Legacy

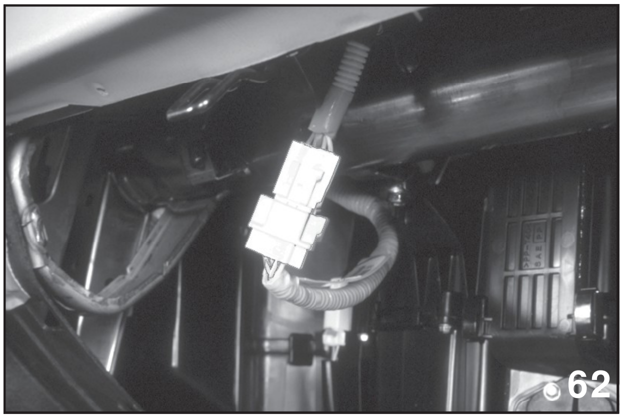
Passenger Airbag

All Legacy vehicles will share an enhancement to the passenger side SRS Airbag System.



Passenger Harness

The Airbag module now contains 2 inflation units. Each one independently controlled by the SRS ECM. During an impact of lower speeds (above the deployment minimum specification) one side of the module will be activated followed by the other side. The time between the two sides activating for deployment is controlled by the ECM to decrease the impact of the bag with the passenger. The higher the impact speed, the shorter the time between the two sides activating for deployment. The two sides will be activated together above a higher impact speed.



Harness Connector

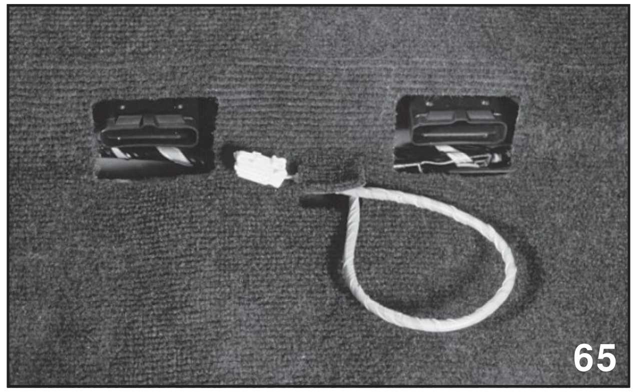
A new style of connector is used for the passenger side Airbag module. The connector is disengaged by pulling down on the wider portion of the body harness while supporting the lower portion.

Driver Side Airbag

There is no change to the driver side SRS Airbag.

2002 Model Impreza WRX

WRX models will have side Airbags as standard equipment.



Under Seat Connector

Caution must be observed while removing the front seats to ensure the SRS wiring harness is not damaged.

Side Impact Sensor

The Side Impact Sensor is mounted on the left and right B pillars behind the seat belt trim panels.

Seat belt Pretensioner

The SRS Airbag for Impreza 2002 will include the addition of seat belt pretensioners for all models (Passenger side Airbag module is the single deployment type).

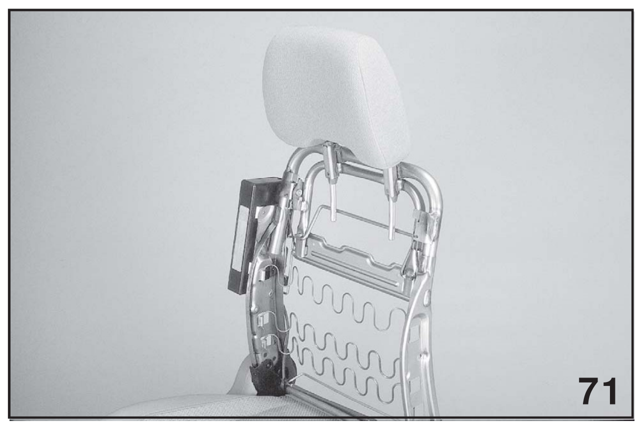
Control Unit

The Control Unit is located in front of the gate type shifter.

2003 Supplemental Restraint System (SRS)

Seat Tag

All Forester models are equipped with front side Airbags. The seat covers are tagged as a reminder for technicians.

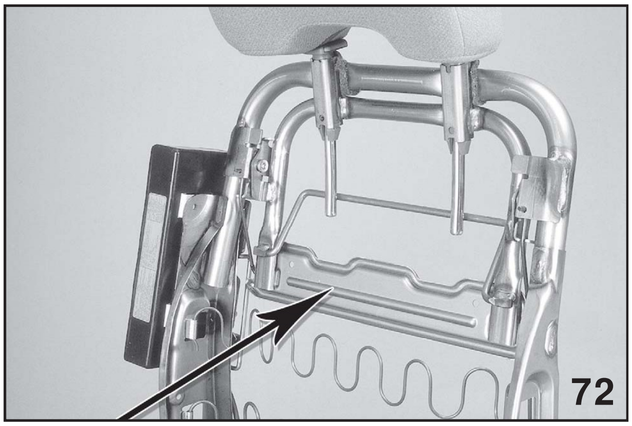


Upper Seat Frame

The Airbag is attached to the upper seat frame and inflates to form a larger pillow when activated in a side collision.

All Forester front seats are also equipped with active head restraint.

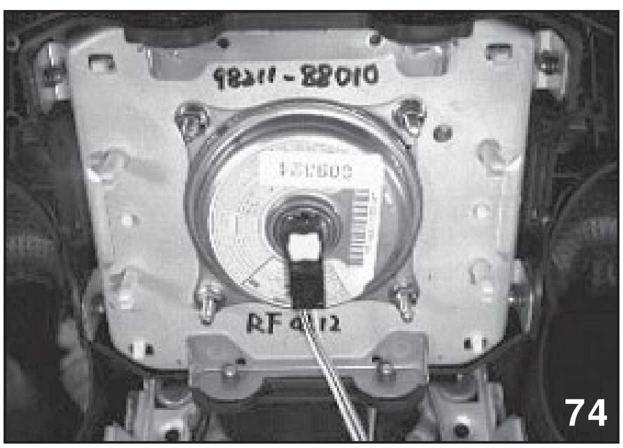
SRS wires routed through the seat are not covered with the yellow plastic cover.



Normal Position

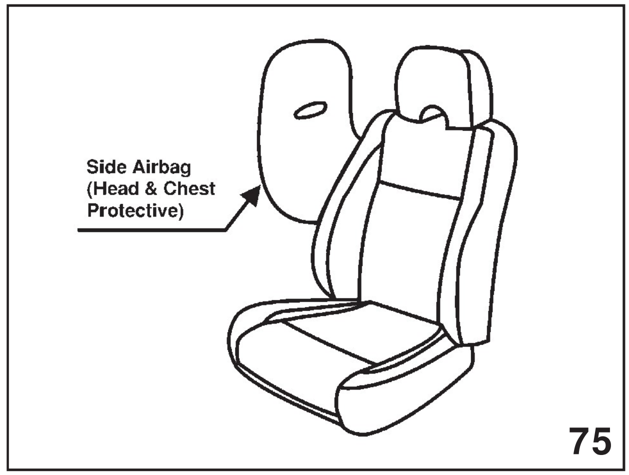
Rear Impact

Position during rear impact.



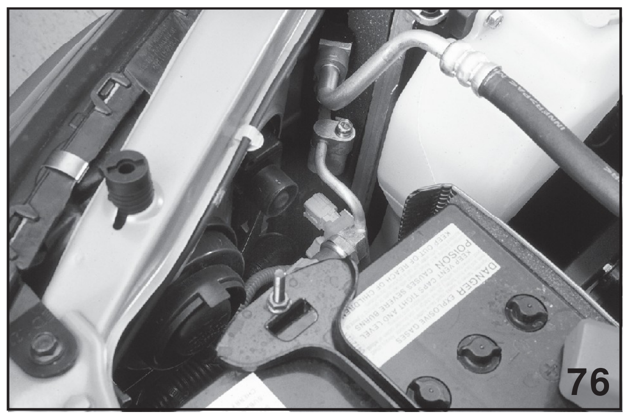
Airbag Module

All 2003 Forester models will be equipped with driver and passenger front SRS Airbags, seat-belt pretensioners and driver and passenger side Airbags.



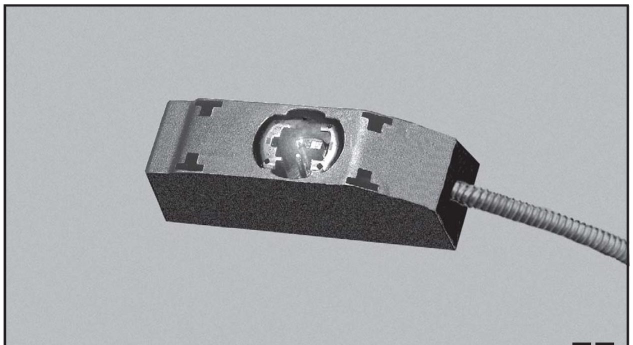
Side Airbag (Artwork)

The side Airbags when deployed are larger and provide additional protection for the chest and head.

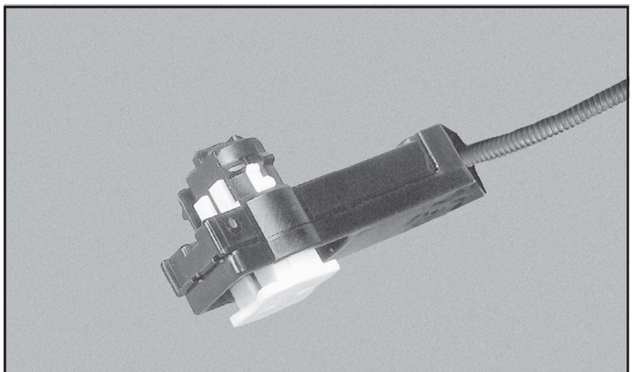


Satellite Discrimination Sensor

The location of the front Satellite Discrimination Sensor has been relocated due to the new vehicle design.


77

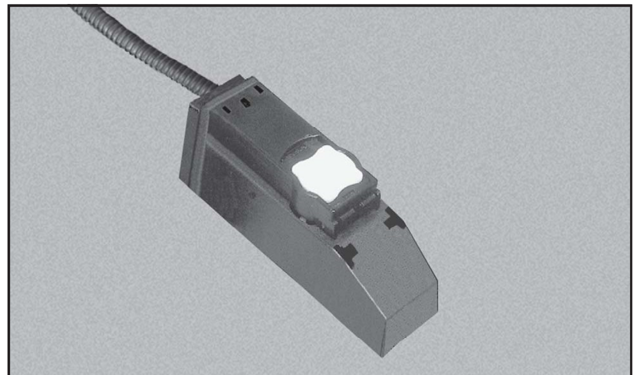
Connector


78

Connector Lock


79

Lock-Up


80

Lock Down

The connector and connector lock on all deployment devices have changed. The new style requires the release of the yellow tab by pulling up on the tab and then separating the connector from the deployment device.

NOTE: FRONT SEAT HEAD / AND CHEST SIDE-IMPACT AIRBAGS (SRS) ARE STANDARD ON ALL WRX AND WRX STI MODELS.

2005 Legacy Airbag System

Warning Label

Driver's Visor

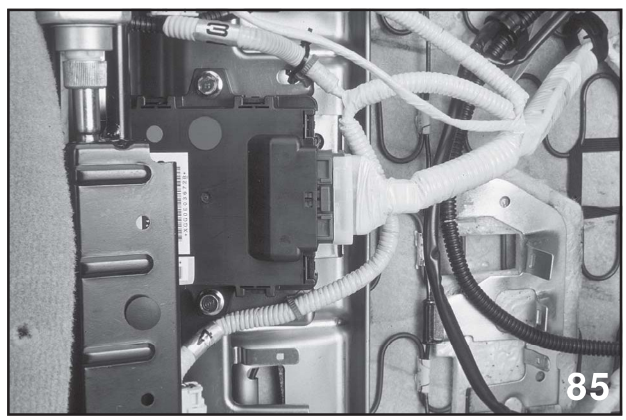
All 2005 Legacy vehicles are equipped with the Occupant Detection System (ODS).

Designed to identify the front seat passenger's weight, the system determines if the front passenger seat is empty or occupied by a person exceeding approximately 80 pounds.

NOTE: THIS SYSTEM IS ALSO EQUIPPED ON FORESTER MODELS BEGINING ON THE 2006 MODEL YEAR.

Under Passenger Seat

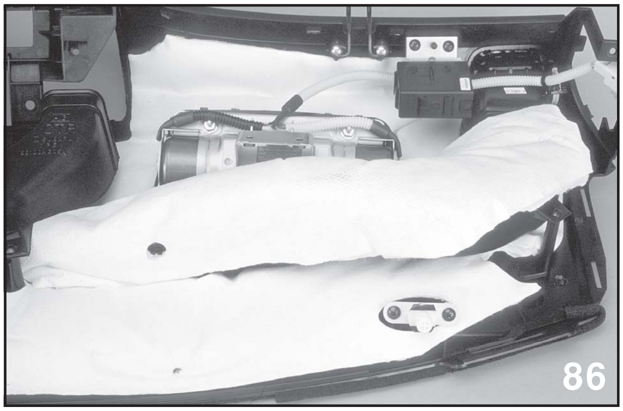
A load cell or strain gauge is located in the corners of the lower seat frame on the passenger side. The weight of the passenger is distributed into the frame and is sensed by the 4 load cells.



Occupant Detection System (ODS) Control Unit

Signals from each load cell are amplified and send to the Occupant Detection Control Module.

The Occupant Detection Control Module sends its determination of the front passenger occupancy to the SRS Airbag control unit. Should the need for deployment occur the data from the Occupant Detection Control Module determines if the passenger side Airbag module will deploy.


86

Airbag Module

With the seat empty the passenger side Airbag will not deploy, but the seat belt pretensioner will activate. With the weight of a person exceeding approximately 80 pounds the passenger Airbag will deploy and activate the seat belt pretensioners.


87

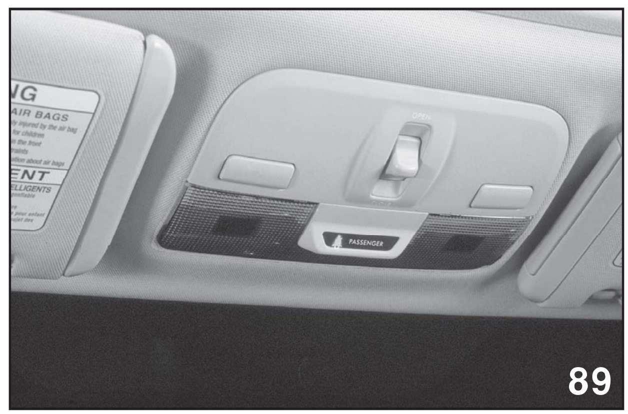
Passenger Airbag Light Off

The vehicle communicates the front passenger Airbag status to the dash using the center Pass Airbag Off/On light.


88

Passenger Airbag Light On

With the seat empty the light will indicate off. When a passenger exceeding approximately 80 pounds occupies the seat the light will change to On.


89

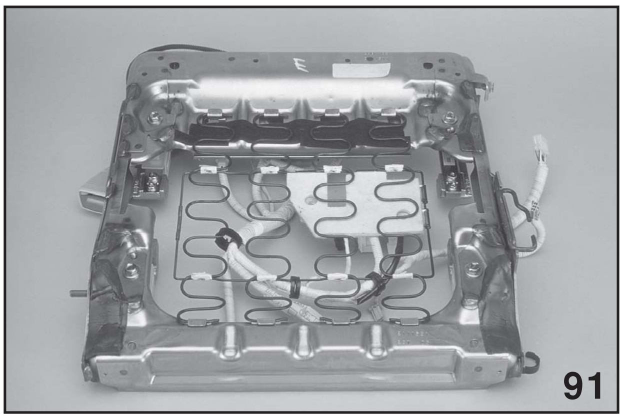
Passenger Seat belt Light

When this light changes to on the warning light above the rear view mirror indicates the status of the passenger side seat belt. The light will illuminate as a reminder for the front passenger to buckle their seat belt.

NOTE: THE PASSENGER SEAT BELT LIGHT WILL ALSO ILLUMINATE WITH A WEIGHT BELOW THE THRESHOLD ON THE SEAR EVEN WITH THE AIRBAG IN PASSIVE MODE.

90

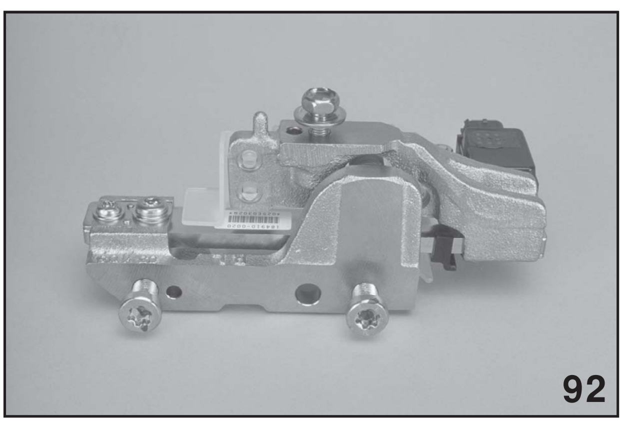
Seat Bottom Corner



91

Seat Frame

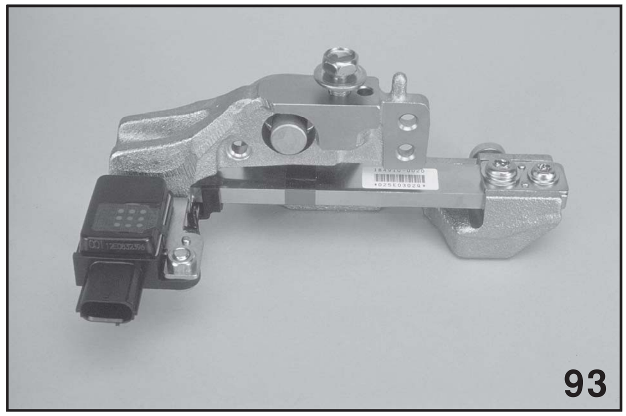
The load cell construction attaches to the slide rail and the seat frame. Force from the downward movement of the seat cushion transfers to the seat frame.



92

Load Cell Slide Rail View

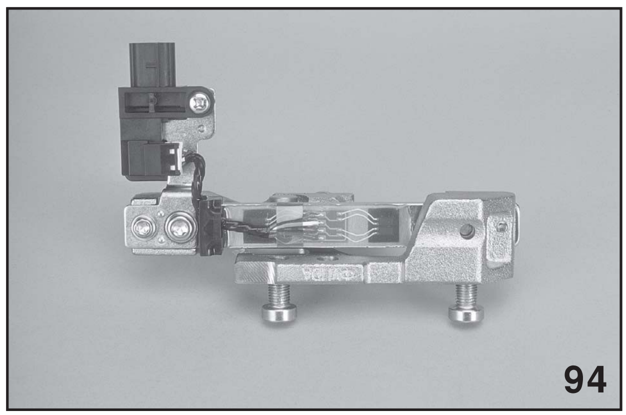
This force changes the output of the load cell.



93

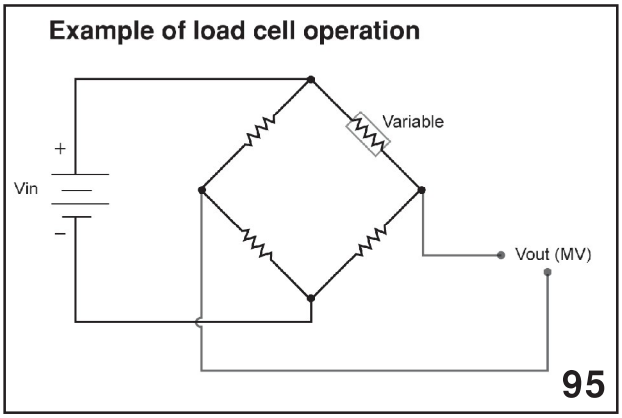
Load Cell Seat Frame View

The output is a very low voltage and must be amplified before it is sent to the Occupant Recognition System control module.



94

Load Cell Bottom View



Bridge Circuit (Artwork)

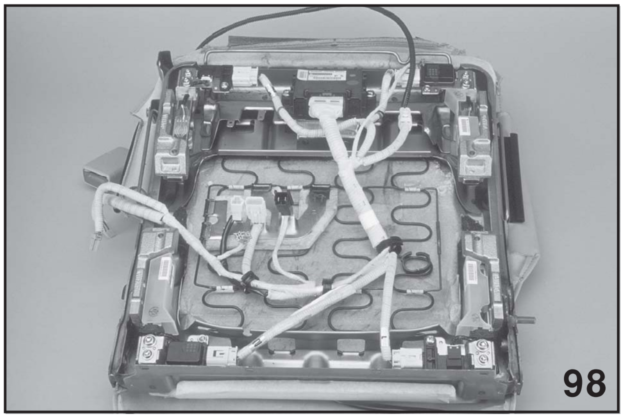
The sensitivity and low voltage output of the load cell makes it necessary to ensure the relationship of the load cell and the parts they attach to remains constant. The load cell operates by comparing the voltage output of two branches of a parallel circuit. One branch is fixed and the other is variable and its output (millivolts) varies by the load placed on the seat. The two outputs are amplified at the load cell by the built in amplifier and compared to each other to form the signal that is sent to the Occupant Detection Control Module.

The components of the ODS located on the lower seat are not serviceable. The lower seat frame and rails are replaced as a unit.

Seat belt Anchor Cover

Seat belt Anchor Cover Removed

If the seat is removed or the bolts of the seat loosened, the load cells will need to be recalibrated. Calibration is accomplished using the select monitor and special tools 98399AG000 and 98399AG010. Before seat removal the front passenger seat belt must be removed from the right side of the front seat.

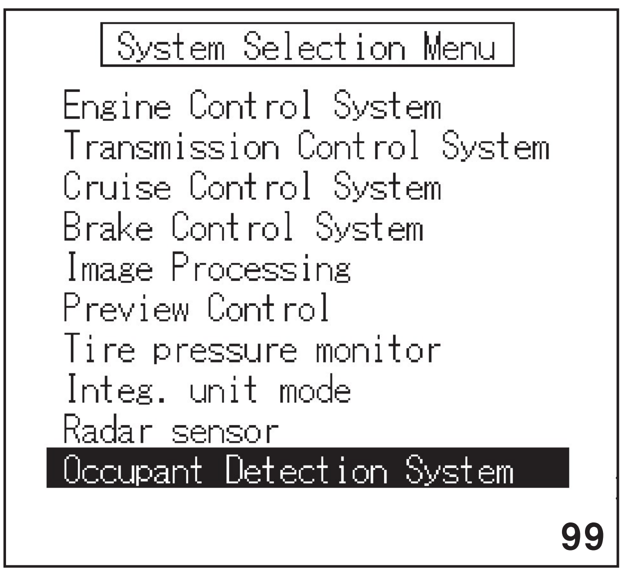


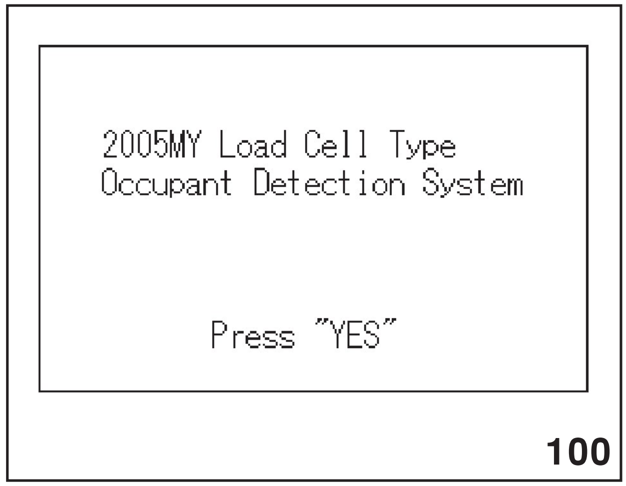
ODS Seat Harness

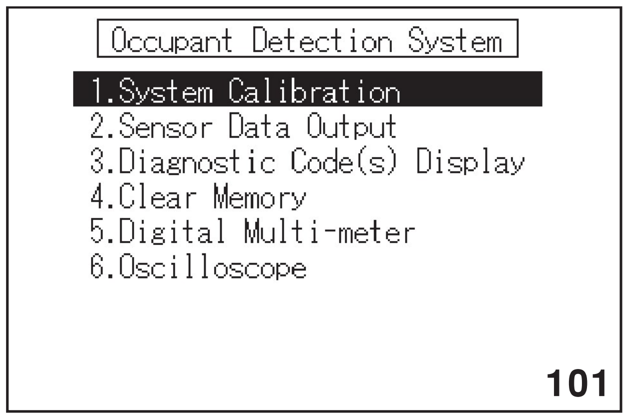
Carefully disconnect all connectors before seat removal.

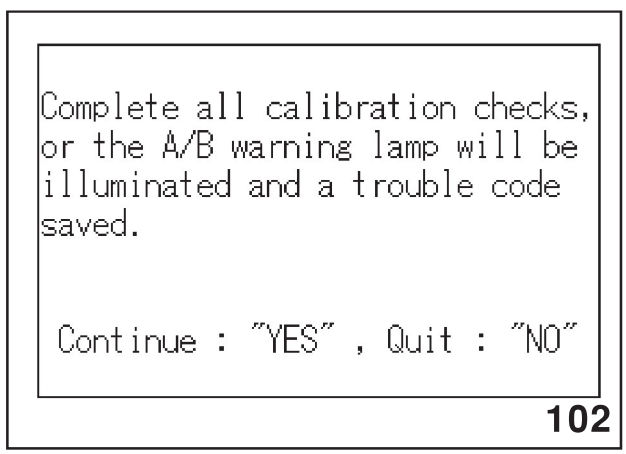
Calibration Process

Using the Select Monitor and cartridge 24082AA260 or SMIII scroll over “Occupant Detection System” Press “yes” and follow the instructions on the Select Monitor.









Adjust the passenger seat
to the condition shown in
service manual

Continue : "YES" , Quit : "NO"

103

In process...

Please wait for a while
without touching vehicle

104

Threshold adjustment
is successfully completed

Weight inspection
will be carried out

Continue : "YES" , Quit : "NO"

105

Empty the passenger seat

Continue : "YES" , Quit : "NO"

106

Adjust the passenger seat
to the condition shown in
service manual

Continue : "YES" , Quit : "NO"

107

In process...

Please wait for a while
without touching vehicle

108

Input threshold weight mass(lbs)
[00.0]

Press "YES"
After inputting weight mass

109

(See appropriate Service Manual for this information)

110

Lower Weight on Seat

111

Upper Weight on Lower Weight

Place the lower calibration weight in place, followed by the upper weight. Be certain to engage the alignment notches before releasing the upper weight.

Put threshold weight in
the position on the passenger
seat shown in service manual

Continue : "YES" , Quit : "NO"

112

Press "YES"
after putting threshold weight
on the seat

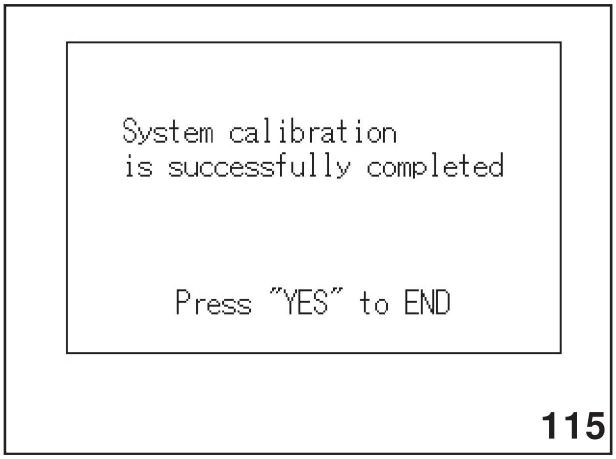
Continue : "YES" , Quit : "NO"

113

In process...

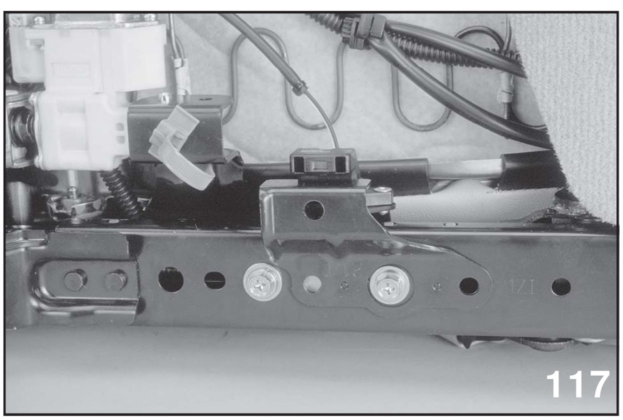
Please wait for a while
without touching vehicle

114



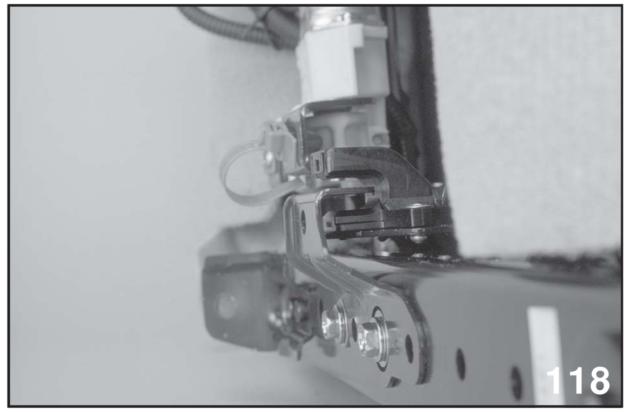
NOTE: THE SMIII CAN ALSO BE USED TO CALIBRATE THE SYSTEM

Steering Wheel

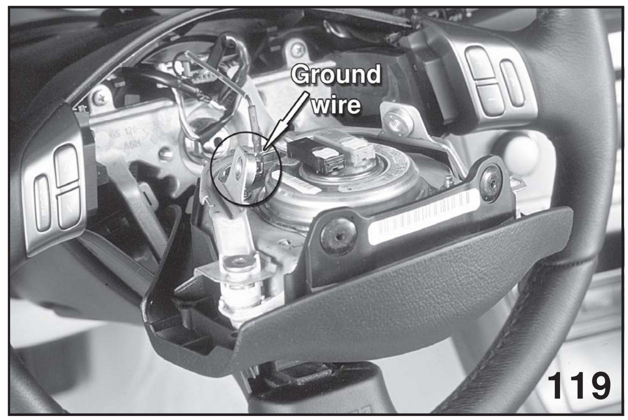


Driver Seat Bottom

The driver seat is equipped with a sensor that is used to judge how close a driver is sitting to the steering wheel.



Hall Type Sensor

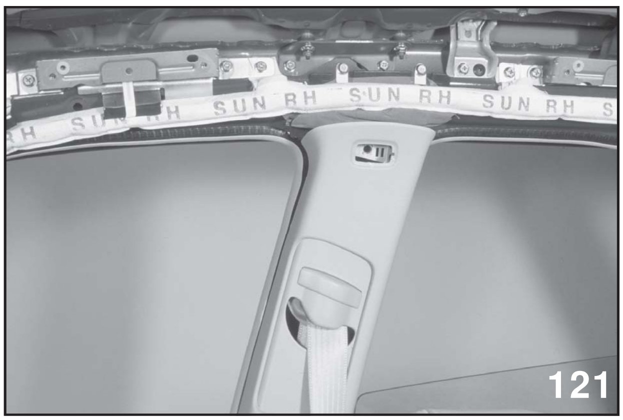


Back of Driver Airbag

When the driver is sitting close to the steering wheel the hall type sensor sends a signal to the SRS control unit which during deployment will activate the SRS Airbag in 2 stages, reducing the deployment force to the driver.

2005 Legacy vehicles are equipped with curtain Airbags. These Airbags will deploy in a side impact which exceeds the preset values of the curtain Airbag sensors or the side Airbag sensors.

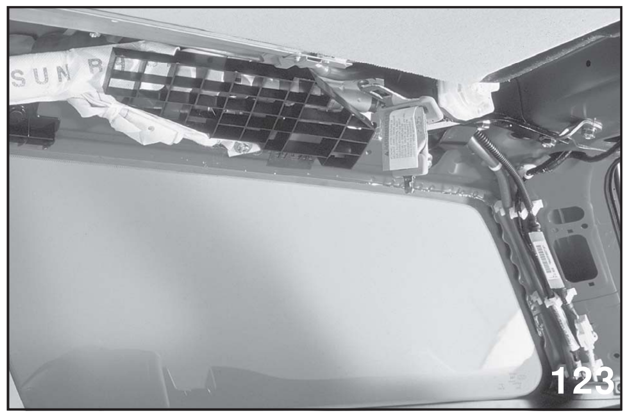
A Pillar



B Pillar

The curtain Airbag module is mounted above the head liner along the entire length of the roof line.

C Pillar



D Pillar

The connector for the curtain Airbag module is located in the D pillar area.

Curtain Beginning Deployment

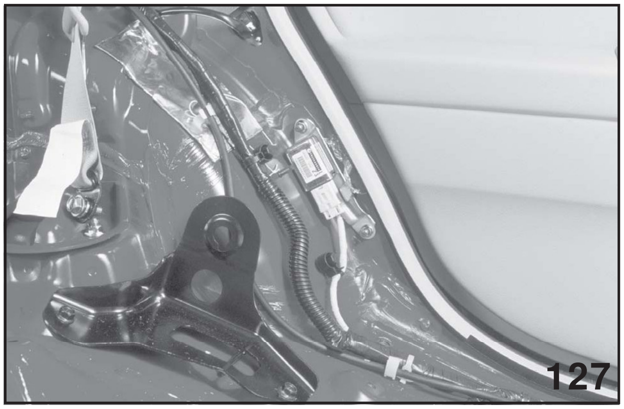
Curtain Airbag Deployed

During deployment the curtain Airbag will push the far side of the headliner down and form a curtain that will provide protection to the head and shoulder areas of the front and rear seat occupants.

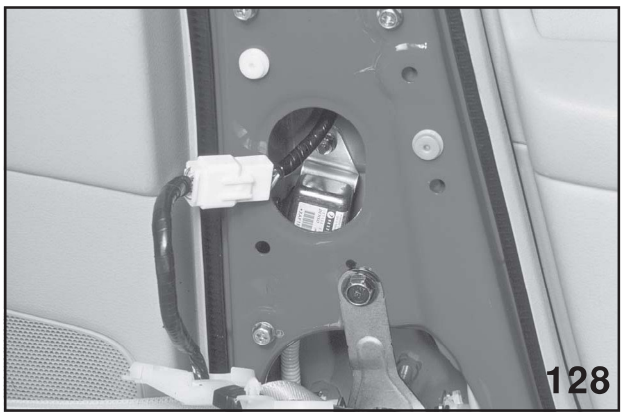
Curtain Airbag Side View

The curtain Airbag will maintain an extended inflation time which will continue to provide protection during secondary impacts.

Side Impact Sensor



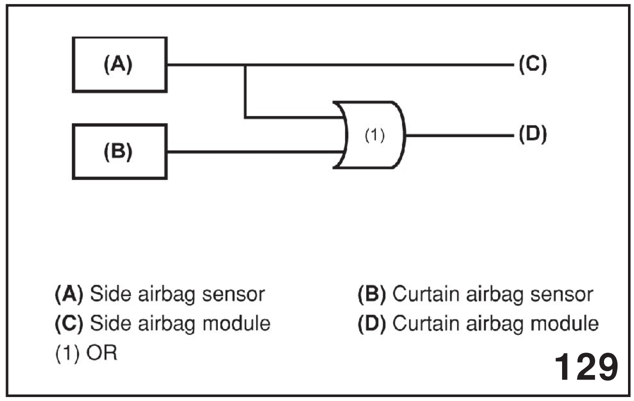
Curtain Airbag Sensor



Side Airbag Sensor

The side impact sensors (side Airbag sensor, curtain Airbag sensor) are installed at the bottom of the center pillars and the rear quarter pillars.

If a sensor detects an impact exceeding the specified level from the side, it sends a signal which is used for Airbag system deployment judgement to the Airbag control module.

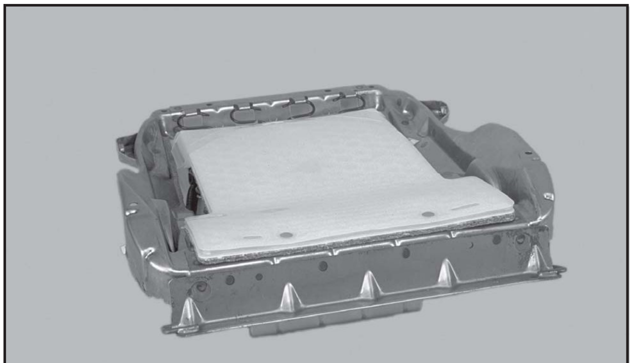


Side Impact Sensors (Artwork)

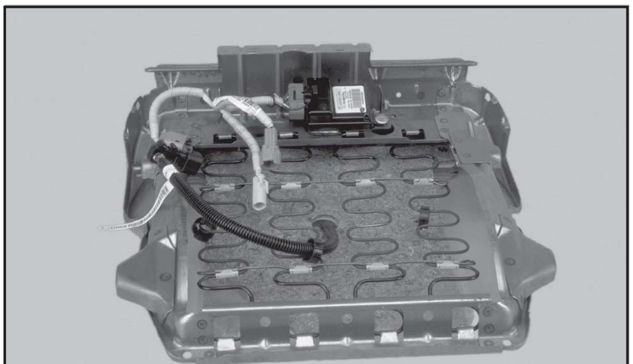
Signals from the side Airbag sensors are effective for both the side Airbags and curtain Airbags, while signals from the curtain Airbag sensors detect impact to the rear seat sides and let only the curtain Airbags deploy.

2006 Subaru B9 Tribeca

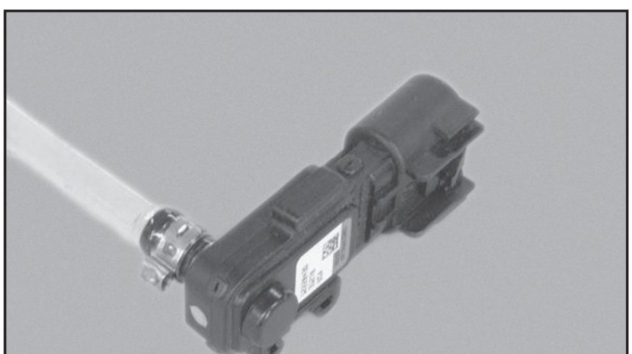
SRS Airbags


131

Seat Frame Top Side


132

Seat Frame Bottom View


133

Pressure Sensor

All Subaru B9 Tribeca models are equipped with driver and passenger front Airbags, front seat active headrests, front seat belt pretensioners, front side Airbags and curtain Airbags. The front passenger seat is equipped with the Passenger Occupancy Detection system. This enhanced system provides the Occupancy Detection System (ODS) with improved diagnostics and calibration.

The occupant detection system for the 2006 model year will consist of the PODS-B system (Passive Occupant Detection System with Bladder). This system will be used to determine if the passenger side Airbag will be deployed or not in a frontal collision.

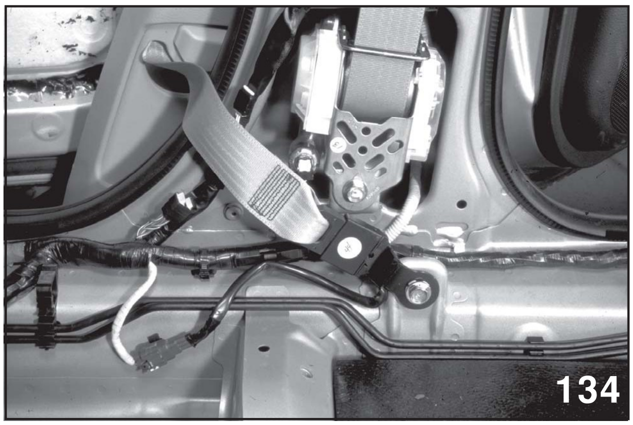
NOTE: DO NOT DISCONNECT ANY ELECTRICAL CONNECTOR OF THE SRS OR ODS UNTIL THE BATTERY HAS BEEN DISCONNECTED.

The PODS system determines the weight of the occupant by measuring the pressure created in a silicon filled bladder. The weight placed on the bladder pushes the silicon through a tube to the pressure sensor. The pressure sensor will then send the value of the weight to the PODS control module. The PODS control module will then send a signal to the SRS control unit, indicating deploy or do not deploy.

Replacement parts for the PODS system are supplied as a service kit, which includes the foam for the lower seat cushion, bladder with pressure sensor, seat harness and PODs control module. Additional replacement items are the Belt Tension Sensor and the seat belt buckle switch. Never change any part of the service kit without changing the contents of the entire kit. Service kit components are calibrated together and calibration of these parts can only be performed at the seat manufacture.

After installation of the service kit or when the seat cover has been removed or replaced, Zero the PODS system with the select monitor. Zeroing tells the PODs control module that the seat is empty and allows the calibration of the service kit items to be compared to empty seat conditions.

Zeroing does not need to be performed when the seat is removed to access other vehicle parts. Unnecessary Zeroing will not harm the system.



134

Seat Belt Tension Sensor

A seat belt Tension Sensor is used with this system. It will send a signal to the PODS Control Unit regarding the current seat belt tension which changes dependant on ALR (Automatic Locking Retractor) function. ALR function of the seat belt is used when child seats are anchored in the front seat.

NOTE: CHILDREN UNDER THE AGE OF 12 YEARS SHOULD ALWAYS BE SEATED IN THE BACK ROW SEATS. INPUT OF HIGH BELT TENSION WILL CANCEL THE ON STATUS OF THE PASSENGER SIDE AIRBAG, DISREGARDING THE WEIGHT VALUE OF THE LOWER SEAT.

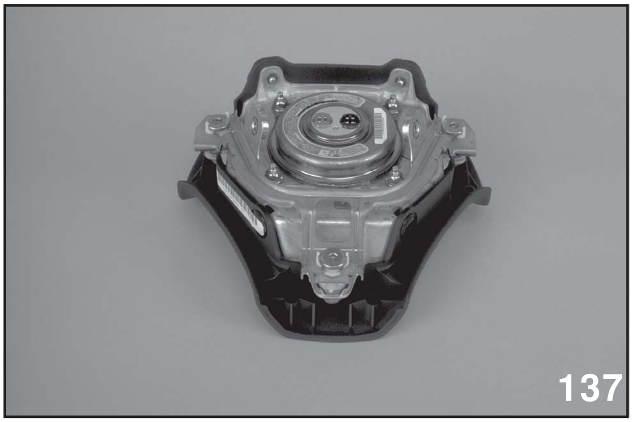
135

Passenger Airbag Light OFF

136

Passenger Airbag Light ON

Status is indicated on the dash in sight of the front seat passenger and works in conjunction with the front passenger seat belt warning light. When the passenger Airbag status changes to on the seat belt warning light will be activated and will be continue to flash until the passenger has connected the seat belt.


137

Driver Side Airbag Module

The driver seat is equipped with a hall effect type sensor that indicates the proximity of the driver to the steering wheel. The hall effect type sensor will send a signal to the SRS control unit. A driver sitting close to the steering wheel will activate a dual deployment of the driver side Airbag in a frontal collision, reducing the force of the Airbag to the driver. The timing of the dual deployment is dependant on the severity of the frontal collision.

Curtain Airbag


138

Close up of Curtain Airbag

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4	Title Slide (SVX System Overview)	6
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6	Title Slide (Component Overview)	7
7	Front Sensors and ECM	7
8	Front Sensor	7
9	Steering Roll Connector	7
10	Double Lock Connector	7
11	SRS ECM Location	8
12	Combination Meter	8
13	Title Slide (Component Operation)	8
14	Open ECM	8
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16	Safety Sensor	9
17	Steering Roll Connector	10
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28	Title Slide (Inflator Igniter)	13
29	Squib (Artwork)	13
30	Title Slide (Airbag)	13
31	Title Slide (Airbag Deployment)	13
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Slide Sequence

Slide Sequence

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105	Select Monitor Image (Threshold adjustment)	31
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138	Close up of Subaru B9 Tribeca Curtain Airbag	39
139	Copyright 2005	
140	The End	

Tools and Equipment

SRS Test Harnesses

Letter Designation	Part Number
K	98299AE000
H	98299FA030
E	98299FC000
F	98299FC010
G	98299FC020
I	98299FC040
I-2	98299FC041
L	98299FE000
M	98299FE020
A	98299PA000
B	98299PA011
C	98299PA020
D	98299AG060
N	98299SA000
P	98299SA020
Q	98299SA040
R	98299FE030
T	98299SA060
U	98299AG000
V	98299AG010
Y	28299AG040
Z	98299AG050
AB	98299XA000
AC	98299XA010
AD	98299XA020
AE	98299XA030
Test resistor 1 of 2 needed	98299PA040
Airbag resistor 2 of 2 needed	98299PA040

Special Tools

Tool Number	Description
24082AA260	Scan Cartridge (05")
24082AA010	Scan Cartridge (06")
22771AA030	Subaru Select Monitor Kit
98399AG000	ODS Weight "A"
98399AG010	ODS Weight "B"
64186AG00A	ODS Spacer Kit
J-39401-B	SPX/Kent Moore Airbag Deployment Tool

Service Bulletins

No.	Date	Subject	Applicability Title
17-01-92	03/17/92	Recommended Parts Replacement when the Airbag is discharged in a Collision	SRS Airbag Equipped Vehicles
17-01-92R	11/22/94	Recommended Parts Replacement when the Airbag is discharged in a Collision	SRS Airbag Equipped Vehicles
17-03-01	02/04/98	De-Powered Airbags	1998 Legacy, Impreza, Forester
17-05-01	05/01/01	Airbag On/Off Switches	1995~1999MY Legacy Vehicles 1994~2001MY Impreza Vehicles
17-02-95R	03/27/01	SRS Airbag-Equipped Vehicles	Airbag Procedures
17-07-04	08/12/04	2003~2004 Forester Vehicles	Trouble code 41 and 42 in the Diagnostic System of the SRS Side Airbag System
17-09-04	11/23/04	Airbag Deployment	Special Tool deploy Airbag

Warranty Bulletin

No.	Date	Title	Subject
WWR-02	06/2004	2005MY Legacy Sedan and Outback Sedan Vehicles	Side Curtain Airbags

Tech TIPS

Date	Subject
06/95	1995 Subaru Legacy Passenger SRS
07/95	Diagnosing SRS (Air Bag) Codes
04/96	Removal of Passenger's Air Bag Module
06/96	Deployed SRS Air Bags
11/96	Passenger's Side Air Bags
02/98	Depowered Air Bags
03/98	All 1998 Model Air Bag Applicability
08/98	Availability of Retrofit Air Bag "On - Off" Switches
08/00	Subaru Vehicles Equipped with SRS Side Airbags
08/00	10 Year SRS inspections
10/00	Diagnosing SRS (Air Bag) Codes
07/01	Subaru Vehicles Equipped with SRS Side Air Bags
10/01	2002MY Impreza SRS Harness Change
07/03	2003MY Forester SRS Codes 41 or 42
09/03	Air Bag Connector
03/05	SRS Codes 41 and 42

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