SUBARU

CERTIFIED SUBARU TECHNICIAN

Technicians Reference Booklet

Automatic Transmissions (4EAT)

Module 302

Technical Training

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Table of Contents

Introduction 8
General Overview 8
Features 10
Major Components 10
Lock-Up Torque Converter 10
Lock Up Operating Modes 11
Oil Pump Assembly 12
Oil Pump Operation 12
Transmission Gear Train 13
Operating Principles: Rear Gear Set 13
High Clutch and Reverse Clutch 14
Operating Principles: Front Gear Set 14
Band Servo Operation 14
Operating Principles: AWD 15
Transfer Clutch Assembly (AWD) 15
AWD component details 15
Final Drive 16
Oil Pump Housing Features 16
Differential Carrier Features 16
Hydraulic Control System 16
Valve Body 17
Accumulators 17
Accumulator Operation 17
Component Disassembly / Inspection 17
Drive Pinion 18
Reassembly 19
Clutch Reassembly Precautions 19
Differential Pinion Backlash 19
Transfer Clutch Valve Assembly 19
Transmission Reassembly 19
Torque Converter Case 19
Final Drive Pre-load & Backlash 19
Forward Clutch Installation 20
Reverse Clutch Drum End-Play 21
Total End-Play 21
Valve Body Precautions 22
Extension Case 22
Transmission Reinstallation 23
Electronic Control System 23
Overview 23
Transmission Control Unit 23
TCU Inputs 23
Legacy TCU Inputs 25
Maintenance Precautions 25
TCU Outputs 25
Shift Modes 26
Combination Meter Light Operation XT - 6 and L – Series 26
Late Model Combination Meter 27
Legacy, SVX, Impreza & Forester Lighting 27
Fail Safe System 27
Fail Safe Components and Failure Results 27
Self Diagnostic System 28
XT and L-Series Diagnostics 28

Contiuned on next page

1990 –1994 Legacy, 1992 – 1995 SVX, 1993 – 1995 Impreza Diagnostics 28
Select Monitor Analysis 28
1995 – 1998 Legacy, 1996 – 1998 Impreza, 1996 – 1997 SVX, 1998 Forester, Diagnostics / OBD – II Vehicles 29
Trouble Codes 29
OBD - II 29
OBD - II Operation Overview 29
OBD - II purpose 29
Control Unit Networking 30
Troubleshooting and Adjustments 31
Preliminary Inspection 31
Gearshift Cable Adjustment 31
Stall Test 31
Stall Test Results 31
Time Lag Test 31
Time Lag Results: 32
Pressure Test 32
On Car Service/Adjustments 32
302 Module Lesson Plan Bulletins 34
302 Module Service Help-Line Updates 35
4EAT Valve Body Bolts 36

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (Four Speed Electronic Automatic Transmission) 4EAT	
2	Created By	
3	Teaching Aids	
4	4EAT Assembly	8
5	XT Selector Lever	8
6	Legacy Selector Lever	9
7	Gear Ratios	9
8	Transaxle Control Unit	9
9	Transmission Features	10
10	Title Slide (Major Components)	
11	Torque Convertors	10
12	Turbine Shafts	10
13	Torque Converter Components	
14	Piston & Cover	
15	Lock-up Clutch	
16	Lock-up Operation (Artwork)	11
17	Duty Solenoid “B” (Artwork)	11
18	Lock-up Control Valve (Artwork)	11
19	Torque Converter (Artwork)	11
20	Oil Pump Assembly	
21	Oil Pump Components	12
22	Oil Pump (Artwork)	12
23	Case Mating Surface Split Slide	
24	Transaxle Gear Train	
25	Rear Sun Gear	
26	Rear Planetary Set	13
27	Overrunning Clutch Hub	13
28	Forward Clutch Drum (Artwork)	13
29	OWC 1-2	
30	Low / Reverse Brake	
31	O.R.C. Hub Installed	
32	O.WC. 3 –4 Installed	
33	Rear Internal Gear	
34	Rev. & High Clutches	14
35	High Clutches	
36	High Clutch Hub Bearings	14
37	Front Gear Set	14
38	Band & Servo	14
39	Servo Operation I (Artwork)	15
40	Servo Operation II (Artwork)	15
41	MPT Assembly	
42	MPT Clutch Drum	
43	Transfer Clutch & Drum	15
44	Title Slide (Final Drive)	
45	Differential Housing	
46	Oil Pump Housing	16
47	Oil Pump Cover Seals	
48	Differential Carrier	16
49	MPT Power Flow	
50	Title Slide (Lab Area)	
51	Title Slide (Hydraulic Control System)	

Slide Sequence

Slide No.	Description	Page No.
52	Valve Body	16
53	Upper Valve Body	
54	Lower Valve Body	
55	Accumulators	
56	Accumulator Operation	
57	Title Slide (Lab Area)	
58	Title Slide (Component Disassembly & Inspection)	
59	Oil Pump Assembly	17
60	Measuring Rotor	17
61	Measuring Pump Housing	18
62	Checking Starting Torque	18
63	Drive Pinion Assembly	18
64	Measuring “A”	18
65	Torque pinion Bearing	
66	Measuring “B”	19
67	Pinion Depth Formula	
68	Mount Pinion to Housing	
69	Title Slide (Reassembly)	
70	Carrier Installed	
71	Wrapping Stub Axles	
72	Lip Seal Retainer	
73	Zero State	20
74	Checking Backlash	20
75	Installing Retainer Assembly	
76	Forward Clutch Drum Installation	
77	Verifying Drum Installation	20
78	Measuring “M”	21
79	Measuring “m”	21
80	Measuring Total Clutch Pack Clearance	22
81	Selected Washers	
82	Valve Body Precautions	22
83	Measuring “I” (MPT)	22
84	Measuring “L” (MPT)	22
85	Selecting Bearing	
86	Lab Area (Reassembly)	
87	Title Slide (Electronic control System)	
88	Over view	
89	TCU Locations	
90	Throttle Sensor	23
91	Speed Sensor #1	24
92	Speed Sending Unit & Speedo Head	
93	Combination Meter	
94	Electric Speedometer System	
95	Inhibitor Switch	
96	Cruise Control	
97	Temp. Sensor	24
98	Forced FWD Switch	25
99	Legacy TCU Inputs	
100	Precautions	
101	TCU Outputs	
102	Shift Solenoids 1 & 2	25

Slide Sequence

Slide No.	Description	Page No.
103	Component Application Chart	25
104	Shift Solenoid 3 & Duty solenoid “A”	
105	Dropping Resistor	26
106	Duty Solenoid “B”	26
107	Duty solenoid “C”	
108	Combination Meter XT-6	
109	Late Mode Combination Meter	
110	Title Slide (Fail Safe System)	
111	Fail Safe System Components	
112	Title Slide (Self Diagnostic Systems)	
113	XT Combination Meter	
114	XT Shift Quadrant	
115	Code Interpretation	28
116	1990-1994 Legacy Diagnostics	
117	Diagnostics OBD-II Vehicles	
118	OBD-II Logic Tree	29
119	OBD-II DTC PO743	30
120	OBD-II DTC PO740	30
121	Control Unit Networking	30
122	Title Slide (Troubleshooting / Adjustments)	
123	Preliminary Inspection	
124	Cable Adjustment	31
125	Inhibitor Switch / Cable	
126	Inhibitor Switch / Adjustment	31
127	Performance Tests	
128	Pressure Test Gauge Set	
129	Pump Outlet Pressure Test Port	32
130	ON car Service	
131	Lab Area (Self Diagnosis / Fault Verification)	

Introduction

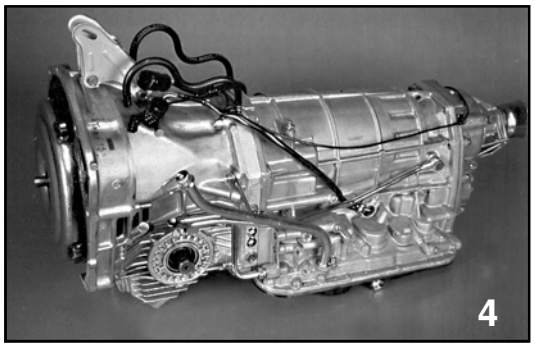
This Technicians Reference Booklet introduces the first generation of Subaru Four Speed Electronic Automatic Transmissions. It covers the components and their operation, its self-diagnostic system, troubleshooting, transmission removal, inspection, reassembly, and reinstallation procedures. The differences 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



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.



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.


6

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

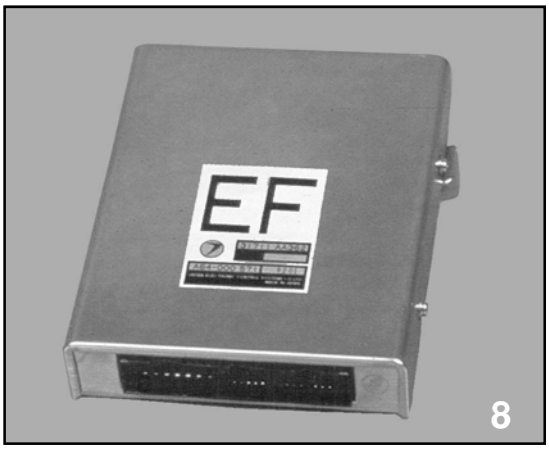
1st	2.785
2nd	1.545
3rd	1.000
4th	0.694
REV	2.272

Final Drive: 3.70:1 or 3.90:1

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

7

Refer to Service Manual for specific model gear ratios.



8

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

9

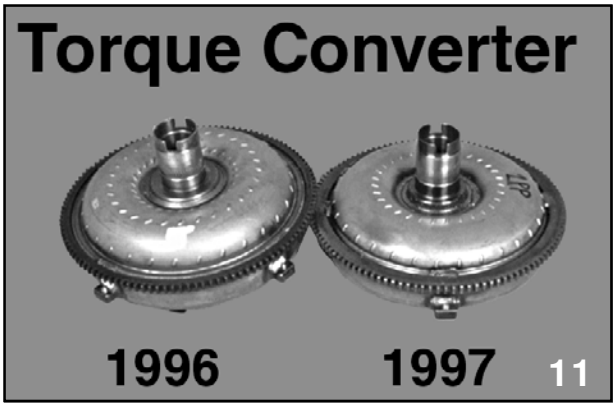
The 4EAT features a double planetary gear set, a lock-up torque converter, and variable displacement oil pump. The 4WD system includes a Multi-Plate Transfer Clutch (MPT).

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

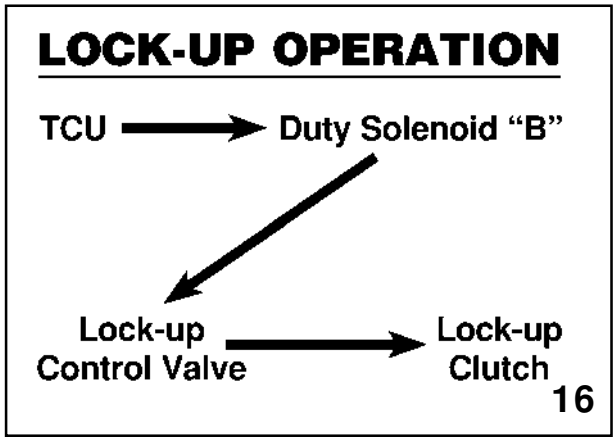
The torque converter developed for the 4EAT is designed to match a wide range of engines from large to small displacement. It is also designed to improve acceleration from a stop and reduce fuel consumption.



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

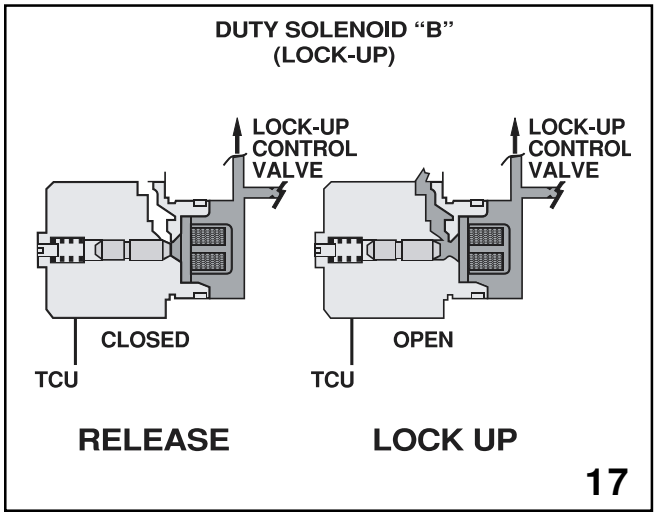
The torque converter has an electronically controlled, hydraulic lock-up clutch system that prevents slip loss during medium to high-speed operation. This system replaces the previous centrifugal lock-up type clutch.

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.



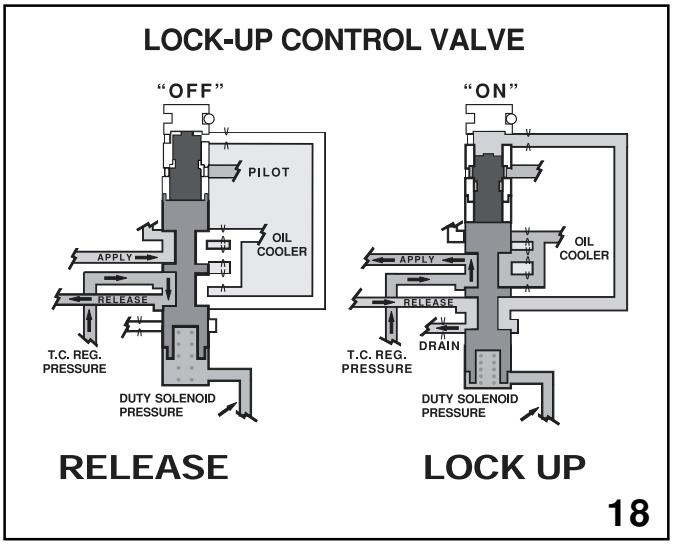
The lock-up operation is controlled by the TCU which then regulates Duty Solenoid "B" mounted on the lower valve body. This solenoid provides control of the lock-up valve located in the transmission upper valve body. Finally, the lock-up valve activates the lock-up clutch (piston) located in the torque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

Lock Up Operating Modes



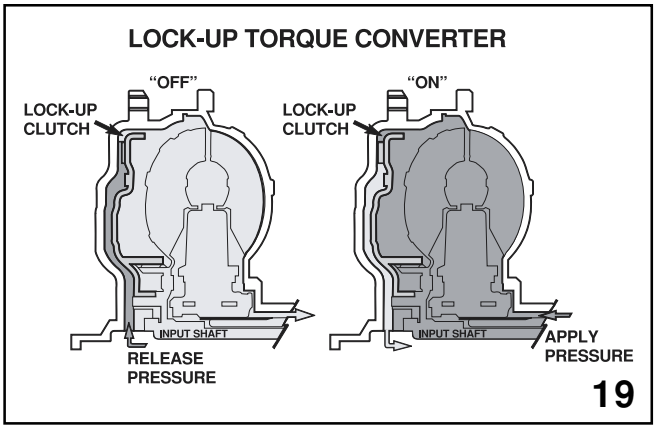
The TCU regulates the cycle of Duty Solenoid "B". When the duty solenoid operates at 5% duty, i.e., substantially more "OFF" than "ON", pilot pressure is directed to the lock-up control valve.

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



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.

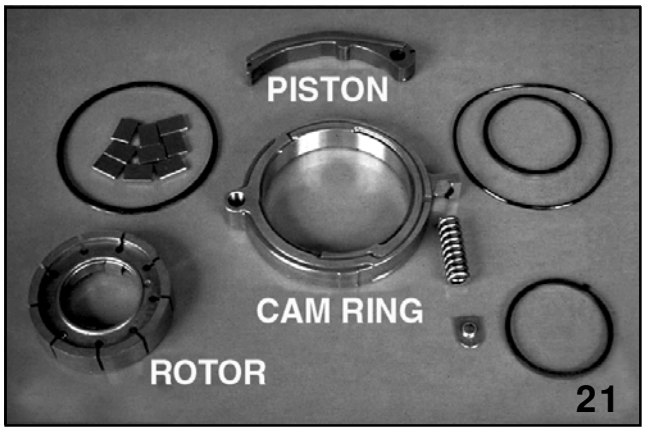


The release pressure then pushes the lock-up clutch (piston) rearward and the lock-up clutch is released from the impeller cover. On the other hand, oil drains through the apply circuit to the oil cooler in the radiator.

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.

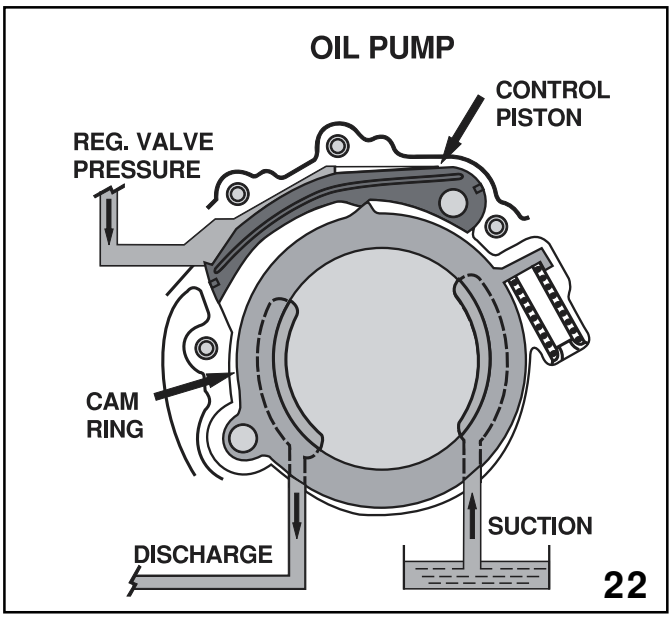


The pump consists of the following components:

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.



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.

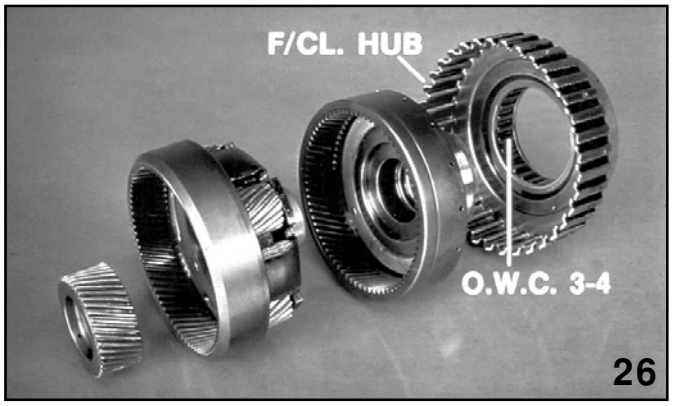
Cases were modified to prevent flexing of the line pressure passage. This condition could cause a gasket failure and reduced line pressure. As a result damage to the high clutch and reverse clutch plates would occur.

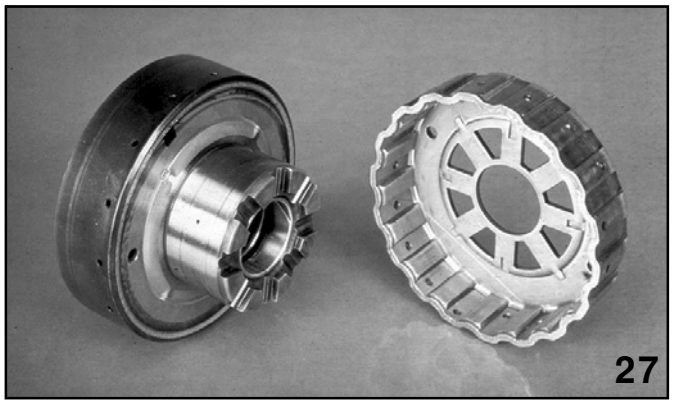
Transmission Gear Train

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.

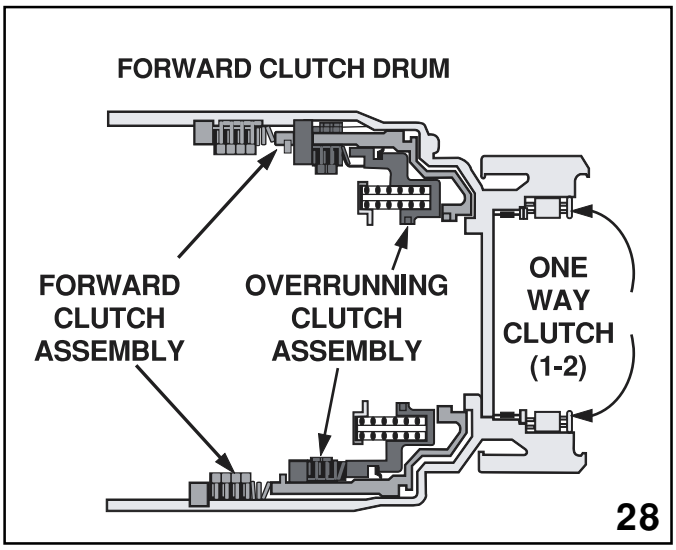
Operating Principles: Rear Gear Set

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





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.



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.

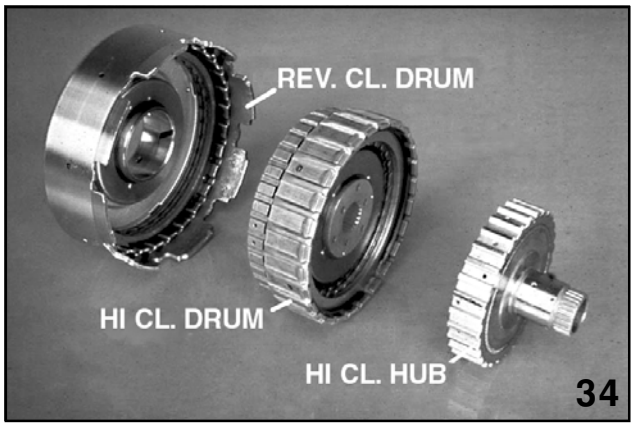
The overrunning clutch provides engine braking during deceleration except in D-1 and 3-1.

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

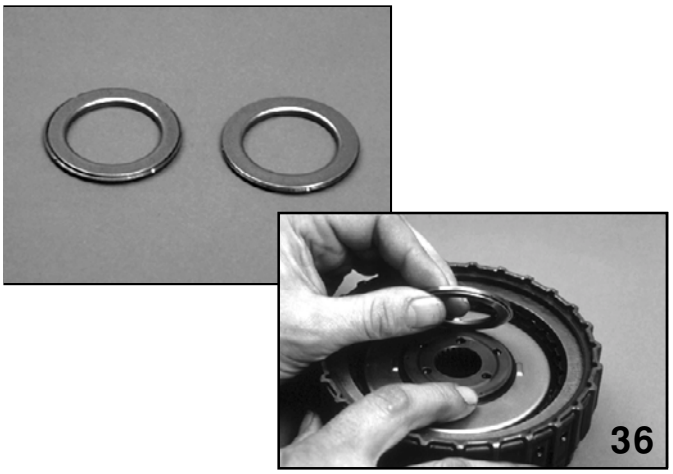
The rear internal gear is controlled by the forward clutch through the O.W.C. 3-4. Additionally, the rear internal gear is controlled by the overrunning clutch. Functioning as an input member in 3rd. Fixed member in 1st and free member in reverse.

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.

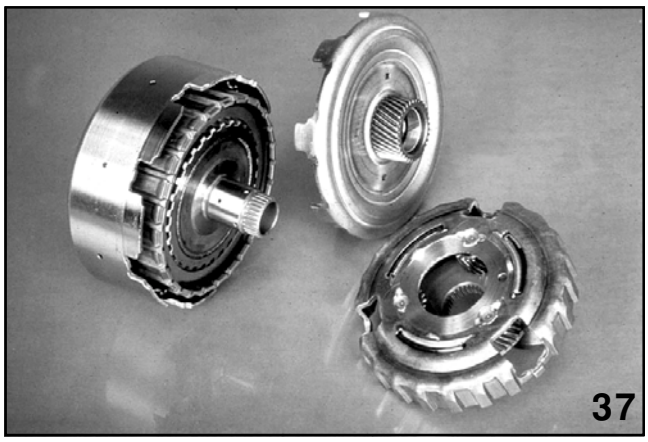


Lubrication holes for the high clutch bearing were changed from the original, with 3 – 1mm holes. The second version had 3 – 1.5mm holes. The third and final version has 6 – 2mm holes.



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.

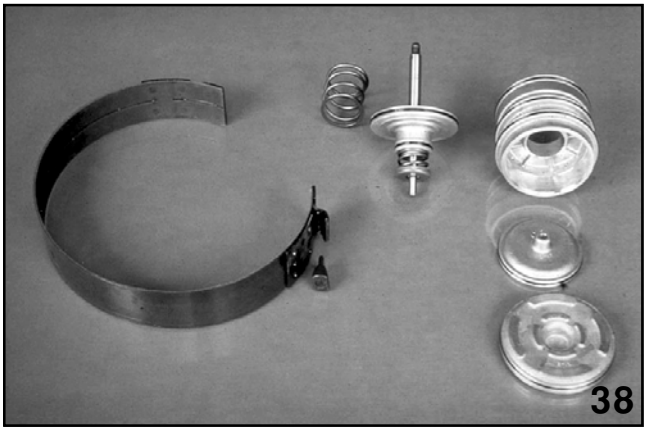
Operating Principles: Front Gear Set



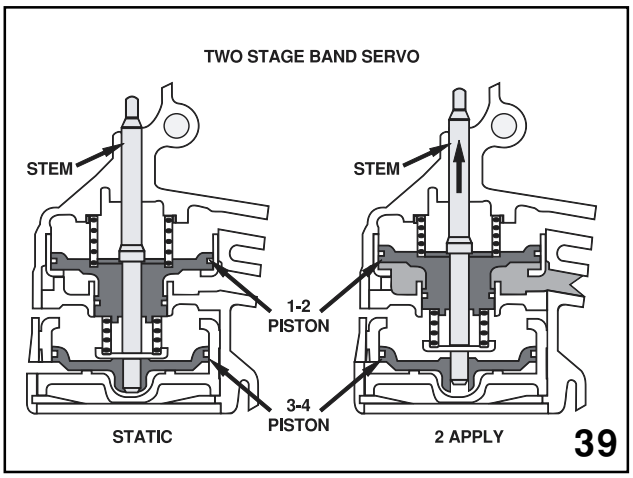
The front sun gear is dogged to the reverse clutch drum. It functions to be the main input member in reverse, never used as an output member. It serves as a fixed member in 2nd & 4th gear. Is a free rotating member in 1st & 3rd gear.

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.

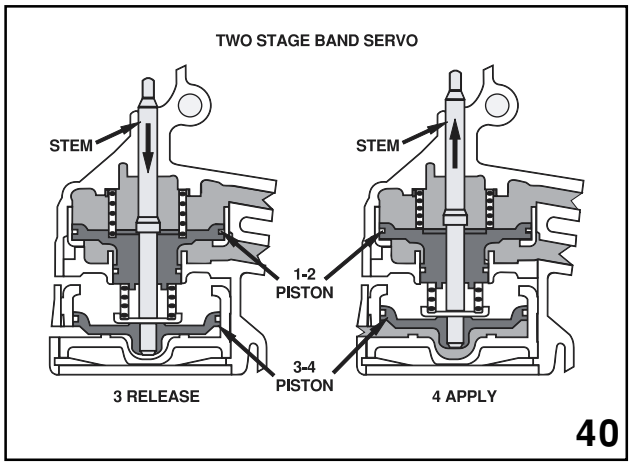
Band Servo Operation



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



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.



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.

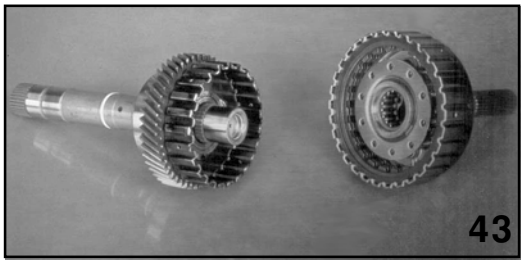
The clutch itself features friction discs that are designed to slip. This eliminates torque binding during tight cornering. In order to get power to the front wheels; the reduction gear powers the reduction driven gear, which is attached to the drive pinion shaft.

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.



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.

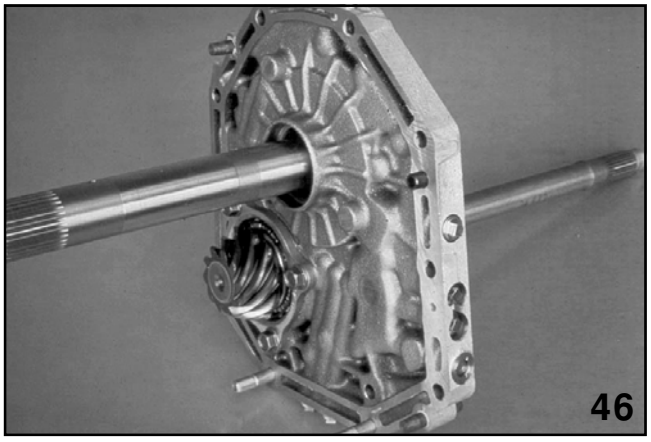
The transfer clutch drive and driven plates are sold as a set. The plates are “broken in” as part of the manufacturing process. It is necessary to keep in specific order they are packed when installing them into the old drum. Also to order the correct set you must measure the existing clutch pack clearance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

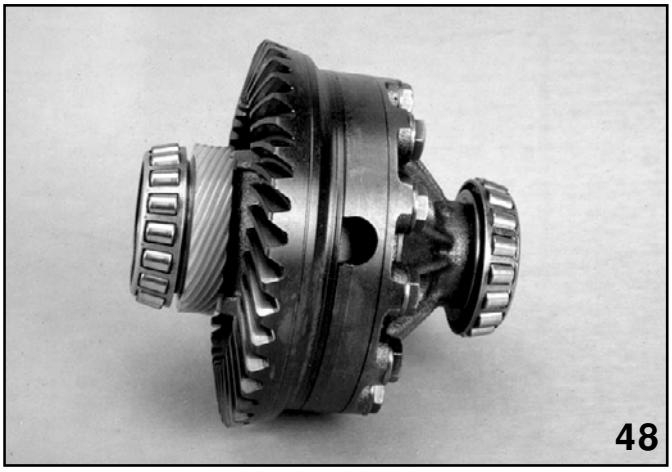


Pinion depth is set by shims, which are located between the bearing flange and the oil pump housing.

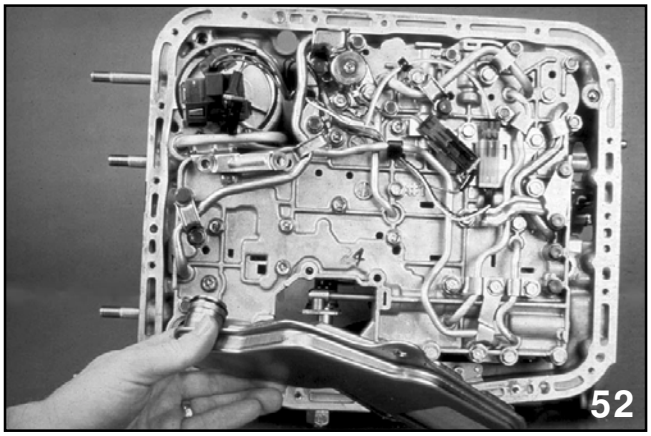
A double-lip oil seal separates transmission fluid from the hypoid gear oil. This greatly improves the fluid system reliability.

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.



Hydraulic Control System



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.

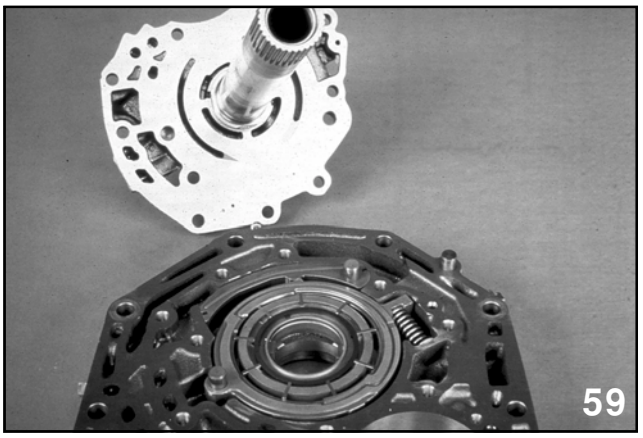
Accumulator Operation

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.

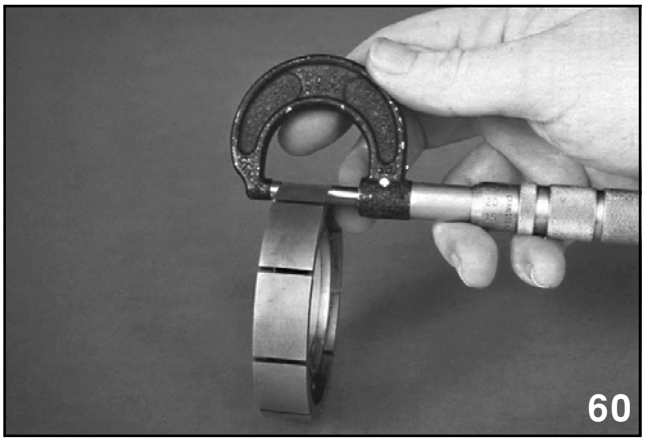
In the 4EAT Accumulators, however, the line pressure is applied to the back of the accumulator piston. Therefore, the resistance to pressure is proportionally increased hydraulically. This keeps the pressure shock under control, allowing smoother component application.

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.

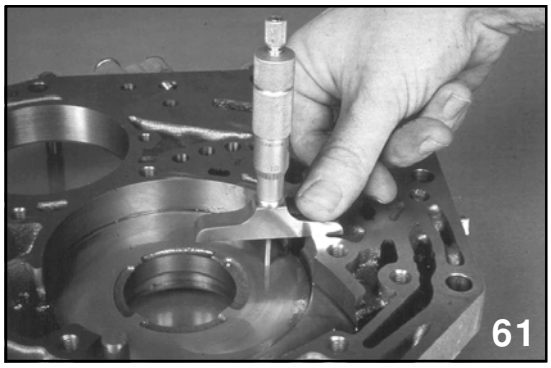
Component Disassembly / Inspection



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.

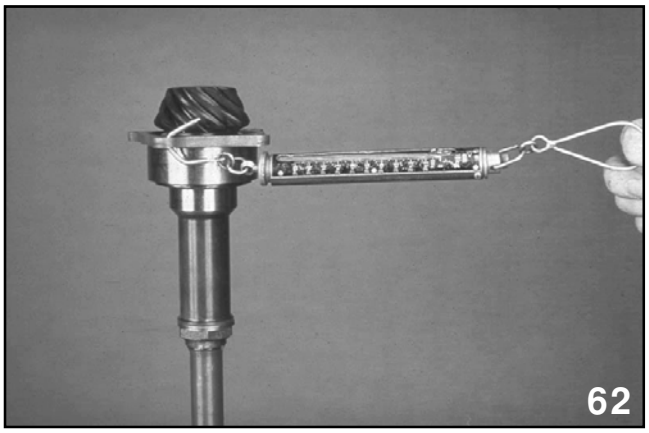


Measure the oil pump housing depth in several places. Then subtract the readings from the previous measurements. Finally, check the wear limits in order to determine the proper clearance when installing new components. Select vanes, which are the same height as the rotor.

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.

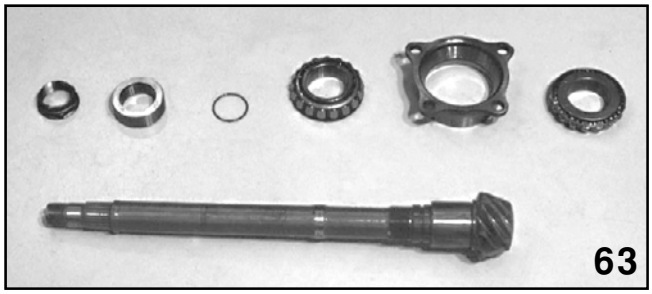
Drive Pinion



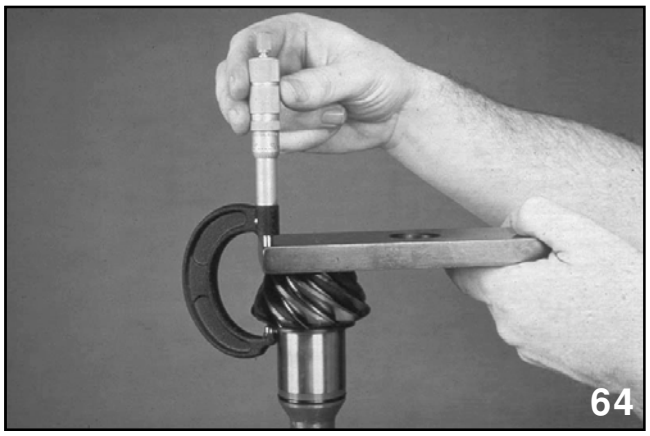
Prior to disassembling the pinion shaft, verify proper starting torque of the bearings.

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.

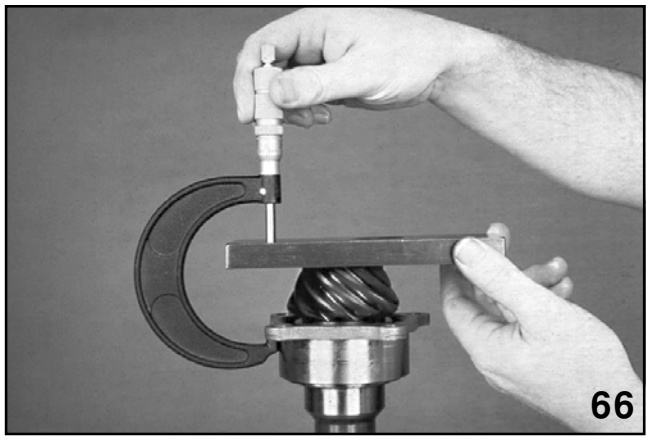


Next, determine the pinion depth. A two step process is used to determine the number of shims and the thickness of the shims.

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.



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 ± 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

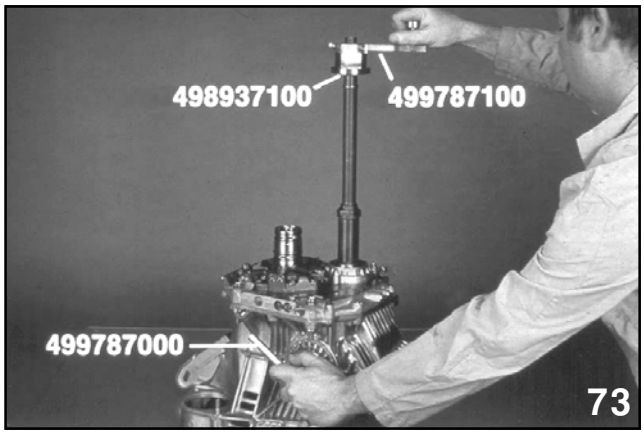
Install the differential carrier into the case being careful of the nylon speedo gears. Then insert the stub axle shafts using new snap rings and check the axle shaft thrust play.

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.

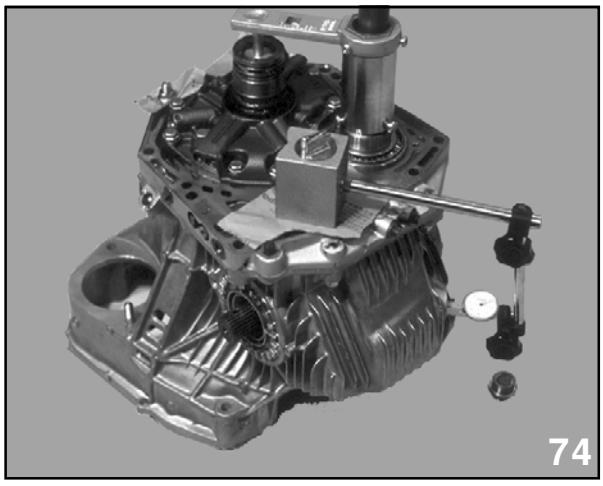


Next, rotate the pinion several times using the following special tools:

- **#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.



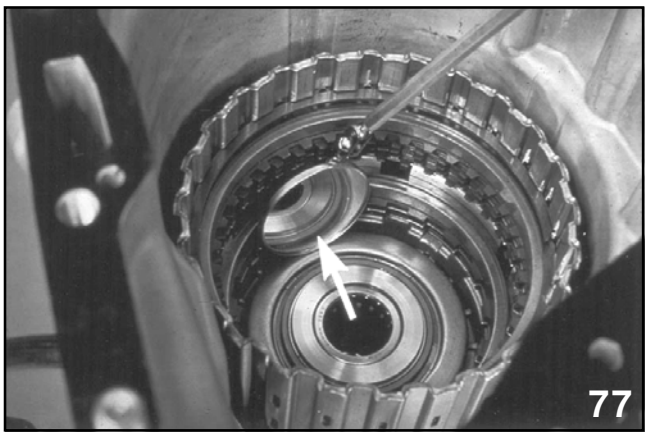
In order to check the backlash; mount a dial indicator securely so that it extends through the drain hole. Then lock the pinion shaft using the special tool #499787100 (Wrench), and check the backlash.

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.



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.

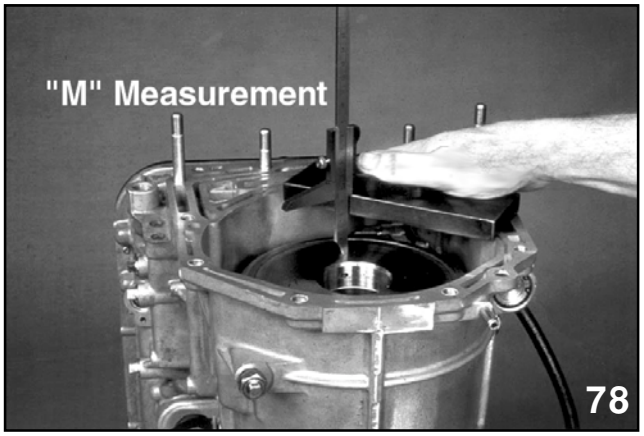
Reverse Clutch Drum End-Play

NOTE: THE BALANCE OF THE GEAR TRAIN COMPONENTS HAS ALREADY BEEN INSTALLED.

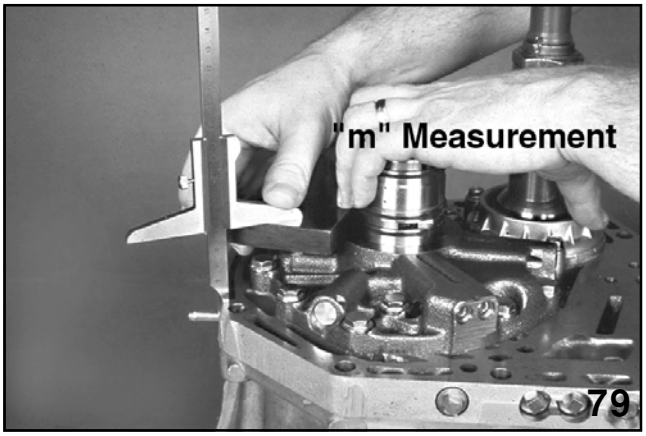
Select a washer for proper end-play adjustment using the following formula.

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.

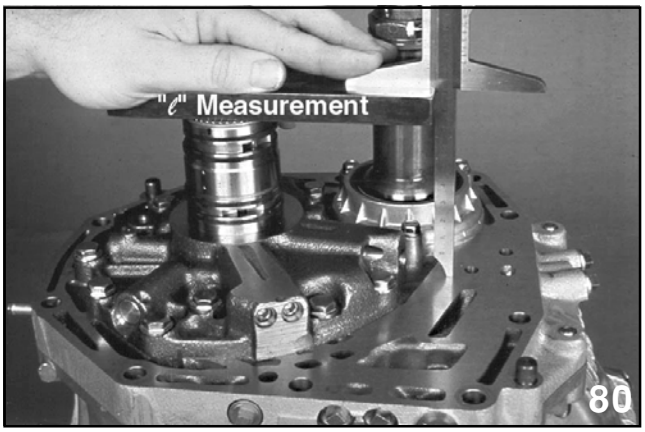
Total End-Play

Select a washer for total endplay using the following formula:

FORMULA (mm):

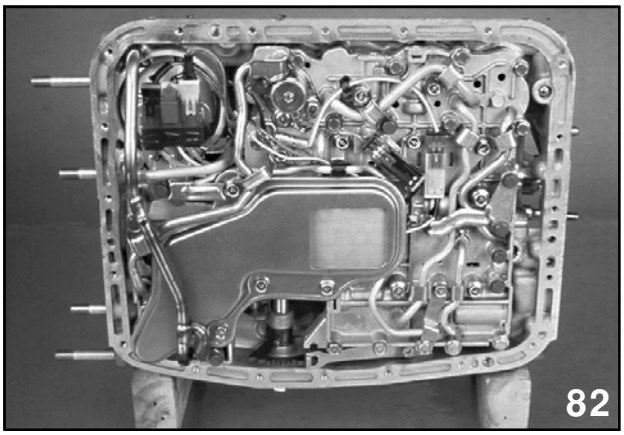
- T = (L + 0.40) - l - (0.25 to 0.55)
- T = Thickness of race
- L = Distance from case to reverse clutch drum race surface
- 0.40 = Thickness of gasket
- l = Distance from top of oil pump cover needle bearing to oil pump housing
- 0.25 to 0.55 = Ideal total end-play

First measure “L” using a depth gauge. Again, note that there is no gasket. Measure to the race surface and record the reading.



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.

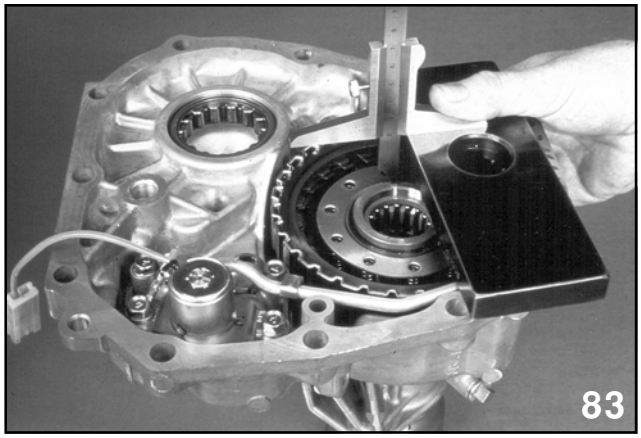
Valve Body Precautions

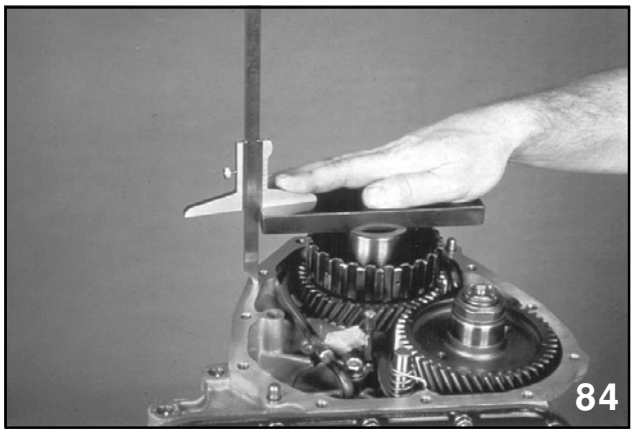


- Route the harness correctly.
- Torque the mounting bolts evenly.
- Use a new O-ring on the strainer.
- Install the oil cooler pipe.
- Make sure the magnet is properly positioned on the pan.
- Torque the pan bolts evenly.

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.





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

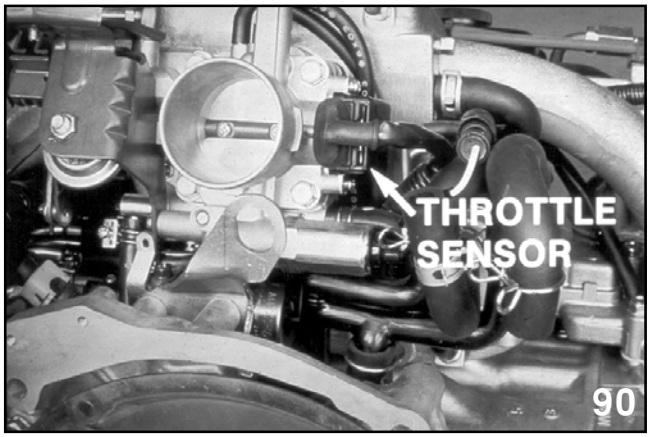
The TCU is a highly sophisticated microprocessor with a self-diagnostic long-term memory. It also has a fail-safe function, which maintains driveability in case of a major electrical component failure.

In a transmission equipped for 4WD the TCU utilizes a program which continually changes the degree of 4WD based upon vehicle operating condition(s).

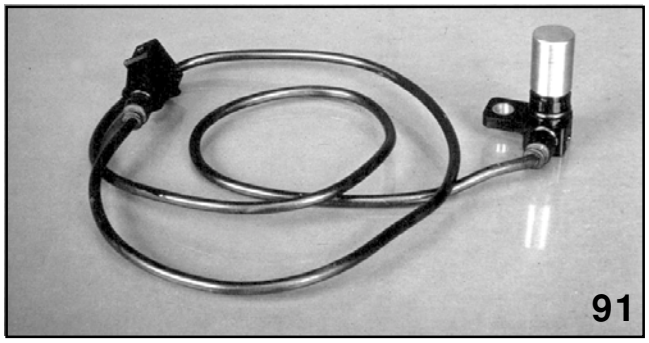
The TCU controls shifting and line pressure in addition to the lock-up torque converter and the MPT clutch.

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



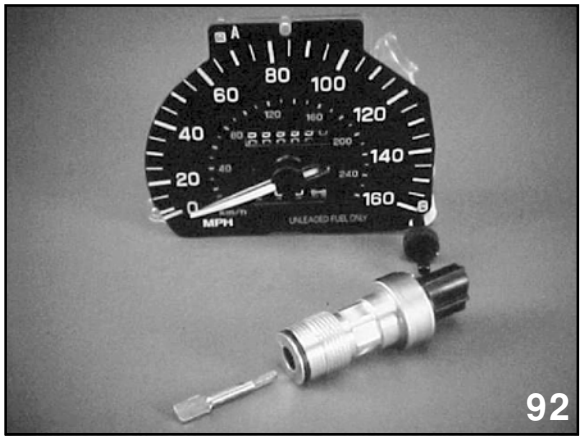
The throttle sensor/idle switch is basically electrical throttle pressure. The load signal effects: shifting, line pressure and lock-up. The closed throttle input effects the lock-up release mode as well as smooth downshifting into 2nd gear. It also causes a reduction in the pressure.



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.



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.

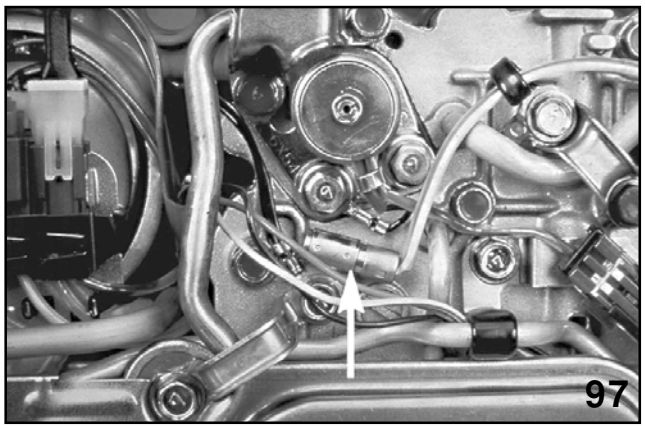
The Speedometer Driving Unit (SDU) receiving pulses from the MRE sensor processes the signal sending the information to the transmission control unit.

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.



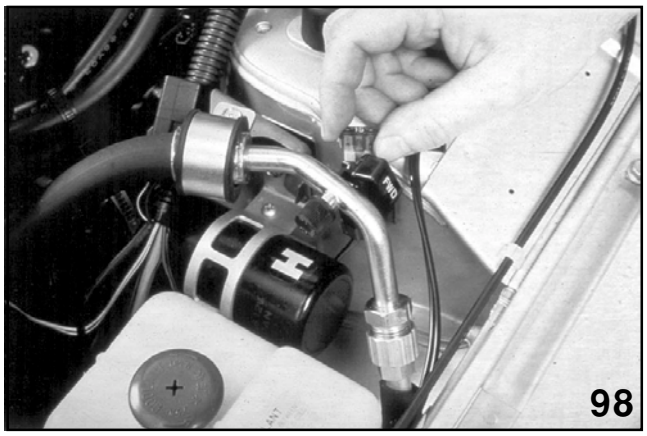
The ATF temperature sensor is located on the lower valve body next to duty solenoid “B”. When the ATF is cold, the TCU won’t allow an up-shift into 4th gear. The object is to warm the engine quickly for lower emissions. It is more sophisticated than the KDLH system and less objectionable for the consumer.

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.



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

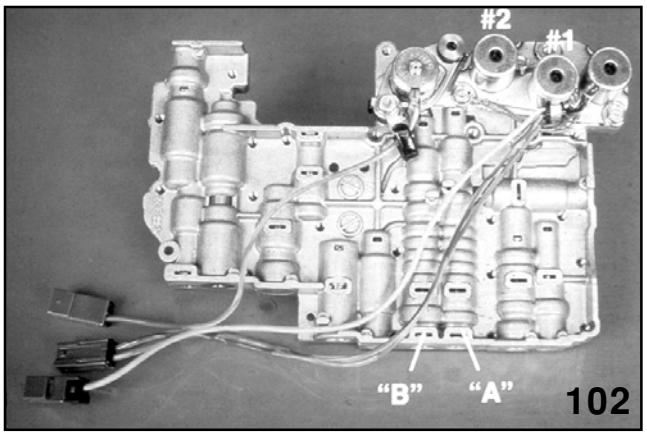
Before jacking up one or two wheels for maintenance with the engine running or before running the vehicle on a chassis dynamometer, the electronic 4WD engagement system MUST be disengaged by installing the spare fuse (15A) of the fuse box into the FWD connector located under the hood. Failure to do so 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.



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				●	●			●	●	●
	2nd		●		●	●				X	
	3rd			●	●	●				X	X
	4th		●	●	●						X

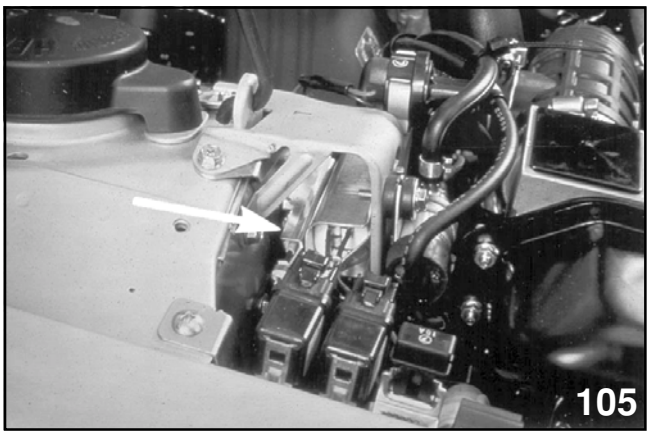
103

Shift Modes

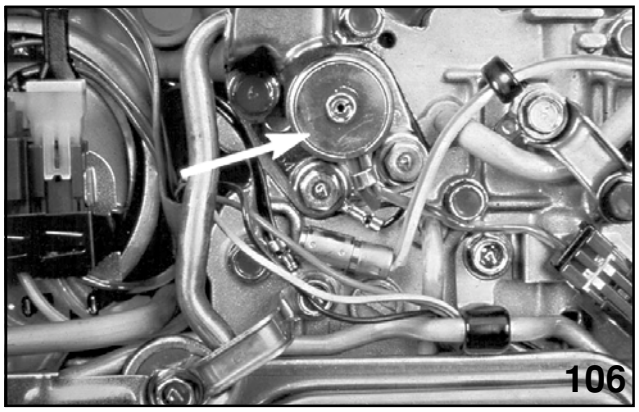
Shift solenoid #3 is located on the upper valve body. It is used to control downshifts. It quickly releases the 3-Release pressure during low speed, heavy load situation in order to provide smooth 3-2 downshifts. It operates the overrunning clutch in order to provide engine braking during deceleration. 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.



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".



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

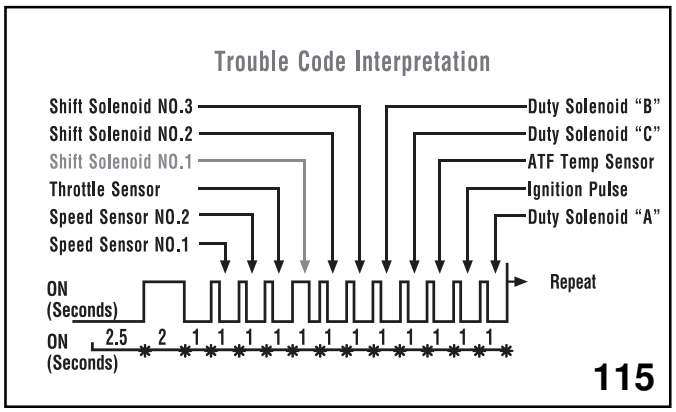
The 4EAT self-diagnostic system has three modes: a user mode and two dealer modes. In the first instance, the user is notified through the POWER light when a malfunction occurs. The failure is communicated after the next ignition "OFF/ON" cycle. For a more detailed description of the user mode, see the 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.



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

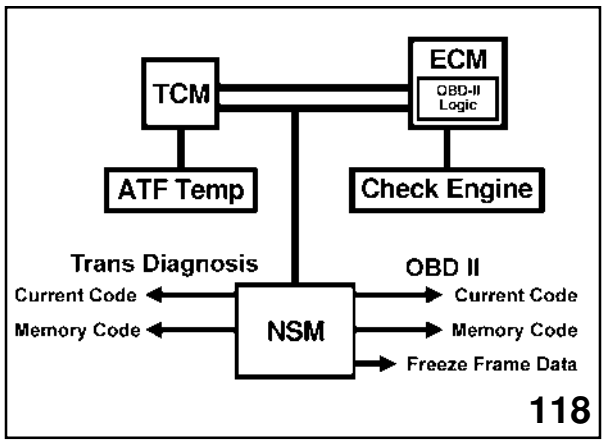
Abnormal ATF Temperature is too high. AT temp light comes on and stays on until ATF temperature returns to normal.

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



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.

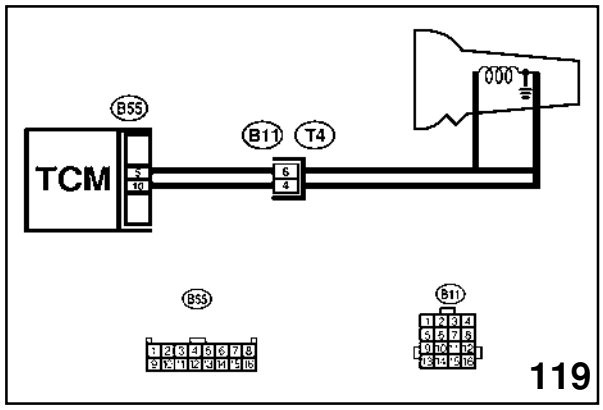
There are 2 trouble codes that are generated as soon as a problem occurs, turning on the MIL. With 22 others requiring a fault or error during two consecutive trips, before turning on the MIL. A trip is defined as a driving pattern in which test parameters are reached for a given time. A failed trip 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

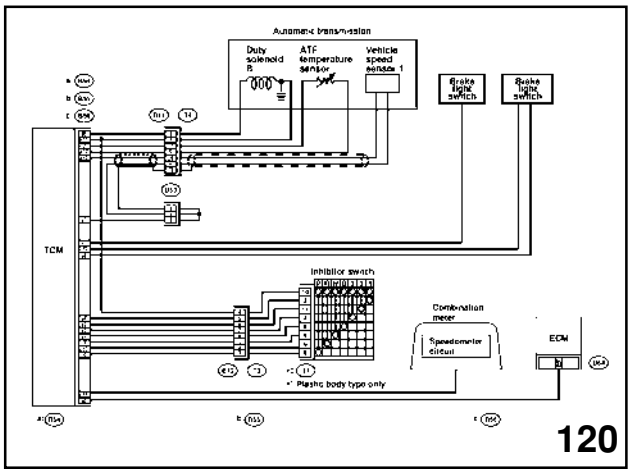


The TCM continuously monitors duty solenoid B Circuit. A fault will register if the following conditions are met:

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.



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:

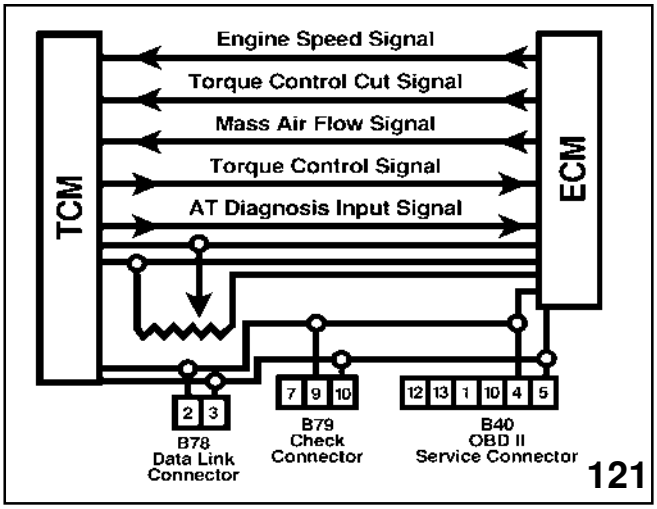
Engine speed is equal to or greater than output shaft speed (speed sensor 1) multiplied 4th gear ratio multiplied by 9/8.

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



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.

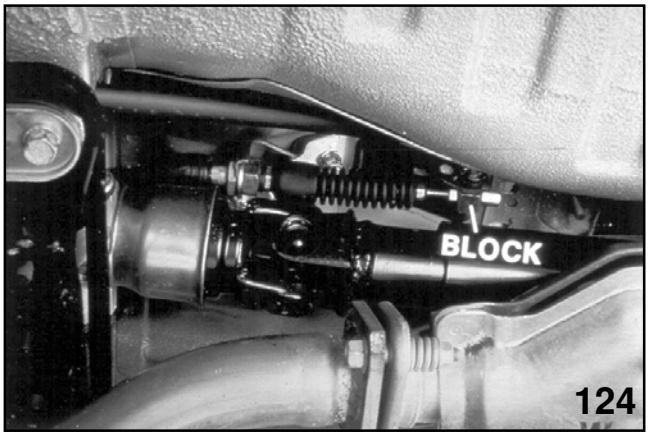
Troubleshooting and Adjustments

Preliminary Inspection

Check the following:

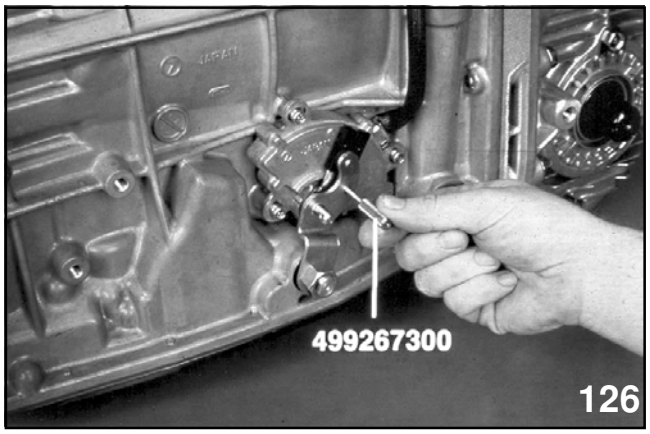
1. Fluid level
2. ATF leaks
3. Road Test:
   - Check proper shift points
   - Engine performance
4. Correctly adjusted throttle sensor
5. Gearshift cable adjustment
6. Correct stall test results
7. Inhibitor switch connections
8. Correct pressure test results

Gearshift Cable Adjustment



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.



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

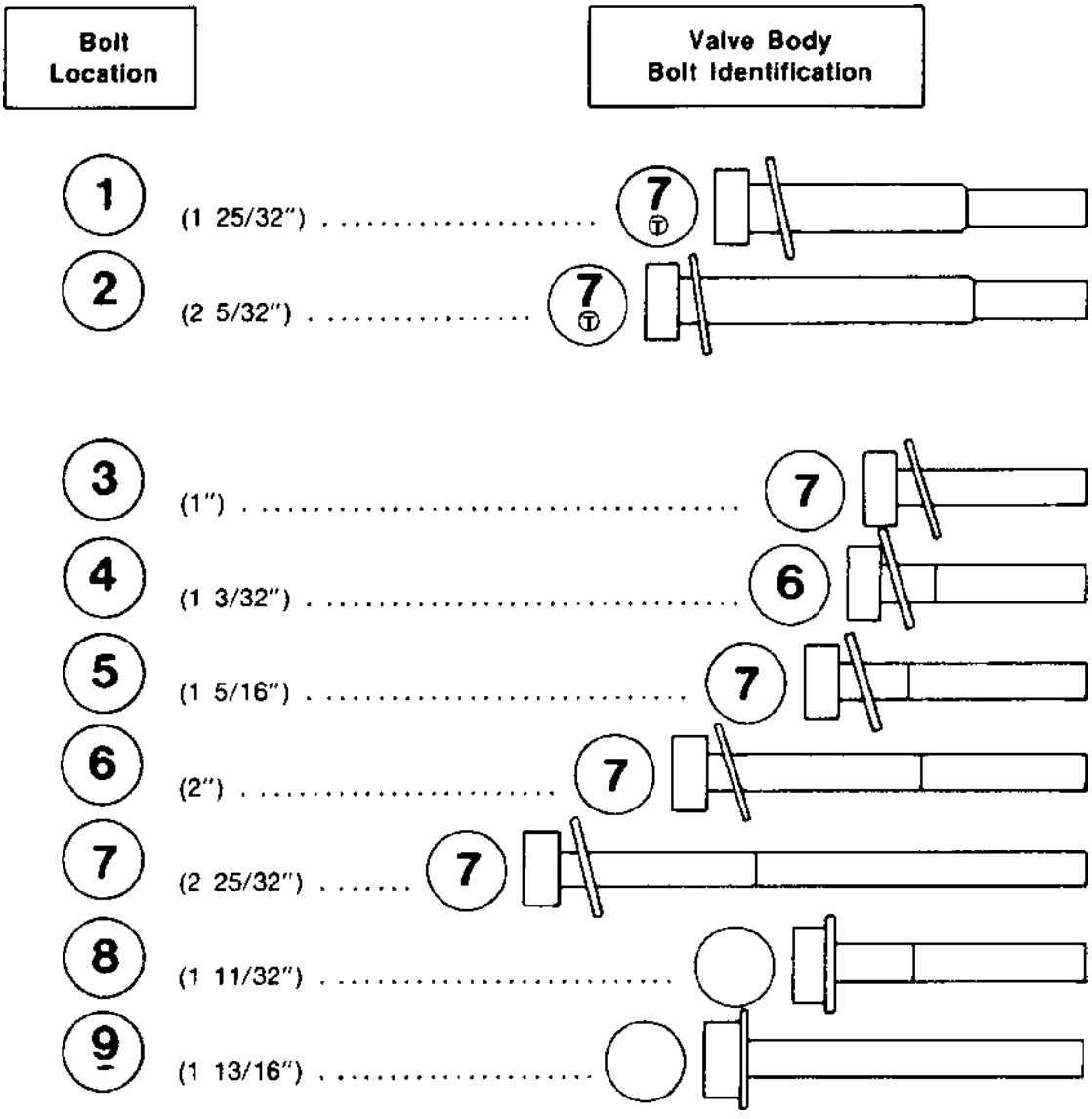
11 bolts at location 8

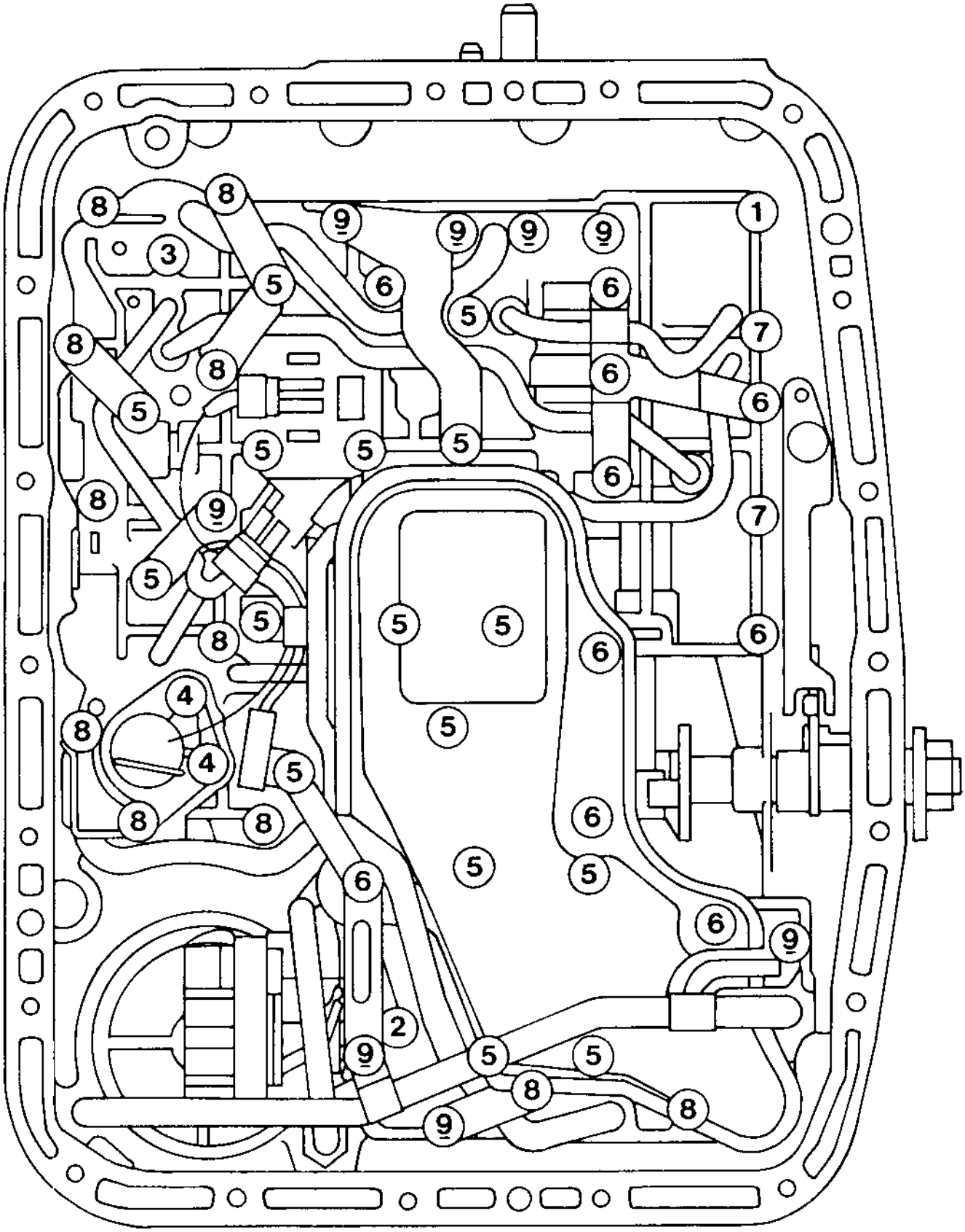
INSTALL SCREEN

4 bolts at location 6 (4 screen bolts)

INSTALL OIL COOLER PIPE

8 bolts at location




8
8
9
9
9
9
1
3
5
6
6
5
7
8
8
6
5
6
5
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SUBARU

CERTIFIED SUBARU TECHNICIAN

Technicians Reference Booklet

4EAT Phase II

Module 304

Technical Training

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4EAT Phase 2

Table of Contents

Slide Sequence **4**
Introduction **6**
Disassembly **7**
Variable Torque Distribution (VTD) **9**
4EAT Phase 2 Disassembly Continued 13
Servicing the Oil Pump **17**
Servicing the High and Reverse clutch **18**
Servicing the Planetary Gear Assembly and Low Clutch **19**
Hydraulic Control **21**
Line Pressure **21**
Lock up Engagement 22
Lock up Release 22
1st gear 24
2nd Gear 25
3rd Gear 26
4th Gear 27
TCM Control **29**
Normal Shifting 29
Slope Control 29
Control at Low Temperature 29
Control During ABS Operation 29
Engine Over Speed Prevention Control 29
Timing Control **30**
Low Clutch Timing Control **31**
Engine Torque Control 31
Learning Control 32
Reverse Inhibit Control 32
Engine Brake Control 33
Self Diagnosis **34**
Failsafe Function 35
2002 Impreza 4EAT Phase 2 Enhancements "Chopper Voltage Signal" 36

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (4EAT Phase 2)	
2	Created By	
3	Teaching Aids	
4	Title Slide (General Information)	6
5	Left Side (Introduction)	6
6	Right Side	6
7	Bell Housing	6
8	Disassembly	7
9	Extension Housing	7
10	Transfer Clutch	7
11	Reduction Gears	7
12	Hammer and Punch	7
13	Tool Usage	7
14	Gear on Bench	7
15	Tool Usage	8
16	Filter	8
17	Solenoid	8
18	Artwork	8
19	Oil Pan	9
20	Title Slide (Variable Torque Distribution (VTD))	9
21	Rear View of 4EAT	9
22	Transfer Planetary	9
23	Transfer Area	10
24	Transfer Planetary	10
25	Reduction Drive Shaft	10
26	Power Split	11
27	Transfer Clutch	11
28	Transfer Planetary	11
29	Piston Clutch Side	12
30	Piston Case Side	12
31	Pressure Ports	12
32	Valve Body with Artwork	13
33	Valve Body	13
34	Failsafe	13
35	Seal Pipe Removal	14
36	Oil Pump	14
37	High Clutch	14
38	Hub	14
39	Front Sun Gear	14
40	Leaf Spring	14
41	2-4 Clutches	14
42	High Clutch	15
43	High Clutch Hub and Front Sun Gear	15
44	Leaf Spring	15
45	Planetary	15
46	2-4 Brake Piston	15
47	Tool Usage	16
48	Tool Usage	16
49	2-4 Brake Piston	16
50	Spring Retainer	16

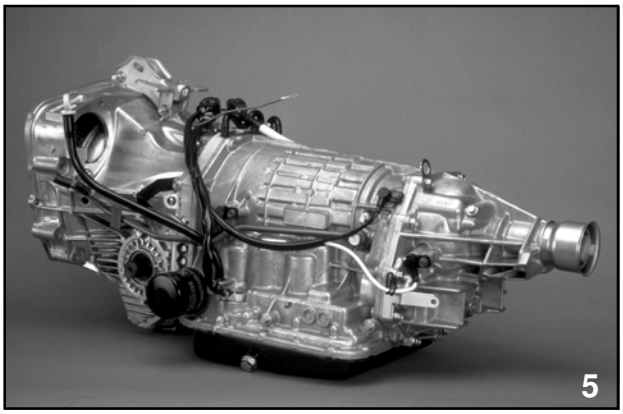
Slide Sequence

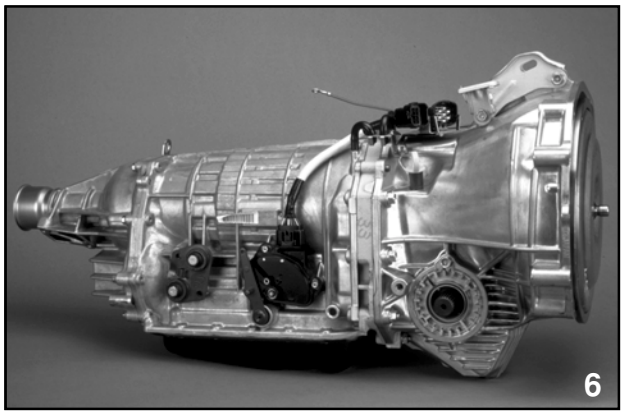
Slide No.	Description	Page No.
51	Leaf Spring	16
52	Valve Body with Seal Pipe	16
53	One-Way Clutch Inner Race	16
54	One-Way Clutch Outside Bolts	16
55	Wave Washer	17
56	Piston and Seal	17
57	Oil Pump	17
58	Oil Pump Inner	17
59	High Clutch	18
60	Tool Usage	18
61	Planetary	19
62	Front Planetary and Rear Sun Gear	19
63	Rear Planetary	19
64	Low Clutch	19
65	Tool Usage	20
66	Tool Usage	20
67	Title Slide (Hydraulic Control)	21
68	Artwork: Line Pressure	21
69	Artwork: Line Pressure	21
70	Artwork: Lock-Up Engagement	22
71	Artwork: 1st Gear	24
72	Artwork: 2nd Gear	25
73	Artwork: 3rd Gear	26
74	Artwork: 4th Gear	27
75	Input / Output Charts	28
76	Input / Output Charts	28
77	Artwork: 2-4 Brake Timing	29
78	Artwork: Low Clutch Timing	30
79	Artwork: Reverse Inhibit Control	32
80	Artwork: Engine Brake Control	33
81	Title Slide (Self Diagnosis)	34
82	Self Diagnosis (11-15)	34
83	Self Diagnosis (16-24)	34
84	Self Diagnosis (25-36)	34
85	Title Slide (Failsafe Function)	35
86	Failsafe Function	35
87	Failsafe Function	35
88	Title Slide (2002 Impreza 4EAT Phase 2 Enhancements)	36
89	Ignition On / Engine Off	36
90	Idle	36
91	Part Throttle	36
92	Half Throttle	36
93	Stall Speed	36
94	Copyright	
95	The End	

4EAT Phase 2

Introduction

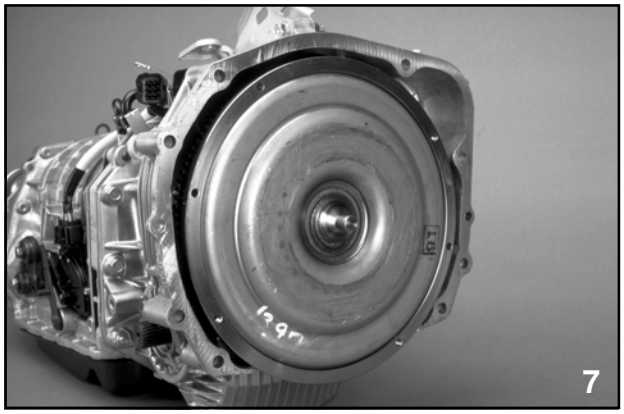
The 4EAT Phase 2 (introduced on 1999 Model Year vehicles) provides the same type of electronic control used by prior model year vehicles and shares many of the same diagnostic procedures, however there have been internal and external changes that require this 4EAT to be viewed as an entirely new automatic 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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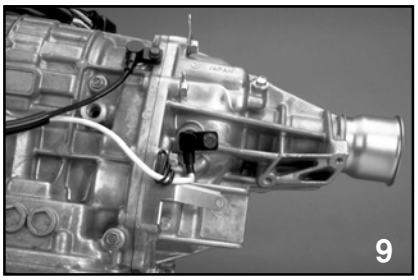
Externally, the number of bolts in the torque converter housing area have increased to match the increase in the number of bolts in the bell housing of the engine. The use of an external canister type oil filter has been adopted which requires no scheduled maintenance. Three speed sensors are now located 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.

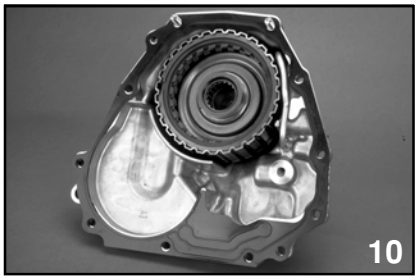

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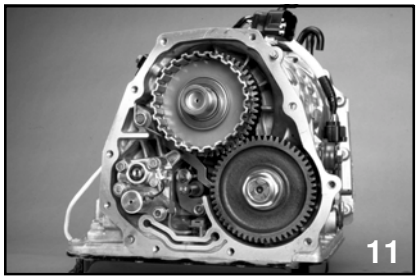
Disassembly

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

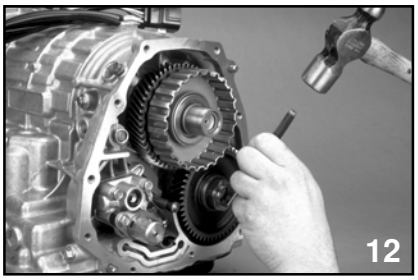


Remove vehicle Speed Sensor 1 from the extension case. Followed by the bolts that secure the extension case to the rear of the transmission.



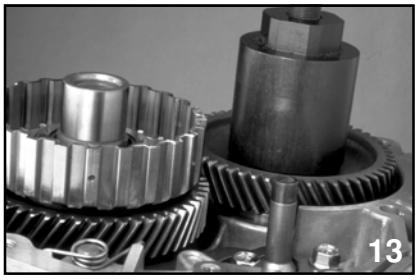


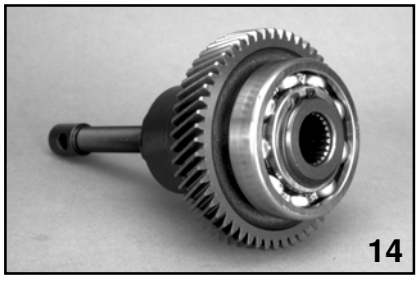
Set the select lever to the park position to engage the Parking Pawl to the front of the reduction drive gear.



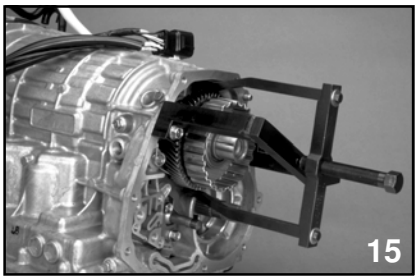
Straighten the peen mark of the locknut. (This locknut is designed to be used only once.) Remove the locknut and washer.

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

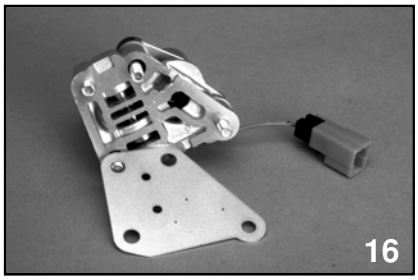


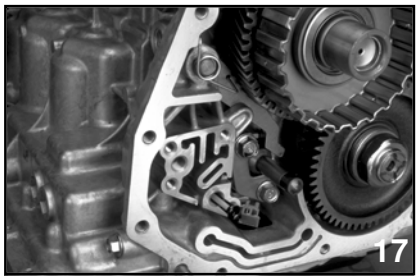


Turn the puller until the Reduction Driven Gear has cleared the Pinion shaft.

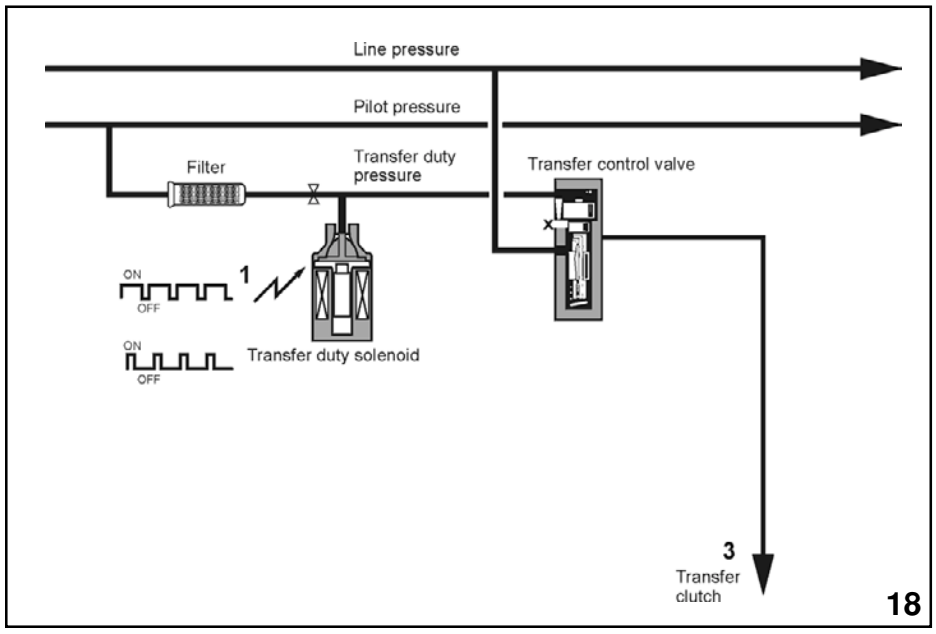


Install the reduction drive gear puller to the rear of the transmission as shown and slowly remove the drive gear assembly. (499737100 and 899524100)

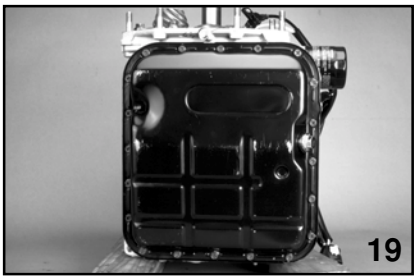




Disconnect the Transfer Duty Solenoid Connector and remove the bolts that secure the Duty Solenoid and Transfer Control Valve to the Transmission Case. Remove the small filter from the cavity in the Transmission case at this time. Remove the Parking Pawl, spring and Parking Pawl Shaft.



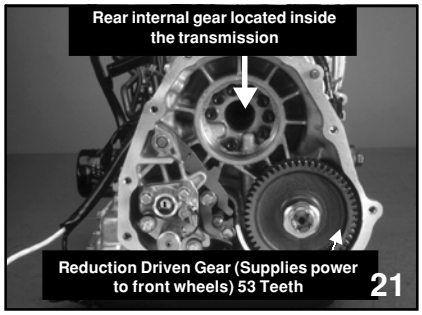
The Transfer Duty Solenoid controls the amount of pilot pressure supplied to the backside of the Transfer Control Valve Piston. If the duty ratio signal from the Transmission Control Unit (TCU) is small the Transfer Duty Solenoid stays off more than it is on and drains less of the pilot pressure. This 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.



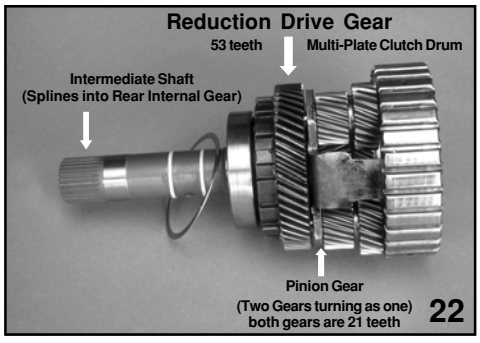
The next step in the disassembly process is to remove the Oil Pan. Position the transmission on the worktable with the Oil Pan facing upward and held in position with wooden blocks.
Remove the Oil Pan Bolts. Use a putty knife or similar tool with a hammer and carefully separate the pan from the transmission.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

Variable Torque Distribution (VTD)

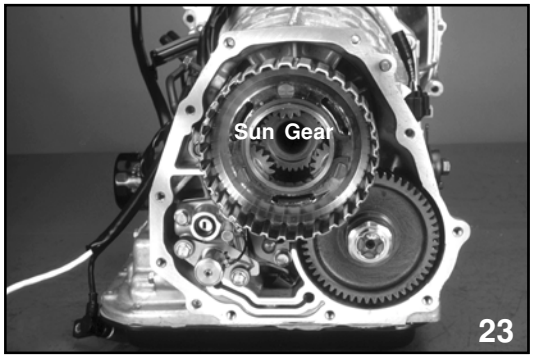
Variable Torque Distribution (VTD) is an addition to the current 4EAT transfer section. VTD is designed to smoothly transfer and divide the power from the engine to the wheels. This new system for North America is equipped on all Subaru vehicles with Vehicle Dynamic Control (VDC).



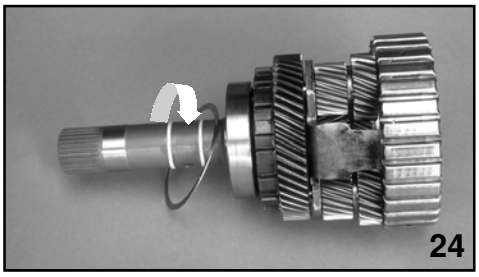
The view of the extension case area is similar to the current 4EAT Phase 2. The difference is the Reduction Drive Assembly.



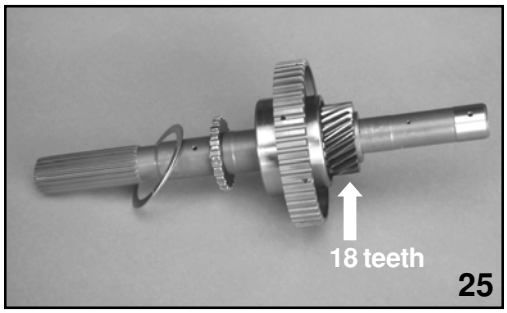
An Intermediate Shaft is splined to the Rear Internal Gear, carrying power to a Sun Gear. The Sun Gear is made onto the end of the Intermediate Shaft. The rotating Sun Gear delivers power to a set of Pinion Gears.



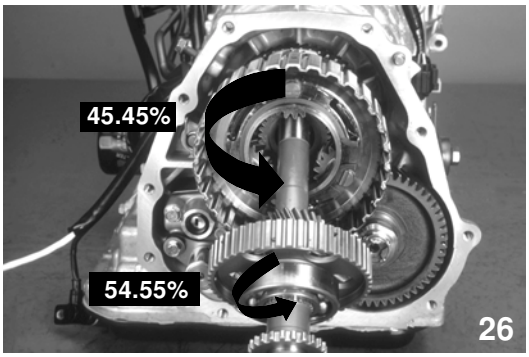
The Pinion Gears are two gears made together. The smaller gear and larger gear have the same number of teeth. The Intermediate Sun Gear drives the smaller Pinion Gear and the larger Pinion Gear.



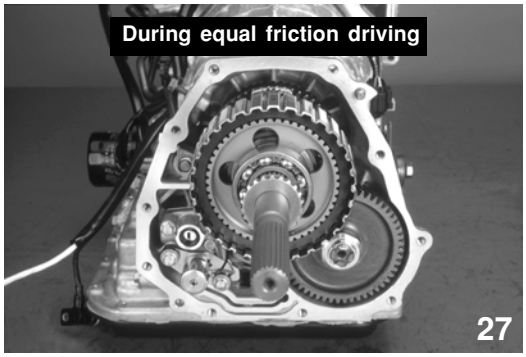
The Pinion Gear is secured to the carrier and delivers power to it. The carrier will now rotate, driving the Reduction Drive Gear. This supplies power to the front wheels. At the same time, the larger Pinion Gear is driving the Rear Drive Shaft.



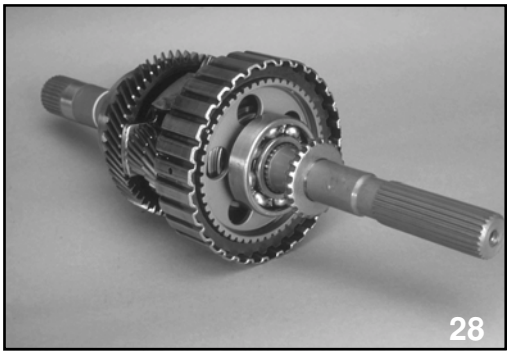
A Sun Gear made on to the end of the Rear Drive Shaft receives the power and transfers the power to the shaft.
The final drive shaft is splined to the Rear Drive Shaft. This carries power to the rear differential.



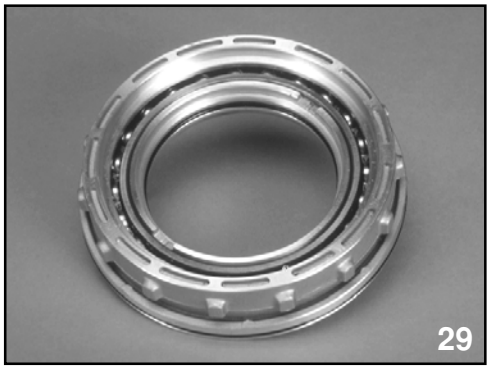
Assuming the friction of the front and rear tires is the same, the power is split 54.55% to the rear and 45.45% to the front.



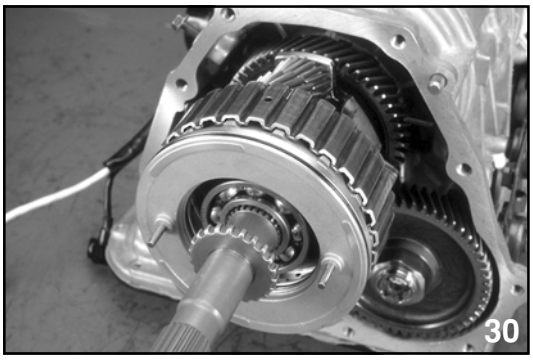
The Front Wheels load the reduction drive and driven gears.
The Rear Wheels load the Rear Drive Shaft and Pinion Gears.
Driving the vehicle results in the Pinion Gears rotating and advancing around the Intermediate Sun Gear.
The Intermediate Sun Gear has 33 teeth; the Small Pinion has 21 teeth.
The Rear 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.



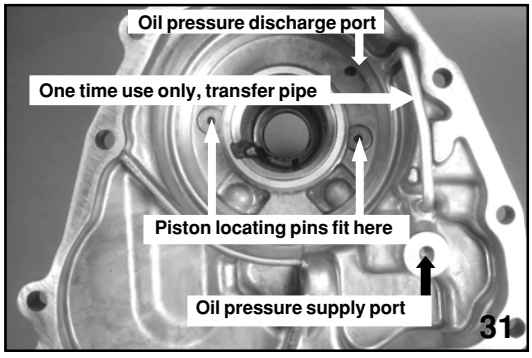
The TCM adjusts the duty ratio of the MPT clutch to maintain the optimum transfer of power.
A large speed difference in the rear to the front wheels results in the MPT clutch locking the Rear Drive Shaft to the carrier.
Power is then split 50% to the front and 50% to the rear.



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.

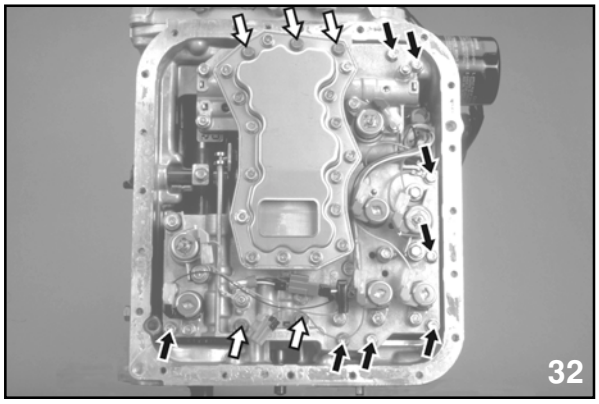


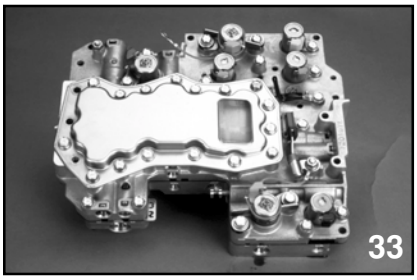
Pressure port locations.
Note: Oil Pressure Transfer Pipe is one-time use only.

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).



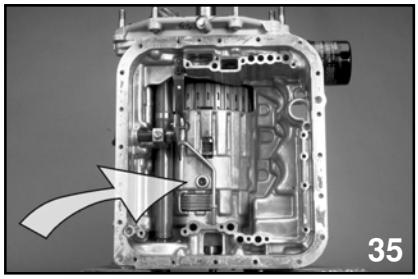


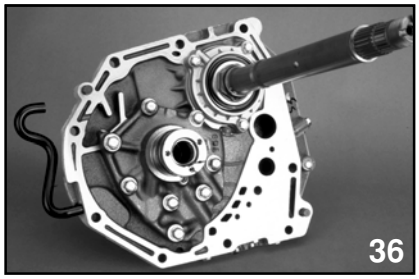
Carefully disconnect all solenoids. Observe the color of the connectors and the color of the wire that connects to them.

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

34

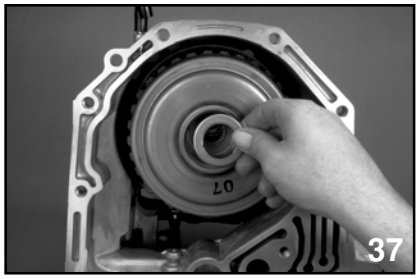
Reposition the transmission to vertical using the wooden blocks to stabilize the case. Remove the bolts and nuts that secure the pump assembly to the transmission case. Remove Seal Pipe.

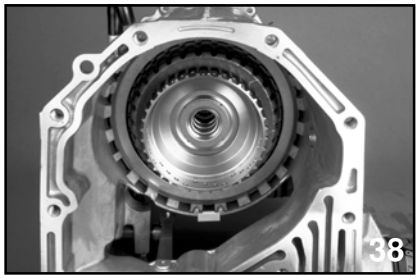

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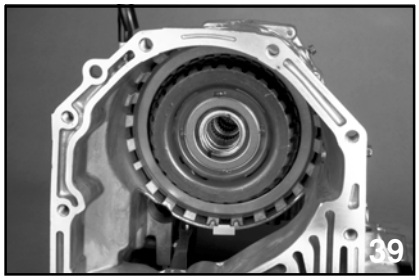
Use the stator support as a handle and remove the pump assembly and gasket.
Caution: the Thrust Needle Bearing may stick to the pump. Ensure it is set aside as it may be used during reassemble if the total end play requires the thickness of the needle bearing to be the same as the original.

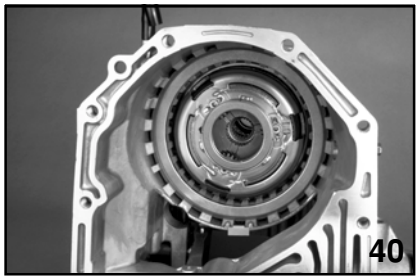
Remove the High Clutch Drum, Thrust Needle Bearing and the High Clutch Hub.


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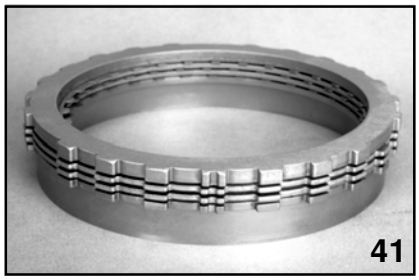

38

Remove the Thrust Needle Bearing and the front Sun Gear.

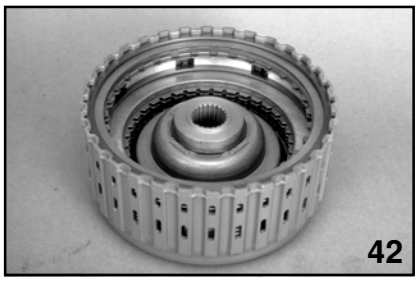

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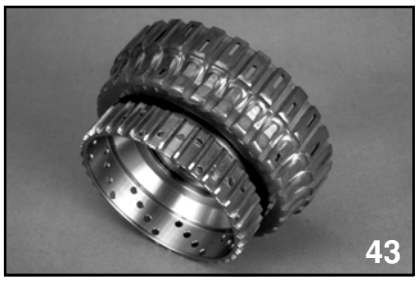

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Remove the Snap Ring and the drive and driven plates of the 2-4 brake clutch with pressure plate.


41

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


42

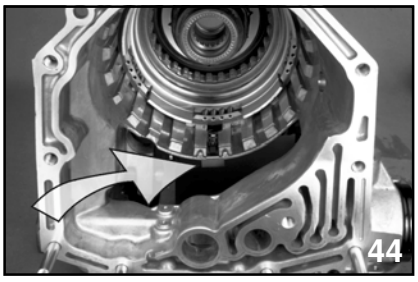

43

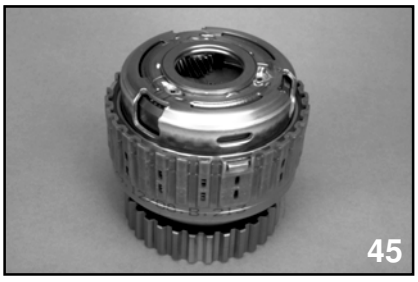
The High Clutch Drum houses the high and reverse clutch. The high clutch is applied in all 3rd and 4th gear ranges. The Reverse clutch is applied in the reverse range only. Position the high clutch with the open end facing upward. The lower positioned clutch assembly is the high clutch. The wide end 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.

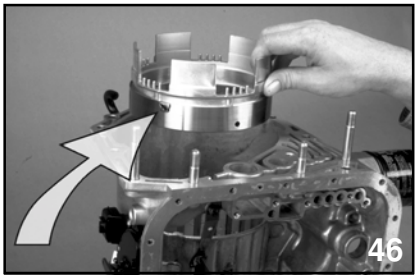
The High Clutch Drum itself is splined to the turbine shaft. When the high clutch is applied the power from the drum is transferred to the rear Sun Gear via the High Clutch Hub and turns the rear planetary carrier.

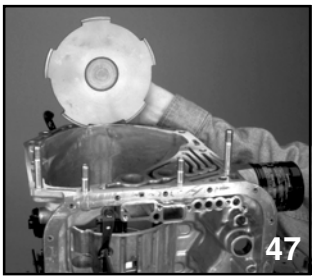
Remove the Upper Leaf Spring. This device reduces chatter and vibration. Carefully observe its location.

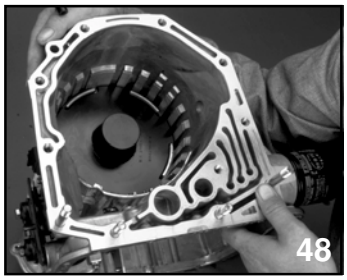

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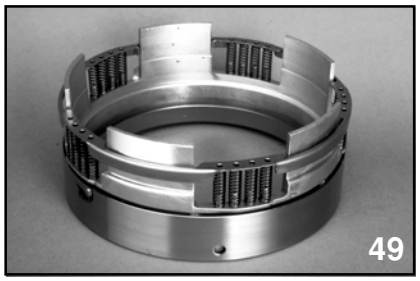
Remove the planetary assemble as a unit. Followed by the Snap Ring and Spring Retainer of the 2-4 Brake Piston. Observe the location of the 2-4 locating lug of the 2-4 Brake Piston so that it is properly positioned during reassembly.

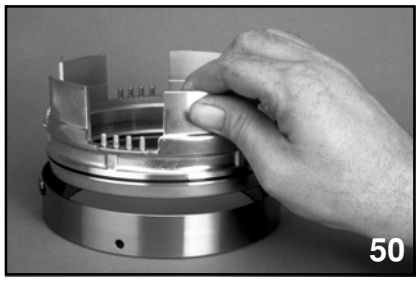

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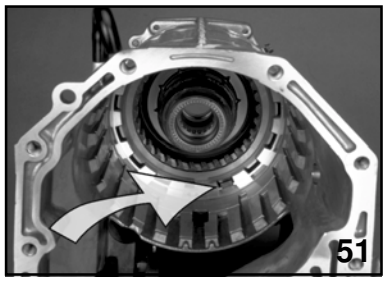

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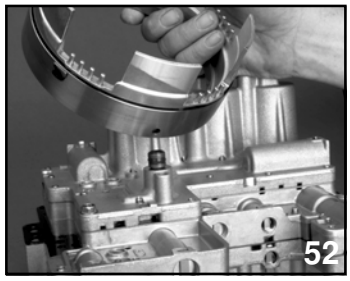
During reassembly, the installation of the Snap Ring of the 2-4 brake Spring Retainer requires the use of a special tool. Carefully position the Snap Ring over the retainer and place the special tool on top of the Snap Ring. Apply steady, firm pressure until you hear the Snap Ring fully seat. Remove 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.


49

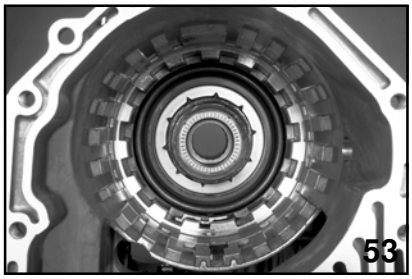

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Remove the Lower Leaf Spring followed by the Snap Ring and Low and Reverse Brake Clutch. Observe the orientation of the Dish Plate so it is properly positioned during reassemble.


52

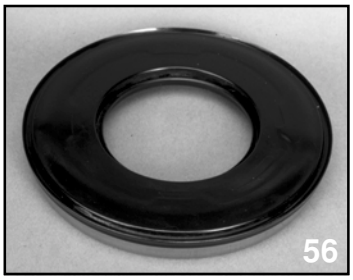
The Seal Pipe carries pressure from the valve body to the 2-4 Brake Clutch Piston Retainer.


53

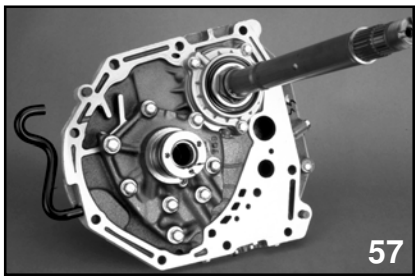

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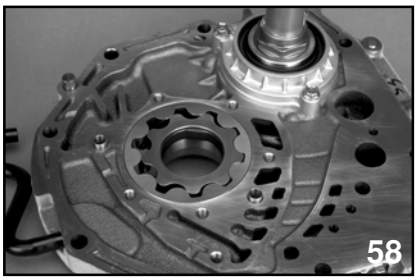
Remove the Thrust Needle Bearing from the machined surface of the one way clutch inner race. Reposition the transmission case horizontally and remove the bolts that secure the one way inner race to the transmission case. Carefully remove the inner race from the transmission.





Also remove the Spring Retainer, Wave Washer and the Low and Reverse Brake Piston.





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.

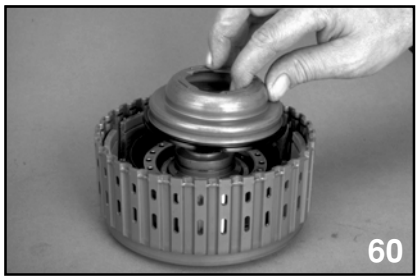
Parts number	Thickness
15008AA060	11.37-11.38
15008AA070	11.38-11.39
15008AA080	11.39-11.40

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.


59


60

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.

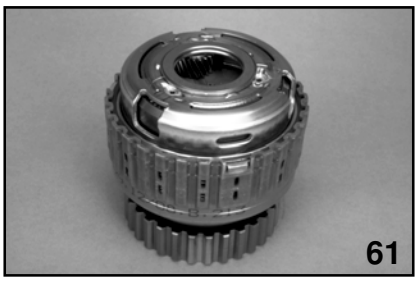
Check for proper clearance between the Snap Ring and Retaining Plate of each clutch assembly.

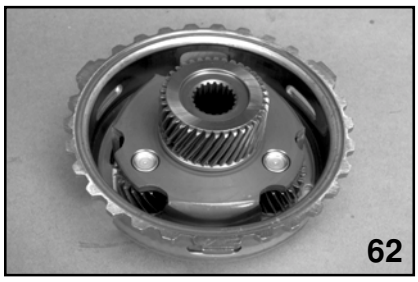
If the clearance is beyond specifications replace the Retaining Plate with one that will provide the proper clearance.

Retaining Plate		Retaining Plate	
High Clutch	Thickness	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

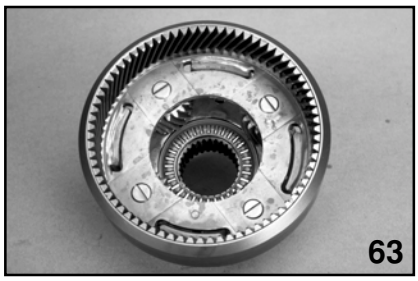
Servicing the Planetary Gear Assembly and Low Clutch

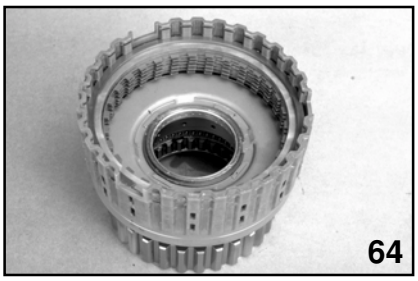
Position the planetary gear assembly with the open end upward. Remove the Snap Ring.
Caution: There are 2 Thrust Needle Bearings and Thrust Washers used in this assemble. They may stick to components when they are removed. Use extreme care when handling.
Remove the Front Planetary Carrier, Thrust Needle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


61


62

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

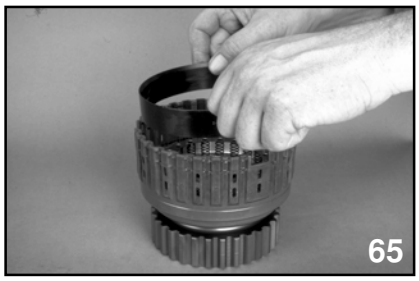

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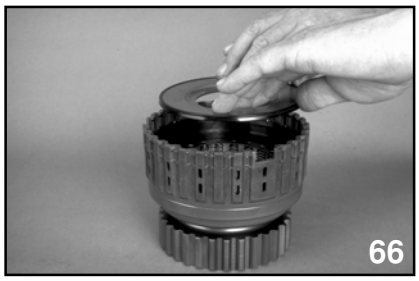

64

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.


65


66

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.

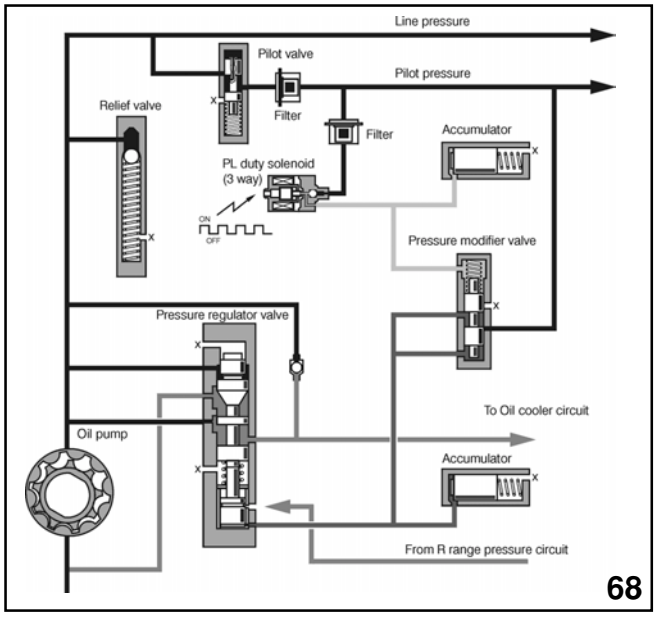
Caution: Do not place hands inside drum when air checking.

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.

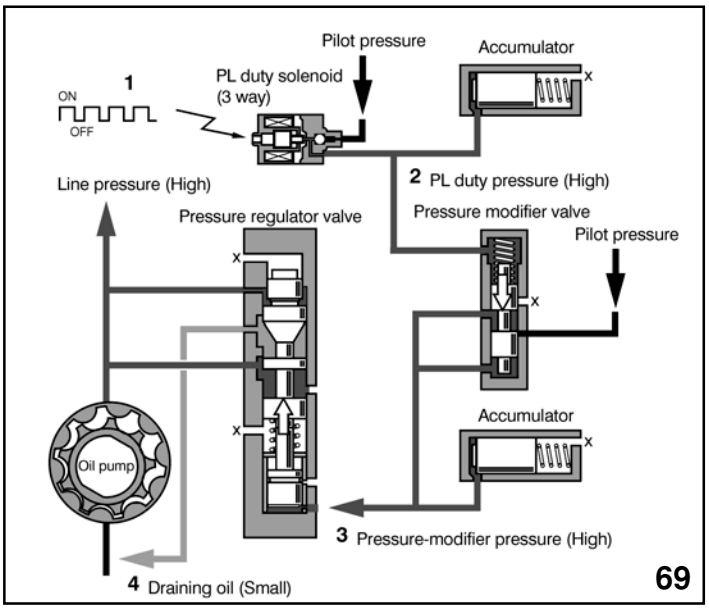
Hydraulic Control

Line Pressure

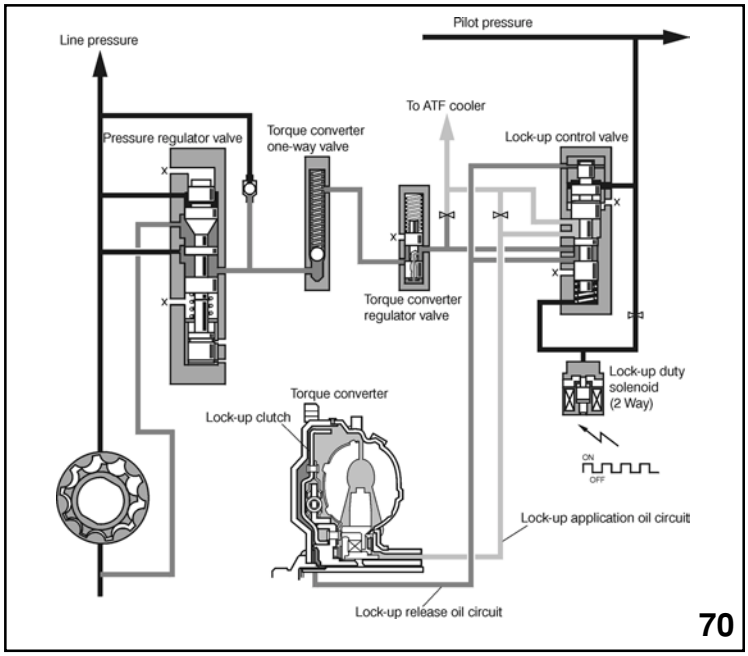


Line pressure provides the force necessary to engage driving and holding members as well as lubricate and cool the transmission. Adjusting the line pressure to various levels reduces the amount of load placed on the engine and minimizes wear on the transmission.

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.



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.



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.

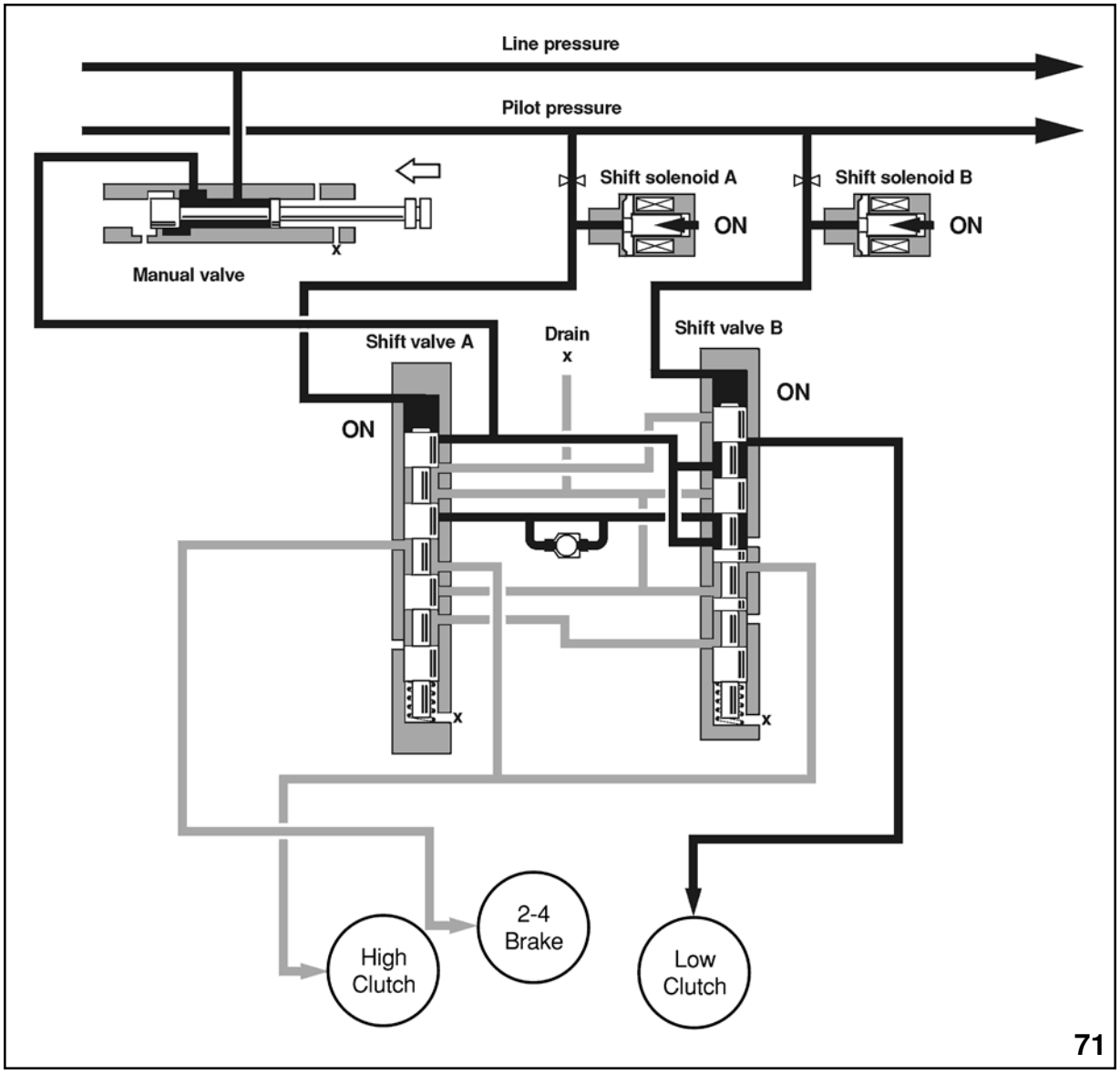
Gear Shift Control

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.

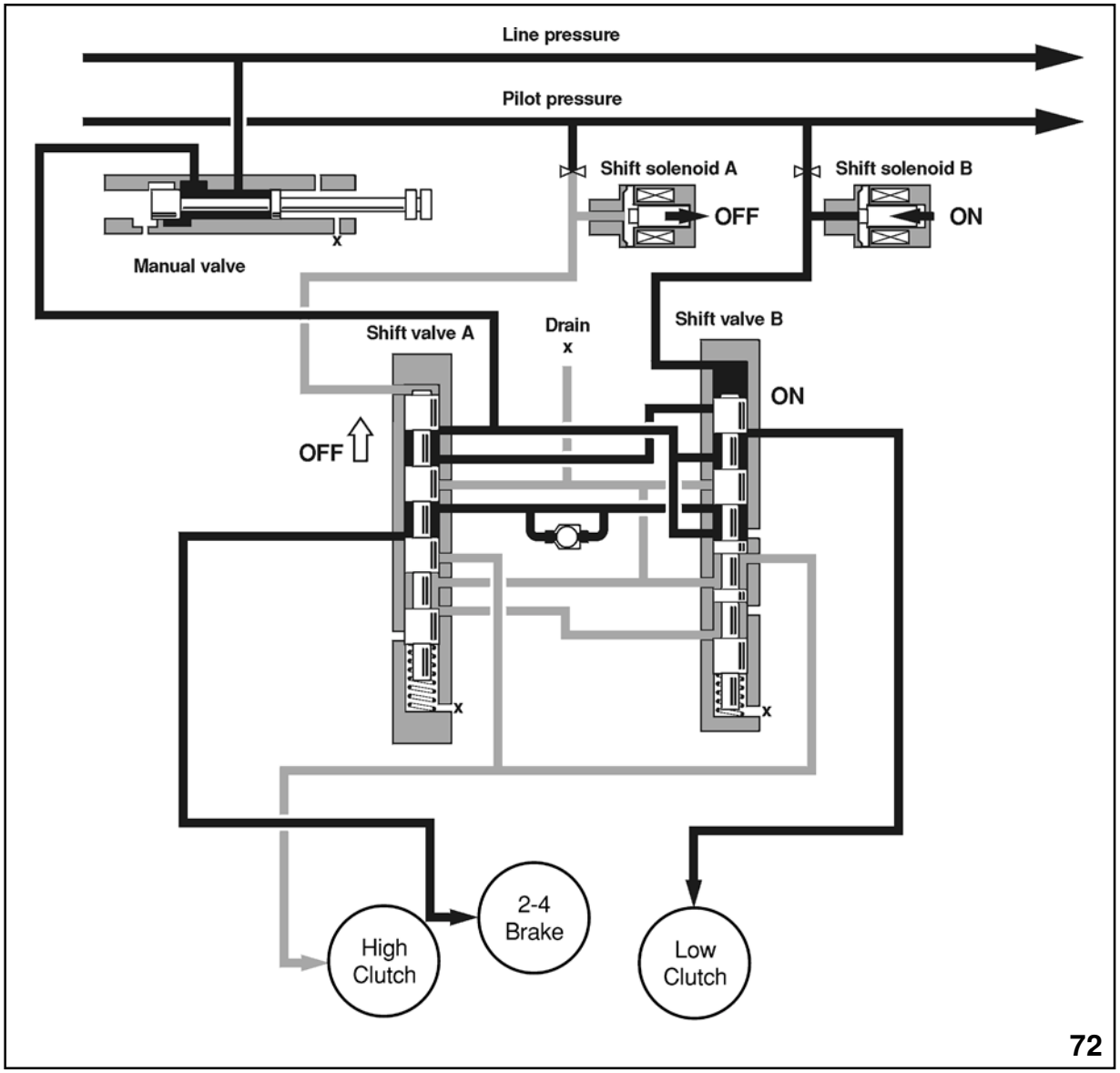
1st gear

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.



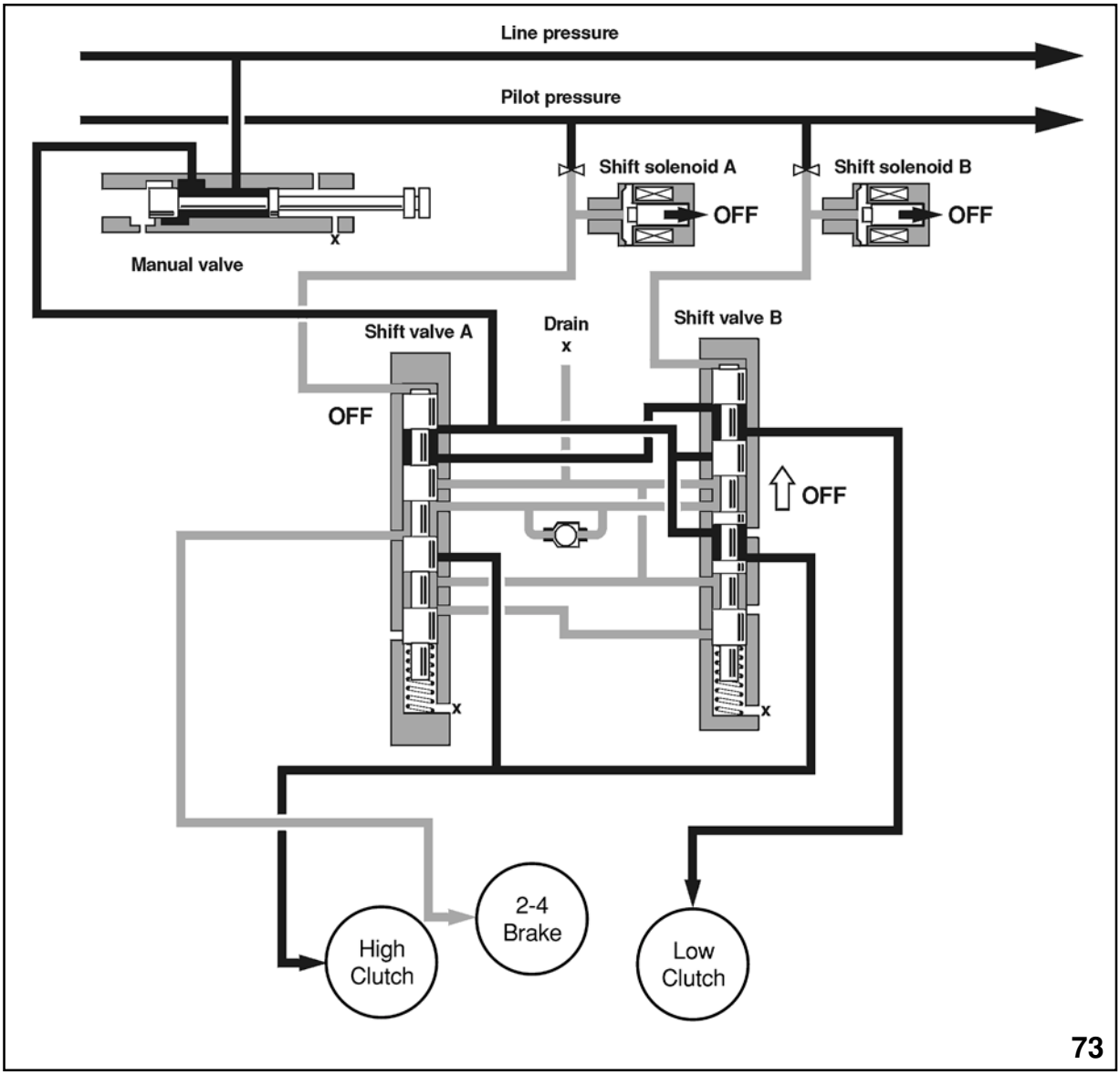
2nd Gear

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.



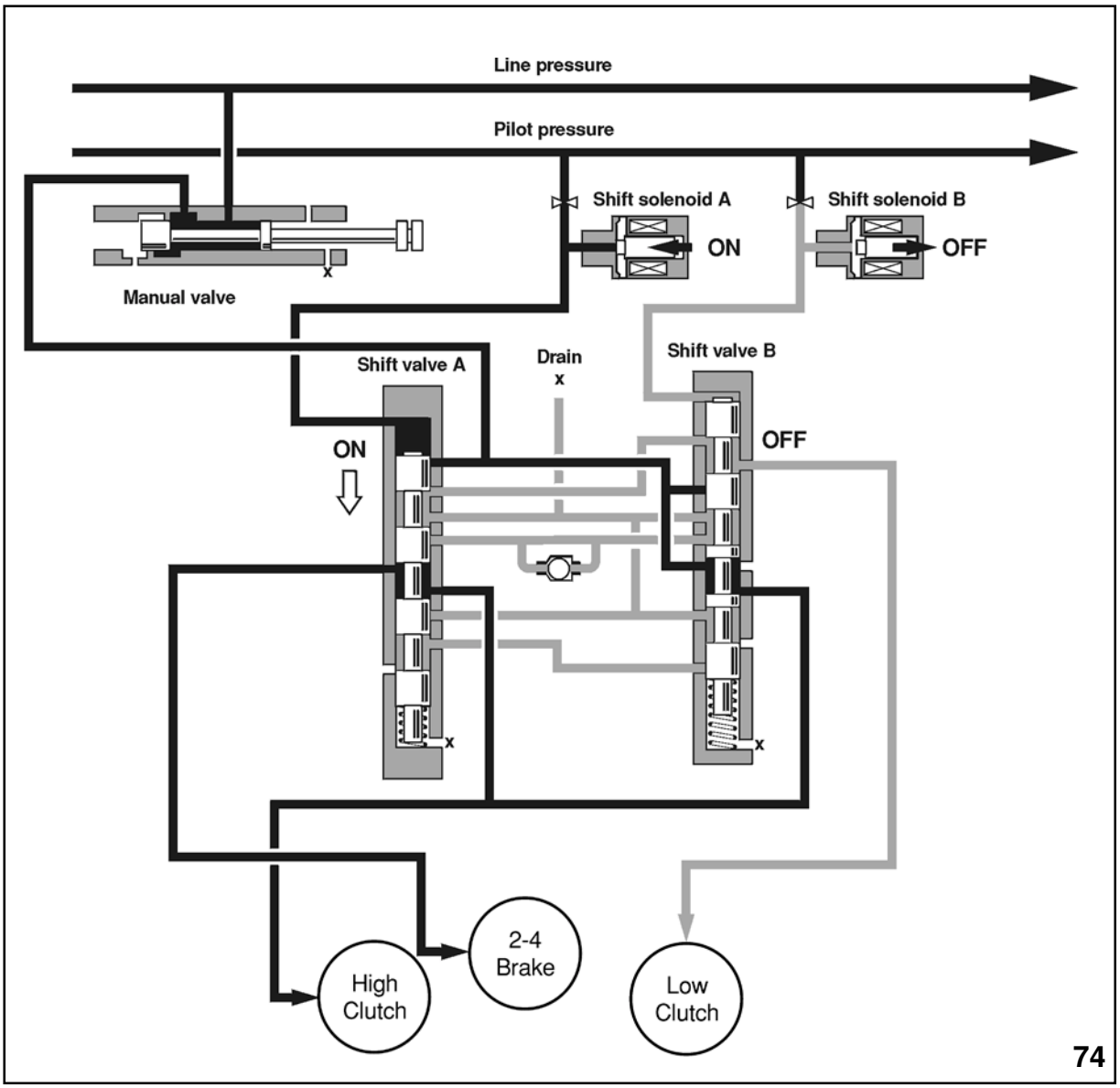
3rd Gear

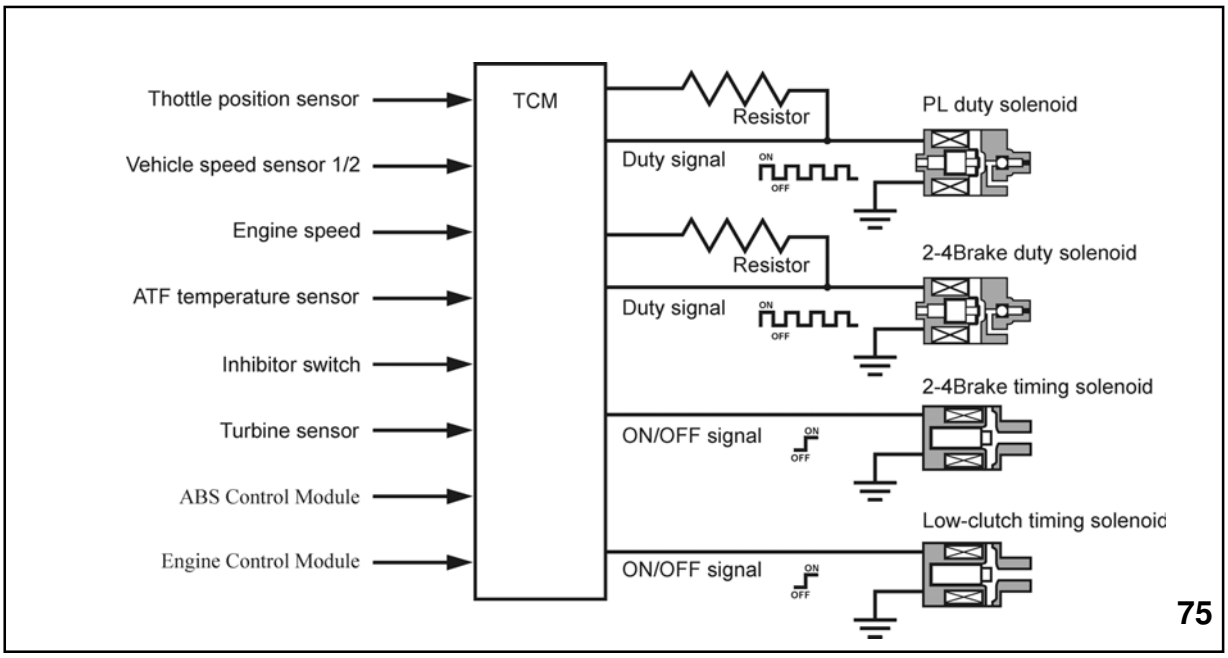
Both solenoids are turned off allowing the pilot pressure supplied to the shift valve to drain. The shift valves move upward allowing line pressure to the Low Clutch and the High Clutch.

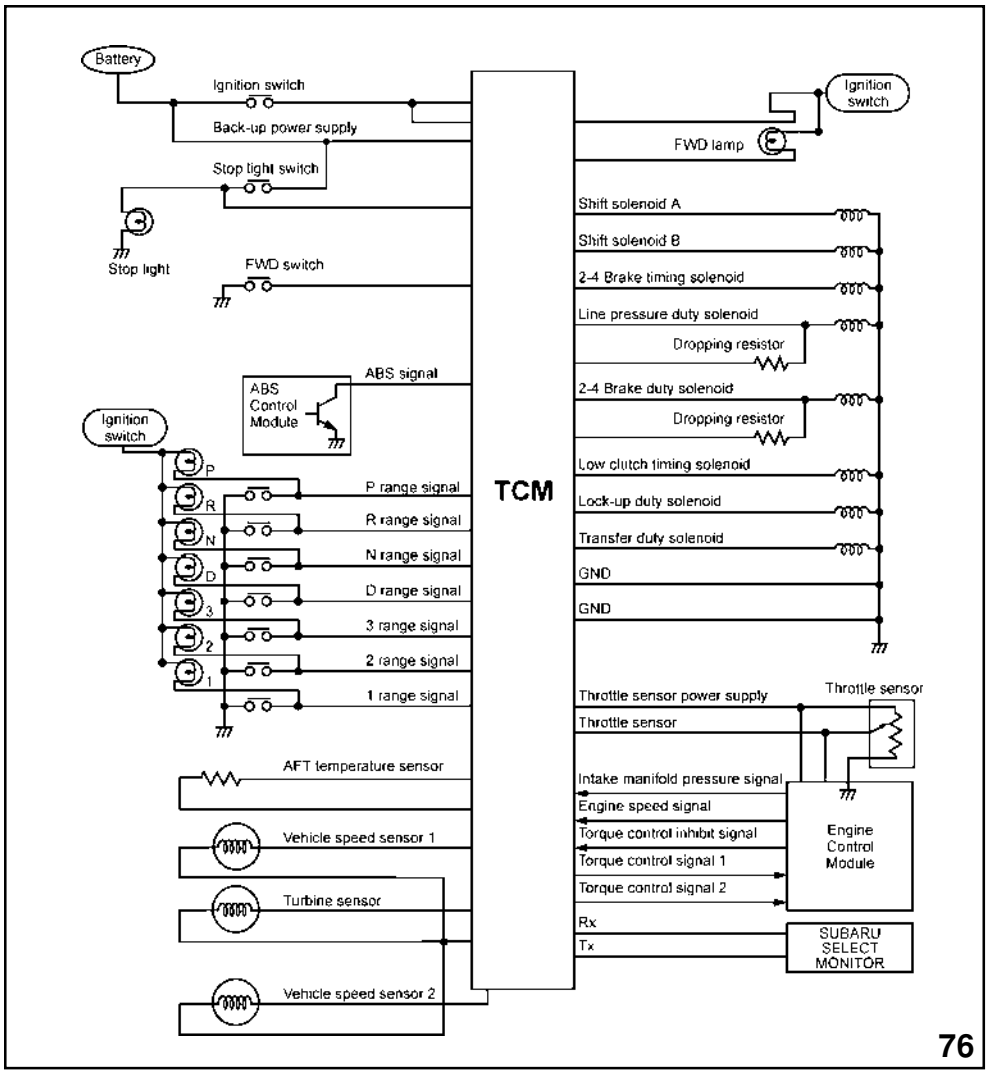


4th Gear

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
2-4Brake timing solenoid
ON/OFF signal
Low-clutch timing solenoid
ON/OFF signal
75


Battery
Ignition switch
Back-up power supply
Stop light switch
Stop light
FWD switch
ABS signal
ABS Control Module
Ignition switch
P
R
N
D
3
2
1
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
76

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

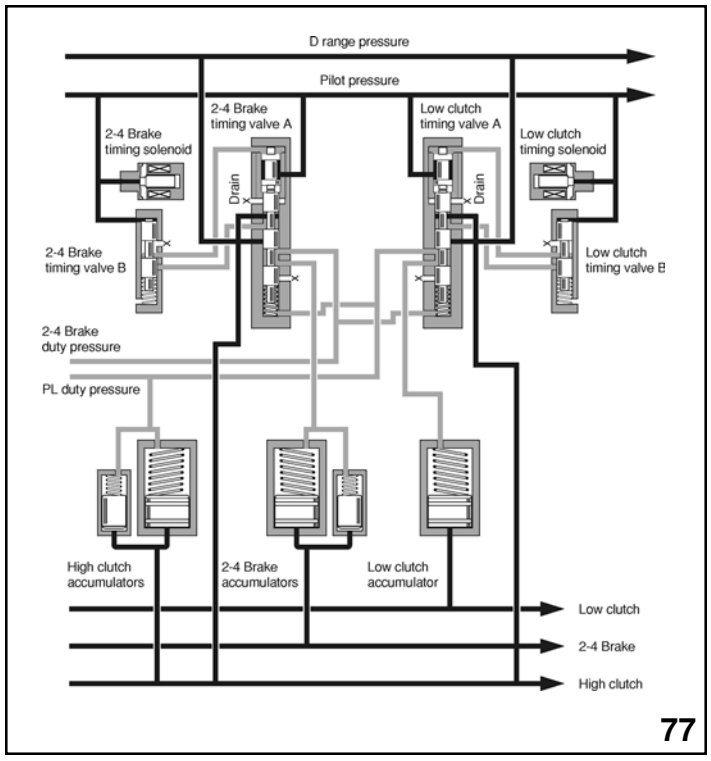
To prevent shift shock, shifting up to D range 4th gear is not performed when the ATF temperature is below approximately 12 degrees C.

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.



Timing Control

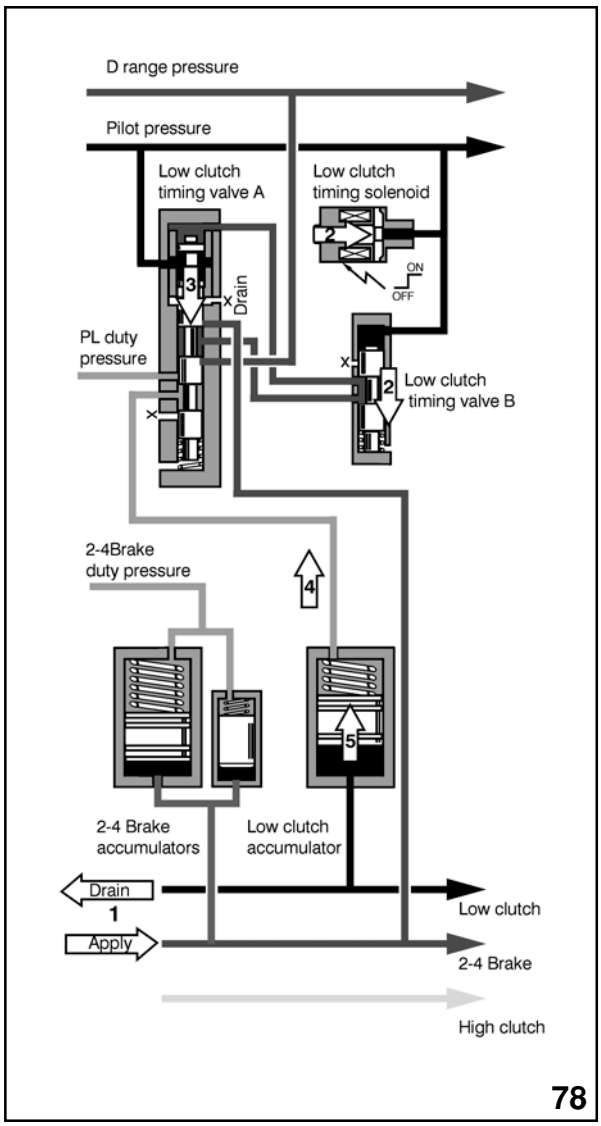
Timing control is designed to prevent shift shock and engine racing. Two types of timing control are used with the new eat. 2-4 brake timing and Low Clutch Timing.

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.



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.

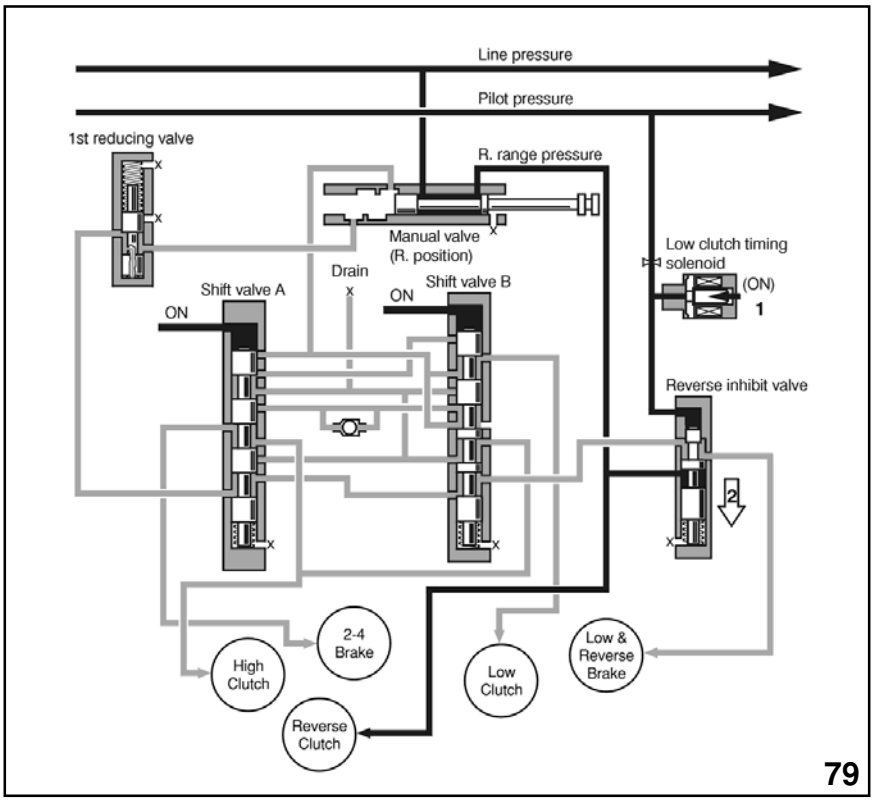
While shifting is in progress, the TCM detects the brake and clutch engagement \ release conditions by comparing the turbine sensor signal and the speed sensor signals. The TCM outputs a signal to the ECM to reduce the torque when set conditions are reached.

Learning Control

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

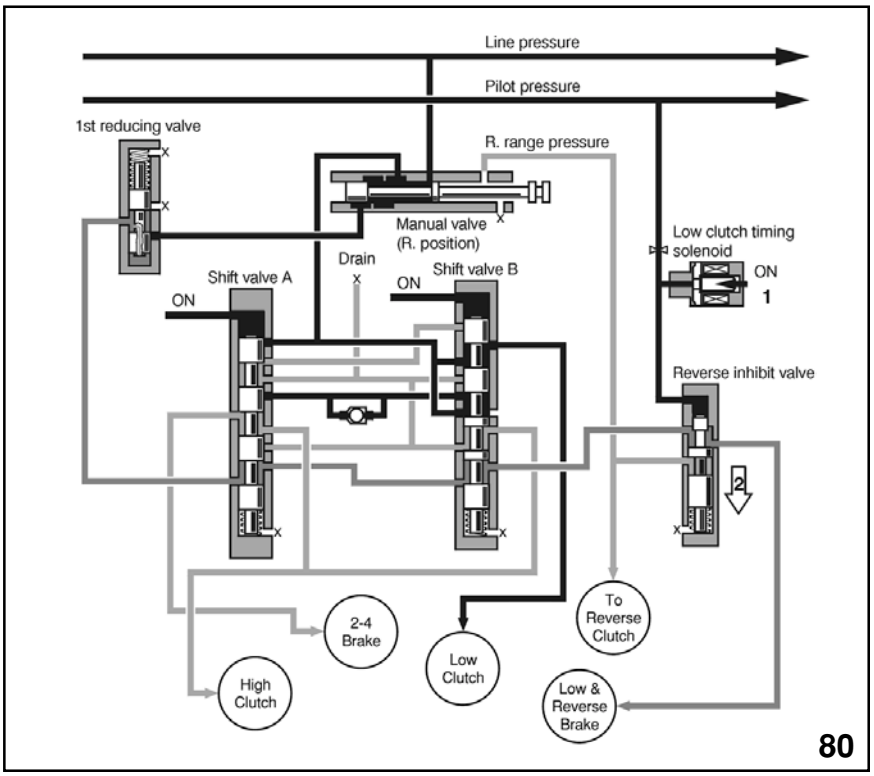
The TCM always detects the turbine sensor signal after starting shift control. It measures the time from when this signal changes until the clutch or brake starts to engage and the time from that point until the clutch or brake fully engages.

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.



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.



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

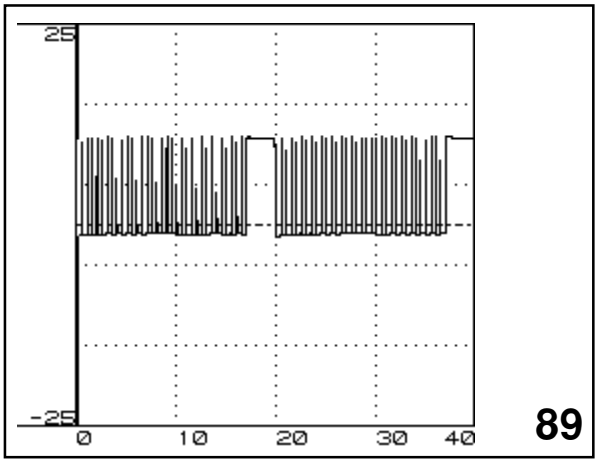
Failsafe function is a TCM controlled function that enables the vehicle to be driven in the event of malfunction of the vehicle speed sensors, throttle sensor, inhibitor switch, or the various solenoids.

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

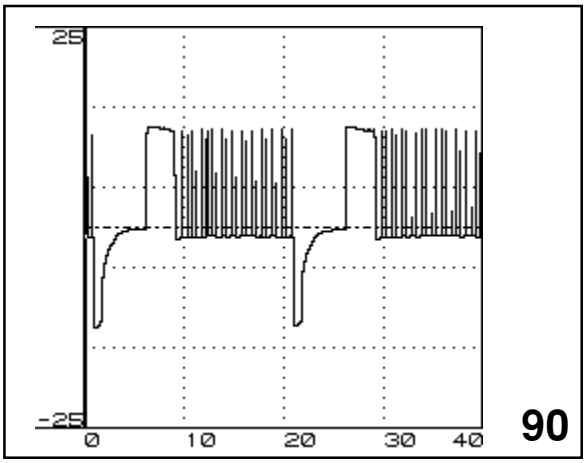
Item	Failsafe Function
Line pressure duty solenoid	TCM turns the solenoid off and sets the transmission so only 1st and 3rd are available . The line pressure is also set to maximum.
Lockup duty solenoid	TCM turns the solenoid off and torque converter lock up does not occur.
2-4 brake timing solenoid	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"



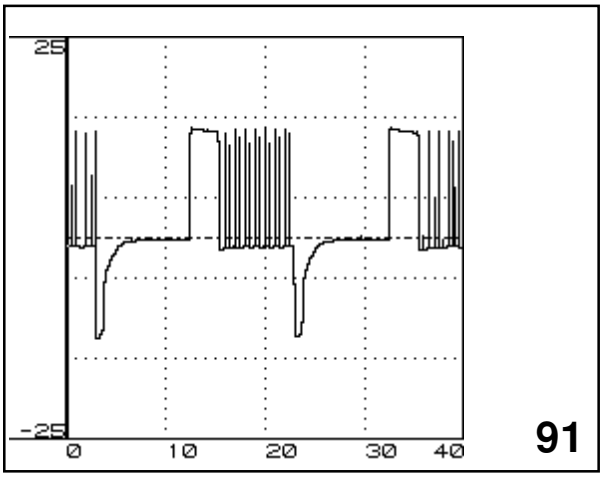
Ignition On Engine Off (line pressure)



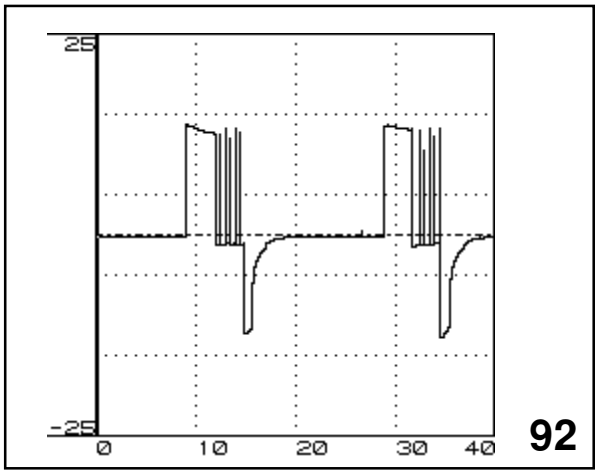
Idle (line pressure)

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.

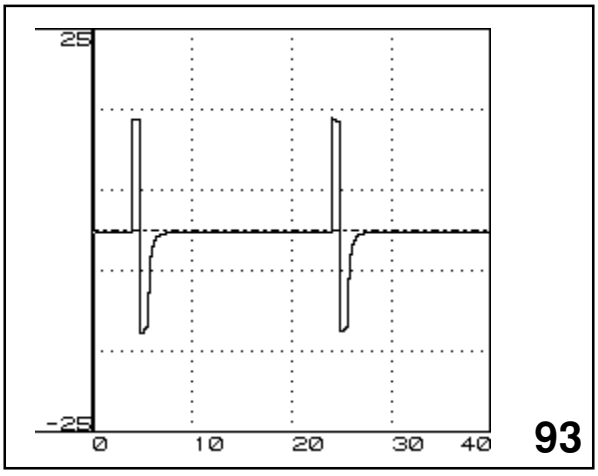
The “chopper voltage signal” is a series of voltage pulses up to 12 volts that average out to approximately 3 volts. This will function to hold the line pressure control and 2-4 brake solenoid in the open position until the signal is removed.



Part Throttle (line pressure)



Half Throttle (line pressure)



Stall Speed (line pressure)

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Technicians Reference Booklet

2003 New Model Updates

Module 912

MSA5P0250C

Technical Training

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Table of Contents

Introduction 6
2003 Forester 6
Exterior 6
Interior 11
Supplemental Restraint System 14
Brakes 16
Automatic Air Conditioning 19
Legacy 23
VCU / VIU Remove 29
SPORTSHIFT 31
Baja 33
New for Pre-Delivery Inspection 39
Slide Sequence 41

Introduction

This Technicians Reference Booklet introduces the 2003 Forester 2.5X, 2.5XS, Baja and the OnStar system. 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 Subaru 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.

2003 Forester


6

The New Forester for the 2003 model year is available in three models. The 2.5X, 2.5XS and the 2.5XS Premium Package.

The 2003 Forester is not only the consolidation of recent enhancements and refinements to the Legacy and Impreza in a new more aerodynamic body style. The Forester is also the continuing effort by Subaru to increase safety and drivability by introducing to the new Forester such items as the active head restraint, high pillow side airbags and reduced turning radius.


7

Weighing in at 3,175 lbs. (Curb 4EAT) the new Forester is equipped with either the 5-speed manual or the 4 speed electronic automatic transmission, coupled with the 165 horsepower 2.5-liter SOHC engine.

Exterior



9

The complete taillight assemble is housed on body of the vehicle rather than splitting the light as previous Forester Models.



Servicing of the taillight bulbs is achieved by opening the rear gate and removing two 6 mm bolts and removing the taillight assemble from the body. The bulbs are reached from the backside of the taillight assembly.



An additional line in the rear defogger grid located in the wiper park position provides improved wiper deicing. The rear wiper now parks on the left side of the rear window.



XS models have a larger side view mirror than the X model and are equipped with heated side view mirrors which are activated by the front windshield deicer switch. (15 minute timer)



The side view mirror and the C pillar post trim are metallic colored to improve appearance.



The driver door lock cylinder is the only key position on the exterior of the vehicle. This cylinder will lock and unlock the driver door only. (Keyless entry is standard)



The new (aluminum) hood line is lower on the new Forester. Sliding a thumb across the top of the grill until the release lever is located and slid to the passenger side of the vehicle best activates the secondary release for the hood.





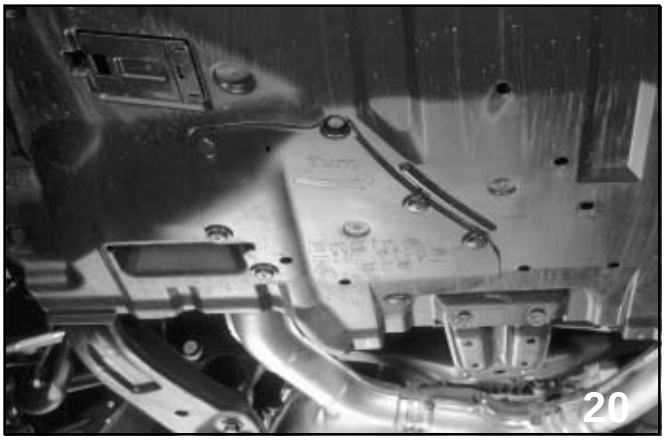
The new headlight assembly can be removed by first removing the grill and the filler panel.



The lower hood line of the vehicle requires the use of a remote located power steering reservoir.



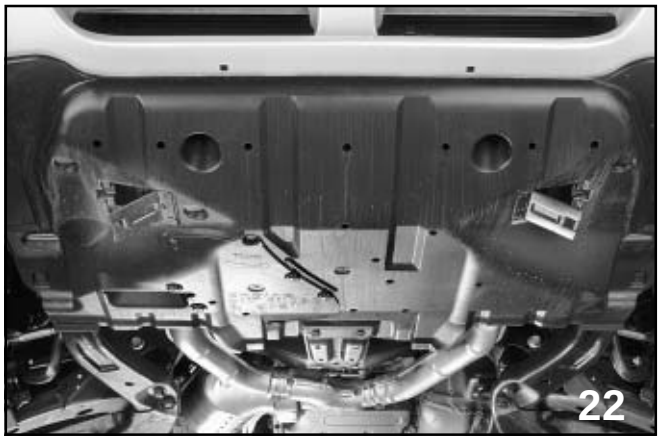
New to the Forester is the use of the module type windshield wiper system. All components are located behind the cowling.



The engine under cover is equipped with an access door to reach the oil filter and the oil drain plug.



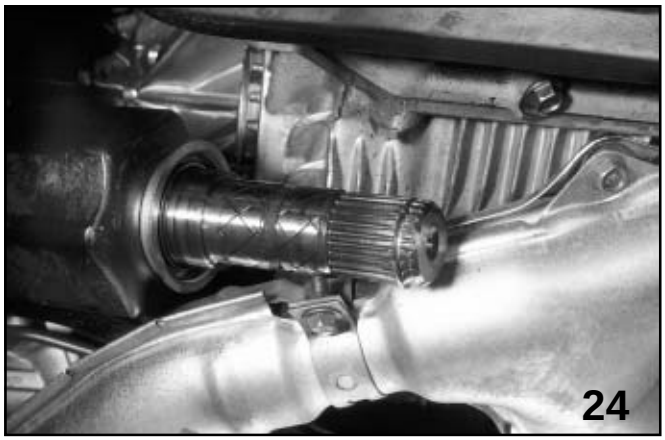
The door is opened by remove the 6 trim plugs and turning the door to the passenger side of the vehicle.



Two visual inspection doors are located near the front of the engine under cover .



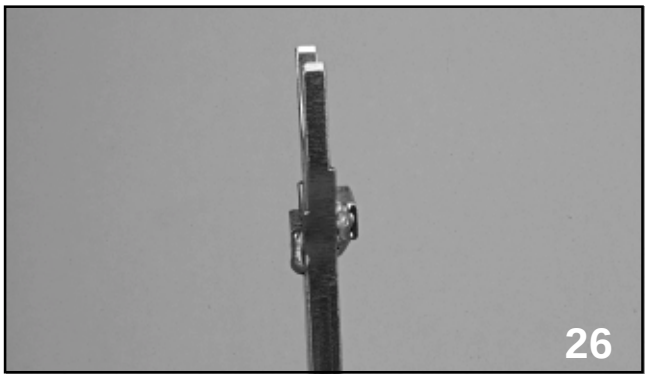
Forester is now equipped with same type of subframe introduced with the Impreza WRX.



The stub axles of the front differential have been deleted and replaced with stub axles made onto the end of the drive axle inner joint. The end of the axle has a small circlip that locks the stub axle to the side gear of the differential.



The axle is removed from the differential by using ST28399SA000 and applying pressure between the axle joint and the differential.



The tool is directional. The higher side is placed next to the differential when servicing manual transmission vehicles while the shorter side is placed next to the differential when servicing automatic transmission vehicles.



A new oil seal installer for the differential is available.





An axle oil seal protector is used to prevent damage to the seal when installing the axle.

Interior





Compartment storage configuration has changed to provide more convenience.



Child seat anchors now have easy open covers to conceal the anchor when not in use.



The moonroof on the 2.5XS and 2.5XS premium package model operates slightly different than previous Subaru moonroofs. When activated to open the moonroof will continue to open with no continued contact with the open button to the ¾ open position.



Pushing the button again and releasing the button will carry the moonroof to the fully open position.



When activated to close the moonroof will continue to close with no continued contact with the close button to the ¾ closed position. Pushing the button again and releasing it will carry the moonroof to the fully closed position.



An increase in the amount of current closing the moonroof will activate an obstruction safety feature that will interrupt the auto close feature and reverse the moonroof to open about 6 inches beyond the obstruction. Removing the obstruction and pushing the close switch again should restore the auto close of the moonroof. If the safety feature continues to operate the auto close feature will turn off. It will only be restored after the safety feature circuit has cooled down. A vehicle speed sensor input is supplied to the moonroof control unit it will increase the sensitivity of the obstruction detection.



New cup holders for the driver and passenger.



Gate type shifter is now equipped on the Forester.



All Forester models are equipped with a front seat ash tray and lighter receptacle. No lighter is delivered with the vehicle. Use only lighter 86719SA000 as other lighters may be too long and make contact with the ashtray door when it is closed, engaging the lighter.



Overhead storage is more convenient by the use of an additional compartment.



The Subaru logo now appears on the steering wheel.



The new clock position makes it necessary to open the center dash storage door to adjust the time.



The window controls in the front and rear seats are illuminated when ever the ignition is in.



Combination meter configuration including the gear shift indicator. The fuel gauge also has a low fuel warning light illuminating when the fuel level is 2.4 gallons (9 liters) or less.

Temp and odometer stays illuminated 5 seconds after the key is turned off.

Supplemental Restraint System



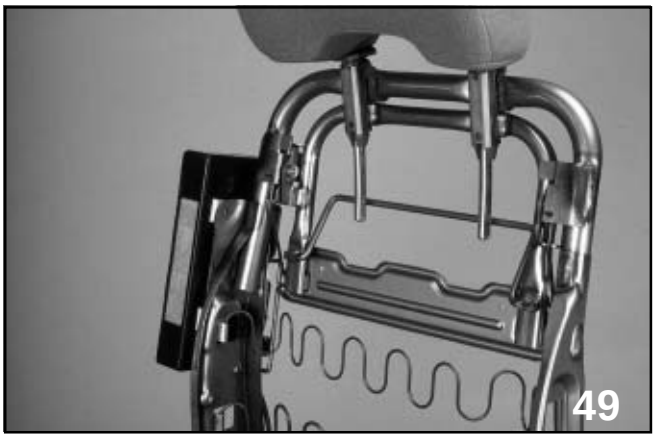
All Forester models are equipped with front side airbags. The seat covers are tagged as a reminder for technicians.



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.

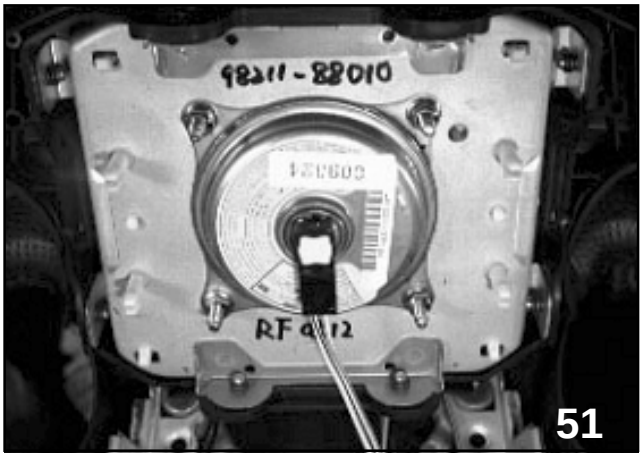
SRS wires routed through the seat are not covered with the yellow plastic cover.



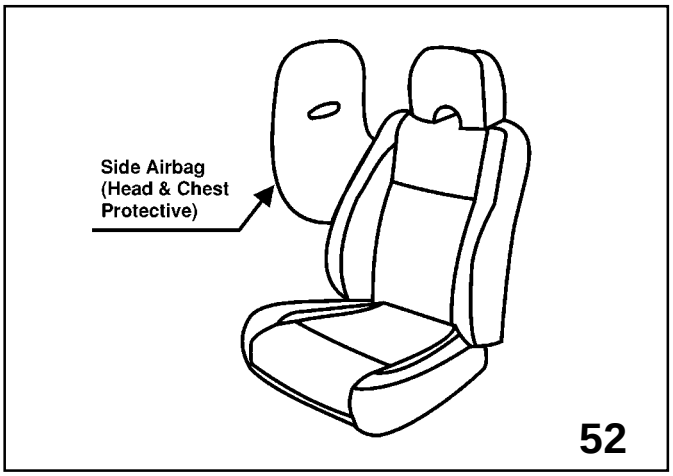
Normal position.



Position during rear impact.



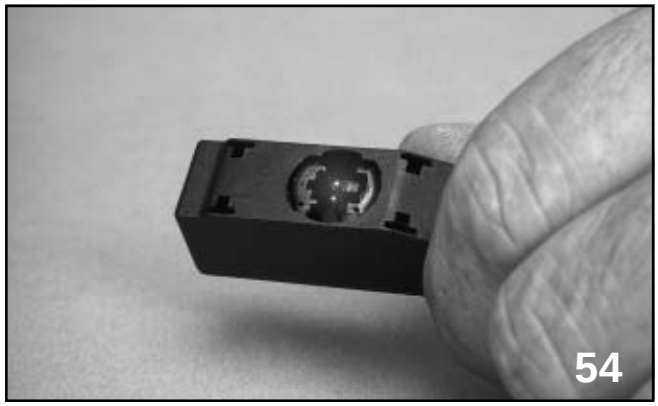
Drivers airbag module.

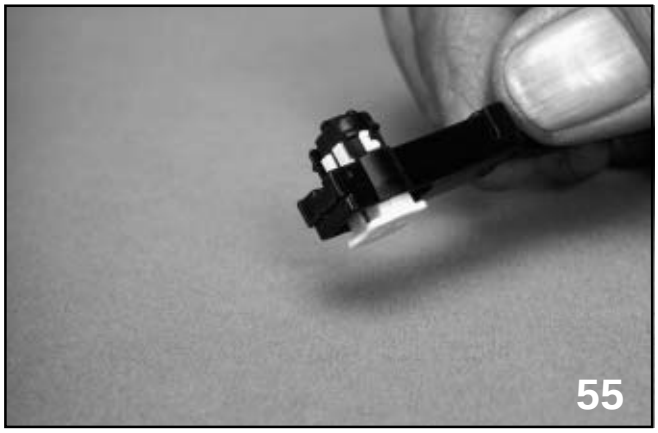


All 2003 Forester models will be equipped with driver and passenger front SRS Airbags, seat belt pretensioners and driver and passenger side airbags. The side airbags when deployed are larger and provide protection for the chest and head.



The location of the front Satellite discrimination sensors have been relocated due to the new vehicle design.





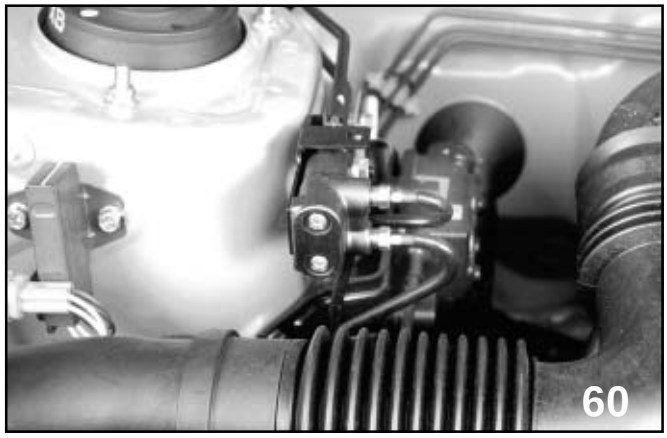




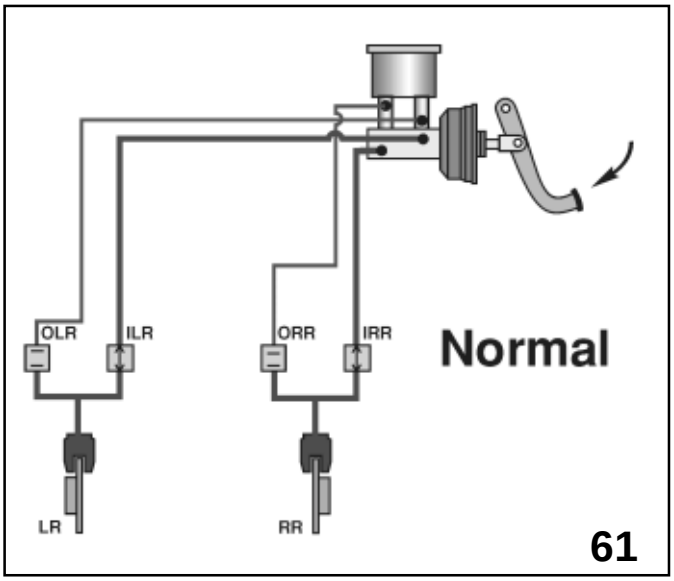
The connector and connector lock on all deployment devices has changed. The new style requires the release of the yellow tab by pulling up on the tab and then separating the connector from the deployment device.

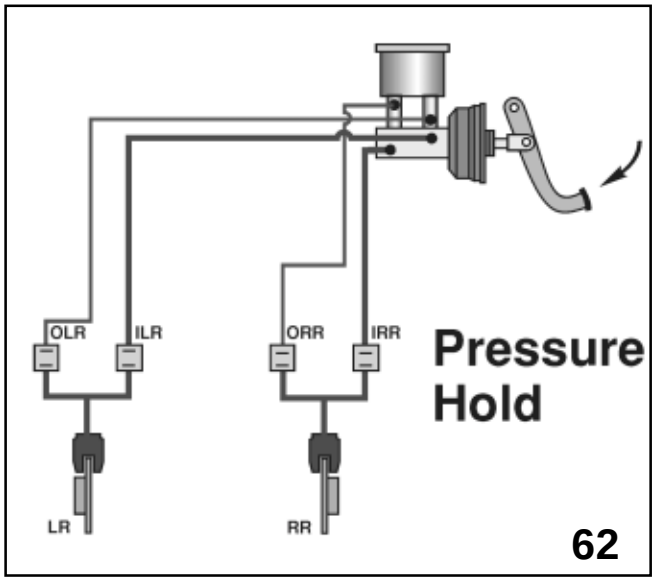
Brakes



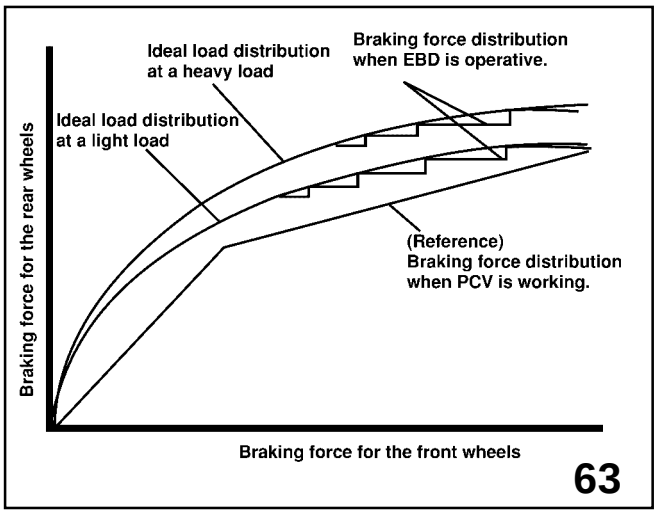


Forester 2.5XS and 2.5XS Premium Package models are equipped with Electronic Brake Distribution (EBD). This new system controls the brake fluid pressure to the rear wheels by taking advantage of existing ABS 5.3I components. This process eliminates the mechanical proportioning valve.





The hydraulic control unit will activate the inlet solenoid valves to achieve pressure hold controlling the pressure to the rear wheels.



The control unit built inside the HCU monitors the wheel speed of the front and rear wheels to decide how much braking force is generated from the rear wheels. The wheel speed difference between the front and rear on a vehicle with a light cargo load generates a higher wheel speed difference and results in lower braking force from the rear wheels. Heavier cargo loads in the rear generate lower speed differences between the front and rear and can receive higher brake fluid pressure.

Hill Holder

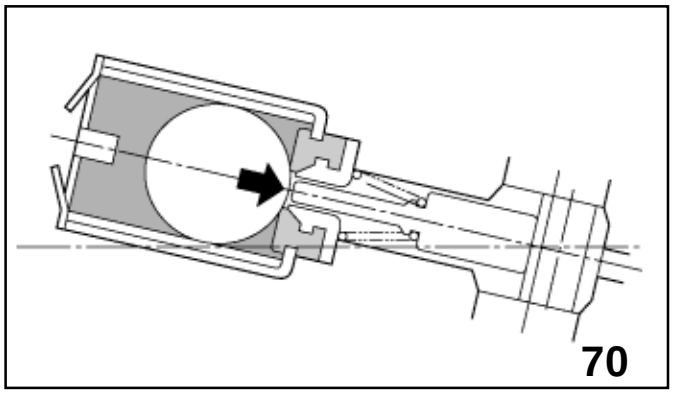
The 2003 Forester 5 speed manual transmission model is equipped with a hill holder. The hill holder activates with the clutch and brake pedal pushed when the vehicle is at about a 3 degree incline. Releasing the brake and holding the clutch will trap the brake pressure in the left front and right rear.



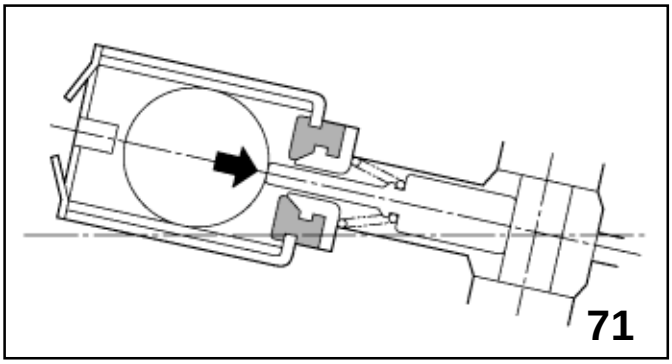


Operation of the pressure control valve (PHV) is accomplished by means of a cable connected to the clutch pedal and routed through the bulk head to the PHV. The end of the cable at the PHV is adjustable.

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.



Clutch Pedal in



Clutch Pedal Out

Automatic Air Conditioning

The Forester 2.5 XS and 2.5 XS premium package models will be equipped with Automatic air conditioning. The 3 control dials of the system communicate their set position to the driver by illuminated LEDs.



Control Dial 1

Driver sets the desired temperature from 65 to 85 degrees Fahrenheit.

Auto button sets the system to automatic. Air flow direction, temperature and speed will be automatically controlled.

Off button turns the system off.

Holding the off button will change the brightness of the LEDs.

Control Dial 2

Driver can set the fan to the desired speed

Indicates the fan speed

Indicates the position of the fresh air door

Driver can set the position of the fresh air door

Driver can activate the Air Compressor for manual A/C control

Indicates the operation of the Air Compressor

Control Dial 3

Indicates the position of the mode door (Air flow direction)

Driver can set the position of the mode door

Driver can activate the front defogger mode

Indicates the operation of the front defogger mode

Driver can activate the rear defogger

Indicates the operation of rear defogger



Self Diagnostic Procedure

Push and hold the "DEF" and the "A/C" switch while starting the engine.

All of the LEDs will turn on and off in following sequence of 5 steps.

Step	Fan	Mode	Def	Rear Def	A/C	Recirc	Auto
1	1	Vent	On				
2	2	Bilevel		On			
3	3	Heat			On		
4	4	Def/Heat				On	
5	4	Def/Heat					On

This process will cycle twice. At the end of the second cycle all LEDs should be off. **Except the A/C LED.** LEDs remaining on indicate a problem and the condition of that problem.

The chart below describes how to interpret the LED and corresponding problem,

Step	Sensor	LED
1	In-vehicle	Vent
2	Ambient	Bi-Level
3	Evaporator	Heat
4	Sun load	Def/Heat
5	Air mix door PBR	Fan Speed 1
6	Combination Meter Communication	Fan Speed 2

If the **"DEF" led** is **off** during any of the 6 steps for sensor checks an **open circuit** can be assumed.

If the **"DEF" led** is **on** during any of the 6 steps for sensor checks a **shorted circuit** can be assumed.

If the **Rear window defogger LED** is **off** during any of the 6 steps for sensor checks the problem is a **current failure**.

If the **Rear window defogger LED** is **on** during any of the 6 steps for sensor checks the problem is a **previous failure**.

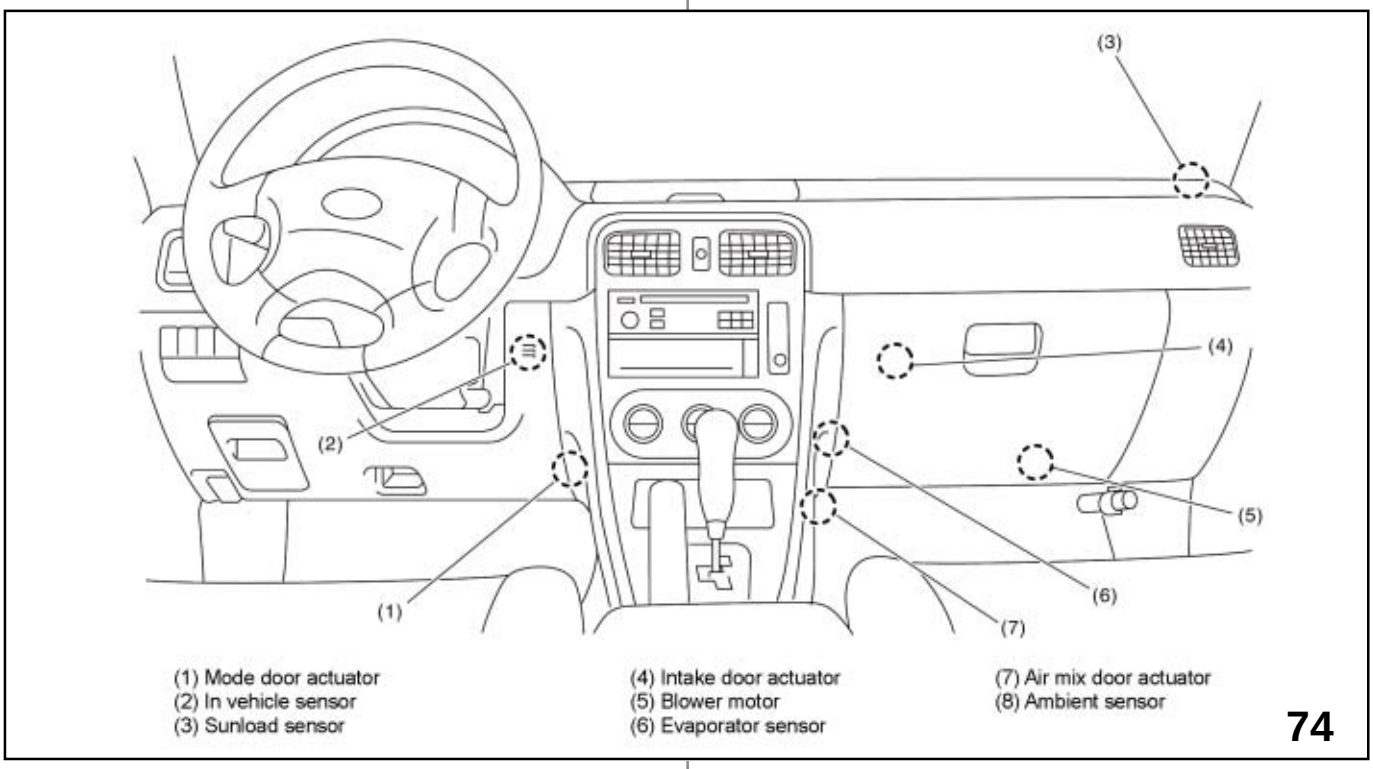
At the end of the sensor check a compulsory check mode can be activated by pushing the “RECIRC” switch. The system will automatically perform the following functions. Check the air flow direction, temperature and speed to determine if any problems are present.

Read the chart from left to right. All of the functions of a step are described on the same line.

Step	LED	Fan Speed	Mode	Intake Door	Air Mix	Compressor
1	Vent	Lo	Vent	Fresh	Full Cool	Off
2	BI/Level	Lo	Vent	Recirc	Full Cool	On
3	Heat	ML	Vent	Recirc	Full Cool	On
4	Def/Heat	ML	Bi/Level	Fresh	50% Hot	On
5	Fan Speed 1	ML	Heat	Fresh	100% Hot	On
6	Fan Speed 2	MH	Heat	Fresh	100% Hot	On
7	Fan Speed 3	MH	Def/Heat	Fresh	100% Hot	On
8	Fan Speed 4	High	Def	Fresh	100% Hot	On

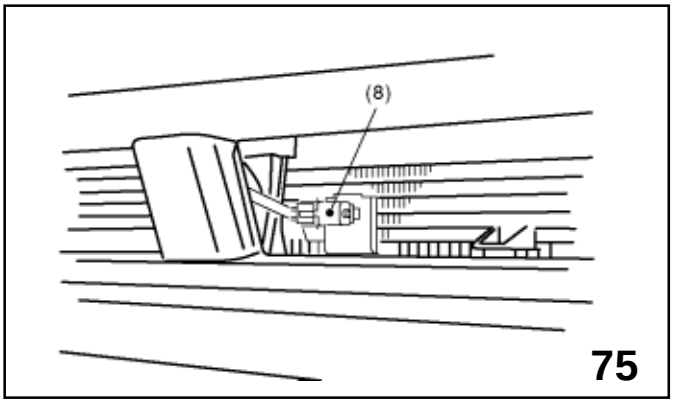
Pressing the auto button after entering compulsory check mode will allow the manual advancement through the 8 steps. Press the auto button when advancing to the next step is desired.

Exiting diagnostic mode is accomplished by cycling the ignition key.



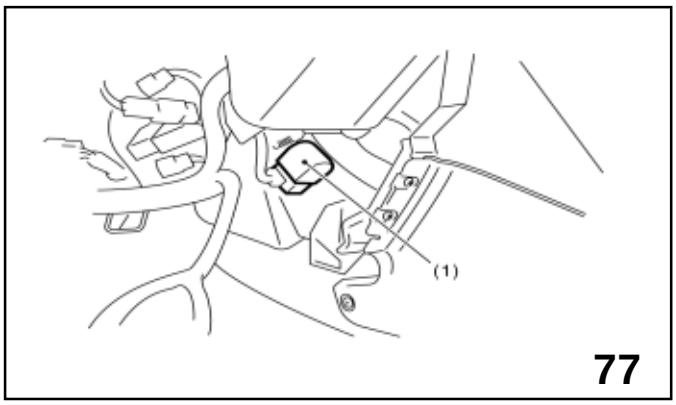
(1) Mode door actuator
(2) In vehicle sensor
(3) Sunload sensor
(4) Intake door actuator
(5) Blower motor
(6) Evaporator sensor
(7) Air mix door actuator
(8) Ambient sensor

74



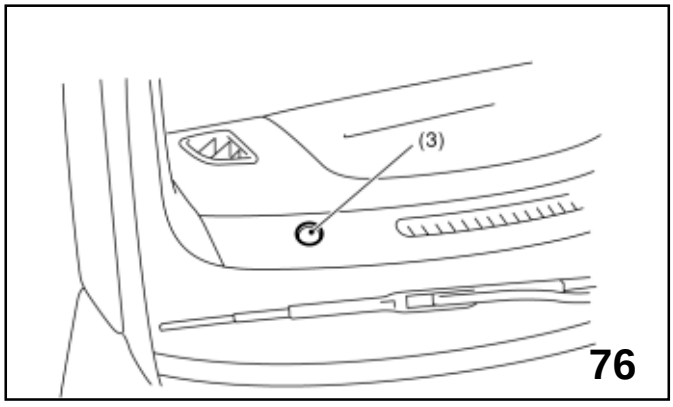
75

(8) Ambient sensor



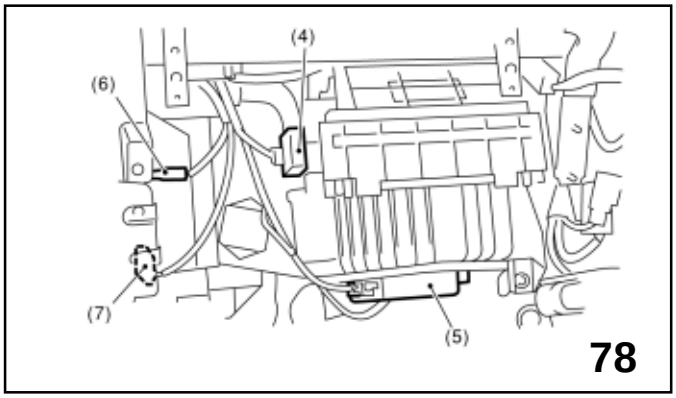
77

(1) Mode Door Actuator



76

(3) Sunload sensor



78

(4) Intake door actuator, (5) Blower motor,
(6) Evaporator sensor, (7) Air mix door actuator

Legacy

OnStar

OnStar, a system that provides communications and other services, will be equipped on all 6-cylinder Legacy vehicles.

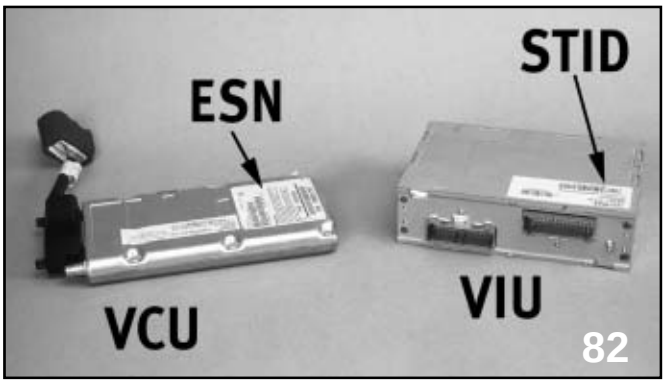


These vehicles will receive a one-year membership to the services provided by OnStar, which begin on the sale date of the vehicle.

The vehicles systems and the OnStar system are networked to provide cellular phone service, automatic emergency cellular phone call to OnStar, concierge service, and vehicle assistance.

The cellular phone strength of the OnStar system is approximately 3 watts compared to the approximately 1 watt of hand held cell phones.

Components of the OnStar system



Vehicle Cell Unit (VCU), Vehicle Interface Unit (VIU)



3-button control module



Microphone

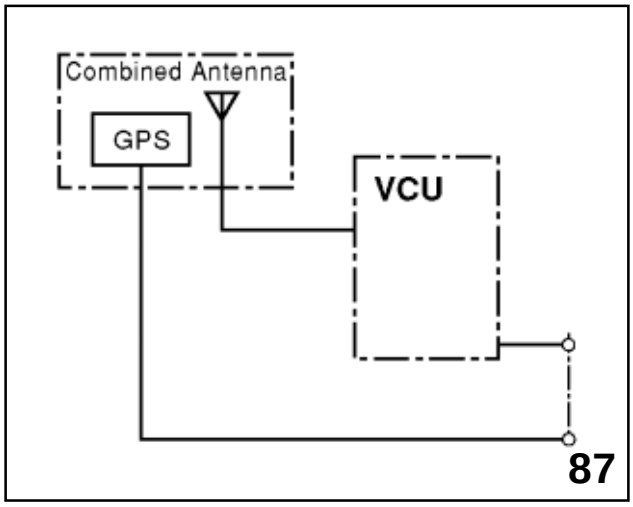


Cellular antenna and Global Positioning System (GPS) antenna.

The VCU and VIU are installed above and below the radio. These parts as well as the remaining OnStar components are installed at SIA. Upon installation the codes for VCU and VIU are recorded and reported to OnStar. This process makes interchanging parts from vehicle to vehicle impossible. Parts replacement of the VCU and or VIU requires a phone call to OnStar to report the new code numbers.

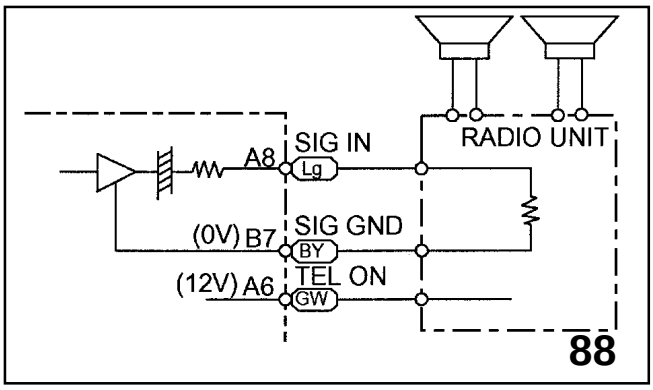


The 3 Button Module provides the input from the driver to make a cellular call, receive a cellular call and end a cellular call. The 3 Button Module is also equipped with a 2 color led that indicates trouble with the OnStar system. Green illumination indicates a present problem while red illumination indicates a past problem during diagnostic mode. During normal operation the green LED indicates no problem and OnStar is ready for operation.

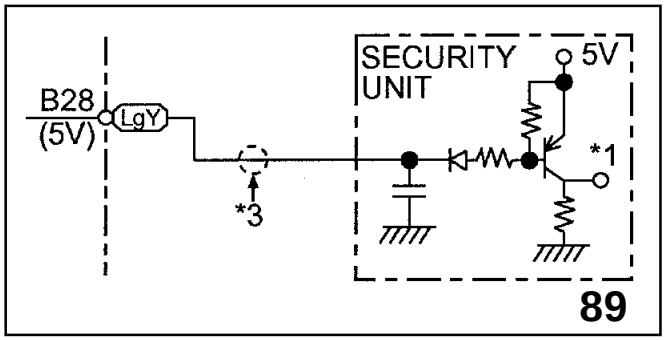


The VCU is the cell phone unit of the vehicle. It is connected to the combined cellular / GPS antenna and the VIU.

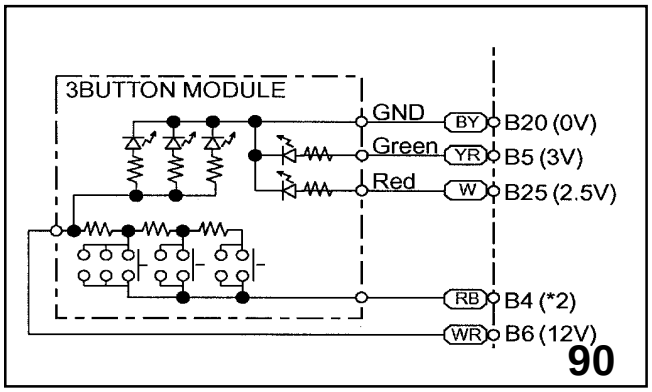
The VIU receives input signals and provides out put signals to perform cellular phone service and vehicle assistance.



The Radio receives output signals from the VIU. The VIU will turn the Radio on, if it is off, bypass the normal sound system for speaker use and turn the Radio off, if it was off before the output signal from the VIU was generated. Three wires are used to control and communicate with the Radio, two wires for the voice output and one wire for the bypass control.



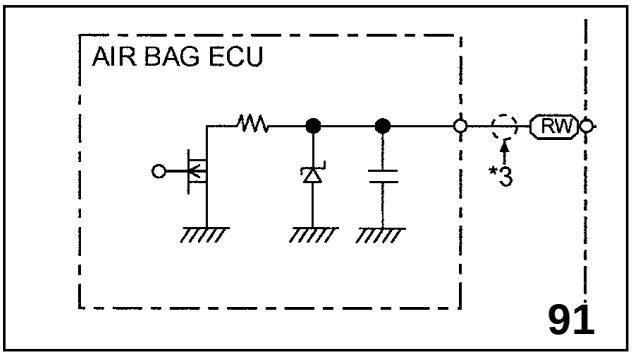
The Security control module receives 2 input signals from the VIU, arm and disarm. Both signals are sent to the security control module on the same wire. The difference between the two signals is amount of time the wire stays grounded. The arm signal provides 20 milliseconds of ground time while the disarm signal provides 80 milliseconds of ground time.



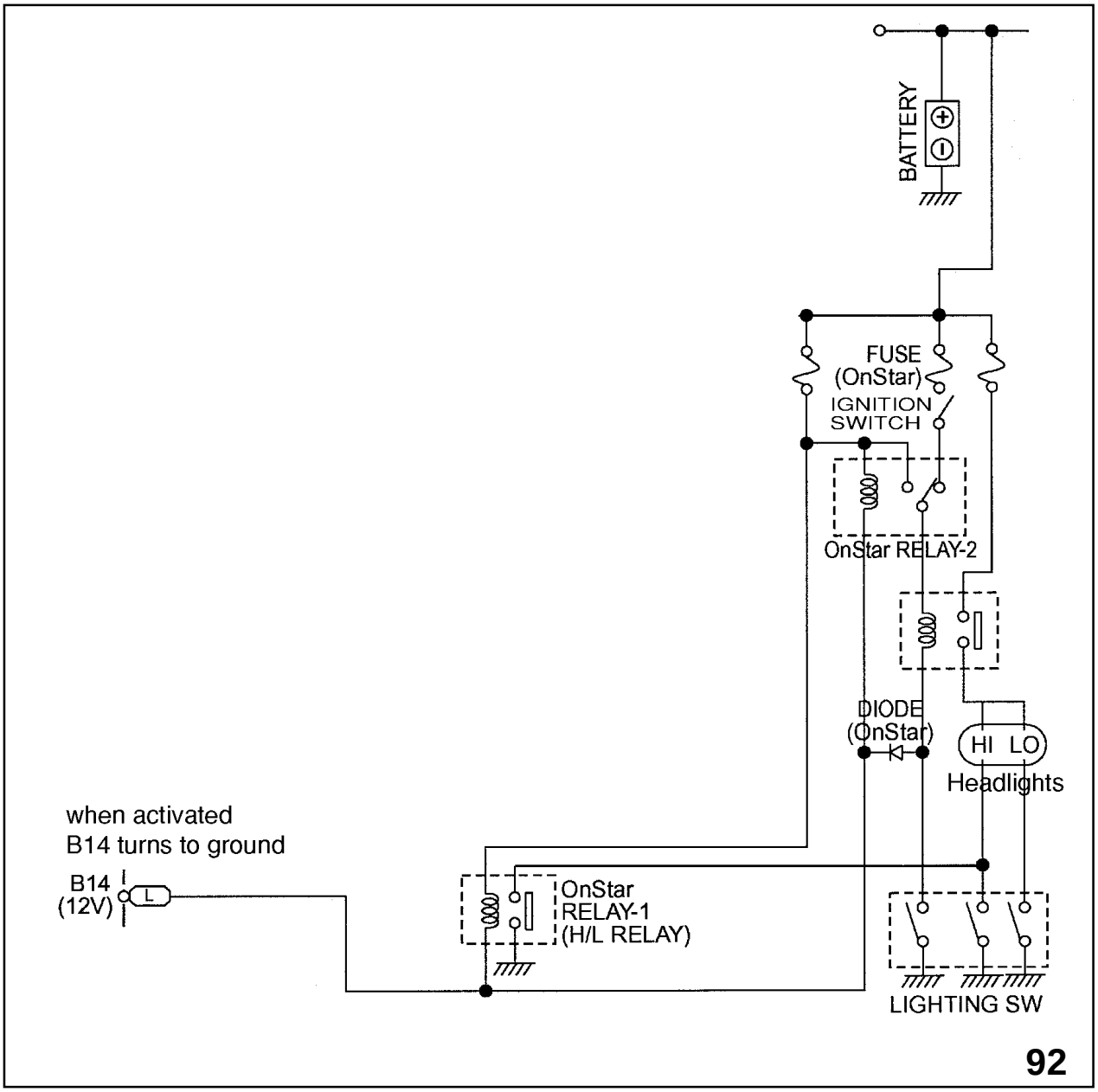
A single wire carries the commands from the 3 buttons to the VIU. The 2 color led is controlled by a different set of wires.

Each button of the 3 Button Module, when pushed, supplies a different resistance value to the wire supplying the input to the VIU. The VIU will perform the commands that match that resistance value. Two wires and a ground control the red/green led. The green illumination control uses 3 volts and the red illumination control uses 2.5 volts.

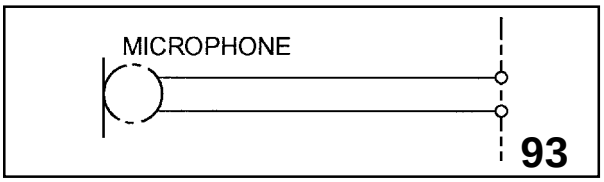
Also contained in the 3 Button Module are the LEDs for each button, which are on when the system is ready to operate.



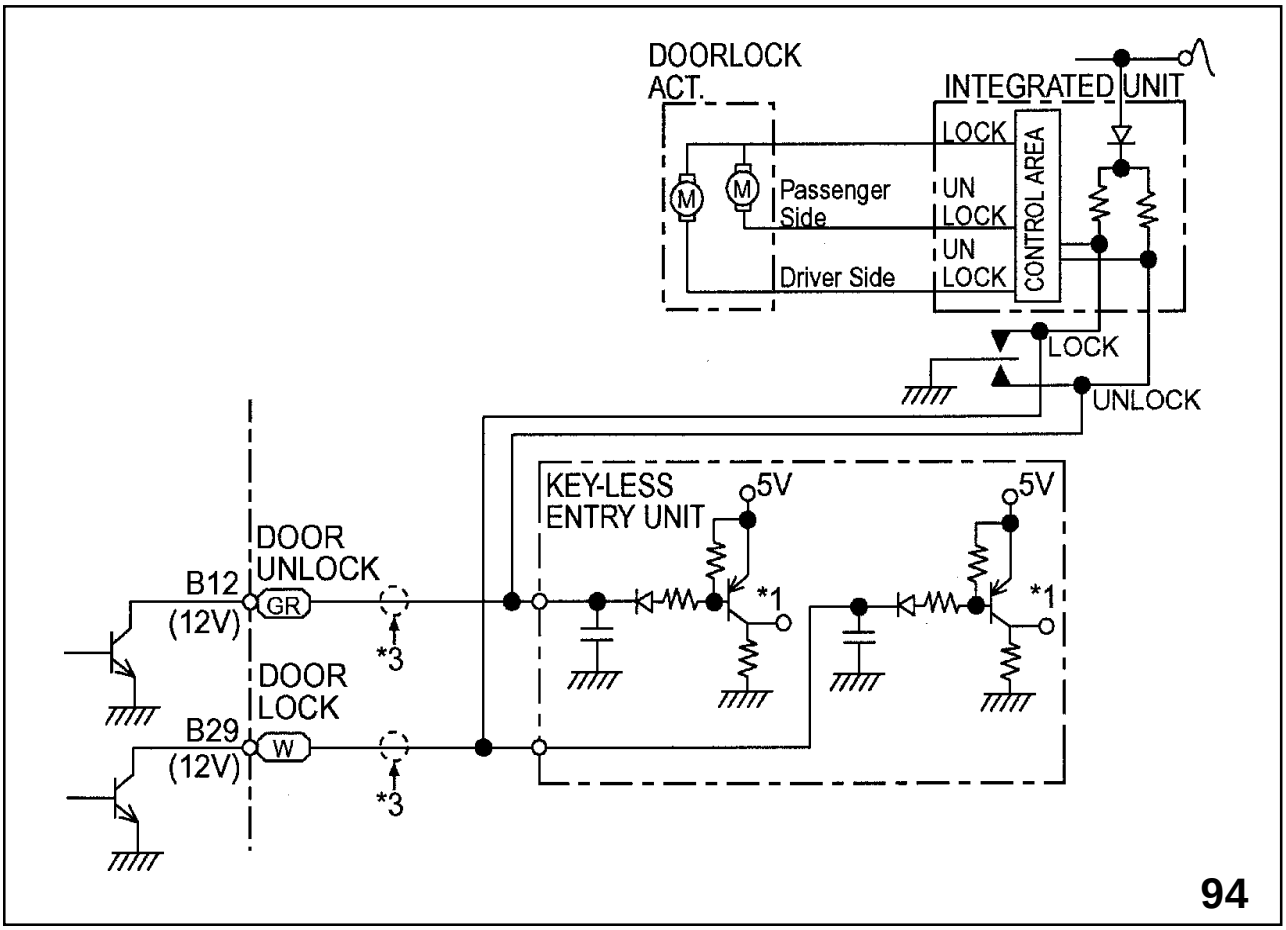
The SRS Air Bag System provides two types of input signals to the VIU, normal and deployed. The normal signal prevents the VIU from illuminating the trouble indicator (2 colored led). The deployed signal will result in the VIU outputting a signal to the VCU. The VCU will then make an emergency cellular phone call to OnStar. OnStar will then call the vehicle. If no response from the vehicle is received emergency vehicles are dispatched to the vehicles location. If the driver pushes the answer button when receiving the cellular phone call from OnStar the driver can decide if emergency vehicles are required. An emergency phone call to OnStar can be made by the driver themselves by pushing the emergency button and request services needed.



The headlight relay receives a signal to ground the coil of the coil of the relay for flashing the headlights. This is done to also assist with locating the vehicle.

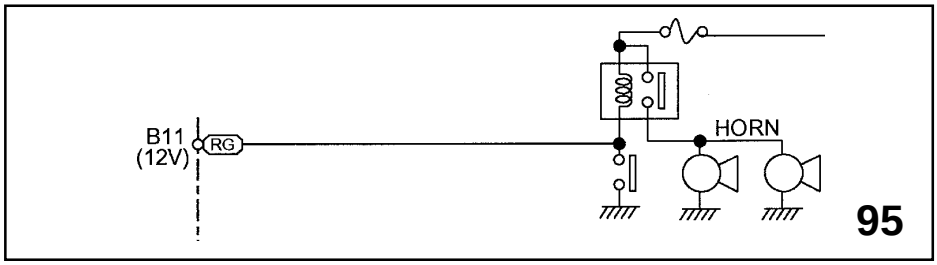


The microphone provides voice input to the VIU. This is used to communicate to the onboard OnStar system and to provide voice input during phone calls.



The Keyless Entry control module receives a Door unlock and Door lock signal from the VIU. Each command uses its own wire. The control of the security system and the keyless entry system are usually commanded together although independent control is possible.

The driver of the vehicle can call OnStar from a separate phone and request that the vehicle be locked, unlocked or security system turned on or off.



The Horn relay receives a signal from the VIU that will supply a ground to the coil of the relay to beep the horn. This is performed if the driver calls OnStar from a separate phone to assist with locating the vehicle.



The OnStar system is equipped with on board diagnosis. The system can perform a DTC check that will evaluate the condition of inputs and outputs as well as perform a compulsory check mode.

Entering the DTC check mode is accomplished using the “Dot” button and the ignition key. Follow the chart below to enter the DTC check mode.

1. Push and hold the “Dot” button
2. With the ignition key off cycle the ignition key to on 4 times within 6 seconds.
3. Release the “Dot” button.

Results

Normal condition-The green LED will turn off and back on steady.

Red LED will flash to indicate a current problem.

Green LED will flash to indicate a code has occurred in the past but does not currently exist.

Number of Flashes	DTC
1	GPS signal error
2	Loss of VCU to VIU communications
3	SRS signal fault (**Only flashes green**)
4	GPS and Mircroprocessor communication fault
5	Button assembly malfunction

Exceptions

During a GPS and microprocessor communication fault, DTC occurs that disables the button module the VIU will not enter the DTC display mode.

The EEPROM checksum error, DTC shows a transition in the memory but does not mean there is a fault. Therefore no DTCs are displayed.

The SRS signal fault DTC will only show as history in the DTC display mode. (Requires ignition to enable algorithm and the ignition is the only reference for entering the DTC display mode.

The DTC codes will be displayed in two cycles.

Current codes are always displayed first, followed the DTCs in memory.

The codes with the least number of flashes are displayed first.

Five codes or less shall be displayed in the same cycle.

The same code shall not be displayed more than once.

Deleting DTC codes

DTC history status can be cleared at the end of the Display mode by pressing and releasing the OnStar button within 3 seconds at the end of the DTC display mode.

Output mode

Output mode can be used to enter a compulsory check of the lock, unlock, security system, horn, and light outputs.

The output mode can be entered at the end of the DTC display mode by switching the ignition to off within 3 seconds at the end of the DTC display mode. (LED returning to normal condition).

Order of occurrence	Length of signal
1. Security arm signal	20 milli seconds
2. Door lock	300 milli seconds
3. Security indicator	1.125 seconds
4. Security disarm	80 milli seconds
5. Door unlock	300 milli seconds
6. Horn and lights	750 milli seconds

VCU / VIU Remove

Set the Parking Brake Turn the ignition switch to the on position.

Place the shifter in the neutral position.

Turn the ignition switch off and disconnect the battery. Apply gentle up pressure to the corner of the shifter trim plate.



Continue applying pressure around the shifter trim plate until it can be removed.



Remove the two screws that secure the coin tray. The forward end of the tray has a point that is set into a notch under the ash tray.



Remove the two screws in the area indicated by the two fingers. A third screw is under the tray near the back.



Apply gentle up pressure to the radio /HVAC bezel. Apply pressure around the bezel until it can be removed.

Pull the bottom of the bezel outward and then slightly down to remove the top of the bezel.



Disconnect the electrical connectors from the back of the radio / HVAC bezel.



Remove the indicated screw to allow the dash bezel to move upward when the radio is being removed.



Remove the two screws located under the OnStar buttons.

Remove the two screws from the driver side of the radio.



Remove the two screws from the Passenger side of the radio.

Complete radio / HVAC removal is then required. Remove the aspirator from the connector above the accelerator pedal.



The aspirator tube is routed between this bracket and harness.

Protect the radio and shifter from scratches during removal and installation.

Carefully disconnect all the connectors from the back of the radio.



Slowly begin to slide the radio outward. This tab will catch on the area below the A/C vent. Push it down slightly to clear.

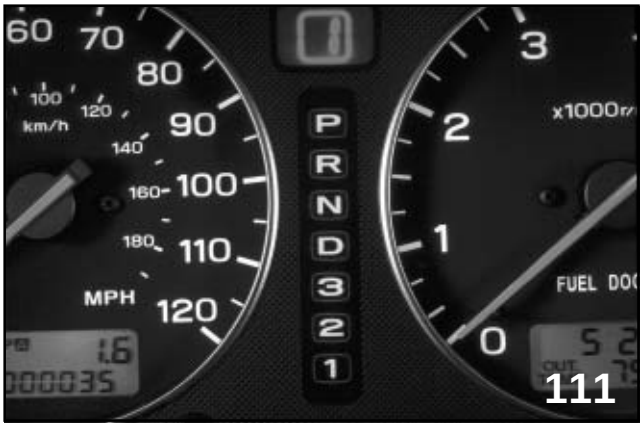


After reinstalling the OnStar components and the radio, the LED will blink red after connecting the battery and turning on the ignition. This condition will only last a few seconds followed by the LED turning on steady green.

SPORTSHIFT

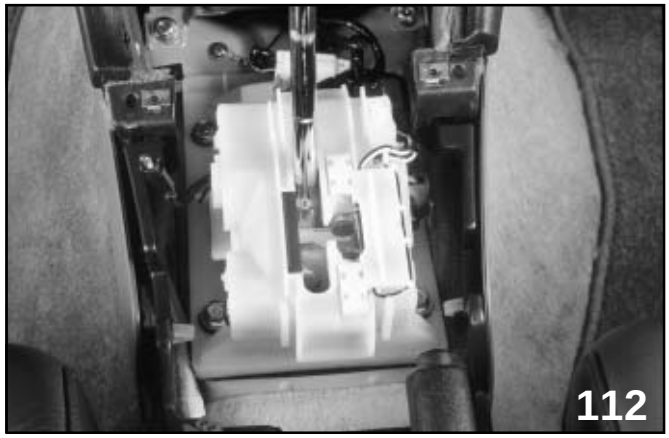


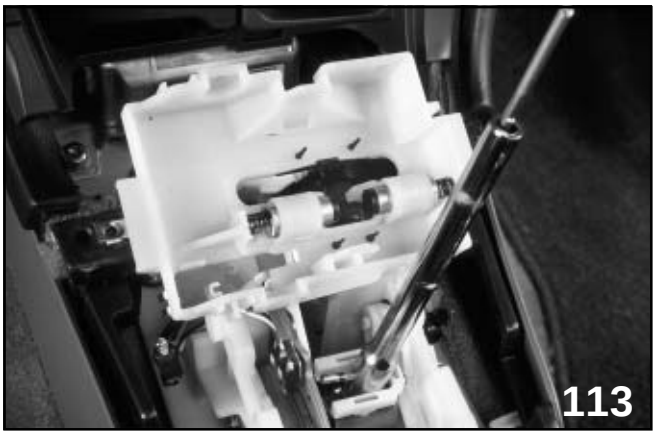
The 2003 Legacy GT model is equipped with VTD and a SPORTSHIFT type gate shifter. This added control feature of the 4EAT allows the driver to operate the changing of the forward gears by using a special SPORTSHIFT gate.



Operation is accomplished by placing the vehicle in “D” range and moving the shift lever to the right. Once in the SPORTSHIFT gate the shifter can be tapped forward for up shifting or tapped backwards for down shifting. Changing of the gears in SPORTSHIFT must be timed with the SPORTSHIFT indicator light on the combination meter. A small box at the top of the shift indicator will communicate the current gear position along with an arrow pointing up, down or both. This tells the driver if the current vehicle operation is good for up shifting to the next gear or down shifting to the previous gear. Normally the shift indicator will illuminate the gear position but while in SPORTSHIFT this feature is turned off. No upshift to 4th with cold ATF fluid. (Buzzer will sound)

Automatic up shifting is not performed while in SPORTSHIFT. Engine over rev protection is accomplished with a fuel cut and a full vehicle stop will result in the TCM activating 1st gear. At this point the driver will need to advance the forward gears with the shift lever.



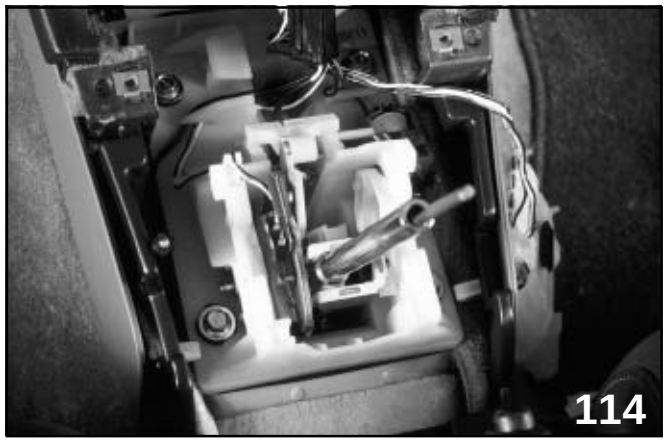


TCM control for SPORTSHIFT is accomplished using input signals from the SPORTSHIFT micro switch , up shift micro switch and down shift micro switch.

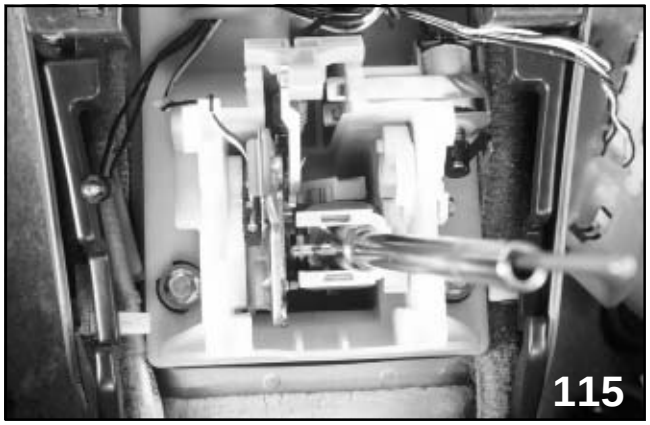
Output signals are sent to the SPORTSHIFT indicator and sport shift solenoid. The sports shift solenoid is used to turn the low and reverse clutch on and off to provide engine braking should the 1st gear be chosen while in SPORTSHIFT.

The transmission trouble code for a failed SPORTSHIFT solenoid is 78. There are no codes for the micro switches.

Spring tension is applied to the shifter lever while in SPORTSHIFT by two spring-loaded pistons that push on the front and backside of the shifter lever.



The shift lever has a pin that engages with shift cable actuator. During normal shifting the pin moves the actuator back and forth to provide 1st through park.



When shifting to SPORTSHIFT the pin is moved away from the shift cable actuator and operates independently in the SPORTSHIFT gate.

Baja



The BAJA is an all-new hybrid vehicle developed and built on the Legacy Outback platform. This vehicle provides pick-up truck versatility and passenger carrying capabilities for four people.



The BAJA is available in a single trim level coming standard with a 2.5-liter engine and a 5 speed all wheel drive transmission.



The gas cap is opened from the outside of the vehicle and is not equipped with an interior release.





The front bumper tow hook cover must be removed to access the tow hook.

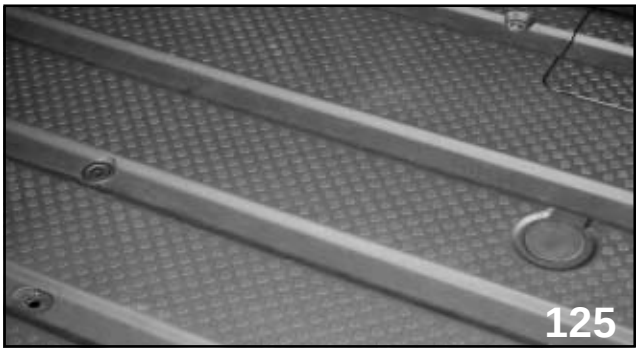




The rear of the passenger compartment is equipped with a cargo light that will illuminate the cargo area. The light is operated from a switch on the left side of the steering column and is operable with the key on or off.



The bed liner of the cargo area is equipped with a water drain in each front corner.







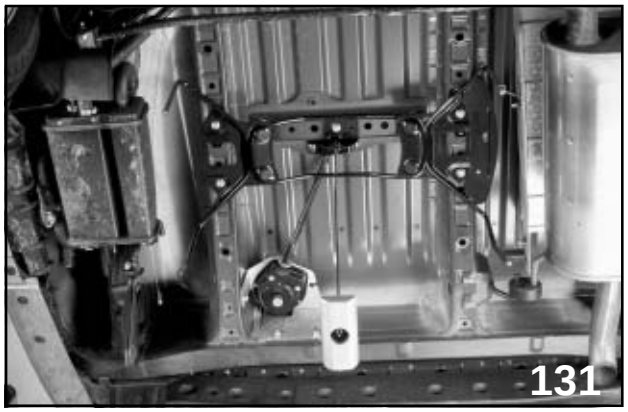
The bed liner is also the access point to lower the temporary spare tire. The full size flat is stored in the cargo area using the full size tire holder and the captured nut in the bed.





The tool used for lowering the spare is located in the tool kit provided with the vehicle. The kit is stored in the passenger compartment behind the rear seat on the driver side.







The mechanism that lowers the spare tire is located under the vehicle and has enough travel to pull the spare tire beyond the rear bumper for removal from the storage cable.



The spare tire is secured to the storage cable by positioning the tire with the valve stem facing up and holding the keeper sideways. Push the keeper through the rim and allow gravity to pull the keeper into place.













To reconfigure the rear seats locate the fabric pull handle under the passenger side of the rear seat and pull upward. Lift the seat 90 degrees and then pull on the upper seat cushion release handle on either the driver or passenger side. Lower the upper cushion until it engages with the provided catches on the lower seat back. The Switchback release handle can be activated to lower the Switchback.



The backside of the upper seat frame is equipped with 2 child seat anchor points.



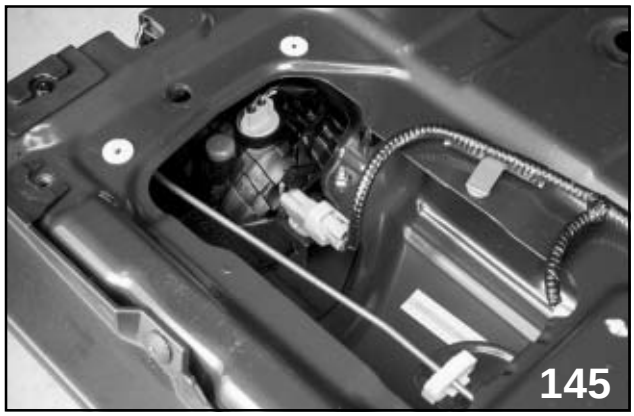
Any time the Switchback is open the Switchback position indicator light will be illuminated. The light will blink for about 5 seconds after the ignition key has been turned off.





Operation of the vehicle with the tail gate down requires that the license plate be repositioned. Before opening the tailgate push the top of the black release tabs in and swing the license plate holder upward by about 90 degrees. The holder will lock into position.





Removing the plastic cover and metal cover over the tailgate accesses the taillights mounted in the tailgate.



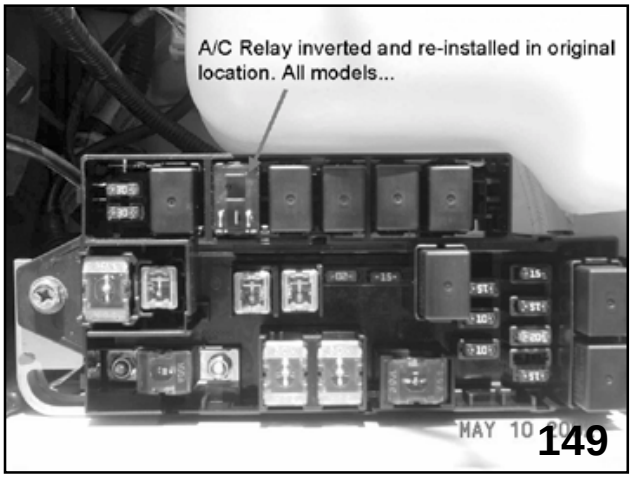
The rear suspension on all Legacy vehicles including the Baja has been enhanced with the introduction of an additional sub-frame support.

NOTES

New for Pre-Delivery Inspection



All models will be equipped with rotor covers. Remove rotor covers at PDI. Tires do not need to be removed. (Operate vehicles at slow speeds until covers are removed)



Invert the A/C relay on all Legacy models at PDI.

NOTES

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (2003 NMUD)	
2	Created By	
3	Teaching Aids	
4	Introduction	6
5	Title Slide (2003 Forester)	6
6	Forester	6
7	Forester RH Side	6
8	Title Slide (Exterior)	6
9	Tailgate	6
10	Rear Light	7
11	Rear Defogger	7
12	Side View Mirror	7
13	“C” Pillar Trim	7
14	Door Lock	7
15	Secondary Hood Release	8
16	Head Light	8
17	Grill Area	8
18	Engine Compartment	8
19	Cowling	8
20	Engine Under Cover	8
21	Oil Filter Door	9
22	Inspection Door	9
23	Subframe	9
24	Stub Axle	9
25	Special Tool Usage	9
26	Special Tool	10
27	Oil Seal Installer	10
28	Oil Seal Tool	10
29	Oil Seal Tool Usage	10
30	Title Slide (Interior)	11
31	Cargo Area	11
32	Storage Configuration	11
33	Child Seat Anchors	11
34	Moonroof Closed	11
35	Moonroof ¾ Open	11
36	Moonroof Open	12
37	Moonroof ¾ Closed	12
38	Cup Holders	12
39	Gate Shifter	12
40	Ash Tray	12
41	Overhead Storage	13
42	Steering Wheel	13
43	Cock	13
44	Window Controls	13
45	Combination Meter	13
46	Supplemental Restraint System	14
47	Seat Tag	14
48	Upper Seat Frame	14
49	Normal Position	14
50	Rear Impact	14

Slide Sequence

Slide No.	Description	Page No.
51	Airbag Module	14
52	Side Airbags (Artwork)	15
53	Satellite Discrimination Sensors (SDC Sensor)	15
54	Connector	15
55	Connector Lock	15
56	Lock-Up	15
57	Lock Down	15
58	Title Slide (Brakes)	16
59	HCU	16
60	Proportioning Valve	16
61	Normal Hydraulic Control (Artwork)	16
62	Pressure Hold Hydraulic Control (Artwork)	16
63	Big Graph (Artwork)	17
64	Ideal (Artwork)	
65	PCV Operation (Artwork)	
66	EBD (Artwork)	
67	Title Slide (Hill Holder)	17
68	Pressure Hold Valve (PHV)	17
69	Clutch Pedal	17
70	Clutch Pedal In	18
71	Clutch Pedal Out	18
72	Title Slide (Automatic Air Conditioning)	19
73	Control Dials	19
	Control Dials	20
74	Component Location	22
75	Ambient Sensor	22
76	Sunload Sensor	22
77	Mode door Actuator	22
78	Behind Glove Box	22
79	Title Slide (Legacy)	23
80	Title Slide (OnStar)	23
81	Radio	23
82	VCU/VIU	23
83	Three Button	23
84	Microphone	23
85	Antenna	23
86	Three Button	24
87	VCU (Artwork)	24
88	Radio (Artwork)	24
89	Security (Artwork)	24
90	Three Button (Artwork)	25
91	SRS (Artwork)	25
92	Headlight (Artwork)	26
93	Microphone (Artwork)	26
94	Keyless (Artwork)	27
95	Horn (Artwork)	27
96	Three Button Module	28
97	Title Slide (VCU/VIC Removal)	29
98	Shifter Trim	29
99	Coin Tray	29
100	Ash Tray Bracket	29

Slide Sequence

Slide No.	Description	Page No.
101	HVAC Trim	29
102	Electrical Connectors	30
103	Removing Trim Screw	30
104	Driver Side	30
105	Passenger Side	30
106	Aspirator Tube Location	30
107	Radio Removal	31
108	Three Button Module	31
109	Title Slide (SPORTSHIFT)	31
110	Shifter	31
111	P-R-N-D-3-2-1	31
112	Micro Switch Plate	32
113	Spring Pistons	32
114	Lever Engaged	32
115	Lever Disengaged	32
116	Title Slide (BAJA)	33
117	Baja	33
118	Name Plate	33
119	Gas Door	33
120	Tow Hook Cover On	33
121	Tow Hook Cover Off	33
122	Cargo Light	34
123	Cargo Light Switch	34
124	Water Drain	34
125	Full Size Storage	34
126	Full Size Holder	34
127	Lowering Spare	34
128	Tool Kit Storage	35
129	Jack	35
130	Spare	35
131	Lowering Mechanism	35
132	Spare in Place	35
133	Connecting Spare	35
134	Tail Gate Open	36
135	Rear Seat Bottom	36
136	Rear Upper Seat Down	36
137	Under Rear Bottom Seat	36
138	Switch Back Closed	36
139	Switch Back Open	36
140	Switch Back Indicator Light	37
141	Child Seat Anchor Points	37
142	License Plate Bracket	37
143	Tail Gate Down	37
144	Light Cover On	37
145	Light Cover Off	37
146	Rear Suspension	38
147	Title Slide (New for Pre-Delivery Inspection)	39
148	Anti-Rust Disc Cover	39
149	A/C Relay	39
150	Copyright	
151	The End	


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Technicians Reference Booklet

Advanced Electrical Theory & Diagnosis

Module 602

Technical Training

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Table of Contents

Slide Sequence 4
Slide Sequence 5
Introduction 6
Solid State Devices 6
Testing Transistors 12
Alternators 13
Solid State Voltage Regulator 14
Alternator Testing Precautions 14
Starters 15
Starter Types 15
Operation 15
Starter/Solenoid Testing Procedures 16
Opcilloscope Testeing and Diagnosis 17
Computer Terminology and Operation 18
Computer Hardware 18
Computer Software 18
Terminology 18
Troubleshootingn Diagnosis of Intermittent Faults 19
Intermittent Faults 20
Thermal and Mechanical 20
Select Monitor Usage 20
Electrical Symbols 22
Electrical Terms Glossary 23
Alternating Current (AC) 23
Direct Current (DC) 23
Sine Wave 23
Square Wave 23
Resistance 23
Dynamic Resistance 23
Voltage Drop 23
Resistor 23

Slide Sequence

Slide No.	Description	page No.
1	Title Slide (Advanced Electrical)	
2	Created By	
3	Teaching Aids	
4	Introduction	6
5	Title Slide (Solid State Devices)	6
6	Semi-Conductor	7
7	Lattice Structure	7
8	Electron Current Flow	7
9	Diagram of Diode	8
10	Diode Symbols	8
11	Testing Diode	9
12	AC Sine Wave	10
13	Three Phase Sine Wave	10
14	LED/PSD	10
15	Zener Diode Operation	11
16	PNP Transistor Construction	11
17	NPN Transistor Construction	11
18	Title Slide (Testing Transistors)	12
19	PNP Transistor Testing	19
20	Title Slide (Alternators)	13
21	Alternator Components	13
22	Component Operation	13
23	Stator Construction	13
24	Capacitor Operation	14
25	Title Slide (Starters)	15
26	Starter Types	15
27	Magnetic Switch / Solenoid	15
29	Starter Drive Operation	15
30	Title Slide (Operation)	15
31	Magnetic Switch / Solenoid	16
32	Title Slide (Oscilloscope Interpretation & Diagnostics)	17
33	Oscilloscope CRT	17
34	NSM (Main Menu 1)	17
35	NSM (Main Menu 4)	17
36	NSM	17
37	NSM	17
38	Lab Area	
39	Title Slide (Computer Terminology an Operation)	18
40	Hardware	18
41	Software	18
42	Terminology	18

Slide Sequence

Slide No.	Description	page No.
43	Networking	19
44	CPU Operation	19
45	Title Slide (Troubleshooting Diagnosis of Intermittent Faults)	19
46	Six Step Troubleshooting	19
47	Intermittent Faults	20
48	Select Monitor	20
49	Lab Area	
50	Copyright 2001	
51	The End	

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.

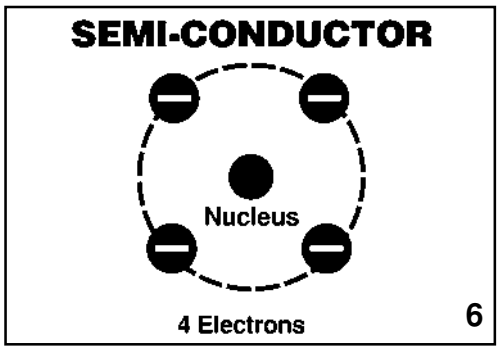
Solid State Devices

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

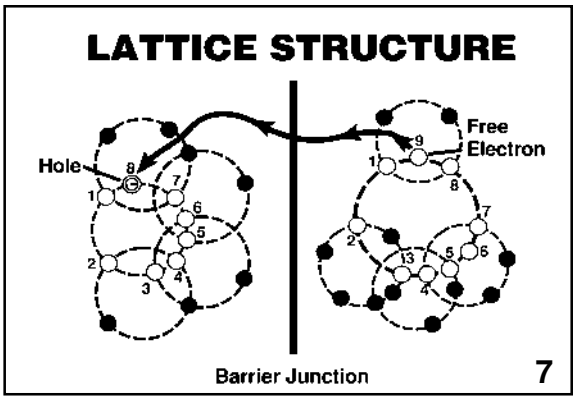
We begin our study of advanced electrical theory with an explanation of the construction and operation of diodes.

Diodes are commonly constructed of one of two materials:

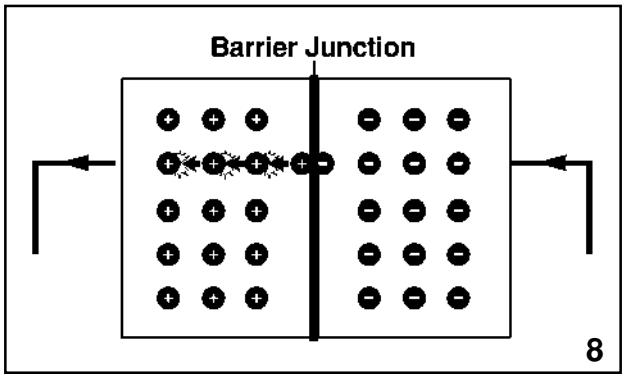
- Silicon
- Germanium

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

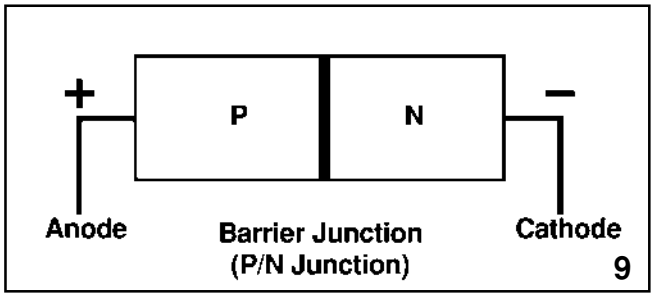


Structural changes to the atoms

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).

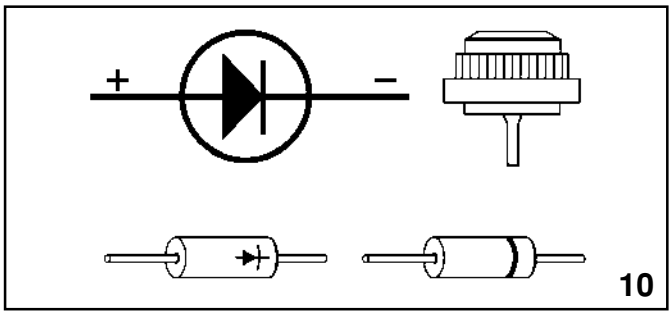
This is also called a "barrier junction". The P/N junction determines the maximum allowable current flow of the diode and it is this feature which allows the diode to function as a one-way switch.

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:

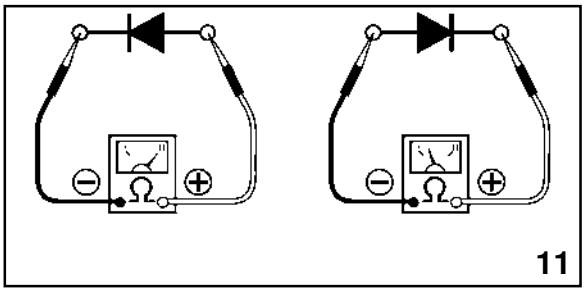
- Fuse the P/N junction, creating a short circuit. The diode will then act like a solid wire conductor, or
- Open the P/N junction creating an open circuit through which no current may flow.

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.

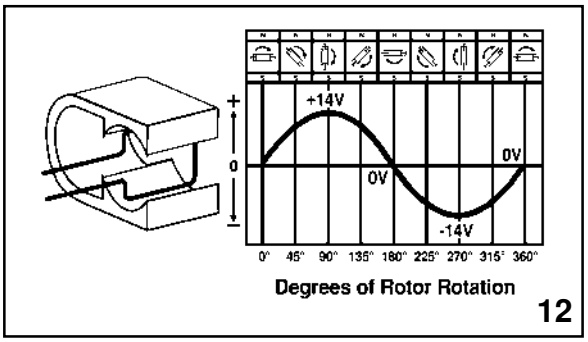
NOTE: WHEN USING AN OHMMETER TO TEST A DIODE, MAKE SURE THE POWER IS TURNED "OFF", OR WHERE POSSIBLE, REMOVE THE DIODE FROM THE CIRCUIT.

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.

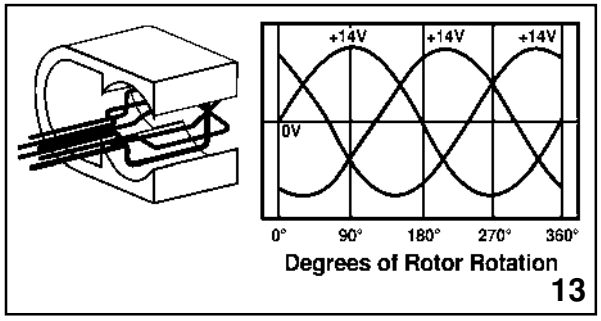
NOTE: A DIODE'S PERFORMANCE DOES NOT DETERIORATE WITH TIME OR USE. THEREFORE, WHEN TESTING, THE RESULT WILL EITHER BE "GOOD" OR "BAD", HOWEVER, IT IS POSSIBLE FOR A DIODE TO BE INTERMITTENTLY "GOOD" OR "BAD".



Full wave rectification

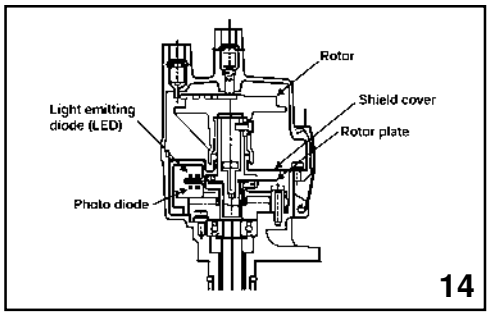
A diode may be used to convert (rectify) AC voltage to a pulsing DC voltage. Because of the diode's polarity, current is only allowed through the diode in one direction. Remember that opposite polarity is denied conduction due to the high P.I.V. (peak inverse voltage rating) of the diode.

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.

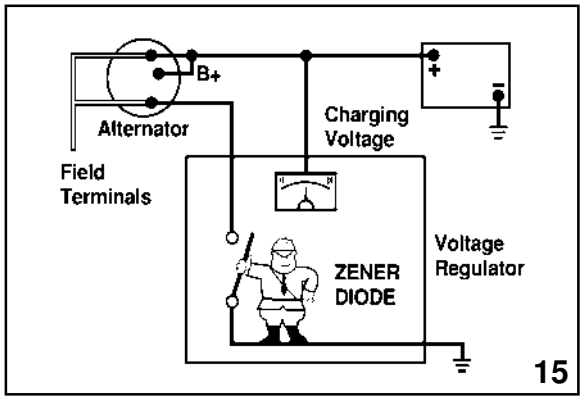


LED/PSD

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.

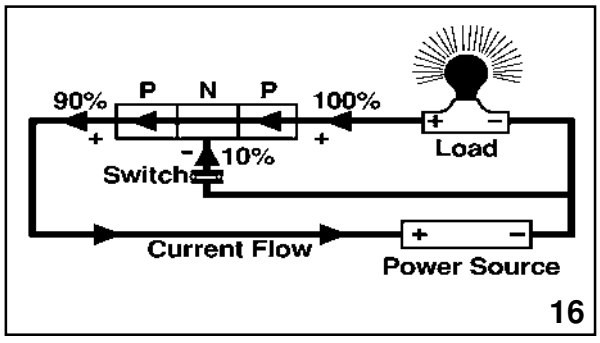
A photo sensitive diode (PSD) is similar to an LED, however, it will conduct current when exposed to light. The PSD can also act as a rectifier. As with the LED, it is better to test the operation of the component than the PSD itself.

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:

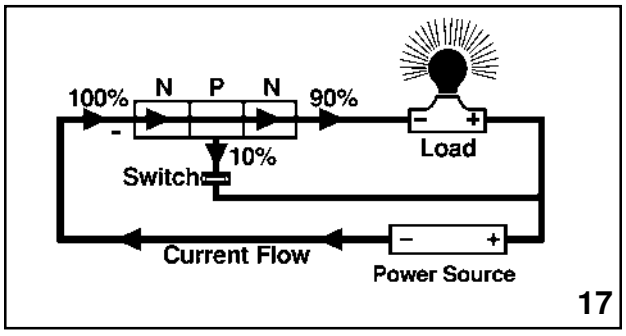
- PNP = positive/negative/positive
- NPN = negative/positive/negative

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.

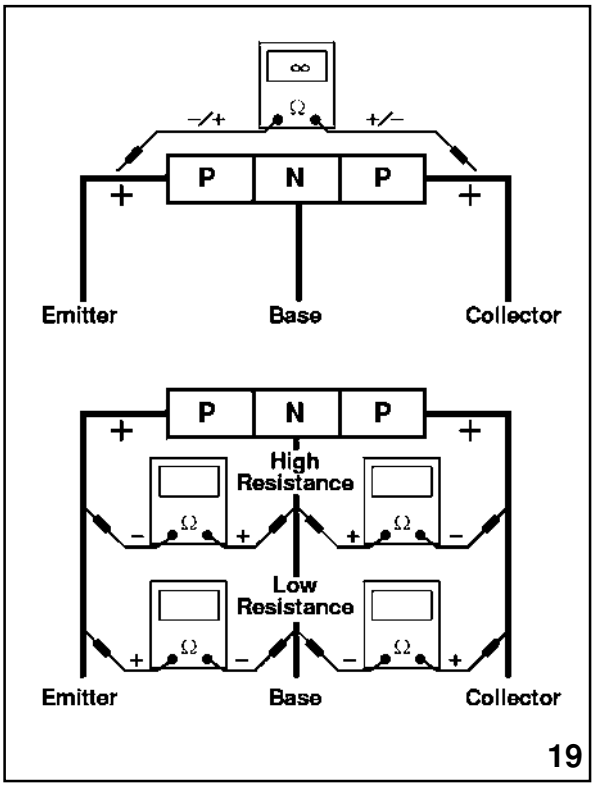
Operational control of a transistor is determined by the polarity of the base material which determines the polarity of the voltage supplied to the base. Thus, a PNP transistor operates by flooding the base material with free electrons (negative polarity). This allows the transistor to act as a switching 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)

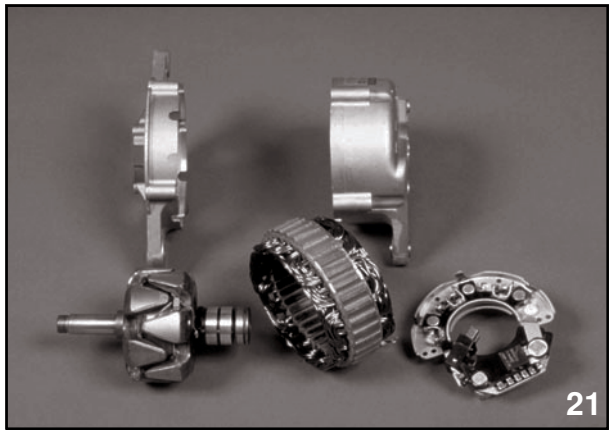
1. Reverse the lead connections in the above test steps.

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.

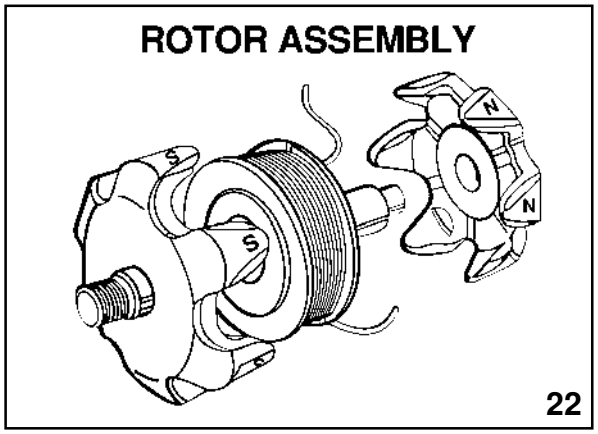
Alternators



Alternator components

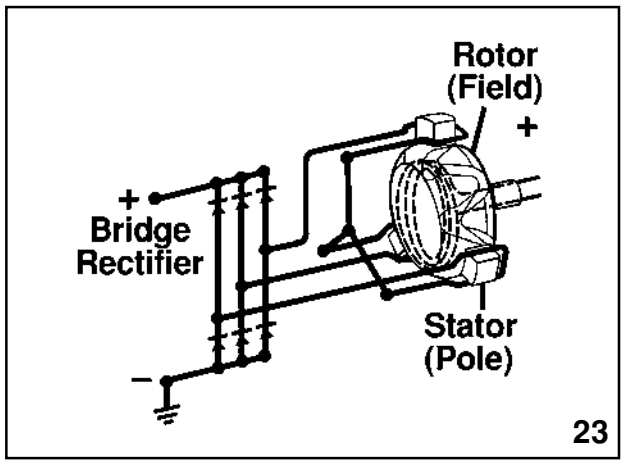
The components of a Subaru alternator are:

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



Alternator component operation

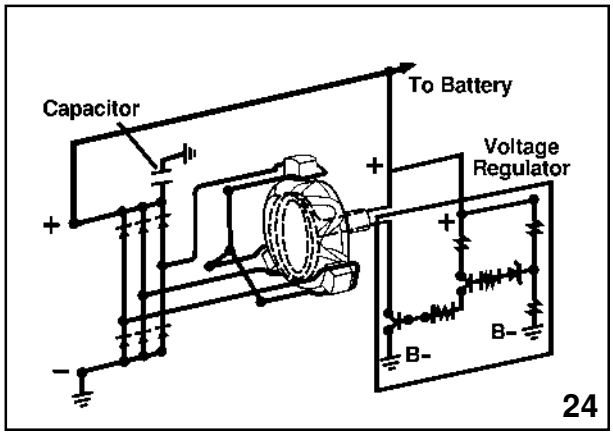
Because the field winding (rotor assembly) is lighter in weight and therefore easier to rotate, it rotates inside a stationary stator. Alternating north and south magnetic fields are created by bending the front and rear plates over the coil in a star-shaped interwoven type pattern.



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.

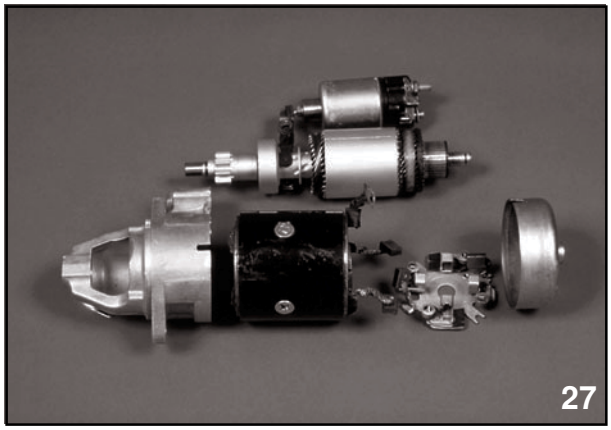
Restore the D-Check and alternator connections to the normal operating condition.

Listed in the appropriate MY Subaru Service Subaru Starting Systems.

Starters

Starter Types

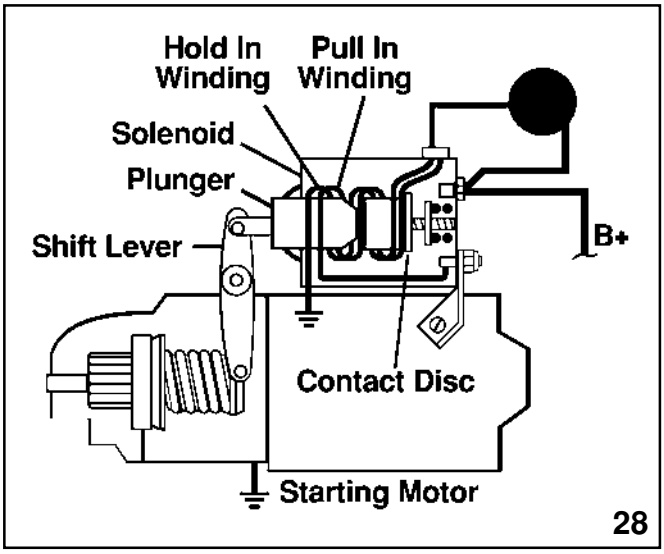
- Reduction Gear
- Direct Drive



Starter components

The components of the starter assembly are:

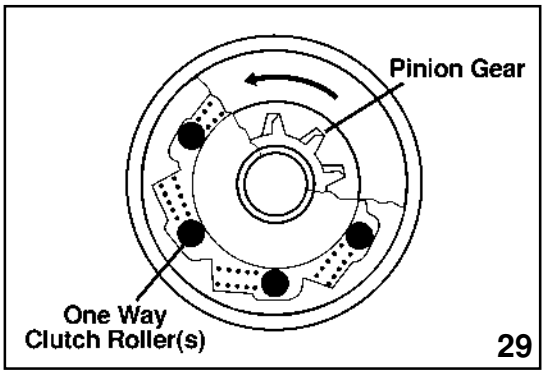
- Pinion (drive)/one-way clutch
- Armature
- Commutator
- Field shoes
- Brushes/brush holders
- End caps/bushings



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.

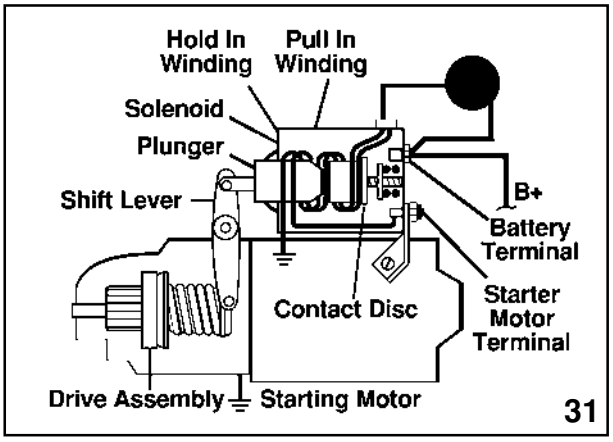
The starter rotates the pinion which rotates the flywheel to crank the engine. When the engine "starts", the one-way clutch "freewheels" to protect the starter armature and commutator from an "overspeed" condition.

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

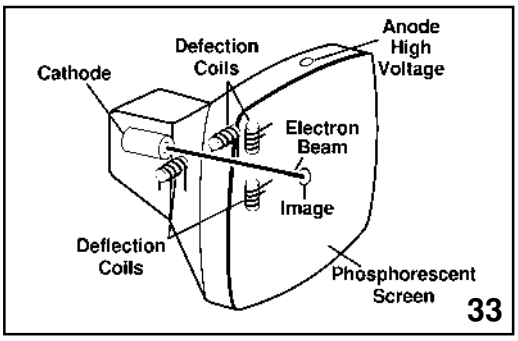
Use an ohmmeter to test the pull-in and hold-in windings. Always refer to the appropriate MY Subaru Service Manual, Section 6-1.

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

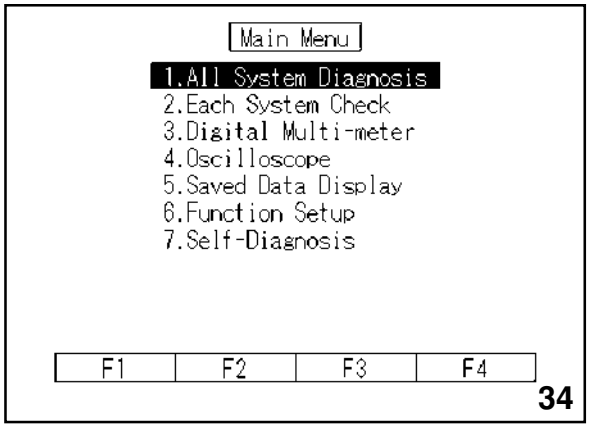
Finally, be sure to test all cables using the voltage drop method.

Opcilloscope Testeing and Diagnosis

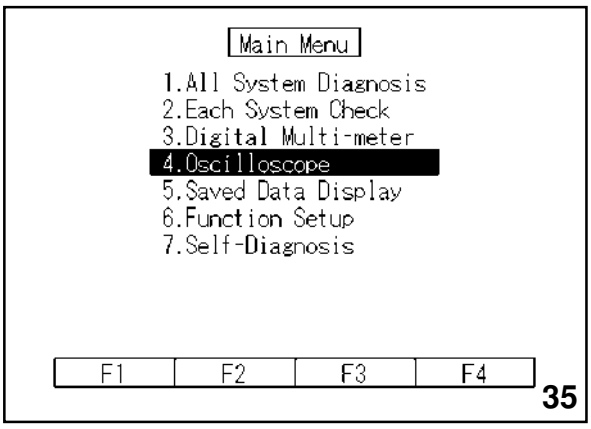


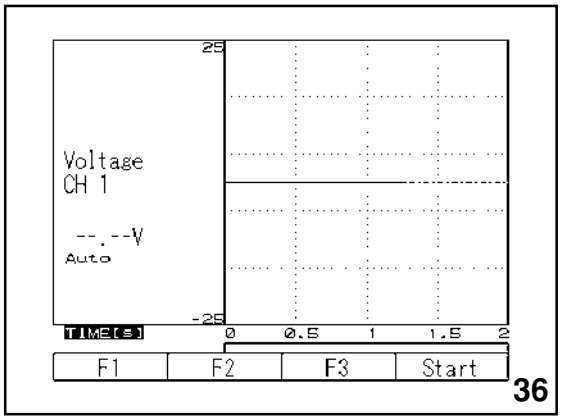
Oacilloscope CRT

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

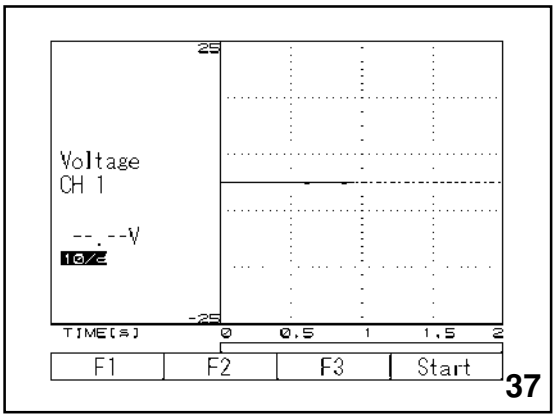


An Oscilliscope function is included on the Select Monitor. From the main menu cursor over item "4. Oscilliscope." Press the "YES" key.





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

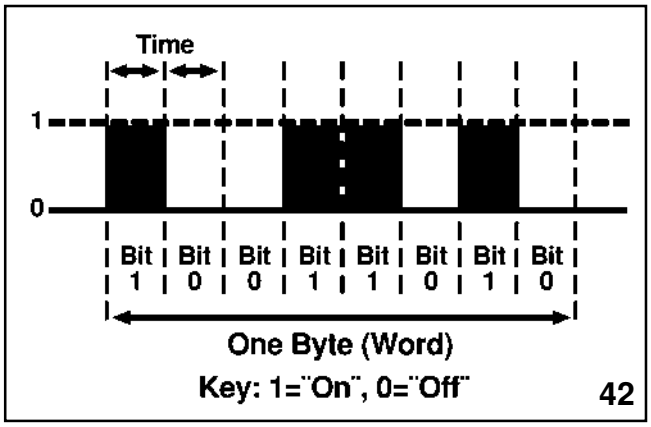
Automotive computer hardware is the electronic and tangible componentry used for its operation.

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.

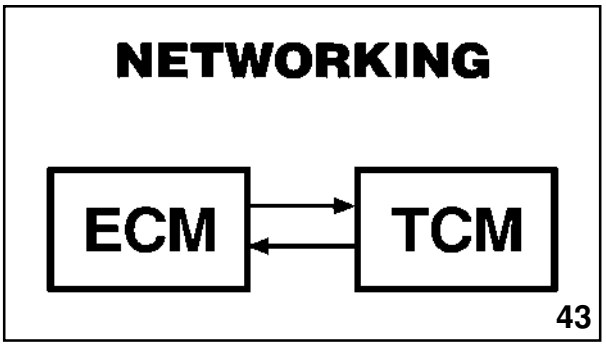
BYTE (binary element string)

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

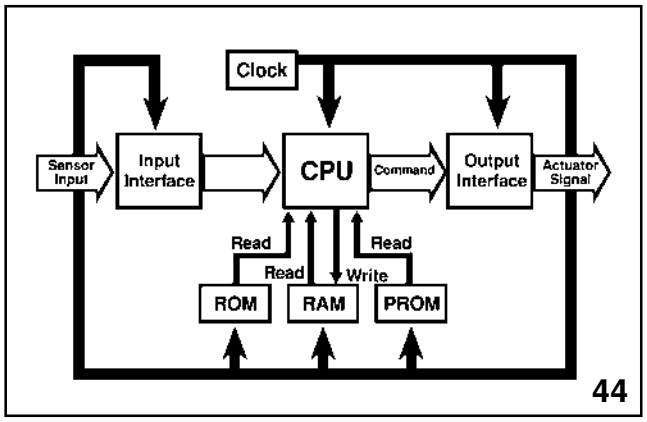
"K" = 1000 or kilo (as in metrics). This term is used to indicate toe amount of memory space available in a computer. If it has 32K BYTES, then it can store 32,000 characters in its memory.

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

Six Step Troubleshooting
Step 1 — Verify the problem(s)
Step 2 — Determine related symptom(s)
Step 3 — Isolate the problem
Step 4 — Identify the cause
Step 5 — Repair/replace
Step 6 — Verify operation

46

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



48

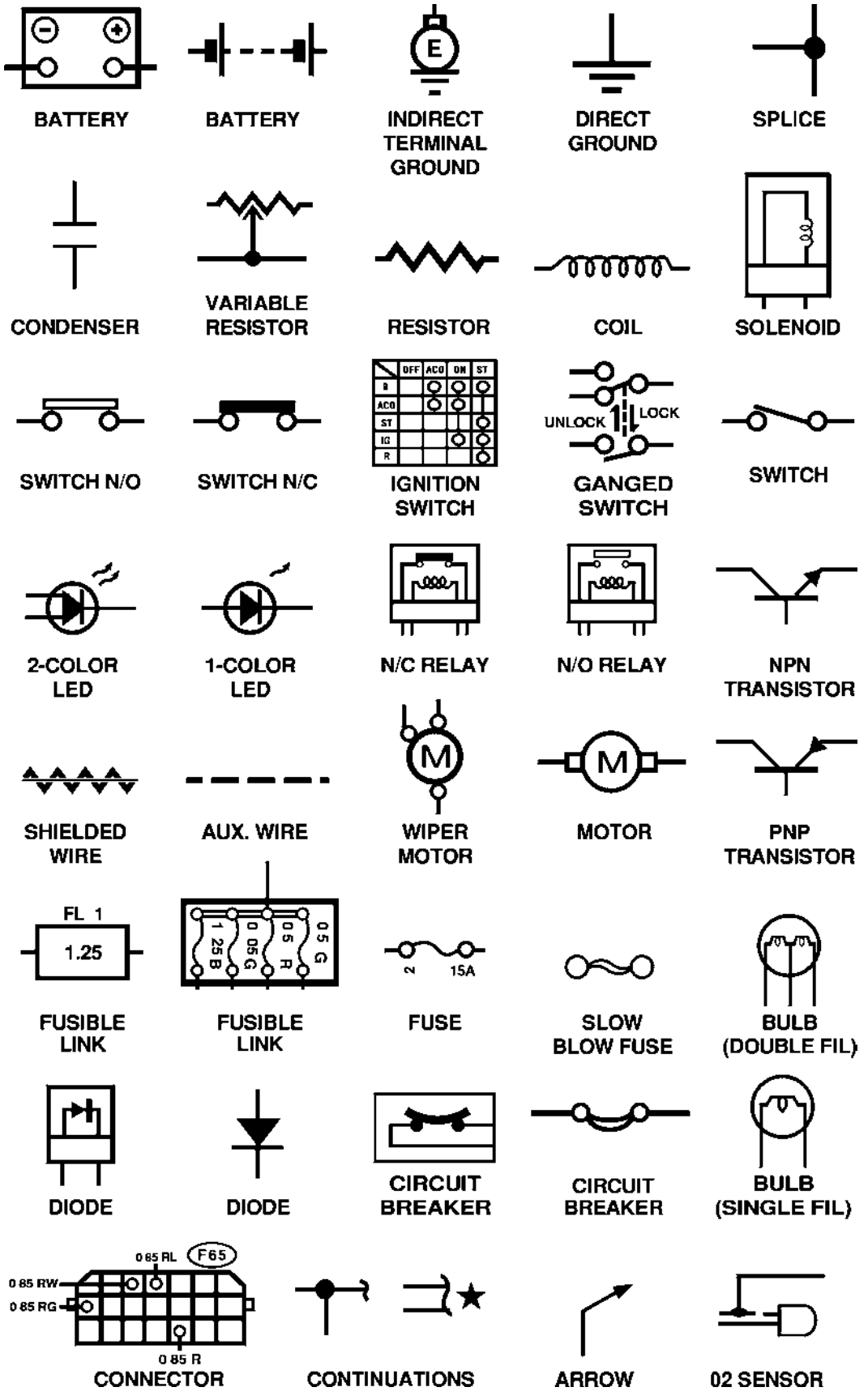
Select monitor

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

CERTIFIED SUBARU TECHNICIAN

Technicians Reference Booklet

Basic Electrical Theory

Module 601

Technical Training

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Table of Contents

Introduction 6
Electrical System Theory 6
    Electrical Terms 8
    Watts 8
    Circuits: Electron Flow 9
Electrical Terminology 10
    Circuit Protectors 10
Battery Testing Procedures 15
Switches, Relays and Motors 16
    System Components 16
Starting and Charging Systems Tests 18
Troubleshooting 20
    The Six Step Troubleshooting Method 20
Electrical Terms Glossary 22

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (Basic Electrical Theory & Diagnosis)	
2	Created By	
3	Teaching Aids	
4	Title Slide (Electrical System Theory)	6
5	Atomic Structure Artwork	6
6	Electron Flow Artwork	6
7	Electron Flow in a Conductor Artwork	7
8	Semiconductors and Insulators Artwork	7
9	Circuit Artwork	8
10	Electrical Terms Artwork	8
11	Watts Definition Artwork	8
12	Electrical Analogy Artwork	8
13	Ohm's Law Artwork	8
14	Ohm's Law Relationships	
15	Electrical Theory Artwork	9
16	Circuit Artwork	9
17	Parallel Circuit Artwork	9
18	Series-Parallel Circuit Artwork	10
19	Shorts and Grounds Artwork	10
20	Title Slide (Electrical Terminology)	
21	Circuit Protectors Artwork	10
22	Fusible Links	10
23	Fuse Interpretation Artwork	11
24	Battery	
25	Battery Characteristic Artwork	
26	Battery Construction Artwork	11
27	Electrolyte Artwork	12
28	Battery Voltage Artwork	
29	NSM	12
30	Analog Volt Meter	12
31	Ammeter Usage	13
32	Ohmmeter Usage	13
33	Logic Probe	14
34	Title Slide (Battery Testing Procedures)	15
35	Weak Battery Diagnosis Artwork	15
36	Vat-40	15
37	Measuring Specific Gravity Artwork	15
38	Title Slide (Battery Performance Test)	
39	Battery Performance Test	
40	Title Slide (Lab Area)	
41	Title Slide (Wiring System Components)	
42	Connectors Artwork	
43	Gold Plated Terminals	
44	Wire Color Code Chart Artwork	
45	Wire Diameter / Amps Artwork	
46	Wire Code Definition Artwork	
47	Precautions Artwork	
48	Title Slide (Electrical Wiring Diagrams and Troubleshooting)	
49	Wiring Diagrams	
50	Title Slide (Switches, Relays and Motors)	
51	Switch Definition Artwork	

Slide Sequence

Slide No.	Description	Page No.
52	Switch Types Artwork	
53	Switch Schematic Artwork	16
54	Lighting Switch and Circuit	
55	Troubleshooting A Switch Circuit Artwork	
56	Relay Definition and Types Artwork	
57	Horn Circuit Relay Operation Artwork	
58	Troubleshooting a Relay Artwork	
59	Relay	
60	Motor Definition Artwork	
61	Lines of Force = Magnetic Field Artwork	
62	Motor Loop rotation Artwork	16
63	Electro Magnet Motor Artwork	17
64	Permanent Magnet Motor Artwork	17
65	Title Slide (Starting and Charging System Tests)	
66	Starting System Test	18
67	Alternator Performance Test-#1	18
68	Alternator Performance Test - Output	19
69	Alternator Performance Test - /Charging System Requirements	
70	Lab Area	
71	Six Step Method	
72	Step 1 - Verify The Problem Artwork	
73	Step 2 - Determine Related Problem Artwork	
74	Step 3 - Isolate The Problem Artwork	
75	Step 3 - Split-Half Techniques Artwork	
76	Step 4 - Identify The Cause Artwork	
77	Step 5 - Repair /Replace Circuit or Component Artwork	
78	Step 6 - Verify Operation Artwork	
79	Title Slide (Troubleshooting Techniques)	
80	Preliminary Actions Artwork	
81	Identifying Loose Grounds Artwork	
82	Identifying Defective Bulbs Artwork	
83	Connector Problems Artwork	
84	Intermittent Faults	
85	Lab Area	
86	Copyright	
87	The End	

Basic Electrical Theory & Diagnosis Module

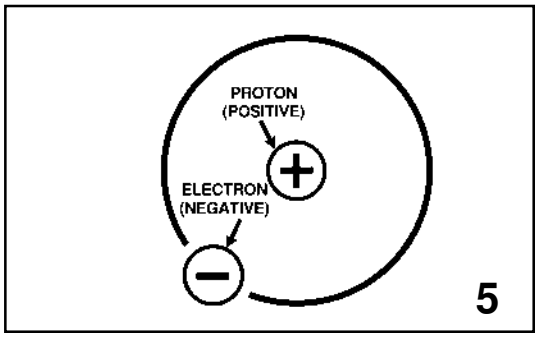
Introduction

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.

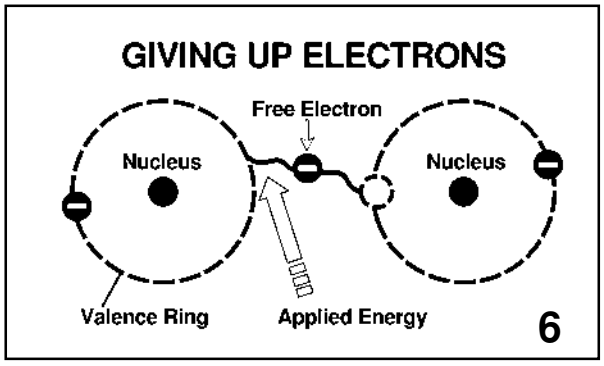
Technicians Worksheets provided by your instructor will be completed during the "hands-on" lab work segments of the Basic Electrical Theory & Diagnosis Module. Always refer to the appropriate model year Subaru Service Manual and the applicable Service Bulletins for all specifications and detailed service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

Electrical System Theory



Electron theory

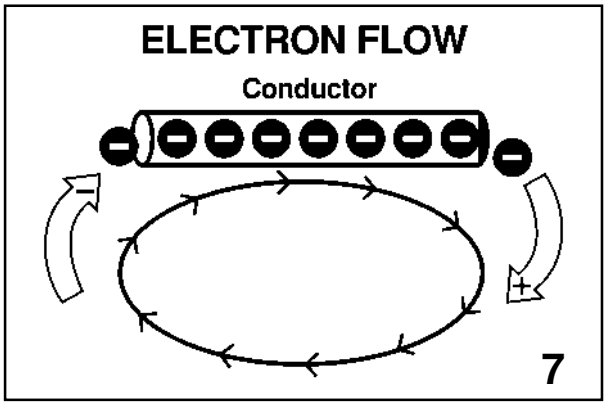
Atoms are composed of electrons and protons. Electrons have a negative charge and whirl around a nucleus composed of protons, which have a positive charge.



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.

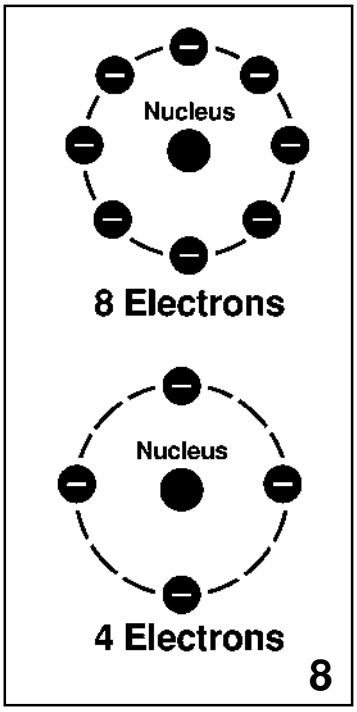


Conductors

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.

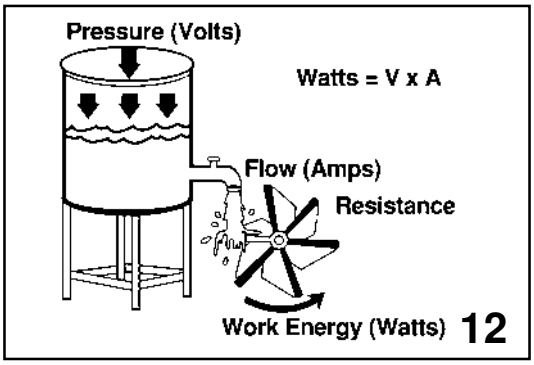
Electrical Terms
- Amps—Current flow of electrons or intensity: Symbol = I
- Volts—Electromotive force or pressure: Symbol = V
- Ohms—Resistance to electron movement: Symbol = R

10

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

11

It is important that you understand the definitions of the electrical terms listed above.



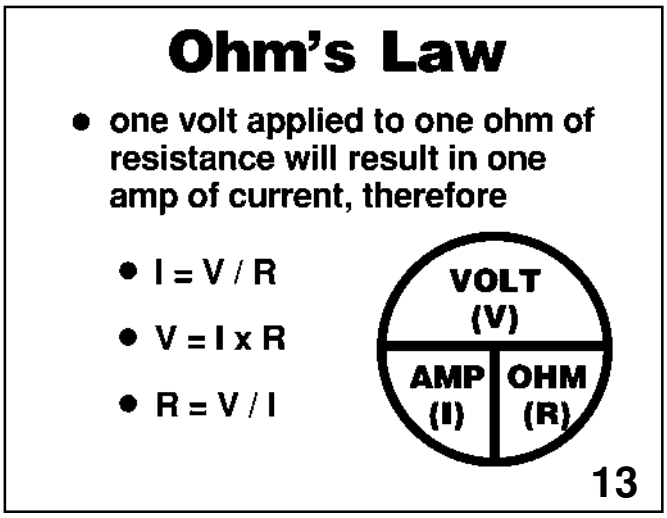
An electrical analogy

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.

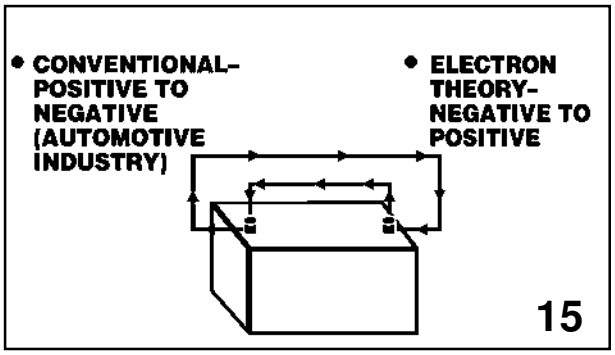


Using Ohm's Law, complete the following problems:

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?

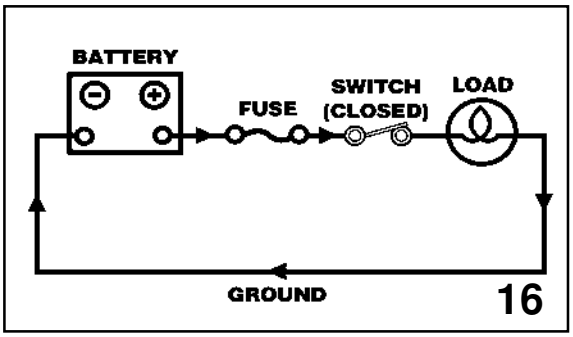
3. What resistance value will allow the flow of 15 amps of current if 12 volts are available?



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.

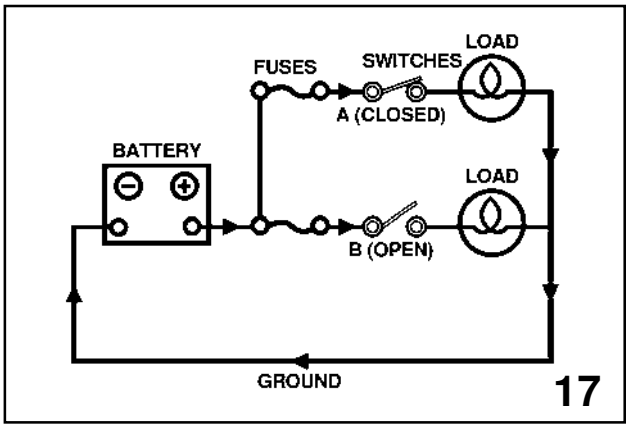
Circuits: Electron Flow



Basic electrical circuit

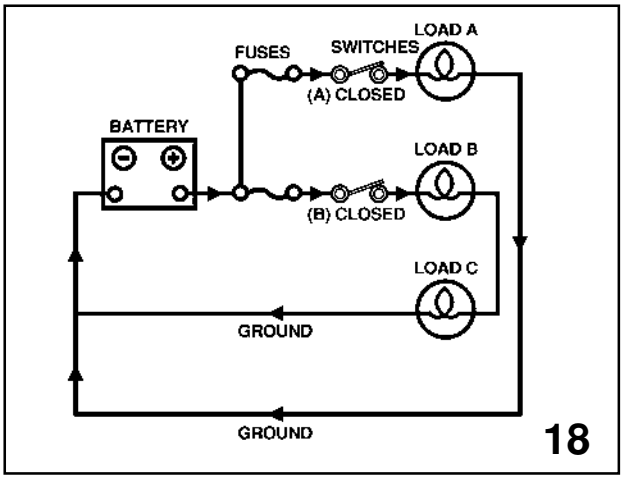
The basic circuit shown above has a battery as the power source. The wires carry the current from the battery (positive wire to the load (bulb) and back to the source (ground wire). A switch controls the flow of current, and a fuse protects the circuit from an overload or an unintentional ground.

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.



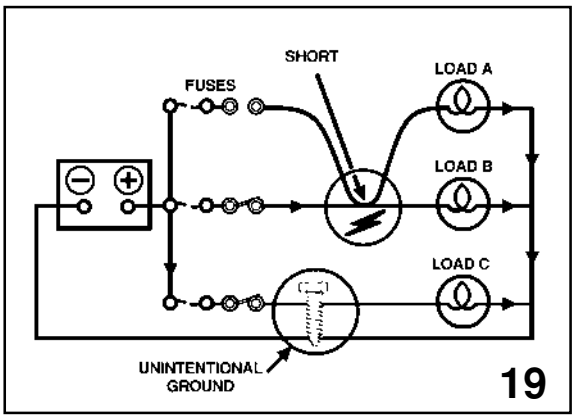
Parallel circuit

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.

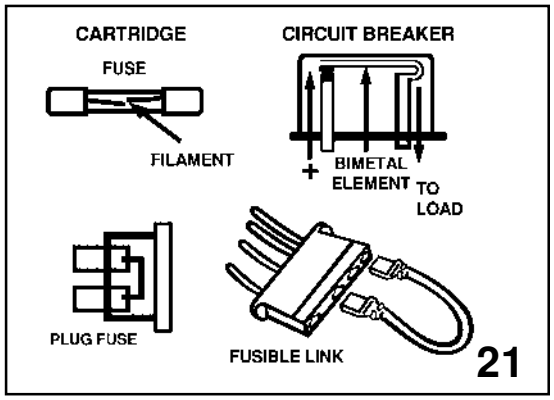


Shorts grounds and opens

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

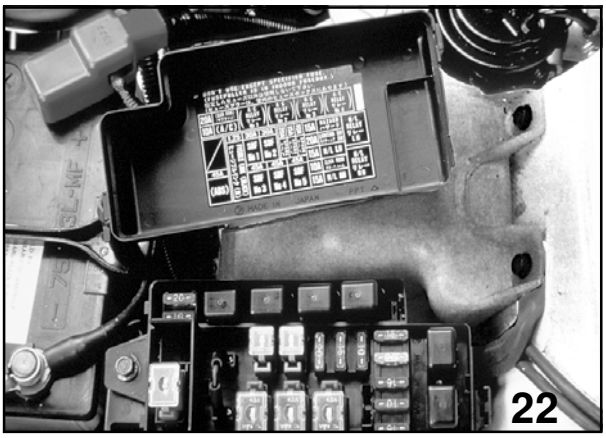
Circuit Protectors



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.

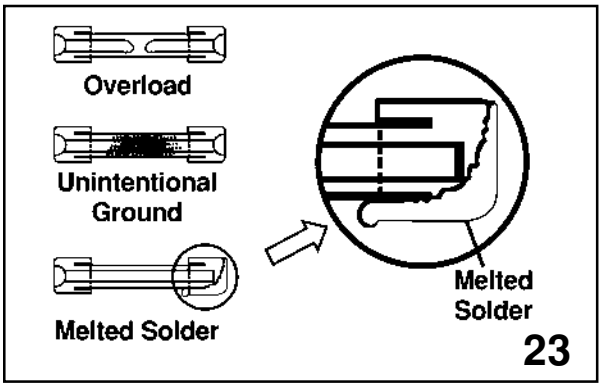
There are two types of fuses used in Subaru vehicles:

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.



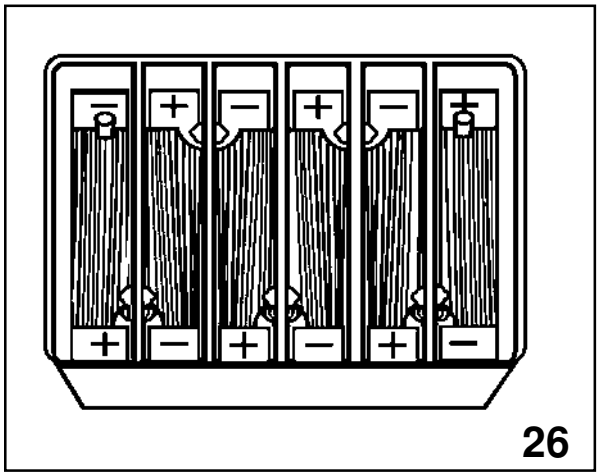
Fuse interpretation

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.



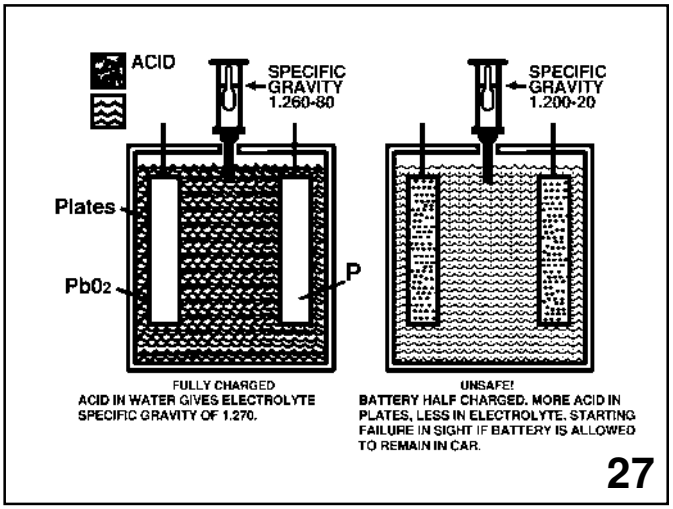
Battery

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).



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.



Voltmeter usage

There are two basic types of voltmeters:

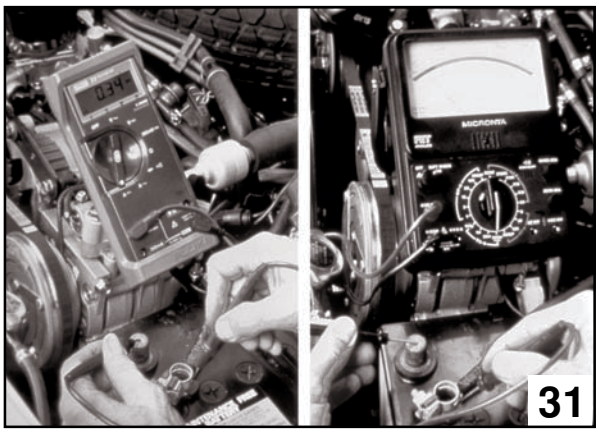
- Digital type which is best for low or fractional voltages.
- Analog type which is best for measuring rapid or large voltage changes.

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.



Ammeter usage

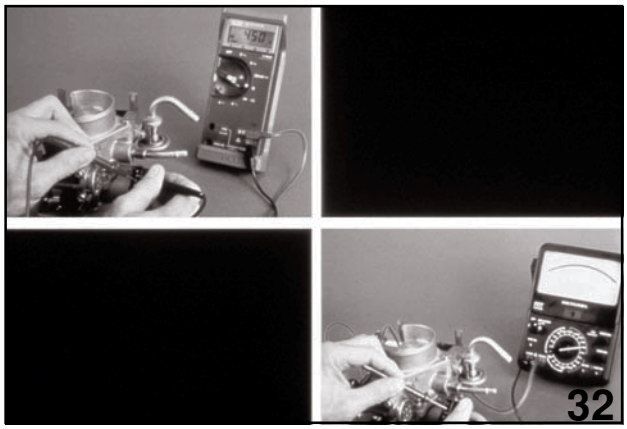
There are two types of ammeters:

- 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



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.

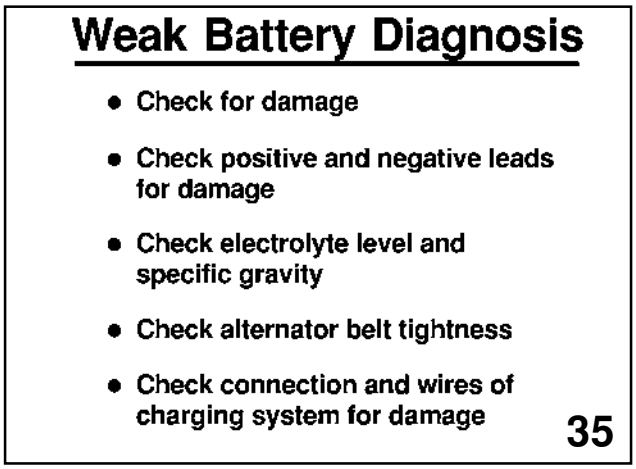
DLP Cautions

- 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:

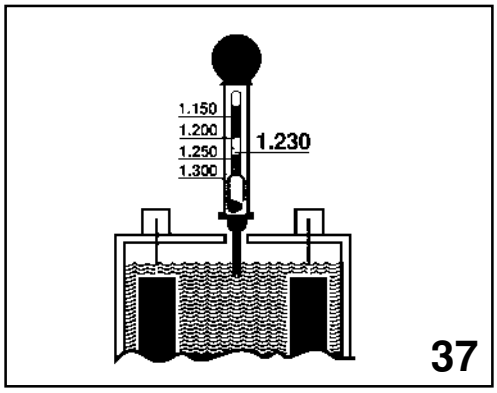
1. Check the battery for damage
2. Check the positive and negative leads for corrosion and proper installation.
3. Check that the electrolyte is at the full level indicator(s). Check the color of the electrolyte.
   — Clear means there is no damage.
   — Red means there is positive plate deterioration.
   — 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.



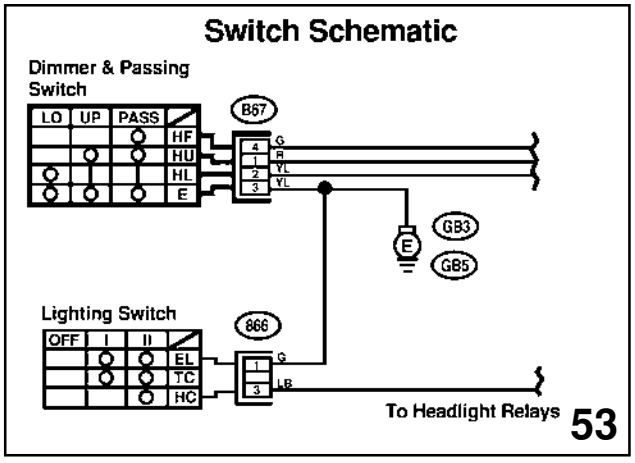
NOTE: WHEN CONDUCTING A BATTERY PERFORMANCE TEST ALWAYS FOLLOW THE EQUIPMENT MANUFACTURER'S RECOMMENDED PROCEDURES. APPLY A LOAD EQUAL TO 1/2 THE COLD CRANKING AMP RATING OF THE BATTERY FOR 15 SECONDS. OBSERVE THE BATTERY VOLTAGE WHILE THE LOAD IS BEING APPLIED AND COMPARE IT WITH THE MANUFACTURERS' SPECIFICATIONS.

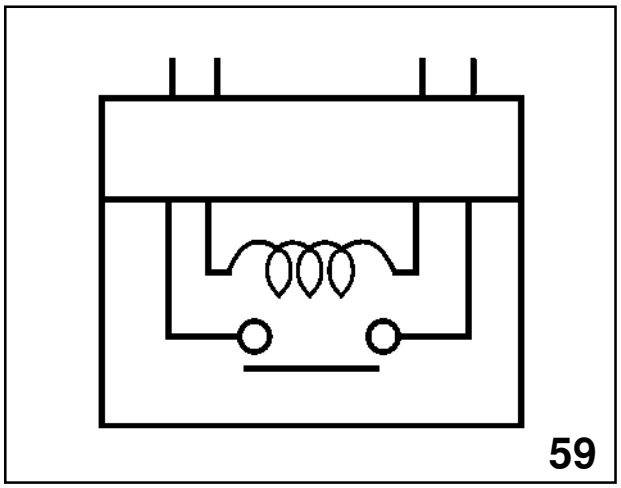
Switches, Relays and Motors

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.

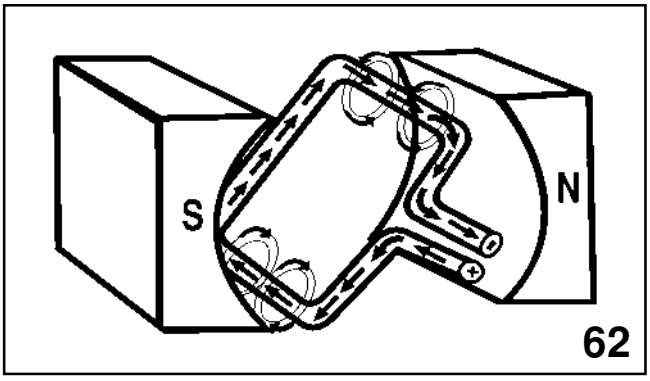
A multiple-position switch, such as a lighting switch, controls the flow of current to several components. Finally, a switch may work in conjunction with other switches, such as the four courtesy light switches in a four-door vehicle.





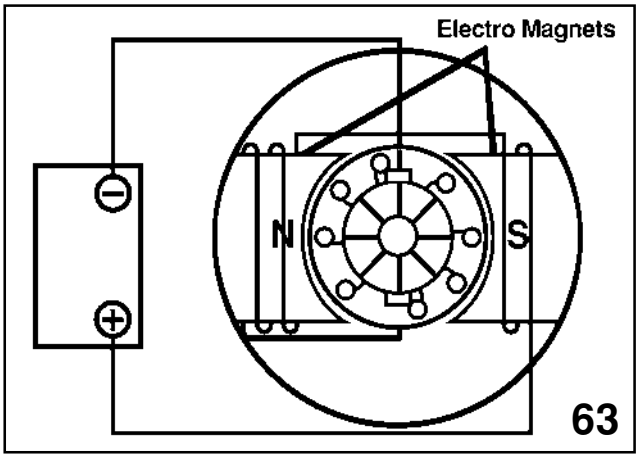
Relays

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.



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.

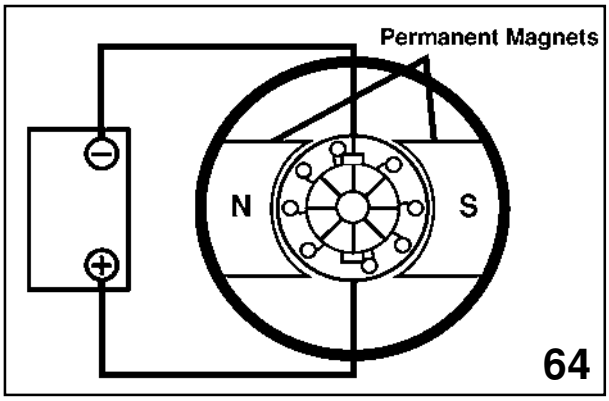


Motor operation

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.

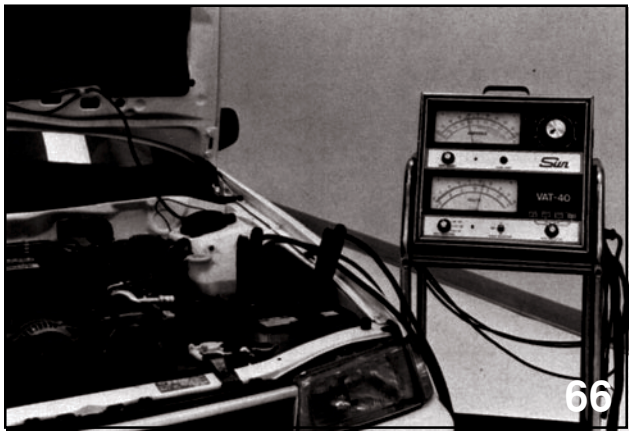
This force limits the current draw of the motor (armature) so that the motor only draws the amount of current to perform the job required. If the force required to perform the job exceeds the current capacity of the armature, the armature will stop rotating, the current will overheat the wires in the 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.

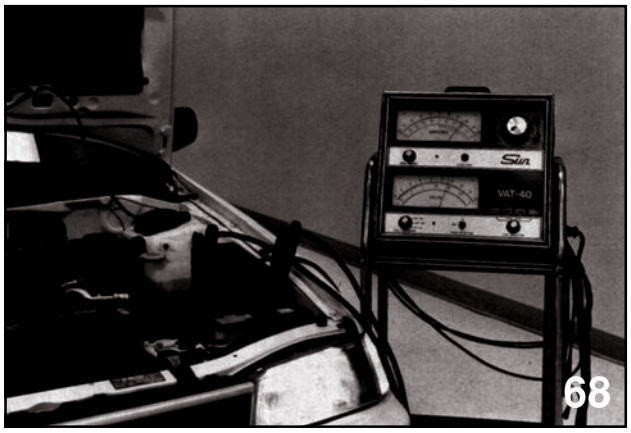


Alternator performance tests

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?

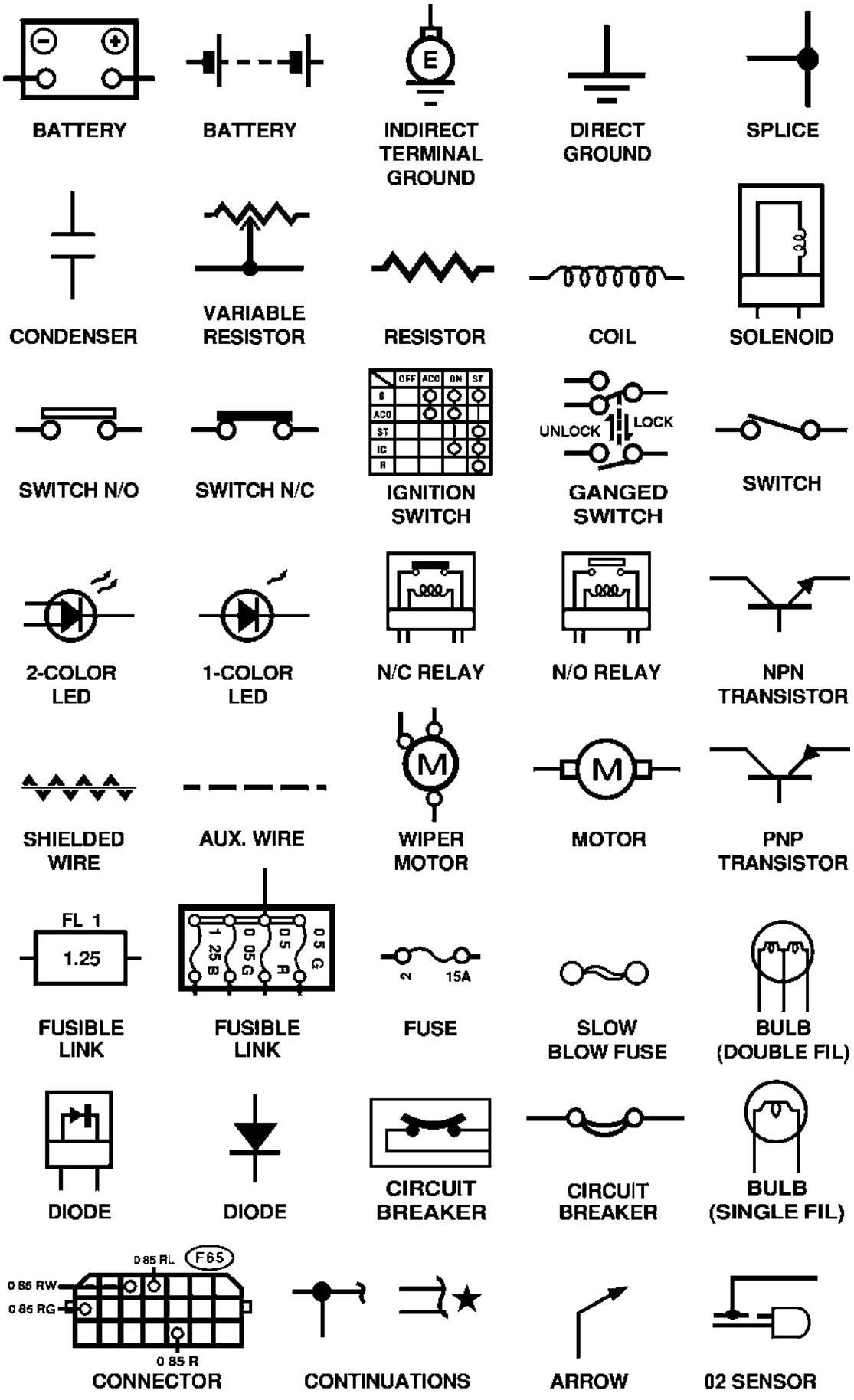
3. Isolate the problem. Use the split half technique*, the wiring diagram, and the wiring harness diagram to locate a short in a grounded circuit.

   *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
0.5 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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QUALITY DRIVEN®

SERVICE

CERTIFIED SUBARU TECHNICIAN©

Technicians Reference Booklet

Basic Emission and Fuel Systems

Module 405

MSA5P0160C

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Table of Contents

Slide Sequence 5
Slide Sequence 6
Introduction 8
Raw Materials For Combustion 8
Low Volatility - 9
High Volatility - 9
Phase Separation 9
Reformulated and Oxygenated Fuel 10
Octane 10
Atmosphere 10
Vacuum 10
Combustion Process 11
Catalytic Converter 13
Tumble Generator Valve 14
Oxygen Sensors 16
Closed Loop 17
Exhaust Gas Recirculation 18
Evaporative Emissions Control 19
On Board Refueling Vapor Recovery 22
Components include: 22
System Operation 22
While driving 22
While refueling 22
Pressure Sources Switching Operation 23
Fuel Delivery Quick Connector 23
Quick connector service procedure. 23
Engine Coolant Temperature Sensor 24
Crankcase Emission Control 24
State I/M Program Advisories Bulletins and Service Bulletins 28
405 Module Service Help-Line Updates 29

Slide Sequence

Slide No.	Description	page No.
1	Title Slide (Basic Emission and Fuel System)	
2	Created By	
3	Teaching Aids	
4	Title Slide (Introduction)	8
5	Beauty Shot Impreza, Legacy, SVX	8
6	Title Slide (Raw Materials for Combustion)	8
7	Legacy Mountain Shot	8
8	Storage Tank	9
9	Atmosphere (Pie Chart)	10
10	Vacuum	10
11	Intake Stroke	10
12	Ported Vacuum	11
13	Title Slide (Combustion Process)	11
14	Power Stroke	11
15	Combustion Process	11
16	Complete Combustion	11
17	Incomplete Combustion	12
18	Nitrogen During Combustion	12
19	NOx Production	12
20	Definitions	12
21	Condition 1, Condition 2	13
22	Condition 3, Condition 4	13
23	Condition 5, Condition 6	13
24	Catalytic Converter	13
25	Normal Catalytic Operation	13
26	SO_2 Production	14
27	Title Slide (Tumble Generator Valve)	14
28	Runner Intake	14
29	Stepper Motor	14
30	Vent Hose	14
31	TGV Sensor	15
32	Manifold Bottom View	15
33	TGV Passage	15
34	TGV Close / Open	15
35	Oxygen Sensor	16
36	0_2 Sensor	16
37	Voltage Chart	16
38	AFR (Artwork)	16
39	Title Slide (Closed Loop)	17
40	Closed Loop	17
41	Stoichiometric Window	17
42	Sea Level	17

Slide Sequence

Slide No.	Description	page No.
43	Title Slide (Exhaust Gas Recirculation)	18
44	EGR Conventional	18
45	Vacuum Diagram 1995 and Newer EGR	18
46	BPT Operation, Off	19
47	BPT operation, On	19
48	Title Slide (Evaporative Emissions Control)	19
49	Conventional Evaporative	19
50	Enhanced Evaporative	20
51	Canister	20
52	Pressure Control Duty Solenoid	20
53	Vent Control Solenoid Valve	20
54	Air Filter	21
55	Roll Over Valve Side In Normal Vehicle Position	21
56	Roll Over Valve Side With Vehicle On Its Side	21
57	Roll Over Valve Roof With Vehicle On Its Roof	21
58	Title Slide (System Operation)	22
59	While Driving	22
60	While Refueling	22
61	Title Slide (Pressure Sources Switching Operation)	23
62	1995 and Newer Manifold	23
63	Title Slide (Fuel Delivery Quick Connector)	23
64	Quick Connector	23
65	Quick Connector Service	23
66	Title Slide and Artwork (ECT) (Engine Coolant Temperature Sensor)	24
67	Title Slide (Crankcase Emission Control)	24
68	Light Load	24
69	Heavy Load	24
70	Copyright	
71	The End	

Introduction



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.



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 _____

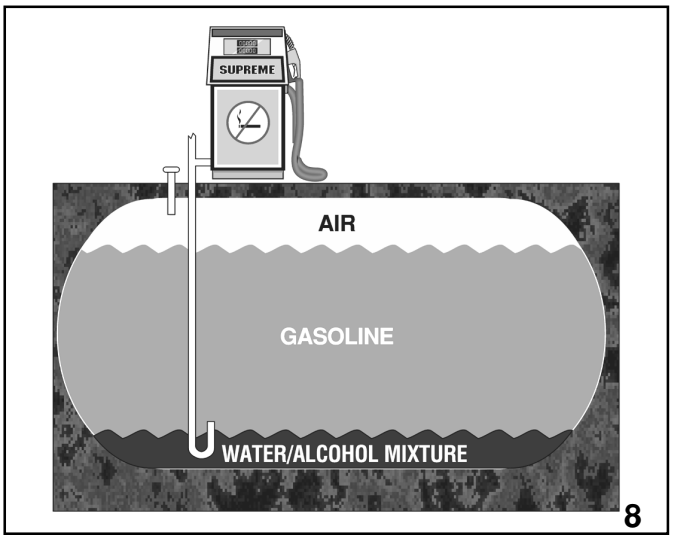
B _____

C _____

D _____

E _____

Higher volatile fuels will evaporate easier than lower volatile fuels so higher pressure readings will be achieved.



Storage Tank

Phase Separation

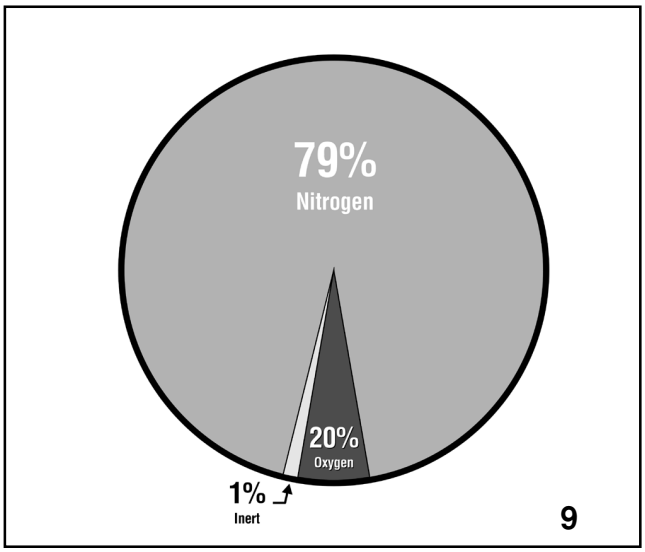
Another problem of today's' gasoline can be created if the fuel is stored in a water contaminated tank. Referred to as Phase separation, this condition results because of the use of alcohols as octane boosters and oxygenates. The alcohol in the gasoline will absorb the water in the tank and separate 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

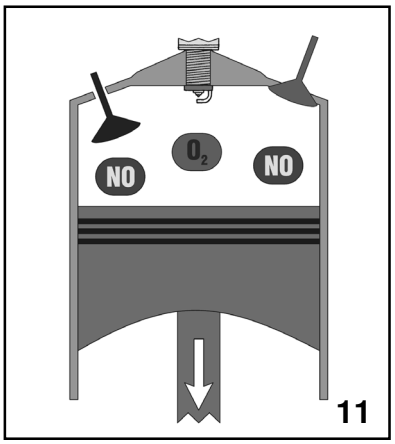


Atmosphere

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.

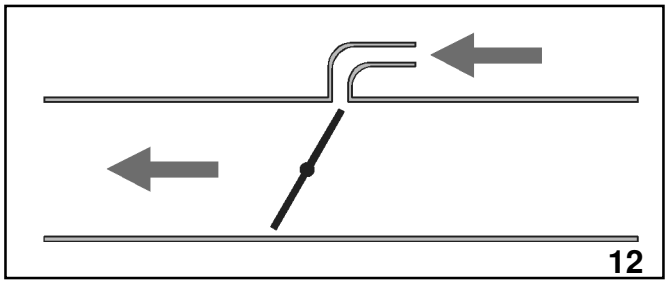
Vacuum



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.

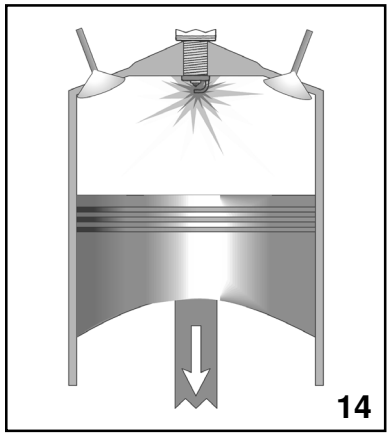
The second type is Ported vacuum. It is produced by the volume and speed of the air entering the engine. The positioning of the throttle plate determines the amount produced and at what spot in the throttle bore it is located. This effect enables the ported vacuum to be used as a working pressure and a controlling pressure.



Ported Vacuum

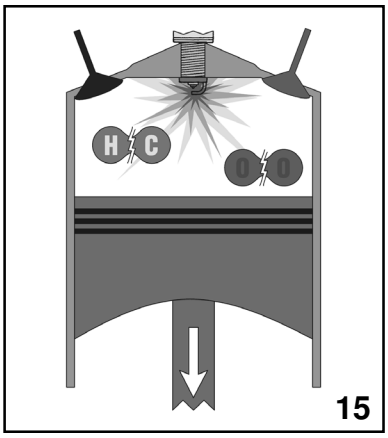
Combustion Process

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.



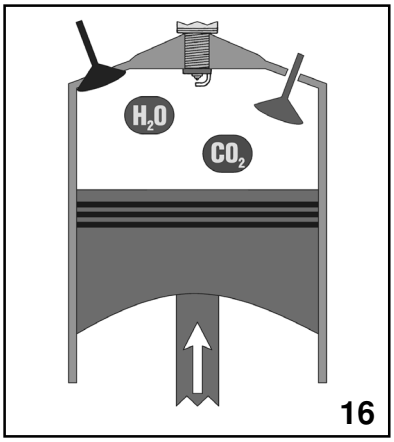
Power Stroke

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.



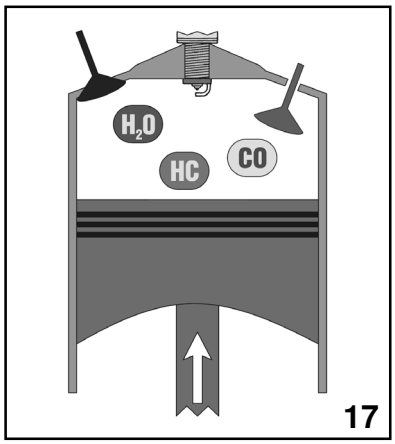
Combustion Process

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.



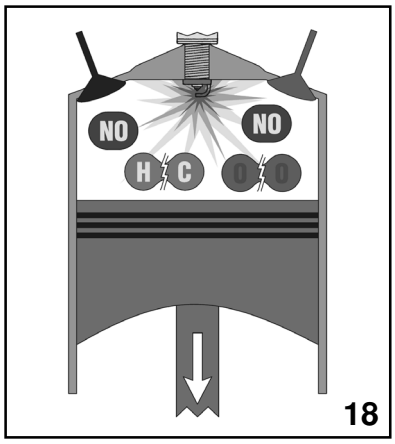
Complete Combustion

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.

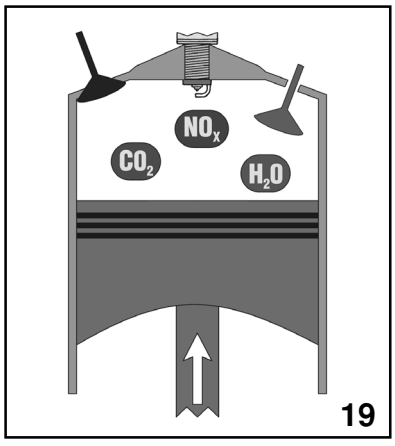


Incomplete Combustion

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.



Nitrogen During Combustion



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 (NOx) *Measured in PPM* Result of combustion chamber temperatures over 2500° F	**<400 PPM**

20

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

21

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

22

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

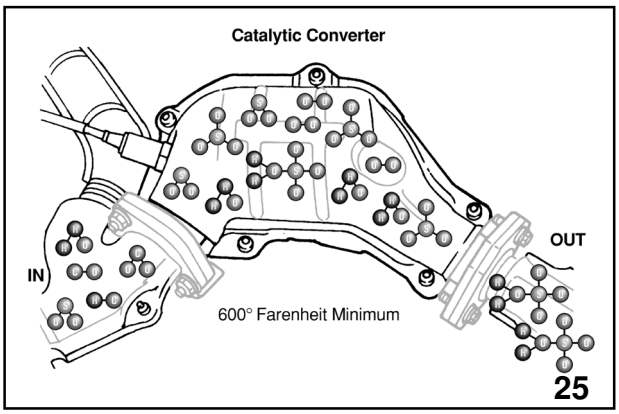
23

Condition 5: _____

Condition 6: _____

Catalytic Converter

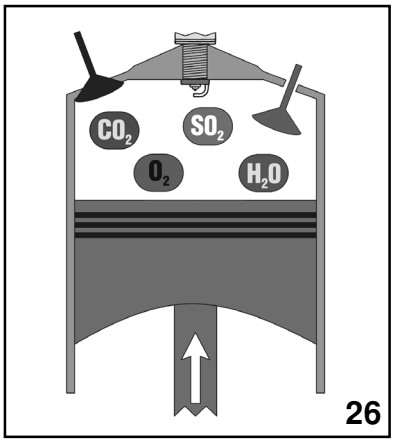
Reducing HC, CO and NOx is the objective of the catalytic converter. The converter is made of a honey comb ceramic structure held in place with a Nickel support shell all contained in a metal housing. Rare nobel metals, Platinum, Palladium and Rhodium, are adhered to the ceramic structure. These two 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.



25

Normal Catalytic Operation

The Nickel content of Catalytic converts has been reduced in recent years because of its natural ability as a reducing agent.

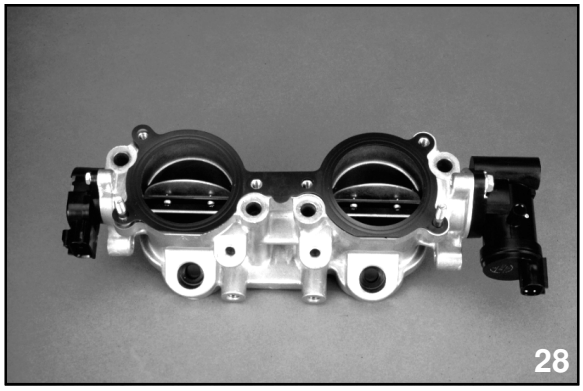


SO_2 Production

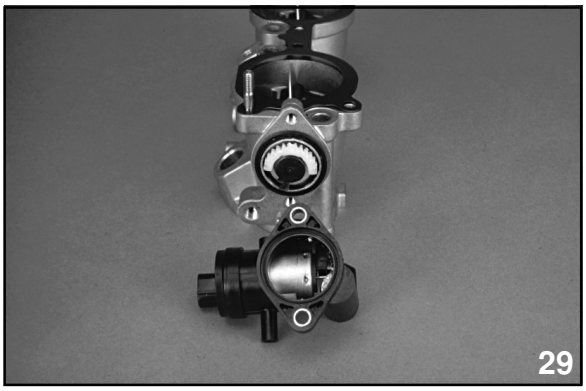
This characteristic normally is beneficial to the reduction of harmful emissions but if the fuel is sulfur contaminated the results is the production of Hydrogen Sulfide, H2S. Federal regulations state that there can only be 1/10 of 1% sulfur content in fuel. Removing sulfur from crude oil is an expensive 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

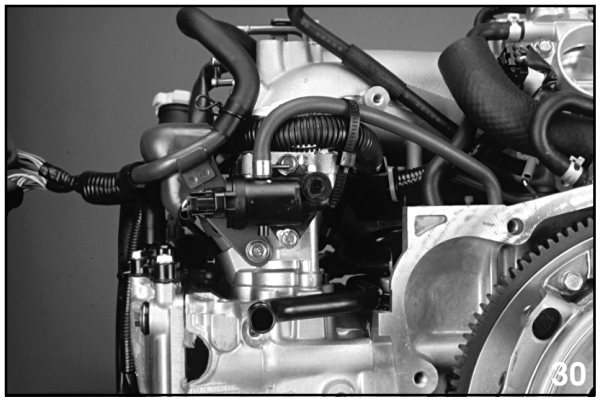


Runner Intake

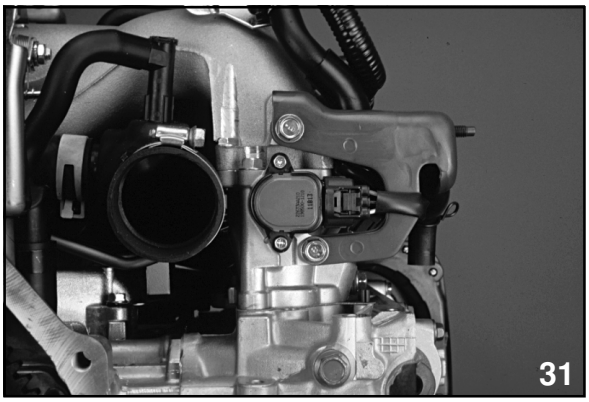


Stepper Motor

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.



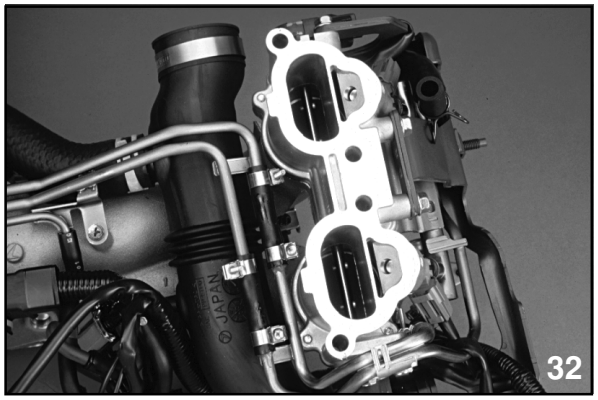
Vent Hose



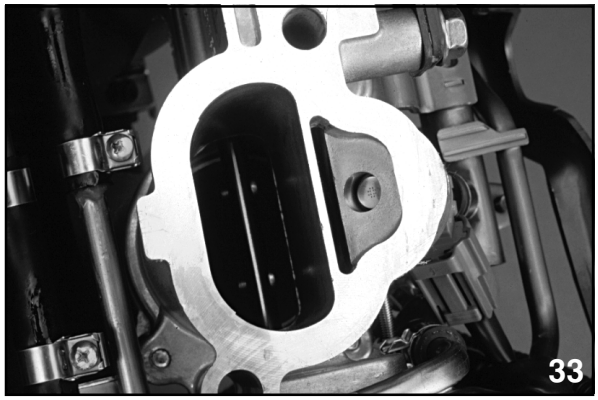
TGV Sensor

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.

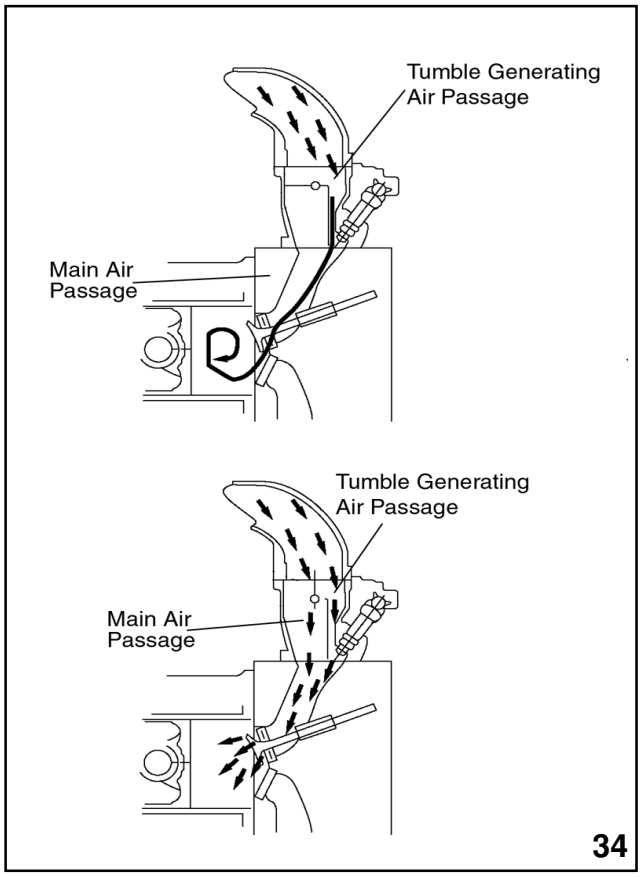


Manifold Bottom View



TGV Passage

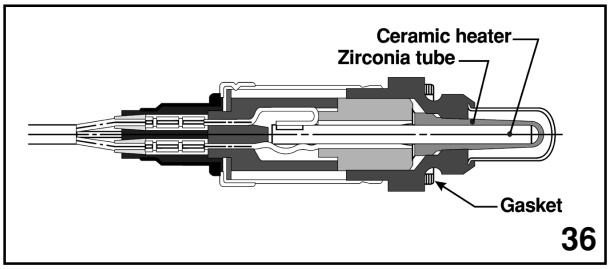
When the plate is closed the main air passage through the intake runner is blocked. This will force all air necessary for engine operation during idle to flow through the bypass channel. This action helps to mix the air fuel mixture by producing a tumbling effect to the incoming air, resulting in a cleaner operating engine while idling.



TGV Close / Open

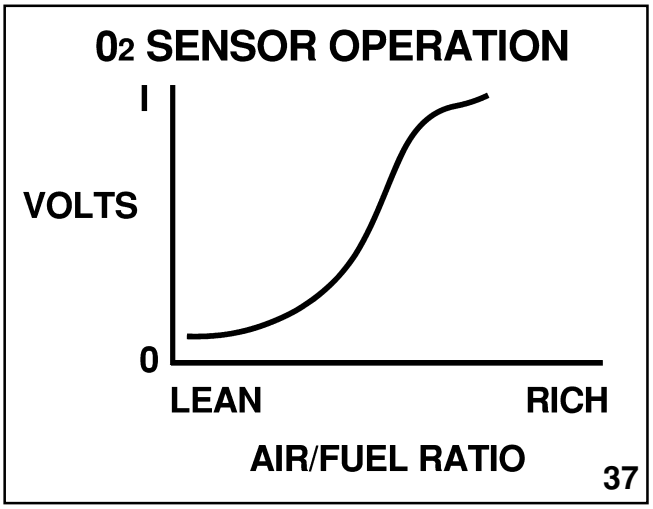
Oxygen Sensors

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

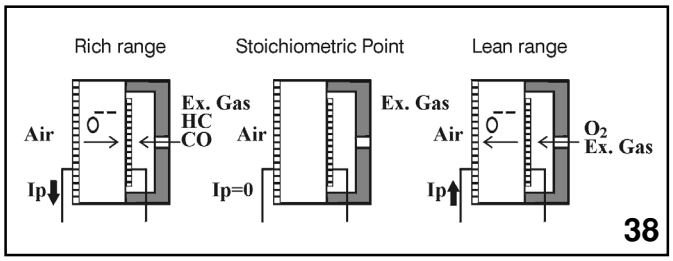
The oxygen sensor after reaching an operating temperature of 600° F (315.55 C) compares the oxygen content of the atmosphere to the oxygen content of the exhaust. Materials making up the oxygen sensor generate a small voltage that represents the air fuel mixture. This electrical signal is sent to the 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.

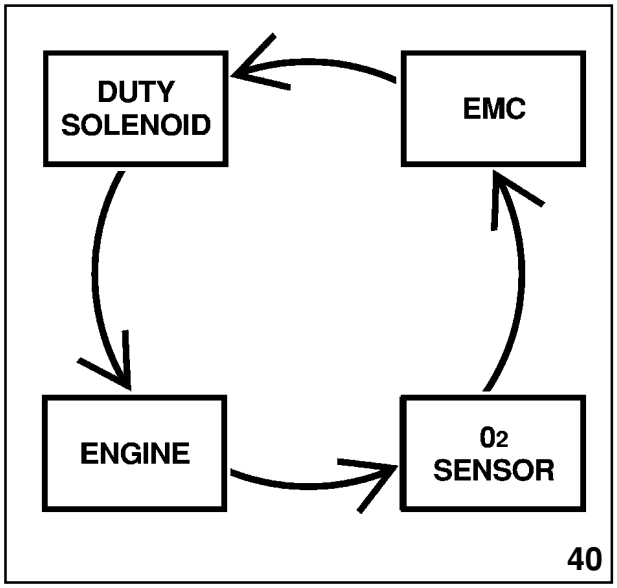
The Air Fuel Ratio Sensor is used on 1999 California Models. Located in place of the front Oxygen Sensor, the AFR begins to operate and effect the Air Fuel Ratio faster than conventional Oxygen Sensors. Zirconia remains the key material in AFR construction. It's ability to absorb oxygen and new ECM circuitry 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

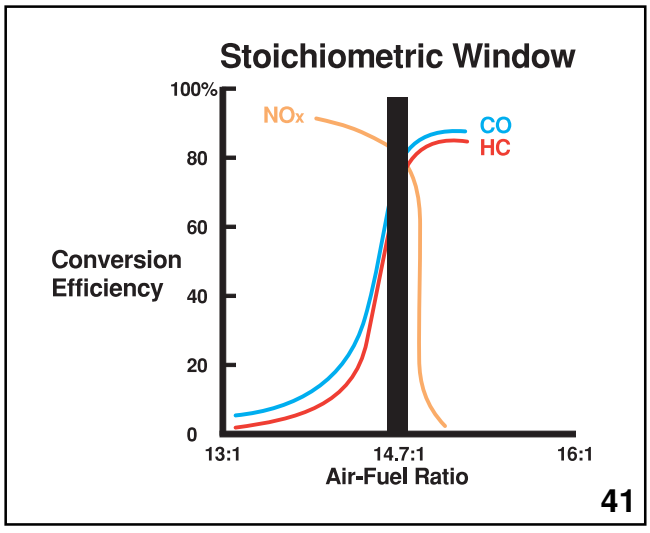


Closed Loop

Closed loop is a description of fuel injection and engine management operation where both systems are monitored and adjusted.

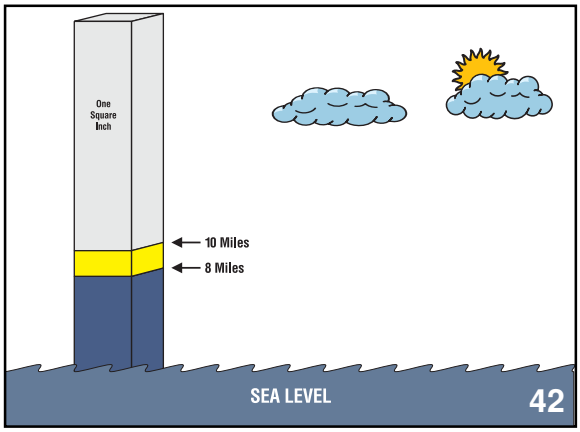
Closed loop relies on input from sensors that monitor engine operation. Providing precise control to increase power and reduce emissions.

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

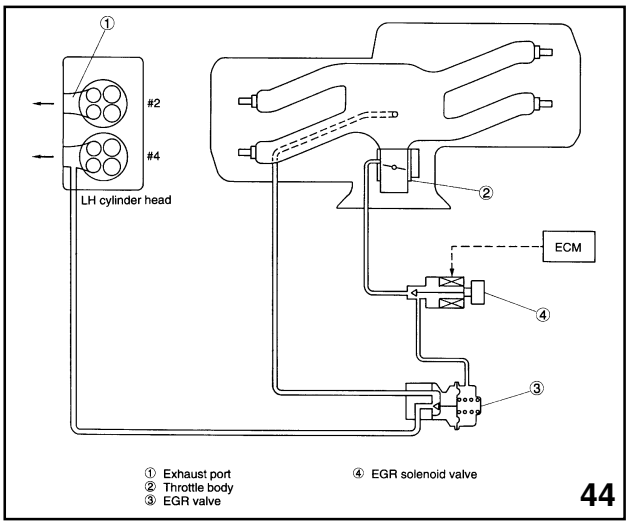
Maintaining the ideal air fuel mixture that creates the most power and lowest emissions is referred to as Stoichiometric. At sea level the weight of the atmosphere is 14.7 pounds per square inch. This column of air extends from the ground to approx. 110 miles straight up. This 14.7 psi burned with 1 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



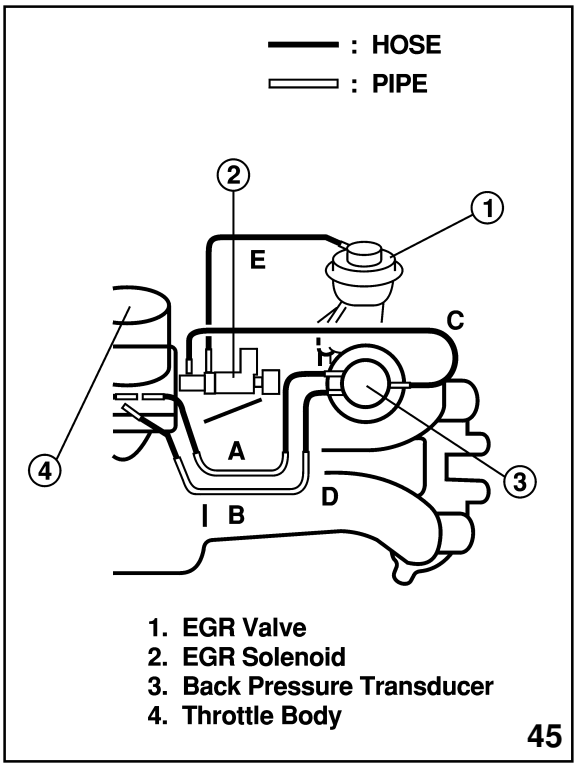
Exhaust Gas Recirculation

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.

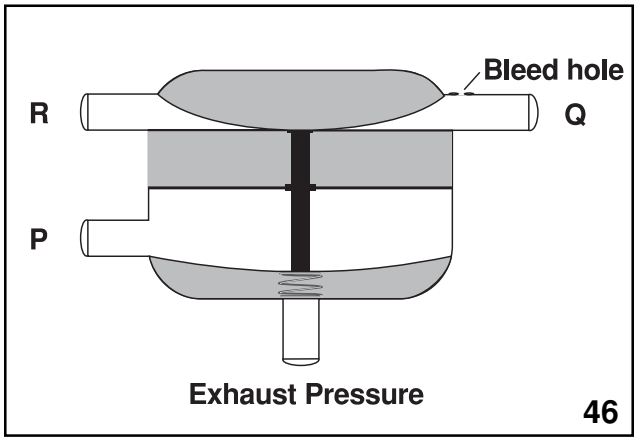
The EGR valve is operated with a ported vacuum signal that is controlled by the EGR solenoid. Solenoid activation is dependent on ECM logic.

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.

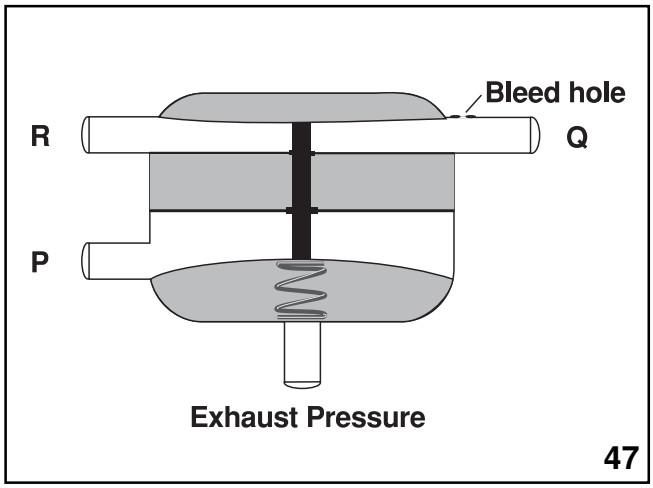
This action continues during all engine operation, however the EGR valve will not operate until the ECM grounds the EGR solenoid.



Vacuum Diagram
Most 95 and Newer EGR



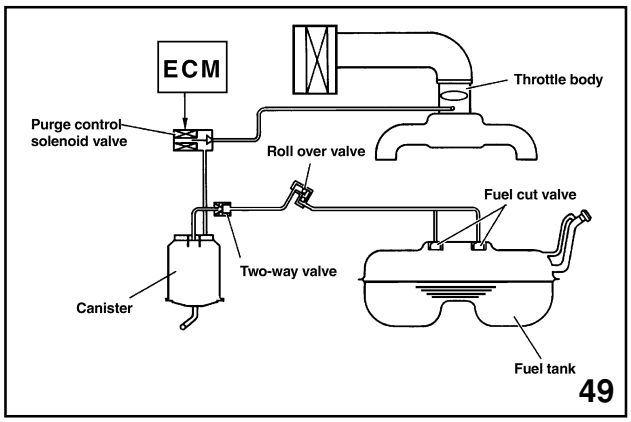
BPT Operation
EGR Off



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.



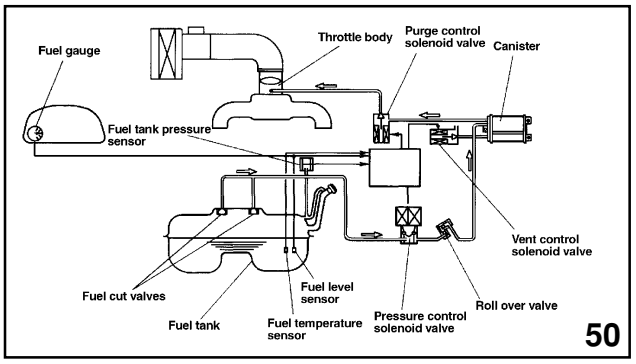
Conventional Evaporative System

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.

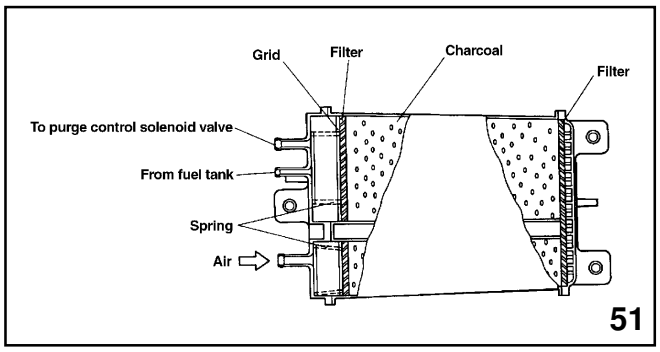
System operation - The ECM grounds the purge control solenoid turning it on. Ported vacuum then removes the stored evaporative gas from the canister. System activation is controlled using coolant temperature engine load and vehicle speed input.



Enhanced Evaporative System

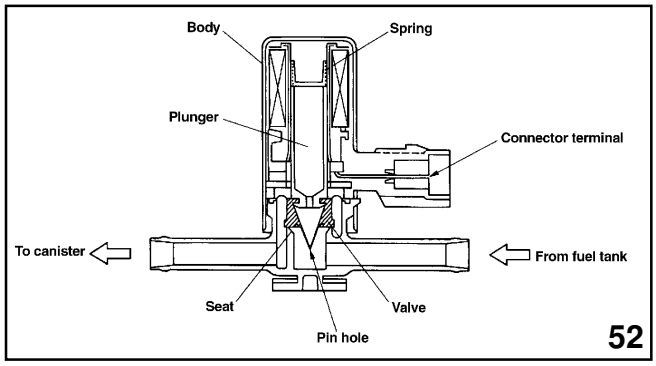
Enhanced Evaporative components include:

1. Canister - Function is unchanged, however the shape is more boxy and is located under the right rear of the vehicle.



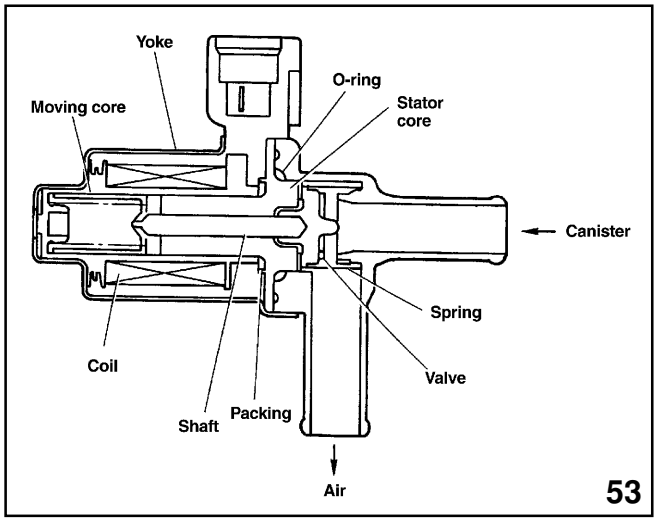
Canister

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.



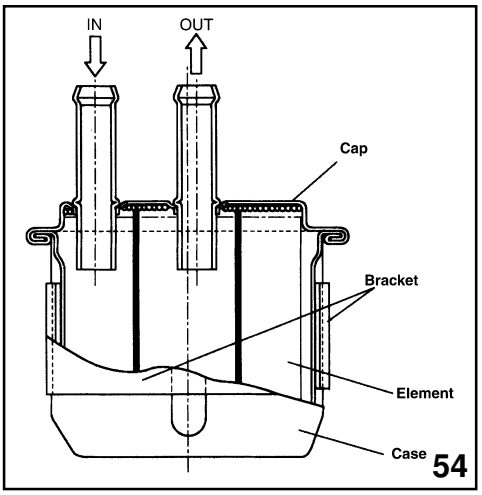
Pressure Control Duty Solenoid

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

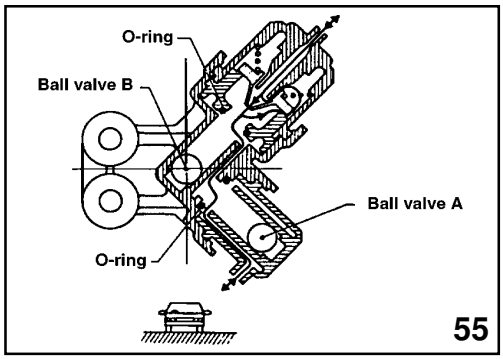
5. Fuel Tank Pressure Sensor - Monitors fuel tank pressure and sends an input signal to the ECM.

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.

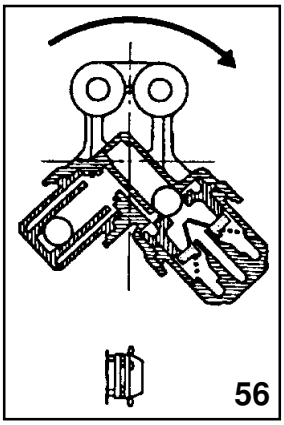
High fuel tank pressure - Pressure control solenoid valve open.

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.

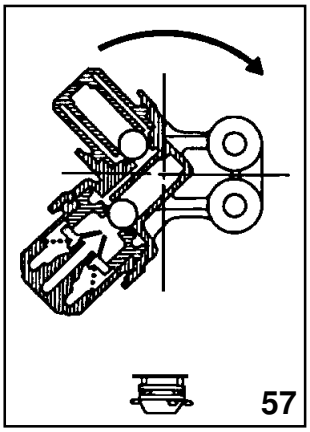


Roll Over Valve In Normal Vehicle Position

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.

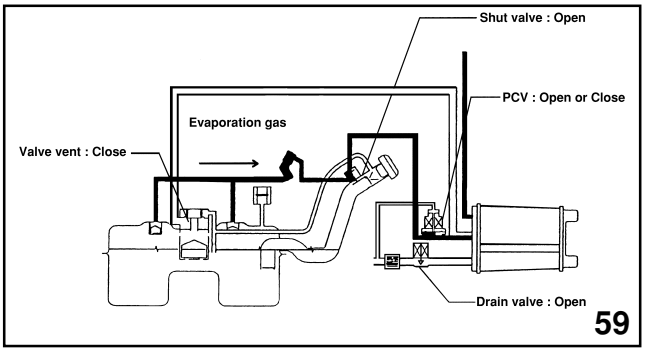
ORVR controls the pressure inside the fuel tank and collects fuels vapors during all vehicle operating conditions and during the time the vehicle is being refueled.

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

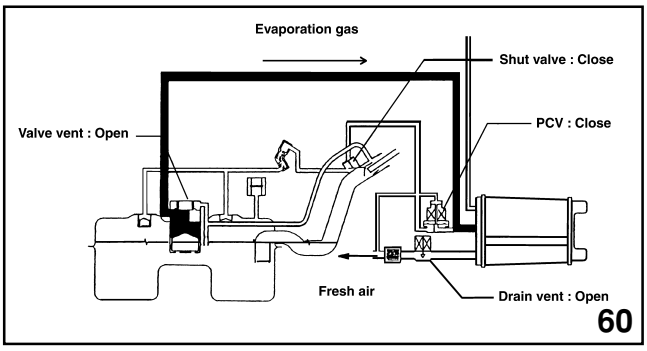
The fuel tank pressure is applied to one side of diaphragm inside the Pressure Control Valve.

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.

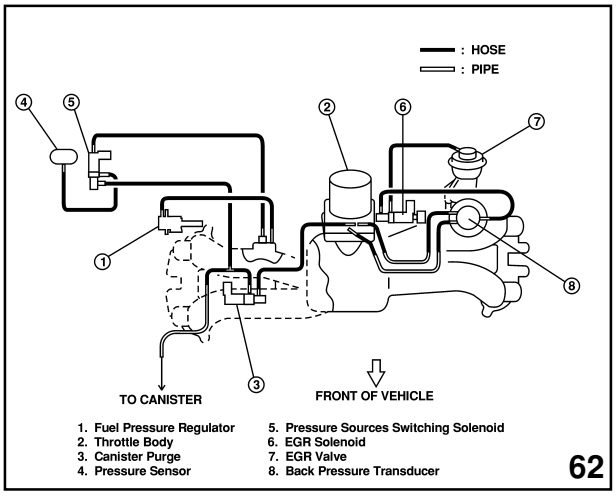
The continued filling of the tank pushes the remaining air and fuel vapors through the cannister. The charcoal element of the cannister absorbs the fuel vapors an directs fuel vapor free air to the atmosphere though the Drain valve and air filter.



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.

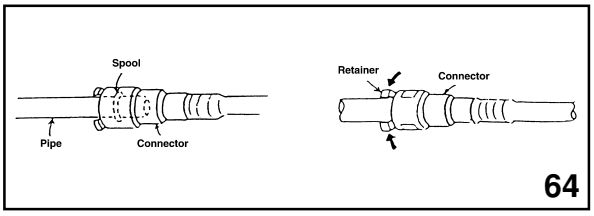
The Pressure sensor Functions to monitor manifold and atmospheric pressure. PSSS position determines pressure source. Changes in pressure positive or negative produce a changing reference voltage signal. Reference voltage signal changes are used to influence ignition timing and injection duration.

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

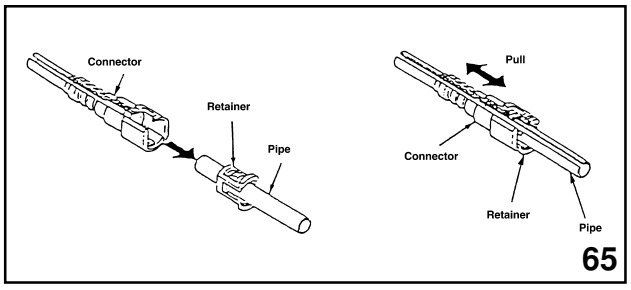
Quick connector service procedure.

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.

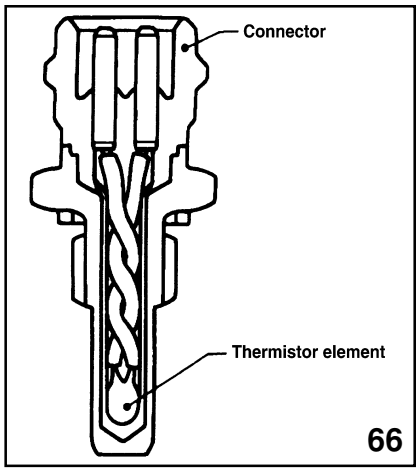
Confirm connection by pulling the connector backward. Also check that the two pawls of the retainer are engaged to the connector.

Replacement part is the retainer only.



Quick Connector Service

Engine Coolant Temperature Sensor

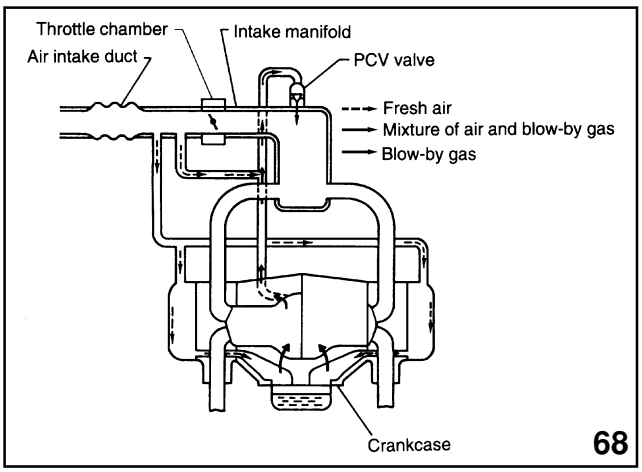


ECT

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.

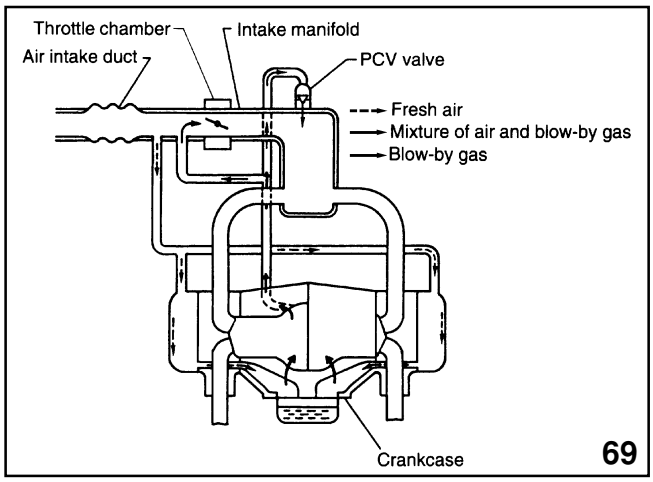
Crankcase Emission Control

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:

Notes:

Notes:

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

MSA5P0131C

AUTOMOTIVE Youth Educational Systems YES

Technical Training

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Boxer Engine Series Module

Table of Contents

Slide Sequence 5
Introduction 10
General Overview 10
    2.2L Engine Identification 10
2.2L Engine (Phase 1) Features 11
2.2L Engine Servicing & Diagnostics 15
    In Vehicle Servicing 15
    Engine Diagnostics 15
2.2L Engine Disassembly 16
2.2L Component Inspection and Servicing 21
    Precautions 23
2.2L Engine Reassembly 24
Notes and Cautions 28
    2.2L Engine Disassembly 28
    2.2L Engine Reassembly 29
Engine Enhancements 2.2 Liter (Phase 1) 29
Other Engine Modifications 31
1999 2.2 Liter (SOHC) (Phase 2) Engine Enhancements 31
New Features of the Phase Two Engines 32
2.5 Liter Engine Features 35
    Spark Plug Replacement Procedure for 2.5 Liter Engine 37
    Installation 37
1997 2.5 Engine DOHC (Phase 1) 38
2.5 Engines 1999 Enhancements DOHC (Phase 1) and SOHC (Phase 2) 41
New Features of the 2.5 Liter (Phase 2) SOHC Engines 42
2.0 Liter Engine Features 45
3.0 Liter Engine 48
    General Information 48
    3.0 Liter Engine Features 48
    3.0 Specifications 48
3.0 Liter Engine Disassembly 51
    Unloading Cam Sprockets 55
    Removal of Oil Pump 57
    O-Ring Placement Inner Cover 58
    Removal of Cylinder Head 58
    Removal of Oil Pan 59
    Piston Pin Access 60
    Spliting Block Halves 60
    Lubrication System 61
    Coolant System 62
    Valve Adjustment 63
    Chain Tensioners 64
3.0 Liter Engine Reassembly 65
Fuji Bond Application Guide for Block Halves 69
    Oil Pan Extension Housing (Upper Oil Pan) 70
    Fuji Bond Application Guide for Oil Pan (Lower) 71
    Fuji Bond Application Guide for Inner Cover 72
    Fuji Bond Application Guide for Outer Cover (Front Chain Cover) 73
3.3 Liter Engine Service Procedures 74
Special Tools 80
    General Hand Tools and Supplies 80
Reference Materials 80
Service Bulletins 82
104 Module Service Help-Line Updates 83

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (Boxer Engine Series Module)	
2	Created By	
3	Teaching Aids	
4	Introduction	10
5	General Overview	10
6	Engine Identification (Artwork)	10
7	Specifications (Artwork)	10
8	Engine Identification Numbers	10
9	Title Slide (2.2L Engine (Phase 1) Features	11
10	Cylinder Head Design (Artwork)	11
11	Combustion Chamber	11
12	Valve Components	11
13	N/A Camshaft Supports	12
14	Rocker Shaft Assembly (Artwork)	12
15	Hydraulic Lash Adjusters	12
16	Head Gaskets	12
17	Crankcase Half	13
18	Crankshaft Assembly	13
19	Connecting Rods	13
20	N/A Pistons	13
21	Cam Belt System	14
22	Cam Belt Covers	14
23	Water Pump Assembly-Cooling System	14
24	Oil Pump	14
25	Oil Pump Cross Section (Artwork)	15
26	Title Slide (2.2L Engine Servicing & Diagnostics)	15
27	Title Slide (2.2L Engine Disassembly)	16
28	Engine on Stands	16
29	Remove Crank Pulley	16
30	Mark Cam Belt	16
31	Remove Idler Pulleys	16
32	Remove Camshaft Sprockets	17
33	Camshaft Sprockets	17
34	Tensioner Bracket Removal	17
35	Inner Cam Belt Cover Removal	17
36	Engine Accessory Removal	18
37	Remove the Water Transfer Pipe	18
38	Remove Knock Sensor	18
39	Remove Crank Angle Sensor	18
40	Remove Cam Angle Sensor	18
41	Remove Water Pump	19
42	Remove Oil Pump	19
43	Cylinder Head Removal	19
44	Remove Oil Pan	19
45	Piston Pin Removal	20
46	Crankcase Hidden Bolts (Right Bank)	20
47	Crankcase Hidden Bolts (Left Bank)	20
48	Crankcase Half with O-Rings	20
49	Title Slide (2.2L Component Inspection and Servicing)	21
50	Cylinder Head Disassembly	21
51	HLA Removal	21
52	Refilling HLAs	21
53	Depressing HLA Check Ball	21
54	Filling the HLA Sockets	22
55	Installing HLAs	22

Slide Sequence

Slide No.	Description	Page No.
56	Tensioner Inspection	22
57	Rocker Arm Inspection	22
58	Valve Guide Removal	23
59	Valve Components	23
60	Installing Valve Guides	23
61	Installing Valve Guides Oil Seal	23
62	Installing the Oil Seal	24
63	Storing Cylinder Heads	24
64	Title Slide (2.2L Engine Reassembly)	24
65	Assemble Crankshaft	24
66	Crankcase Sealer and O-Rings	24
67	Piston Installation	25
68	Circlip Removal	25
69	Installing Oil Pick-Up Tube	25
70	Oil Pan Drain Tube Seal	25
71	Dipstick Tube and Seals	26
72	Installing Rear Crankshaft Oil Seal	26
73	Installing Oil Pump	26
74	Cylinder Head Torque Sequence	26
75	Compressing the Tensioner	27
76	Cam Sprocket Installation	27
77	Installing Idler Pulleys	27
78	Loading Tensioner	28
79	Remove Retaining Pin	28
80	Install Cam Belt Cover / Accessories	28
81	Title Slide (Notes and Cautions)	28
82	Title Slide (Engine Enhancements 2.2 Liter (Phase 1))	29
83	Redesigned Piston	29
84	2.2 Liter Valve Train Assembly	30
85	Cylinder 1 (Artwork)	30
86	Cylinder 3 (Artwork)	30
87	Cylinder 2 (Artwork)	30
88	Cylinder 4 (Artwork)	30
89	Measuring Valve Clearance	31
90	Adjusting Valve Clearance	31
91	Other Engine Modifications	31
92	Title Slide (1999 2.2 Liter (SOHC) (Phase 2) Engine Enhancements)	31
93	Mounting Holes and Studs	31
94	Thrust Bearing	31
95	Main Bearing Oil Grooves	32
96	Title Slide (New Features of the Phase Two Engines)	32
97	Valve Train	32
98	New Head Gasket Design	32
99	Identification of Rocker Arms	32
100	Roller Rockers	32
101	Adjustment Screw and Nut	33
102	Camshaft Secured by Camcase	33
103	Camcase Sealing Passages	33
104	Groove Edges	33
105	Identification Marks of Rocker Arms	34
106	Torque Specs and Measurements	34
107	Bolts Sequence	34
108	Engine Cam belt Timing Marks Locations	34
109	Right Bank Timing Mark	35
110	Open Deck Design	35
111	New Piston Design	35

Slide Sequence

Slide No.	Description	Page No.
112	Title Slide (2.5 Liter Engine Features)	35
113	2.5 Liter Engine	35
114	Camshaft Sprocket (Left Bank) (Rear)	35
115	Camshaft Sprocket Timing Marks (Left Bank)	35
116	Valve Interference	36
117	Camshaft Sprocket Timing Marks (Right Bank)	36
118	Camshafts	36
119	2.2 and 2.5 Liter Head Gaskets	37
120	Valve Spring Assembly	37
121	Direct Type HLA	37
122	Spark Plug Removal	37
123	Title Slide (1997 2.5 Engine DOHC (Phase 1))	38
124	Redesign 2.5 Liter Piston	38
125	2.5 Liter Valve Assembly	38
126	2.5 Liter Head on the Car	38
127	Bucket and Shim Assembly	39
128	Identifying Shim Size	39
129	Checking Valve Clearance On The Car	39
130	Exhaust Valve Clearance on Cylinders 1 and 3	40
131	Intake Valve Clearance on Cylinders 1 and 3	40
132	Exhaust Valve Clearance on Cylinder 2 and 4	40
133	Intake Valve Clearance on Cylinders 2 and 4	40
134	Title Slide (2.5 Engines 1999 Enhancements DOHC (Phase 1) and SOHC (Phase 2))	41
135	Engine to Transmission Mounting	41
136	Thrust Bearing Location	41
137	Main Bearing Oil Grooves	42
138	Title Slide (New Features of the 2.5 Liter (Phase 2) SOHC Engines)	42
139	2 Rocker Shaft Assembly	42
140	New Head Gasket Design	42
141	Rocker Arm Identification	42
142	Roller Rockers and Wave Washers	42
143	Adjustment Screw and Nut	43
144	Camshaft Secured by Camcase	43
145	Camcase Sealing Points	43
146	Sealing Groove	43
147	Rocker Identification	44
148	Rocker Arm Measurements	44
149	Camcase Tightening Sequence	44
150	Timing Belt Marks	44
151	Right Bank Timing Mark Window	44
152	Open Deck Design	45
153	Piston with Valve Release	45
154	Title Slide (2.0 Liter Engine Features)	45
155	2.0 Liter Engine	45
156	Cam Belt and Idler Pulleys	45
157	Intake Camshaft Sprocket Timing Marks (Left Bank)	46
158	Exhaust Camshaft Sprocket Timing Marks (Left Bank)	46
159	Intake Camshaft sprocket Timing Marks (Right Bank)	46
160	Exhaust Camshaft Sprocket Timing Marks (Right Bank)	46
161	Engine Designation Number	47
162	Factory Coolant Pipe Plug	47
163	2.0 Liter Valve Train Assembly	47
164	2.0 Liter Head Bolt Access	47
165	Turbo Oil and Coolant Passages (Right Bank)	47
166	Crankshaft and Camshaft sprockets for the 2.0 Turbo Engine	47
167	Title Slide (3.0 Liter Engine)	48

Slide Sequence

Slide No.	Description	Page No.
168	3.0 Liter Engine with Stands	48
169	Single Serpentine Belt	48
170	Belt Wear Indicator	48
171	Upper Radiator Hose connections	49
172	Oil Cooler	49
173	Individual Coils	49
174	Coil and Igniter Assembly	49
175	Lower Radiator Hose	49
176	Oil Pan and Extension Case	50
177	Crankcase Ventilation System	50
178	Crank Angle Sensor with Reluctor	50
179	Title Slide (3.0 Liter Engine Disassembly)	51
180	Unloading Tensioner	51
181	Fuel Rail Assembly	51
182	Lower Alternator Bolt	51
183	Remove Accessories	51
184	Crankshaft Bolt Cover	51
185	Crankshaft Bolt Seal	52
186	Outer Cover Seals	52
187	Outer Cover Bolts	52
188	Timing Chain Routing	52
189	Timing Chain Oil Jet	53
190	Right Bank Camshafts	53
191	Left Bank Timing Marks	53
192	Camshaft Sprockets	53
193	Timing Chains	54
194	Removal of Right Bank Timing Chain Components	54
195	Removal of Left Bank Timing Chain Components	54
196	Turn Crankshaft to Prevent Piston and Valve Damage	54
197	Right Bank Camshafts in Loaded Position	55
198	Unloading Intake Camshaft	55
199	Unloading Intake Camshaft	55
200	Unloading Exhaust Camshaft	55
201	Unloading Exhaust Camshaft	56
202	Remove Camshaft Sprockets (Right Bank)	56
203	Remove Camshaft Sprockets (Left Bank)	56
204	Water Pump Assembly	56
205	Insert Bolts for Pump Removal	57
206	Oil Pump Cover	57
207	Chain Guide	57
208	Chain Guide Bolts	57
209	Oil Relief Valve Housing	58
210	Inner Cover	58
211	O-Ring Locations	58
212	Valve Train Assembly	58
213	Cylinder Block with Head Gasket	59
214	Open Deck Design	59
215	Oil Pan (Upper)	59
216	Oil Pan (Lower)	59
217	Oil Pan Bolt Locations	59
218	Block O-Ring Locations	60
219	Piston Pin Access (Front View)	60
220	Piston Pin Access (Rear View)	60
221	Engine Block Assembly Bolts (Right Bank)	60
222	Main Bearings	61
223	Crankshaft and Connecting Rods	61

Slide Sequence

Slide No.	Description	Page No.
224	Oil Flow (Artwork)	61
225	Pump Gears (Front Side)	61
226	Pump Gears (Back Side)	62
227	Relief Valve Case (Front Side)	62
228	Relief Valve Case (Back Side)	62
229	Coolant Flow (Artwork)	62
230	Water Pump Housing	63
231	Water Jackets (Left Hand Bank)	63
232	Head Gaskets Coolant Passages	63
233	Cintered Camshafts	63
234	Camshaft Sensor Reluctor	63
235	Valve Adjustment Tool	64
236	Valve Adjustment Tool Placement	64
237	Adjusting Bucket Depression Finger	64
238	Chain Tensioners (Left Bank and Right Bank)	64
239	Worm Gear Assembly	65
240	Title Slide (3.0 Liter Engine Reassembly)	65
241	Crankshaft Timing Mark	65
242	Left Bank Intake Camshaft Timing Mark	65
243	Left Bank Exhaust Camshaft Timing Mark	65
244	Matching Links to Timing Marks (Left Bank)	66
245	Installing Guides and Idlers (Left Bank)	66
246	Loading Exhaust Camshaft (Right Bank)	66
247	Loading Exhaust Camshaft (Right Bank)	66
248	Loading Intake Camshaft (Right Bank)	67
249	Loading Intake Camshaft (Right Bank)	67
250	Aligning TDC Mark	67
251	Intake Camshaft Timing Marks (Right Bank)	68
252	Exhaust Camshaft Timing Marks (Right Bank)	68
253	Lower Idler Timing Marks	68
254	Chain Guides and Idlers (Right Bank)	68
255	Fuji Bond Application Guide for Block Halves	69
256	Oil Pan Extension Housing (Upper Oil Pan)	70
257	Fuji Bond Application Guide for Oil Pan (Lower)	71
258	Fuji Bond Application Guide for Inner Cover	72
259	Fuji Bond Application Guide for Outer Cover (Front Chain Cover)	73
260	Title Slide (3.3 Liter Engine Service Procedures)	74
261	Camshaft Sprocket Alignment	74
262	Camshaft sprocket Alignment (Right Bank)	74
263	Camshaft Sprocket Alignment (Left Bank)	74
264	Camshaft Sub-Gear Servicing	74
265	Two Piece Gear	75
266	Sub-Gear Spring	75
267	Piston Pin Circlip Removal	75
268	Piston Pin Removal	75
269	Piston Removal	76
270	Piston Installation	76
271	Install Intake Camshaft	76
272	Install Intake Camshaft	76
273	Front Camshaft Cover Installation	77
274	Exhaust Camshaft Oil Seal Installation	77
275	Left Camshaft Sprocket	77
276	Crankshaft Sprocket Installation	78
277	Cam Belt Installation (Right Bank)	78
278	Cam Belt Installation (Crankshaft)	78
279	Cam Belt Installation (Left Bank)	78

Boxer Engine Series Module

Introduction

This Technicians Reference Booklet introduces the Subaru 2.2 liter (SOHC) naturally aspirated (N/A), (Phase 1) and (Phase 2) engines, the 2.5 liter (DOHC) (Phase 1) and (SOHC) (Phase 2) engines, the 2.0 liter Turbo engine and the 3.0 and 3.3 liter six cylinder engines

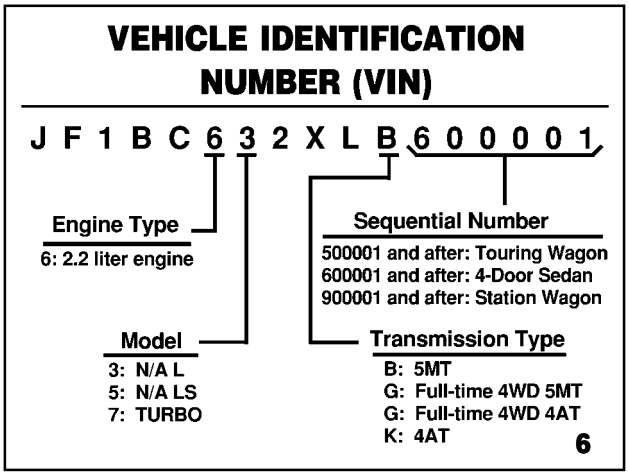
It reviews the mechanical features of these engines and the differences between existing engines. It also covers the procedures used in diagnosing and overhauling these engines. The text and illustrations are derived from and follow the classroom lectures and slide presentations and they are intended to supplement and reinforce classroom instruction and serve as a home-study reference source. A list of applicable Service Bulletins, Important Notes and Cautions, and Special Tools are given within this booklet. Pages for Diagnostic Tips and Notes are also provided.

Technicians worksheets are to be completed during the hands-on lab work segments of the Boxer Engine Series Module.

Always refer to the appropriate model year Subaru Service Manual and the applicable service bulletins for all specification and detailed servicing procedures.

General Overview

2.2L Engine Identification



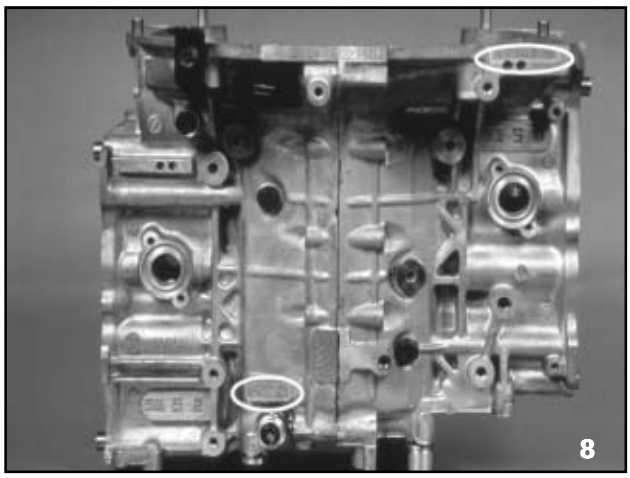
Engine Identification

The 2.2L engine designation is the sixth digit of the vehicle identification number (VIN). It is important to always first identify the engine before beginning diagnosis and servicing. Body type and transmission type, as well as the model year, are also information pertinent to engine diagnosis and servicing. As shown in the illustration, all this information is available from the VIN and the appropriate service manual.

Specifications

Displacement.....2.2 Liters (2212cc)
Bore and Stroke:....3.815 in. x 2.953 in.
96.9mm x 75mm
Compression Ratio:....9.5:1 (1995)
9.7: 1 (1996-98)
10: 1 (1999 & Later)
Firing Order:.....1 - 3 - 2 - 4
Odd numbers: right bank
Even numbers: left bank
Max. Power....135 HP @ 5400 RPM (1995-96)
137 HP @ 5400 RPM (1997-98)
142 HP @ 5600 RPM (1999 & Later)
Max. Torque: 140 Ft. Lbs. @ 4400 RPM 1995-96)
145 Ft. Lbs. @ 4000 RPM (1997-98)
149 Ft. Lbs. @ 3600 RPM (1999 & Later)
7

2.2L N/A Engine

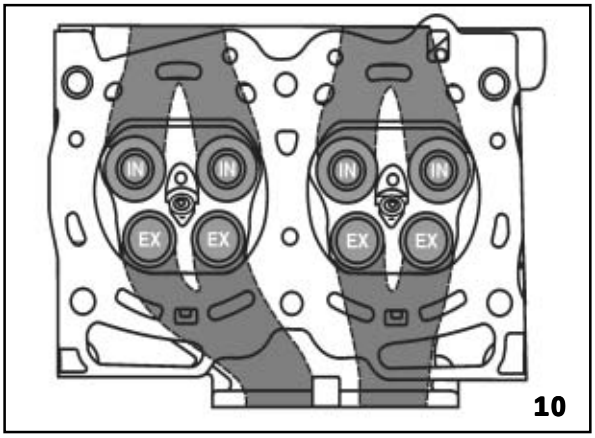


Engine Serial and Designation Number

The engine serial number is located on the machined boss on the left side of the clutch housing. The 2.2L engine designation is EJ22.

2.2L Engine (Phase 1) Features

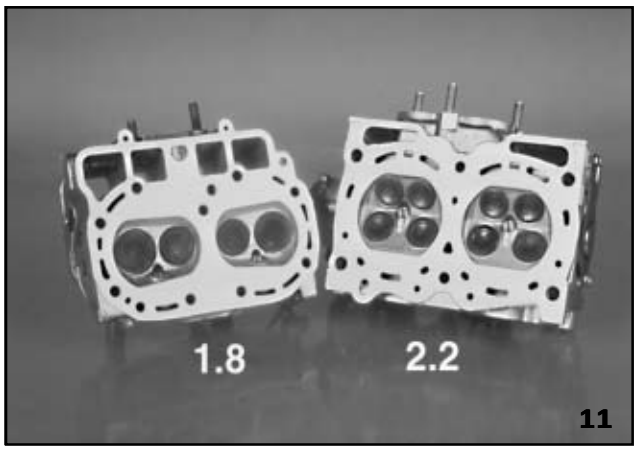
The 2.2L SOHC four valves per cylinder engine is an addition to the existing Subaru "Boxer" design. The horizontally opposed, 4 stroke, 4 cylinder, liquid cooled, gasoline engine has aluminum alloy block and heads. It uses a normally aspirated MPI system. The cylinder liners are of a cast iron dry type design.



Cylinder Head Design

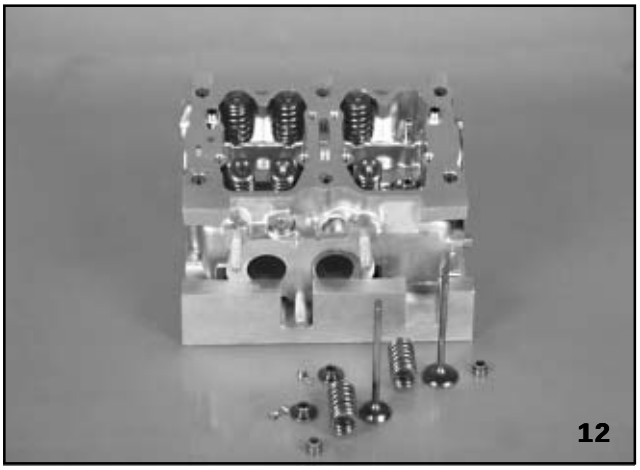
The 2.2L engine uses a cross-flow cylinder head design similar to the 1800cc OHC engine. Better breathing is provided by the two intake and two exhaust valves per cylinder which improves the intake and exhaust flow.

In addition, fine-tuned high velocity intake and exhaust ports are used. The dual intake and exhaust ports are siamesed to further improve intake and exhaust flow.



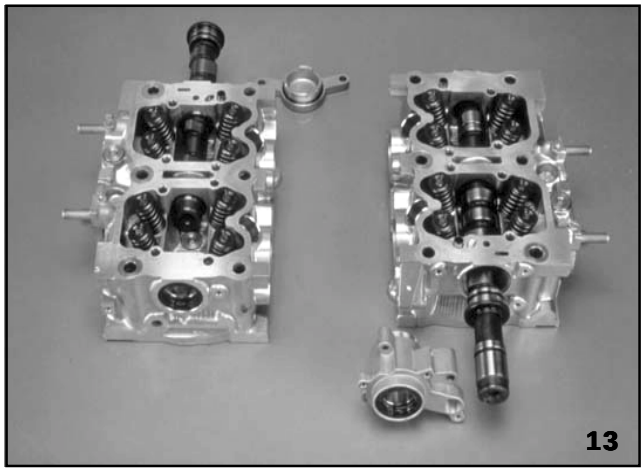
Combustion Chamber

The 2.2L engine uses a compact pentroof combustion chamber vs the bathtub design of the 1800cc/2700cc engines. It has a centrally located spark plug which provides the quickest, most efficient combustion with a uniform flame front from the plug to the top of the piston. This, combined with the 30 degree valve angle compliments the pentroof combustion chamber shape optimizing low and medium speed torque. The cylinder heads are not interchangeable.



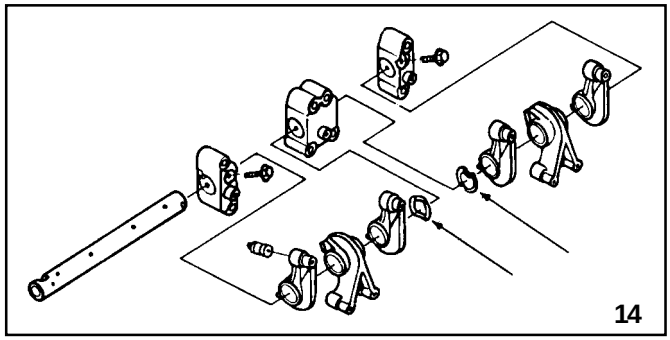
Valve Components

The valve train uses a single valve spring system vs the dual spring system of the old 1800cc engine. The intake valves are larger than the exhaust valves. The valve seal color determines location: intake seals are black, exhaust seals are brown.



N/A Camshaft Supports

The camshaft bearing journals are located in the cylinder head. This design improves camshaft support. The left camshaft is longer than the right camshaft to properly align the cam belt sprockets due to cylinder head offset. A camshaft support bolts to the front of the left cylinder head to support the camshaft. A retaining plate, with oil seal, is attached to the rear of the left cylinder head. The rear of the right cylinder head has a cover plate which also serves as a thrust plate.



Rocker Shaft Assembly

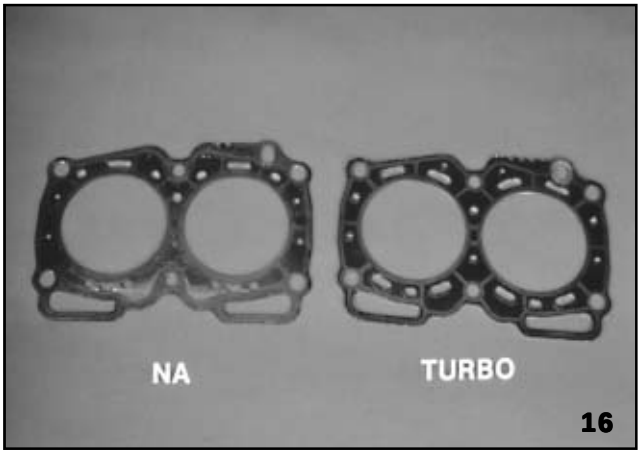
The rocker shaft assembly bolts to the cylinder head. There are 8 bolts through the three cast iron supports. The intake valves have individual rocker arms, while a siamese rocker arm is used for each two exhaust valves. The all aluminum rocker arms have a sintered metal slipper as the cam contact. A pressed aluminum bushing is used for each rocker arm bearing surface. The position of the spring washers on the steel rocker shaft provide proper rocker alignment and spacing. These spring washers must be returned to their original position. The rocker shaft is part of the oiling system providing oil flow to the rocker bearing surfaces and HLAs. Relief valves at both ends of the rocker shafts maintain stable oil pressure to the HLAs.

NOTE: THE ROLLER ROCKER CAM FOLLOWER SYSTEM THAT WAS INTRODUCED ON THE 1.8L IMPREZA ENGINES, IS NOW ON ALL 2.2 LITER ENGINES 1995 MODEL YEAR AND LATER. THE ROLLER ASSEMBLIES ARE NOT SERVICEABLE SEPARATELY, BUT THE ROCKER ARMS MAY BE SERVICED AS INDIVIDUAL UNITS.



Hydraulic Lash Adjusters

The HLA's used in the 2.2L engine are very small in size. Compare them to the size of the 1800cc and 2700cc HLAs. One advantage of these HLAs is the reduction of reciprocating weight. The HLAs are installed in the rocker arms while the 1800cc /2700cc HLAs are installed in the cylinder head. The HLAs directly contact the valve stem instead of contacting the rocker arm as in the 1800cc/ 2700cc engines.



Head Gaskets

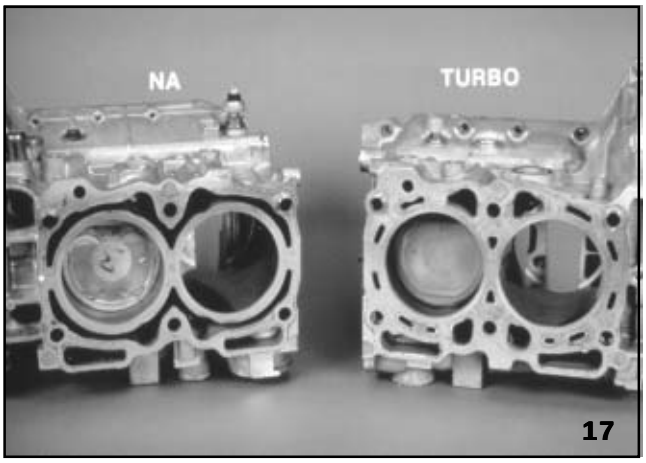
The head gaskets are carbon composition with a metal hooked core. O-rings are used to seal the oil passages. The entire gasket surface is silicon coated to improve sealing characteristics during initial installation. This also eliminates the need for re-torquing after the engine has been operated.

The water ports have been repositioned to match the passages in the heads and crankcase. The grommet area around the cylinder has been increased for improved sealing.

The gaskets can be identified by the number of notches:

*N/A: 2 notches

*TURBO: 3 notches



Crankcase Half

The crankcase has (5) main bearings which provide high case rigidity and improved crank support which increases engine life and performance. The crankcase uses an open deck casting design for the cylinder liners. In addition, the flywheel housing is cast with the crankcase which adds to increased rigidity and strength.



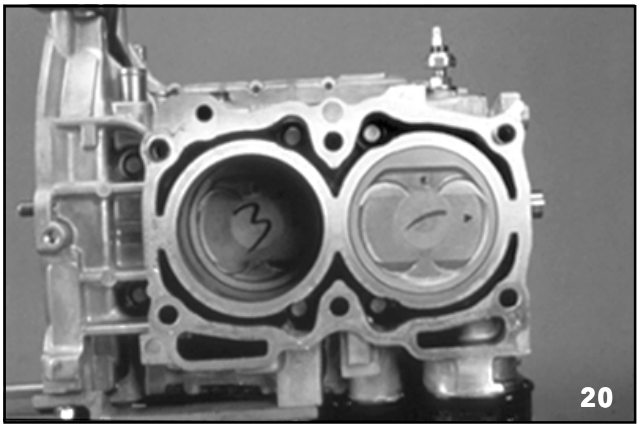
Crankshaft Assembly

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.



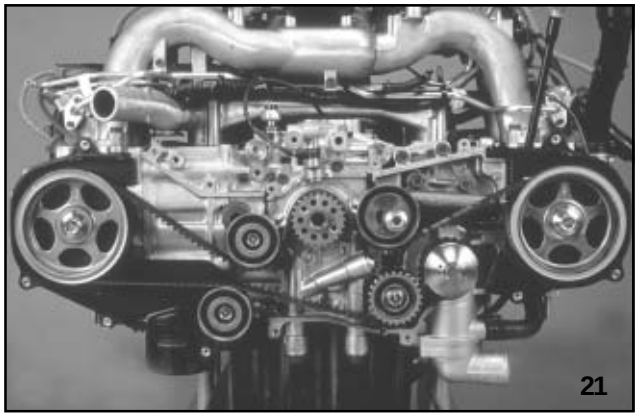
Connecting Rods

Due to increased material used to strengthen the large end of the rod, the rod bolts are pressed into the rod. In comparison, the 1800cc rod bolts are pressed into the bearing cap. 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.



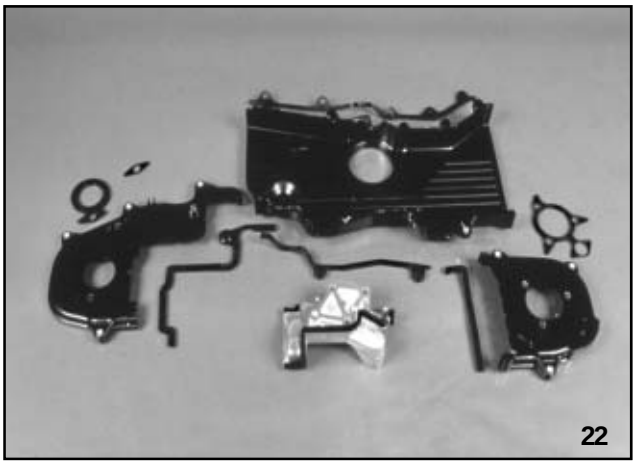
N/A Pistons

The 2.2L pistons are cast aluminum alloy and feature a 2mm 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.



Cam Belt System

A single belt is used to drive both camshafts and the water pump. This provides more precise valve timing. The cam belt width is 30mm (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.



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.

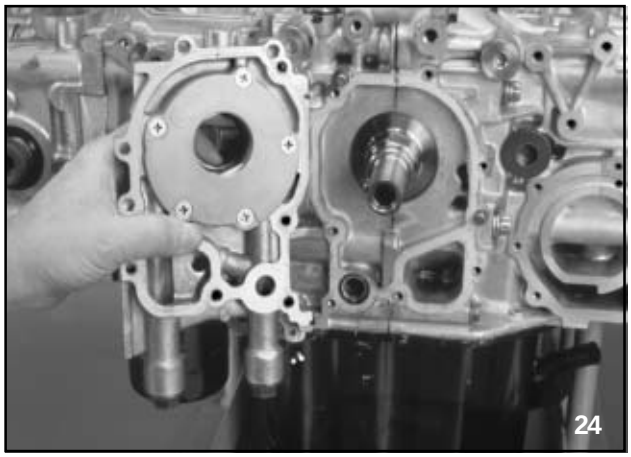


Water Pump Assembly-Cooling System

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.

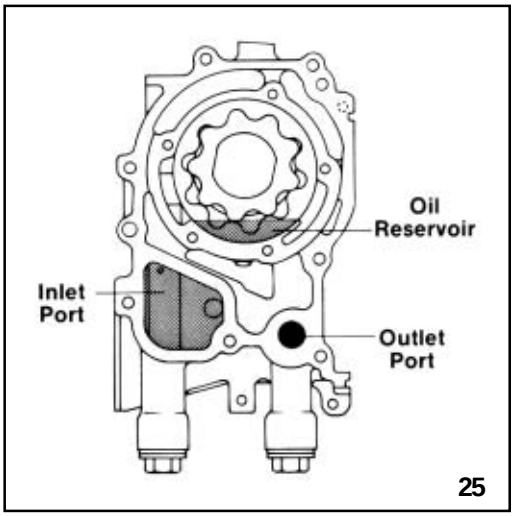
Because the thermostat housing is located on the lower front of the engine, all of the coolant must be drained to change the thermostat.

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.

2.2L Engine Servicing & Diagnostics

In Vehicle Servicing

The following services may be completed without removal of the engine from the vehicle.

a. Removal/replacement of cam belt
b. Water pump removal/replacement
c. Oil pump servicing
d. Intake manifold
e. Rocker covers
f. Rocker arm assemblies
g. Cylinder head removal
h. Camshafts

Engine Diagnostics

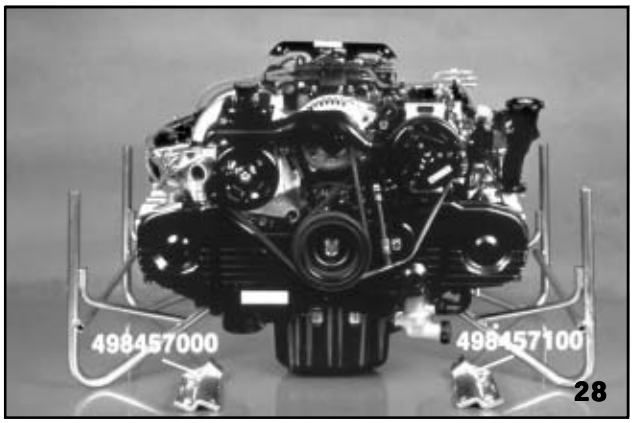
NOTE: THE FOLLOWING DIAGNOSTICS PERTAIN TO THE 2.2L ENGINE ONLY.

a. Valve train noise (clacking sound). Operate the engine for approximately one (1) hour before diagnosing HLAs as the problem.
b. If the rocker shaft relief valves are plugged, the rocker shaft oil pressure will increase during low engine temperature operation This could result in the HLAs being forced part way out of the rocker arm sockets. A clacking sound may be produced which is similar to collapsed HLAs. Engine misfire may also occur during this condition.

If the relief valves will not hold pressure, the HLAs may collapse, again producing a clacking sound.

2.2L Engine Disassembly

NOTE: REFER TO THE SERVICE MANUAL FOR THE DETAILED STEP-BY-STEP DISASSEMBLY SEQUENCE. THE FOLLOWING INFORMATION ADDRESSES SPECIAL STEPS ONLY.



Engine on Stands

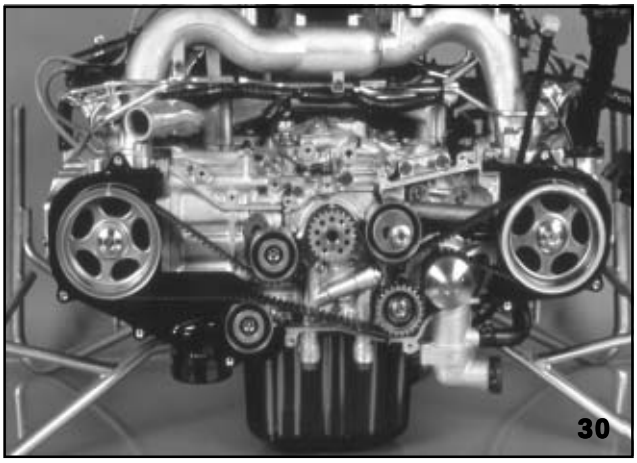
Install the 1800cc engine stands 499817000 with adapter RH 498457000 and adapter LH 498457100. Then remove the engine accessories: i.e. drive belts, alternator, air conditioning compressor, and brackets.



Remove Crank Pulley

Use crankshaft pulley wrench 499977000 to remove the crankshaft pulley bolt, then remove the pulley.

Notes:



Mark Cam Belt

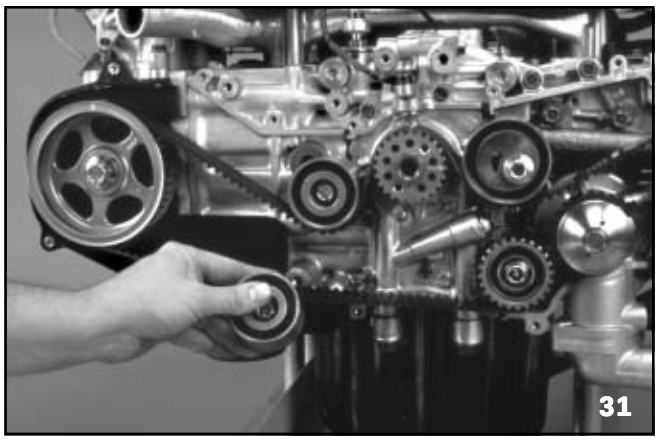
Use the crankshaft pulley to rotate the crankshaft to align the belt timing marks.

NOTE: THERE ARE TWO TIMING MARKS ON BOTH THE CAM PULLEYS AND THE CRANKSHAFT PULLEY, A NOTCH AND AN ARROW. ALIGN THE NOTCH ON THE OUTER RIM OF EACH CAMSHAFT PULLEY WITH THE NOTCH ON THE INNER CAM CASES. ALIGN THE NOTCH ON THE REAR FLANGE OF THE CRANKSHAFT SPROCKET WITH THE NOTCH ON THE OIL PUMP HOUSING.

Mark the belt at the three timing notches. This will make reinstallation much easier and also ensures proper placement of the belt between the left and right cam pulleys.

Mark the belt rotation direction. The belt must be reinstalled to rotate in same direction.

NOTE: NEW BELTS WILL HAVE THE TIMING MARKS PRINTED ON THE BELT AS WELL AS ARROWS INDICATING DIRECTION OF ROTATION.



Remove Idler Pulleys

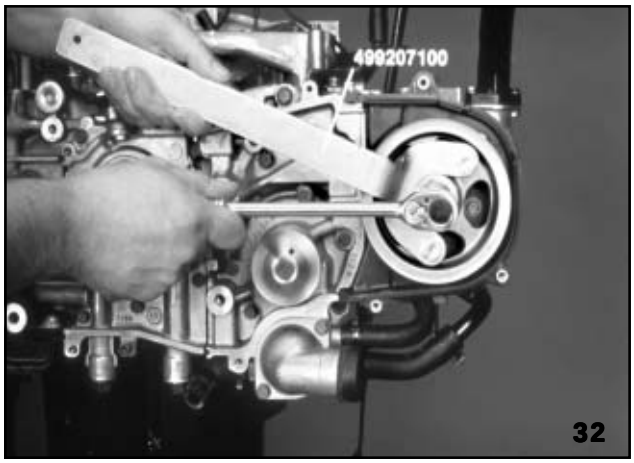
First, loosen the cam belt tensioner mounting bolts.

NOTE: DO NOT REMOVE THE BOLTS.

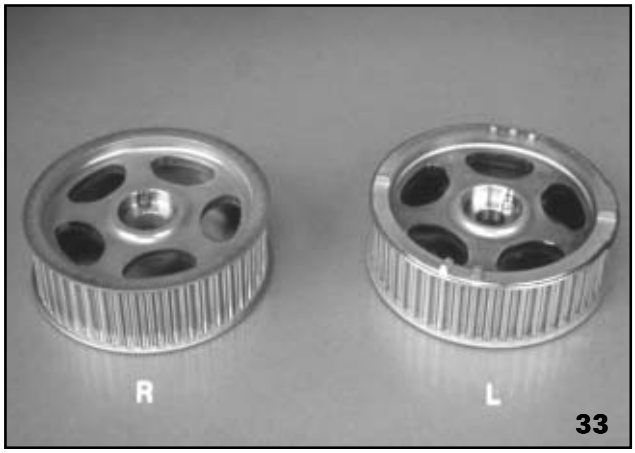
Remove the idler pulleys in this sequence: lower right (1-3 side), then the lower left (2-4 side, next to the water pump). Then remove the cam belt.

Finally, remove the cam belt idler and tensioner assembly, and then the crankshaft sprocket.

Remove the left and right camshaft sprockets using cam wrench 499207100.



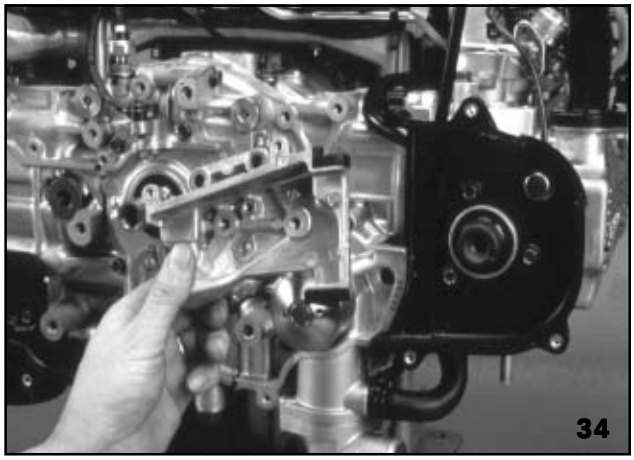
Remove Camshaft Sprockets



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

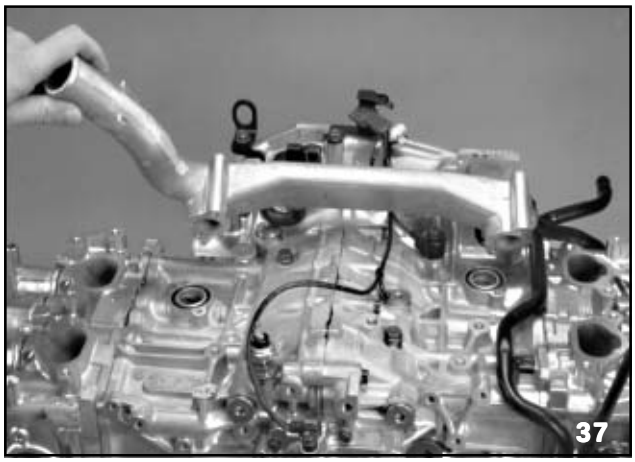
Remove the left and right inner cam belt covers. Note the location of the friction-fit dust seals.



Engine Accessory Removal

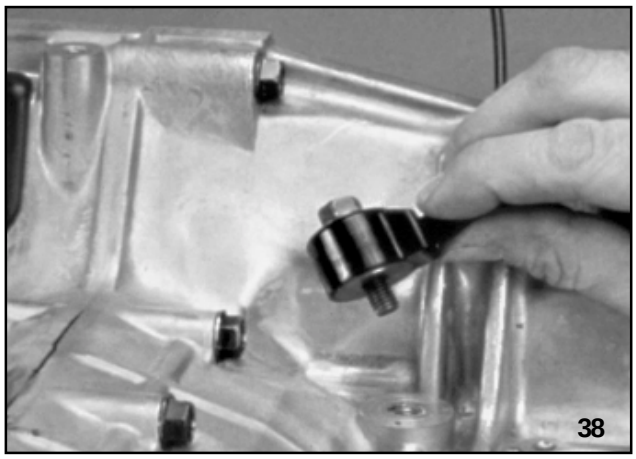
Remove the hoses, electrical connections, sensors, switches, intake manifold, and intake manifold gaskets.

NOTE: THE RUBBER COATED METAL GASKETS ARE ONETIME USE ONLY.

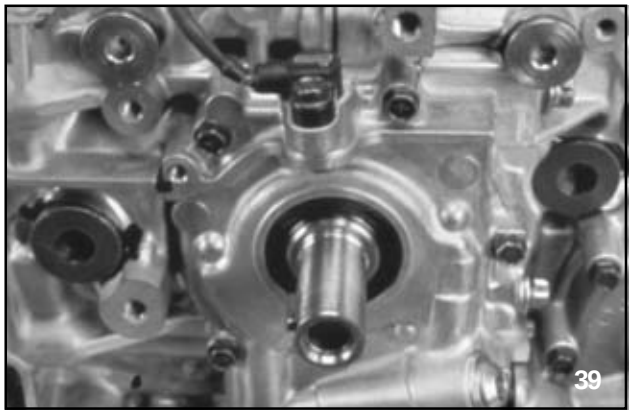


Remove the Water Transfer Pipe

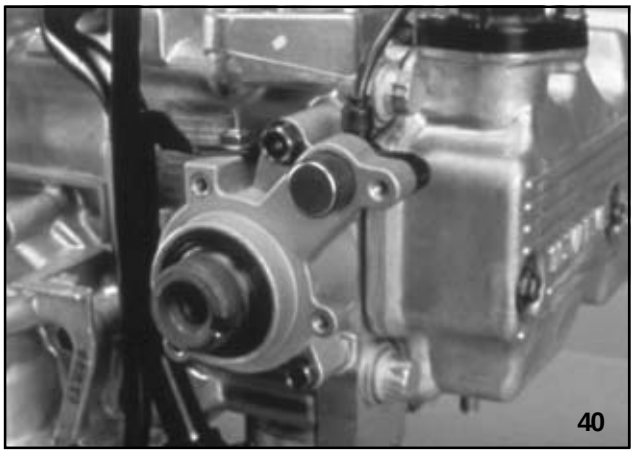
Remove the water transfer pipe and O-rings. New O-rings must be used at reinstallation.



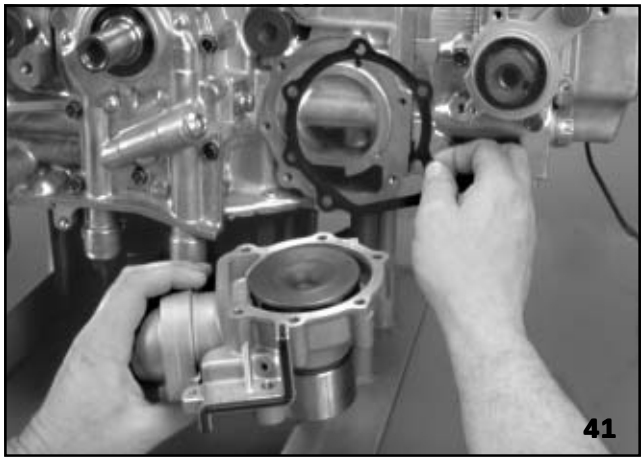
Remove Knock Sensor



Remove Crank Angle Sensor

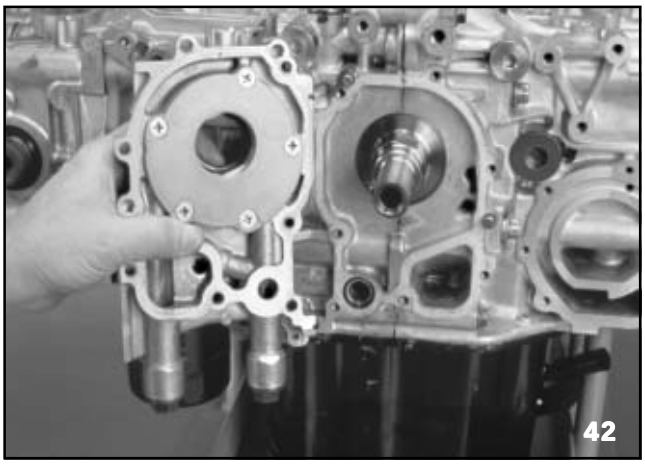


Remove Cam Angle Sensor



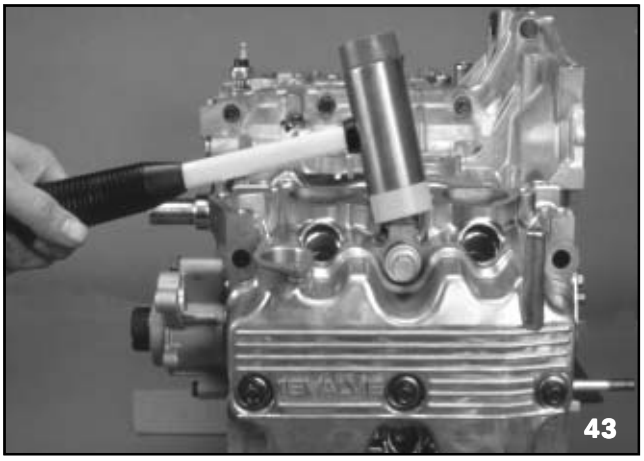
Remove Water Pump

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.

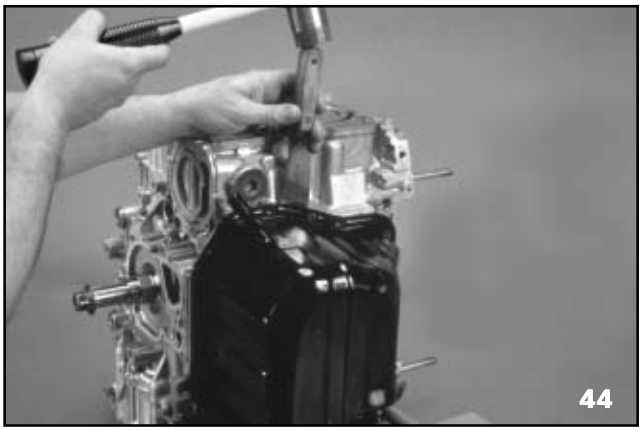


Cylinder Head Removal

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.

NOTE: IT IS NOT NECESSARY TO REMOVE THE VALVE COVER WHILE REMOVING THE CYLINDER HEAD UNLESS SERVICING OF THE VALVE COMPONENTS IS REQUIRED.



Remove Oil Pan

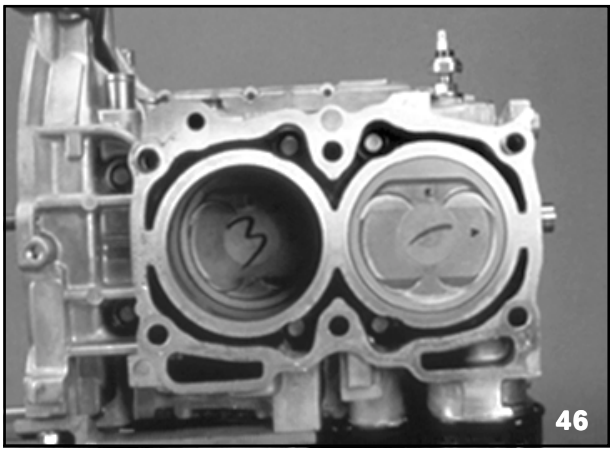
Remove the oil pan bolts. Use a thin gasket scraper/putty knife and a rubber mallet to loosen the oil pan. Remove the oil pan. Notice the location of the oil seal for the drain tube. Remove the oil pickup tube and also note the O-ring. Remove the oil pan baffle plate (windage tray).



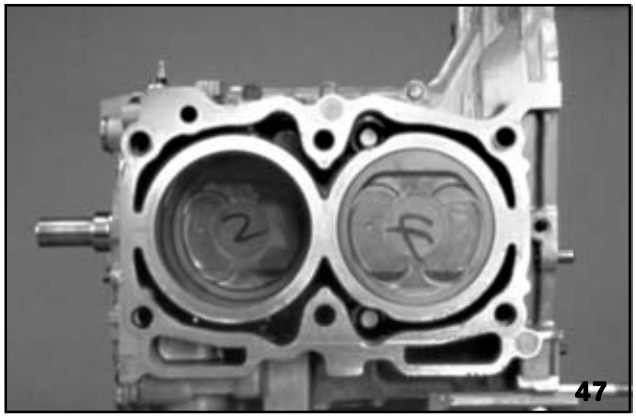
Piston Pin Removal

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.



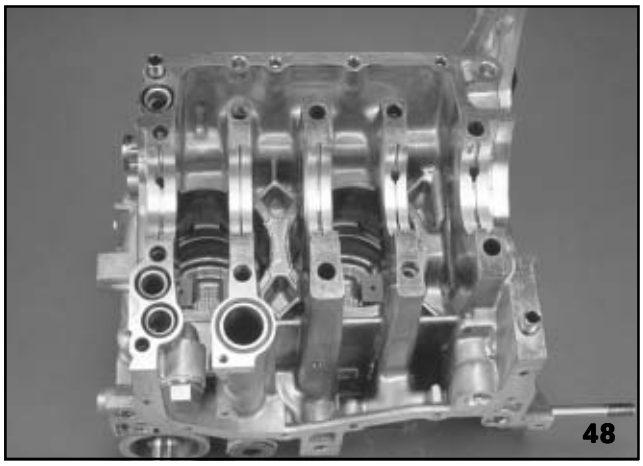
Crankcase Hidden Bolts (Right Bank)



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.

2.2L Component Inspection and Servicing



Cylinder Head Disassembly

Remove the valve rocker cover bolts and the valve rocker cover. Then remove the eight rocker shaft assembly retaining bolts and the rocker shaft assembly.

NOTE: REMOVE THE ROCKER ASSEMBLY SLOWLY TO PREVENT BINDING AGAINST THE MOUNTING DOWELS.



HLA Removal

Use a small screwdriver to remove the HLA from the rocker socket. Do not damage the o-rings or the machined surfaces when removing the HLAs. To check the HLAs for proper operation, squeeze the HLA between your thumb and finger. The HLA should not compress, it should not be spongy.



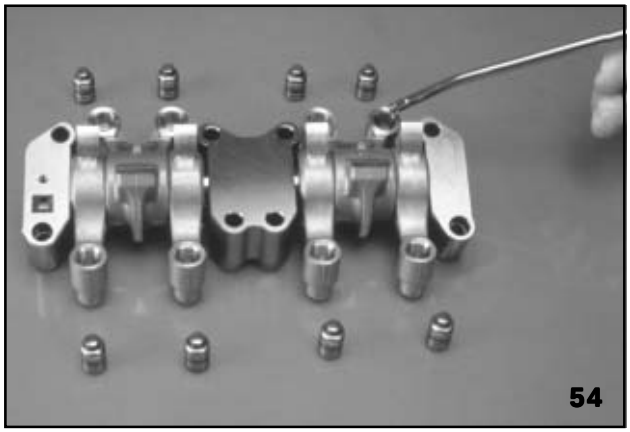
Refilling HLAs



Depressing HLA Check Ball

Place an HLA in a **clean** 12 mm socket. The socket serves as an oil reservoir. Add engine oil to the socket. Use a small Allen wrench or paper clip to depress the check ball. Depress and release the HLA plunger while you hold the check ball open. This purges the air from the HLA and fills the HLA with oil. It usually requires only one stroke to fill the HLA. Store the HLAs in engine oil for later reassembly.

NOTE: PARTIALLY FILLED HLAs WILL RESULT IN NOISY OPERATION OF THE VALVE TRAIN FOR APPROXIMATELY ONE HOUR. TO TEST, SQUEEZE THE HLA BETWEEN YOUR THUMB AND FINGER. IF THE HLA IS SPONGY, REPEAT THE FILL PROCESS. IF THE HLA CAN NOT BE PUMPED TO A FIRM CONDITION, REPLACE IT.



Filling the HLA Sockets

Assemble the rocker shaft components, rocker arms, spring washers, and the rocker shaft supports. Lubricate shaft and rocker arms with oil.

NOTE: THE ROCKERS AND SUPPORTS SHOULD BE RETURNED TO THEIR ORIGINAL POSITION ON THE SHAFT. THE CUT OUT PORTION OF THE ROCKER SHAFT MUST FACE THE OIL HOLE IN THE ROCKER SUPPORT. THE SPRING WASHERS MUST BE PROPERLY LOCATED ON THE SHAFT. ALWAYS REPLACE ANY DEFORMED SPRING WASHERS.

Retain the rocker shaft in the proper position with the two retaining bolts. Torque to specification. Then fill the HLA reservoir with engine oil.



Installing HLAs

Press the HLAs (by hand) into the rockers to install the HLAs in the rocker arms. Some oil will drain from the bleed hole. Press the HLA until the O-ring seats. Install the remaining HLAs. Be sure to check for spongy HLAs during installation.

NOTE: THE HLA O-RINGS SHOULD ALWAYS BE REPLACED WHEN THE HLAS ARE REINSTALLED.

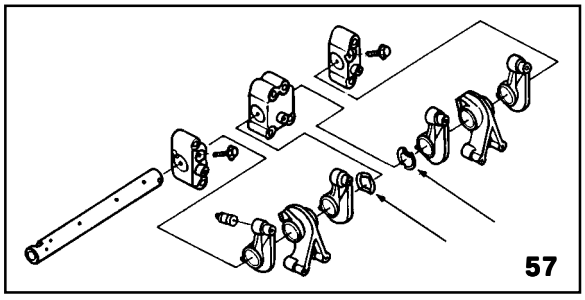


Tensioner Inspection

Look for leakage from the tensioner rod and seal area. Slight traces of oil at rod oil seal does not indicate a problem.

NOTE: REFER TO 1995 SERVICE MANUAL "INSPECTION OF BELT TENSION ADJUSTER" FOR TENSIONER COMPRESSION SPECIFICATIONS. 2-3 [W3B2]

NOTE: STARTING WITH 1997MY (LATE PRODUCTION) A NEW STYLE TENSIONER WAS INTRODUCED. DO NOT USE A VISE TO COMPRESS. CONSULT 1998MY SERVICE MANUAL OR LATER FOR TESTING AND COMPRESSING PROCEDURES. CONSULT SECTION 2-3 [W2C2]. IT IS CRITICAL TENSION IS CORRECT OR THE BELT COULD JUMP CAUSING INCORRECT TIMING THUS RESULTING IN VALVE AND PISTON DAMAGE.

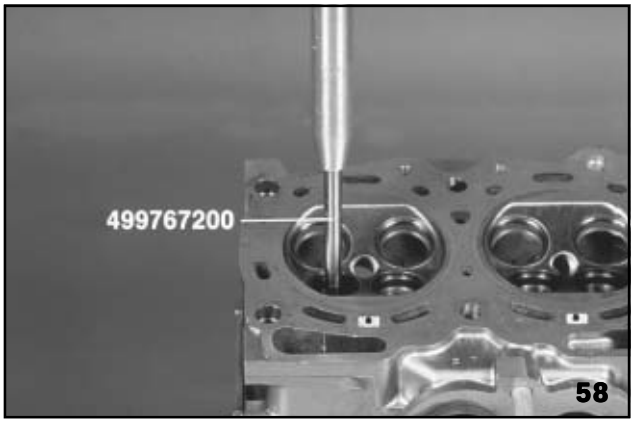


Rocker Arm Inspection

Inspect the rocker arms for damage. Also inspect the rocker arm bearing surface for wear. Replace the rocker arm if bearing wear is excessive.

NOTE: REFER TO 1995 SERVICE MANUAL SECTION 2-3 [W4C2], INSPECTION OF VALVE ROCKER ARM FOR SPECIFICATIONS.

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

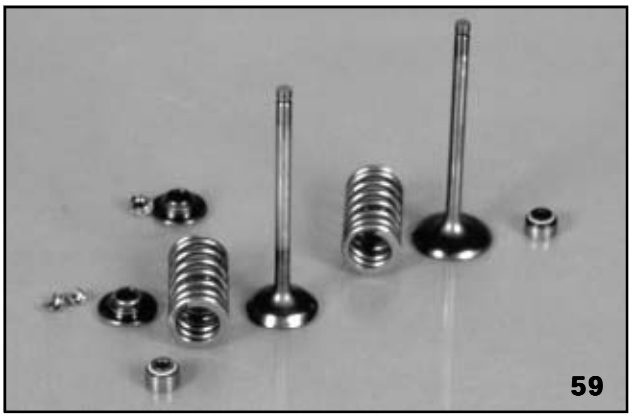
Follow the precautions listed below when inspecting and servicing engine components.

a. Clean all parts thoroughly.
b. Remove all gaskets and sealing material.

CAUTION: DO NOT DAMAGE ALUMINUM MATING SURFACES

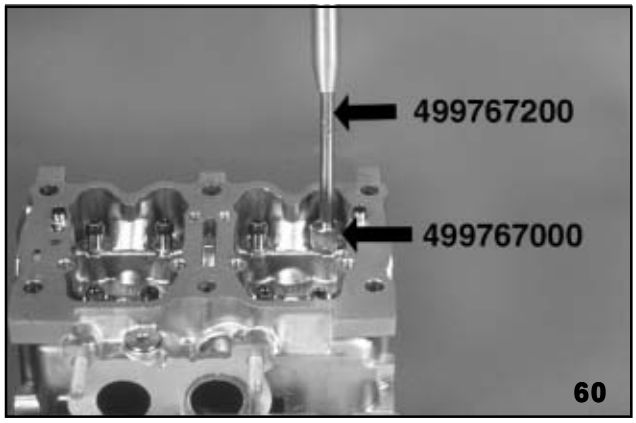
c. Use compressed air to insure clear oil and coolant passages.
d. Do not damage components when removing carbon.
e. Keep parts in order to ease reassembly.
f. Service all valves as a set.

Refer to the Service Manual 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.



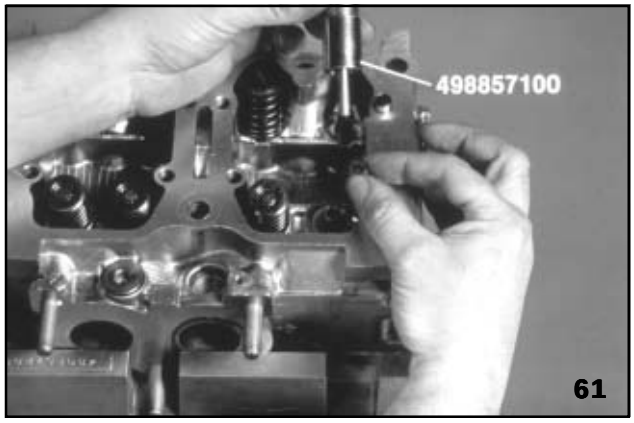
Valve Components

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**.



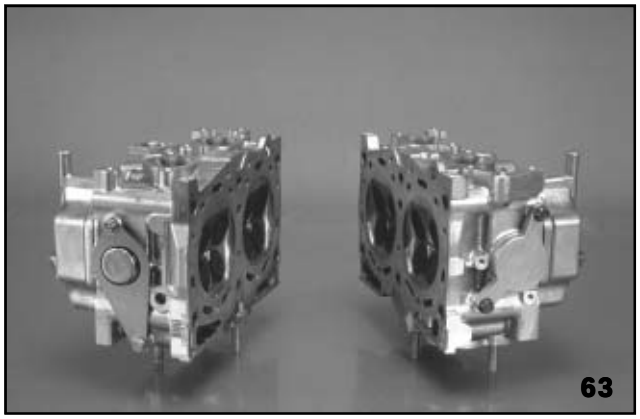
Installing Valve Guide Oil Seal

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

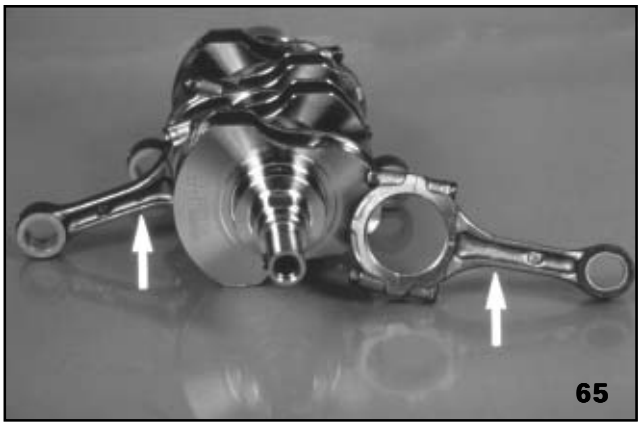
Install the left rear camshaft plug (oil seal). Then install the oil seal using oil seal installer **499587100**.



Storing Cylinder Heads

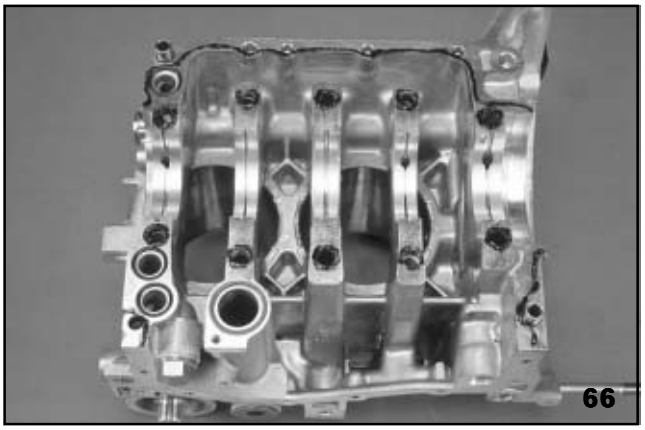
Install the rocker cover to the cylinder head. Temporarily store the cylinder head by standing it on the exhaust manifold studs. This prevents bleed down of the HLAs. Repeat these steps for the other cylinder head.

2.2L Engine Reassembly



Assemble Crankshaft

Always refer to the 1995 Service Manual Section 2-3 [W7C6 to W7D1] for the bearing size, oil clearance, and torque specifications. The "FUJI" symbol on the connecting rods must face the front of the engine.

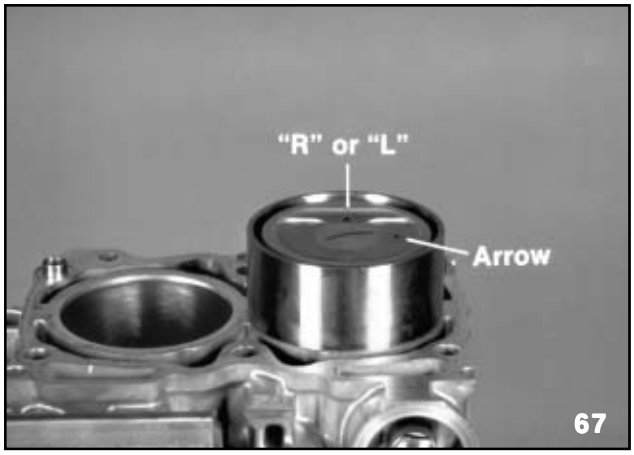


Crankcase Sealer and O-Rings

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.

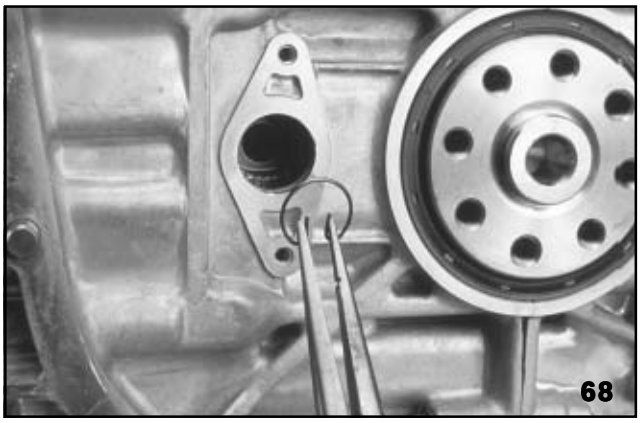
CAUTION: REMOVE ALL FLUIDS FROM THE THREADED PORTIONS OF THE CASE HALVES. THIS PREVENTS HYDROSTATIC LOCK AND POTENTIAL CRACKING OF THE CRANKCASE.

Install the four hidden crankcase bolts on the 1 - 3 side. Always install new seal washers to these bolts. Install the two remaining 1- 3 side crankcase bolts. Torque the 6 large bolts on the right side (1- 3) to 4 to 22 ft. lbs. (2 to 3 Kg-m). Next install the two hidden crankcase bolts on the 2- 4 side. Always install new seal washers. Install all of the remaining crankcase bolts. Torque all the crankcase bolts to specifications. Start with the right side (1 - 3) bolts.



Piston Installation

The pistons are directional and must be returned to the original cylinder locations. Use piston guide **498747100** 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.

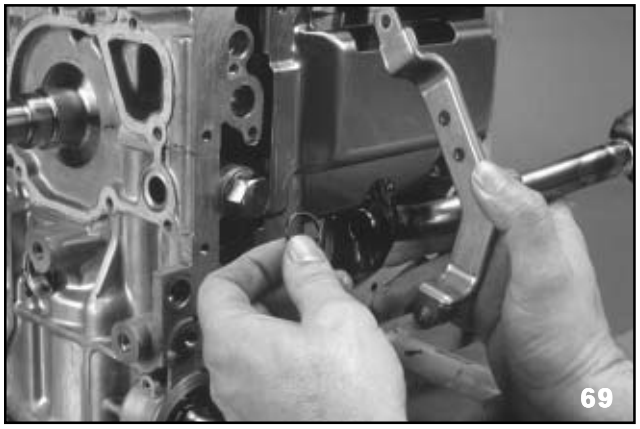


Circlip Removal

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 tang 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 SERVICE MANUAL FOR SPECIFICATIONS.

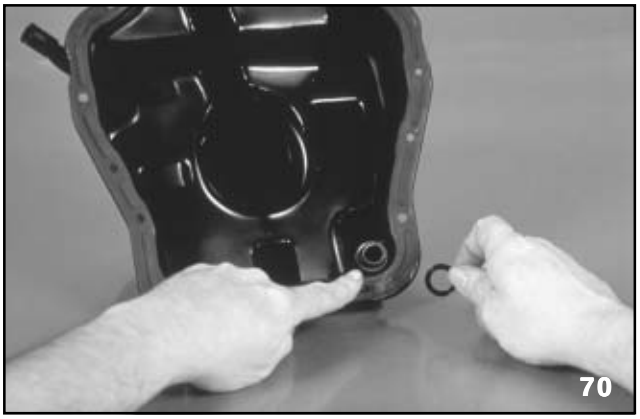
Install the left side access cover and new o-ring, PCV baffle plate, and piston pin plug using a new sealing ring and sealer.



Installing Oil Pick-Up Tube

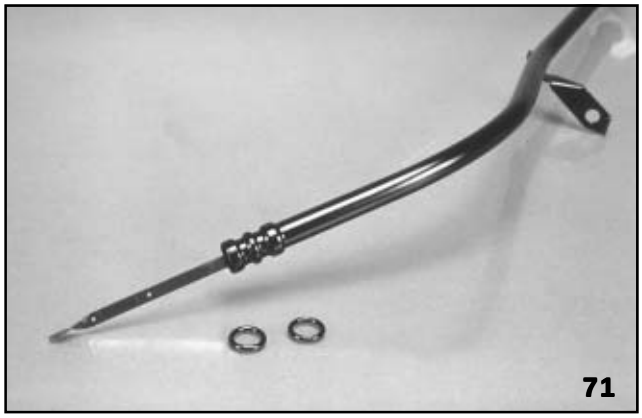
Install the oil pan baffle plate and oil pickup tube. Be sure to install a new O-ring to the oil pickup tube.

NOTE: DO NOT OVER TIGHTEN OR BOLT DAMAGE WILL OCCUR.



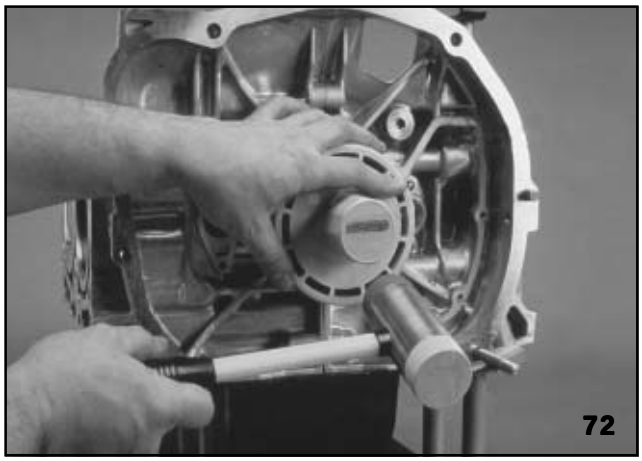
Oil Pan Drain Tube Seal

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).



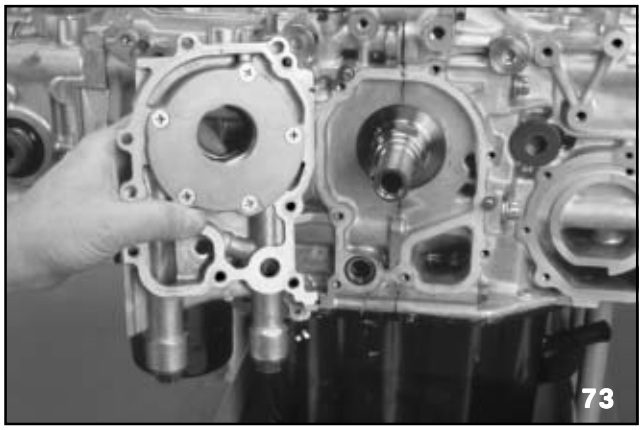
Dipstick Tube and Seals

Install the dipstick tube. Be sure to use two (2) new o-ring seals.



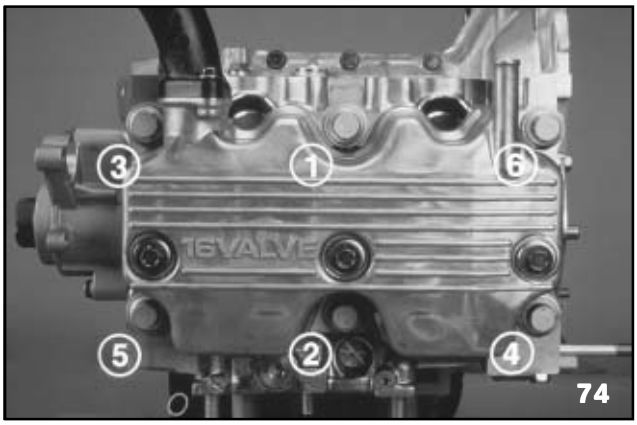
Installing Rear Crankshaft Oil Seal

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.



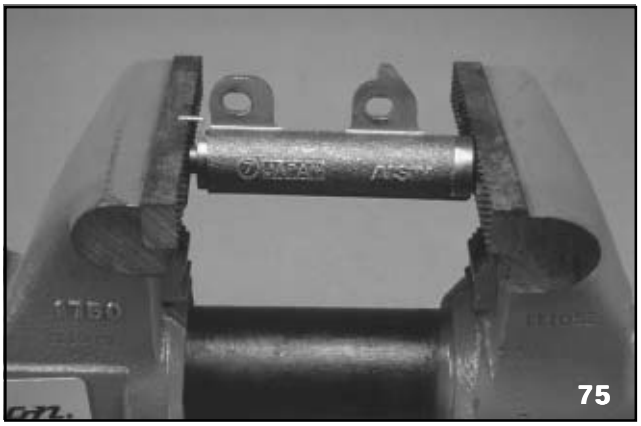
Installing Oil Pump

Install the oil pump. Refer to the 1995 service manual 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.



Cylinder Head Torque Sequence

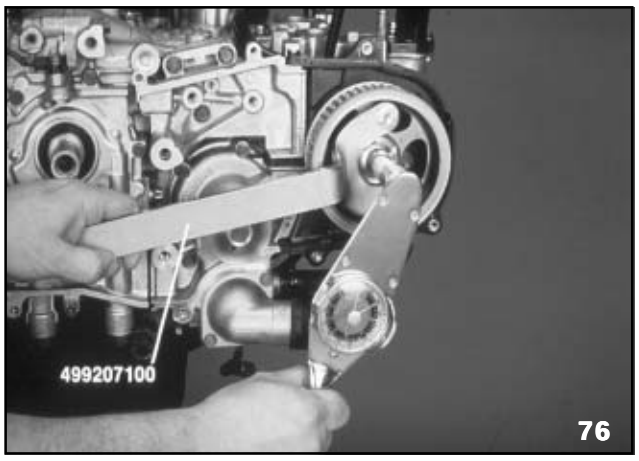
Install a new cylinder head gasket (dry) and the cylinder head. Follow the bolt torque sequence and procedures listed in the 1995 Legacy Service Manual, Section 2-3 [W6E1].



Compressing the Tensioner

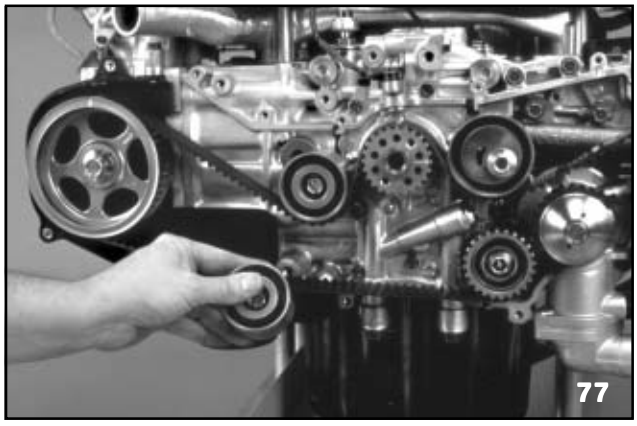
Slowly compress the cam belt tensioner in a vise, using aluminum or brass jaws, until the hole in the piston aligns with the hole in the tensioner case. Install a tensioner plunger retaining pin. You may use a small Allen wrench or rivet as a retaining pin. Install tensioner assembly to the crankcase, do not tighten the mounting bolts.

NOTE: DO NOT REMOVE PLUNGER RETAINING PIN UNTIL CAM BELT IS COMPLETELY INSTALLED.



Cam Sprocket Installation

Install the camshaft sprockets using camshaft sprocket wrench **499207100**. Refer to the service manual for the proper specifications. The left sprocket has the cam angle reluctors and is not interchangeable with the right sprocket. Damage to the dust cover will result from improper installation.

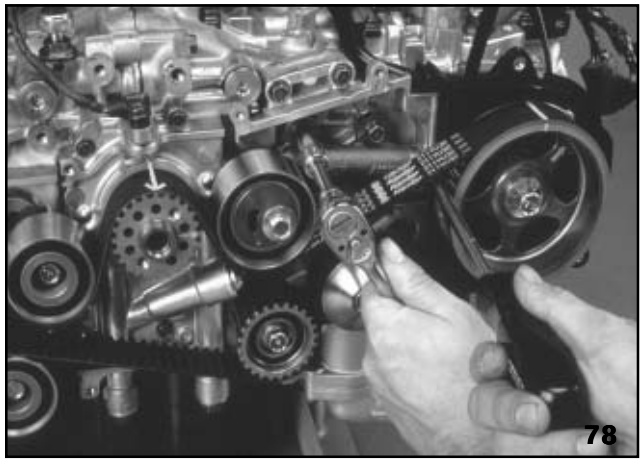


Installing Idler Pulleys

Install the cam belt idler pulleys except the lower right (1 - 3 side) and the lower left (2 - 4). Install the crankshaft sprocket and align the crankshaft sprocket and camshaft sprockets with the belt timing notches (12 o'clock). Do not rotate camshafts more than necessary as the HLAs will bleed down.

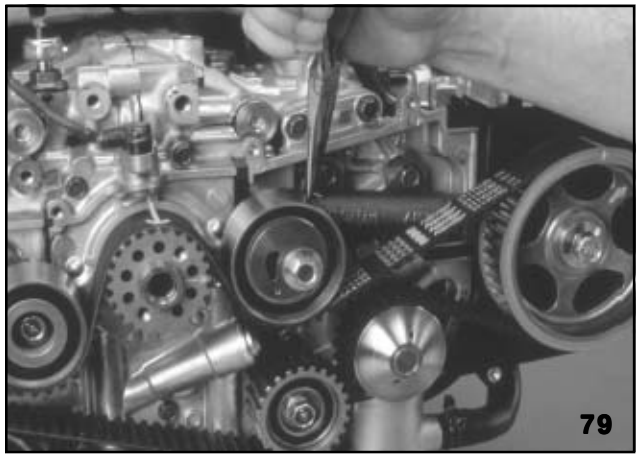
Install the cam belt in the following sequence:

a. Begin at the crankshaft sprocket
    1. Align the mark on the cam belt with the crankshaft sprocket notch.
b. Place the belt under the cam belt tensioner and over the left cam sprocket.
    1. Align the mark on cam belt with camshaft sprocket notch.
c. Place the belt under the upper right idler pulley and over the right cam sprocket.
    1. Align the mark on the cam belt with camshaft sprocket notch.
d. Place the belt over the water pump pulley.
e. Install the lower left and right idler pulleys.



Loading Tensioner

Use a screwdriver to load the tensioner idler. Push the idler toward the crankshaft sprocket. Tighten the tensioner mounting bolts to specified torque.

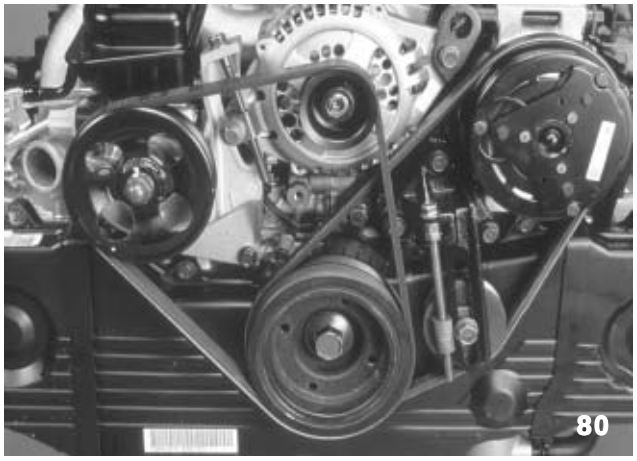


Remove Retaining Pin

Carefully remove the tensioner plunger retaining pin. This automatically sets the cam belt tension. Slowly rock the crankshaft left to right to left to distribute the cam belt tension to the belt.

NOTE: DO NOT ROTATE THE CRANKSHAFT UNNECESSARILY AS THE HLAs MAY BLEED DOWN.

Verify that the cam timing is correct by checking the cam belt alignment. The crankshaft sprocket notch and mark should be aligned. Check to be sure that the notches of the camshafts sprockets and the belt marks are properly aligned.



Install Cam Belt Cover/Accessories

Install the outer cam belt covers. Be sure to install the shouldered bolts in the center cover. Check the position and fit of the dust seals.

Install the pulley using crank pulley wrench **499977000**. Install the engine accessories and drive belts. Note the new style belt tension adjusters. Confirm belts for proper tension after adjustment. Fill the engine with oil.

Notes and Cautions

2.2L Engine Disassembly

There are two timing marks on both the cam pulleys and the crankshaft pulley, a notch and an arrow. Align the notch on the outer rim of each camshaft pulley with the notch on the inner cam cases. Align the notch on the rear flange of the crankshaft sprocket with the notch on the oil pump housing.

New belts will have the timing marks printed on the belt as well as arrows indicating rotation direction.

During the cam belt removal procedure, initially loosen, but do not remove, the cam belt tensioner bolts until the belt and idler pulleys have been removed.

The 1800cc cam wrench must be modified to fit the 2.2L camshaft sprocket. Tool **499207100** is the preferred tool.

The rubber coated metal intake manifold gaskets are onetime use only. Discard and replace with a new set.

It is not necessary to remove the valve cover while removing the cylinder head unless servicing of the valve components is required.

Use caution while rotating the crankshaft to prevent the connecting rod large ends from damaging the lower cylinder bores.

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 onetime use ONLY.

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 coolant passage.

Remove the rocker assembly slowly to prevent binding against the mounting dowels.

Partially filled HLAs will result in noisy operation of the valve train for approximately one hour. To test, squeeze the HLA between your thumb and finger. If the HLA is spongy, repeat the fill process. If the HLA can not be pumped to a firm condition, replace it.

2.2L Engine Reassembly

The rockers and supports should be returned to their original positions on the shaft. The cut out portion of the rocker shaft must face the oil hole in the rocker support. The spring washers must be properly located on the shaft. Always replace any deformed spring washers.

The HLA O-rings should always be replaced when the HLAs are reinstalled.

Install the rocker assembly carefully to prevent binding against the mounting dowels.

Remove all fluids from the threaded portions of the case halves. This prevents hydrostatic lock and potential cracking of the crankcase.

Carefully follow the cylinder head torque sequence. Remember that the retightening angle must not exceed 180 degrees. Proper use of the torque procedure eliminates the need to retorque the cylinder head bolts after running the engine. Refer to 2-3 [W6E1].

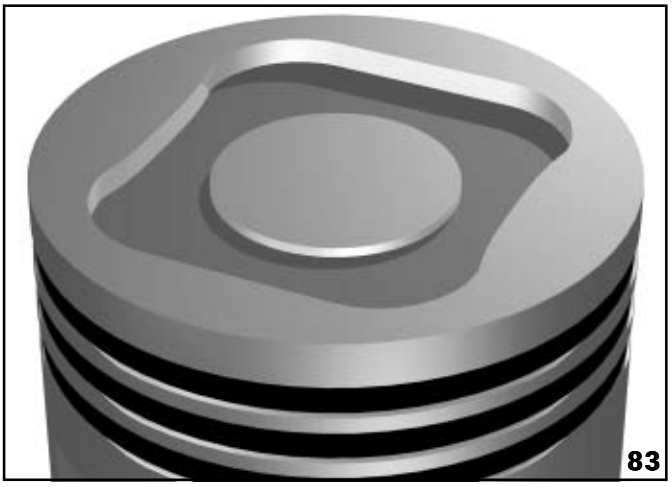
The left camshaft sprocket must not be installed on the right cam shaft, as damage to the inner right cam belt cover will result.

Do not remove the plunger retaining pin from the cam belt tensioner until the cam belt is completely installed.

Do not rotate the crankshaft unnecessarily as the HLAs may bleed down.

Engine Enhancements 2.2 Liter (Phase 1)

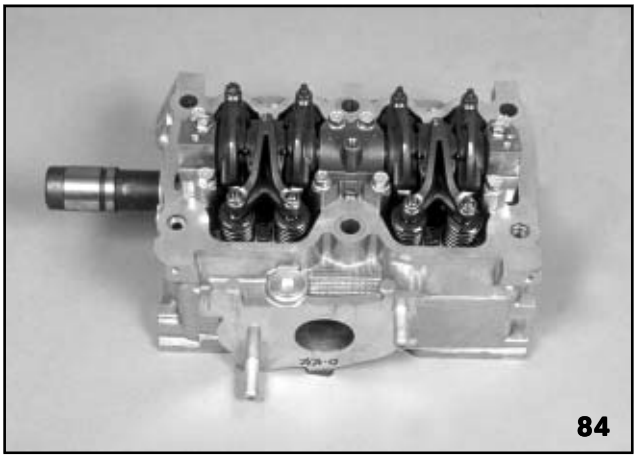
The 2.2 liter (SOHC) (Phase 1) has been enhanced starting with 1997 model year. The single overhead camshaft engines have had internal and external changes that yield an approximately 10 % increase in power and 3% increase in fuel economy. Accomplishing this involves many factors, one of which is engine friction reduction.



Redesigned Piston

The piston, a major source of engine friction has been coated with a friction reducing agent called Molybendum. This thin coating not only allows a smoother travel through the cylinder but also reduces cylinder wall scuffing. This coating will wear off over time and is not an indication of a problem.

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.

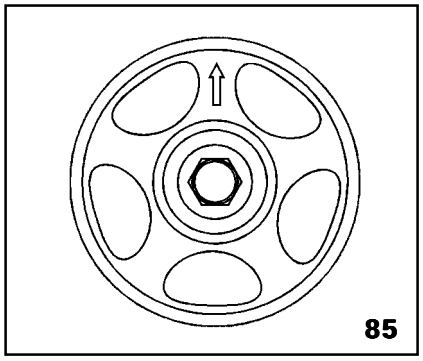


2.2 Liter Valve Train Assembly

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 SOHC 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 SOHC engine uses an adjustment screw and locknut.

Follow the instructions below for set up and adjustment.

Tools required for 2.2 valve adjustment (thickness gauge, 10mm wrench, stubby standard (negative) screwdriver, crankshaft wrench).



Cylinder 1

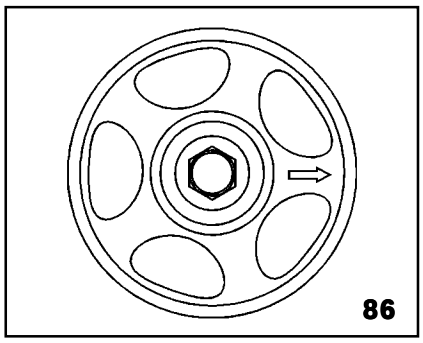
Step 1

Remove the right bank camshaft outer cover

Standard value clearance
(Intake valves 0.20 +/- 0.02 mm)
(Exhaust valves 0.25 +/- 0.02 mm)

Rotate the engine until the arrow on the camshaft sprocket is at 12 o'clock. **(Please remember that the camshaft sprocket has an arrow and a mark for belt timing. Make certain that the arrow is used not the mark for *valve adjustment only*.)**

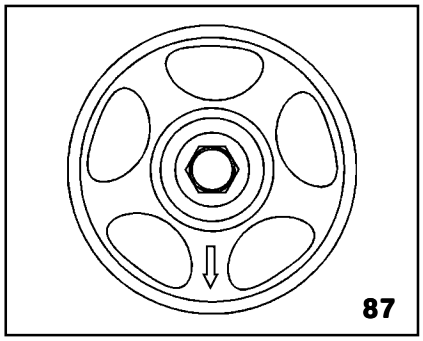
Using a standard thickness gauge measure the clearance of the **intake and exhaust valves on cylinder 1 only**. Adjust the clearance by loosening the locknut and turning the adjustment screw until the proper clearance is obtained.



Cylinder 3

Step 2

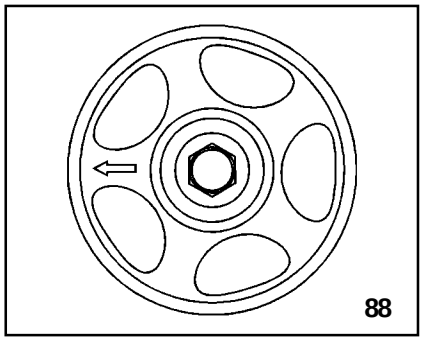
Rotate the engine until the arrow on the camshaft sprocket is at 3 o'clock. Check and adjust the clearance of the **intake and exhaust valves on cylinder 3 only**.



Cylinder 2

Step 3

Rotate the engine until the arrow on the camshaft sprocket is at 6 o'clock. Check and adjust the clearance of the intake and exhaust valves on cylinder 2 only.



Cylinder 4

Step 4

Rotate the engine until the arrow on the camshaft sprocket is at 9 o'clock. Check and adjust the clearance of the intake and exhaust valves on cylinder 4 only.



Measuring Valve Clearance



Adjusting Valve Clearance

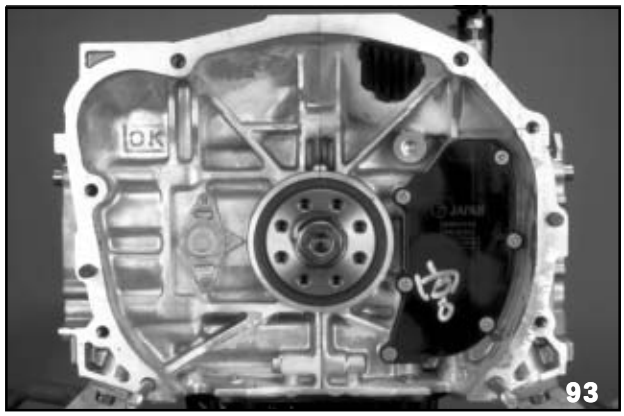
Other Engine Modifications

The intake manifold has been reshaped to increase the air flow mass and speed, contributing to improved low and mid engine speed operation. Components located on the intake manifold have been relocated as compared to the 1996 models. EGR Solenoid, Purge Control Solenoid, etc...

1999 2.2 Liter (SOHC) (Phase 2) Engine Enhancements

All 2.2 liter engine for 1999 are Phase 2 design. The 2.2 liter phase 2 engines are SOHC engine with a newly designed cylinder head.

Changes in the 2.2 liter phase 2 engines are as follows:



Mounting Holes and Studs

The engine and the transmission are fastened with 6 bolts and 2 studs.



Thrust Bearing

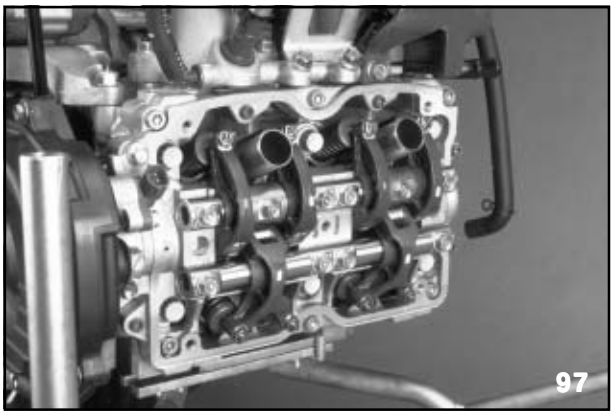
The thrust bearing has been moved to the number 5 position.



Main Bearing Oil Grooves

The oil groove in the number 1 and 3 have been changed to supply additional lubrication to the crank journal.

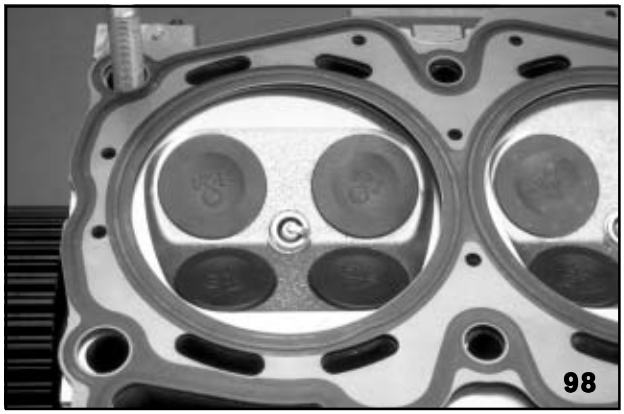
Additional Features of the Phase Two Engine



Valve Train

The cylinder head will be a 2-rocker shaft roller solid type 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.

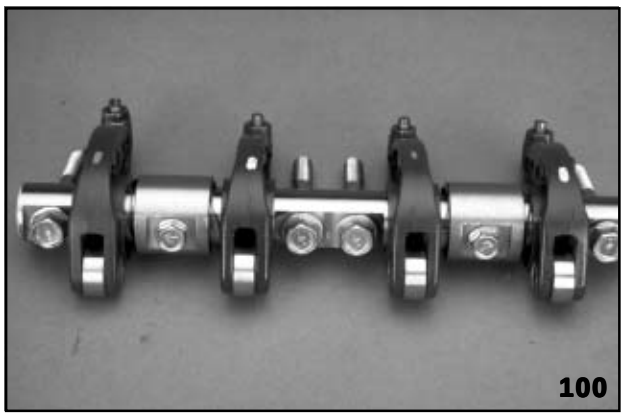


New Head Gasket Design

Head gasket thickness is 0.7 mm.



Identification of Rocker Arms

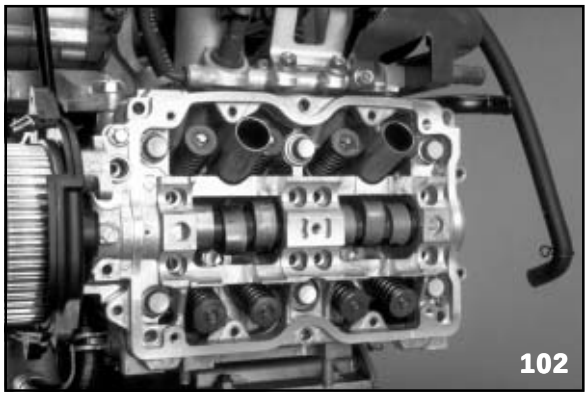


Roller Rockers

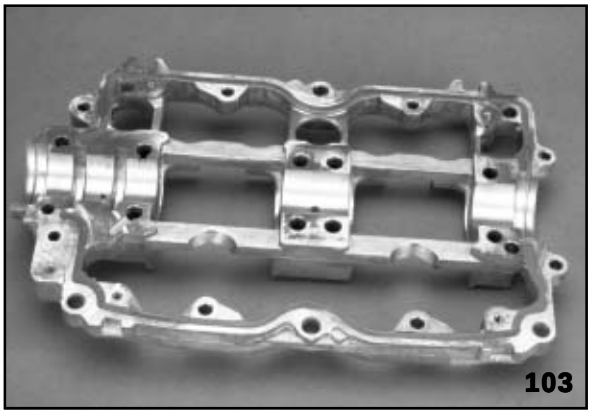


Adjustment Screw and Nut

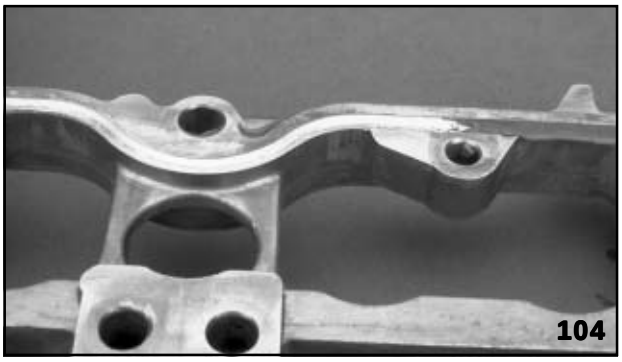
The intake rocker arms are marked so they are correctly placed on the rocker shaft when servicing. An IN1 or IN2 will be embossed on each rocker arm. As viewed from the front of the engine the Number 1 intake valve of each cylinder and the number 2 intake valve have an IN1 marked and IN2 marked rocker 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 Passages

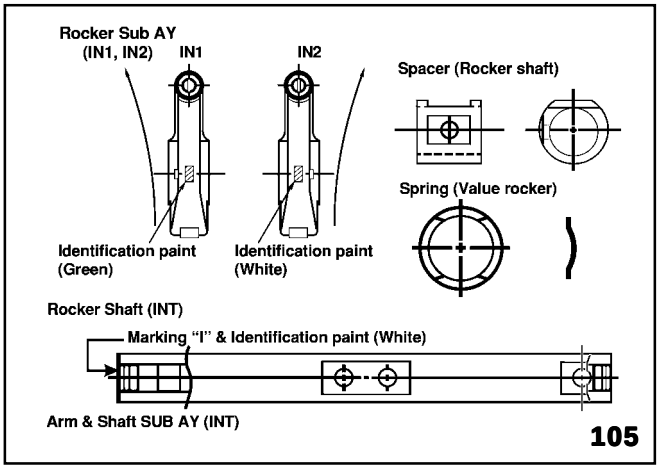


Groove Edges

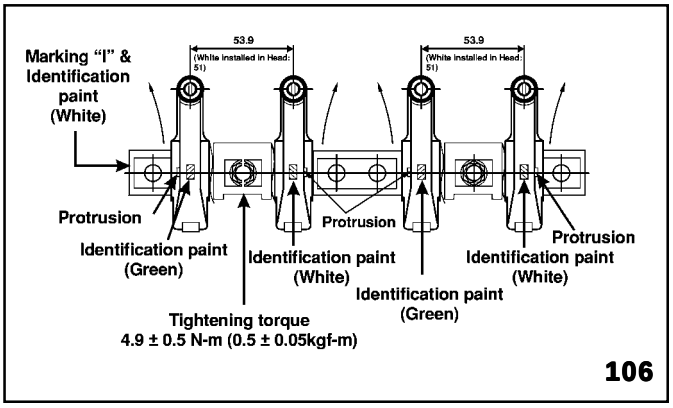
The camshaft is secured to the cylinder head with the camcase. An oil passage in the cylinder head provides the passageway in the camcase with oil that leads to the intake rocker shaft. Oil from the camshaft is collected on the opposite side of the passageway leading to the intake rocker shaft to provide oil to the exhaust rocker shaft.

Sealing of the camcase is accomplished by using a thin layer of three bond (1280B) applied in the channel around the camcase edge. After the three bond 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.

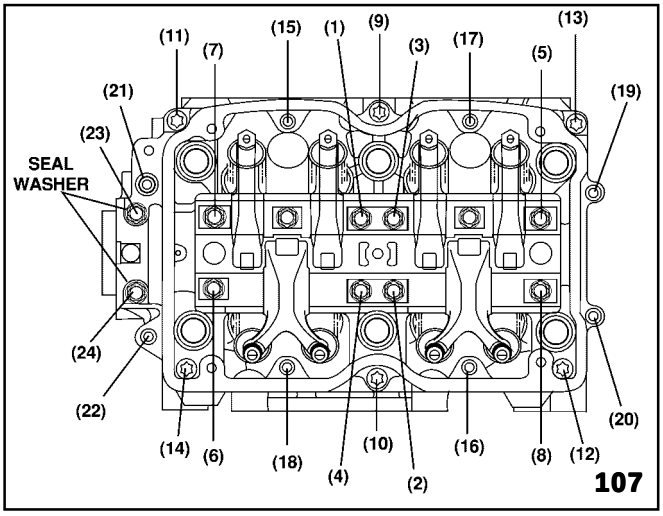
NOTE: CYLINDER HEAD AND CAMCASE MUST BE REPLACED TOGETHER. (LINE BORED)



Identification Marks of Rocker Arms

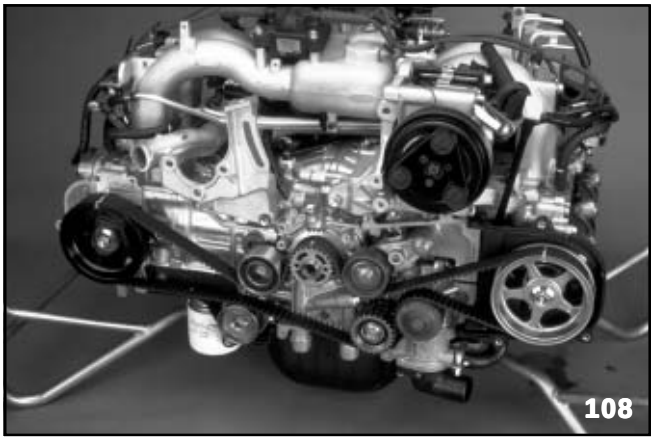


Torque Specs and Measurements



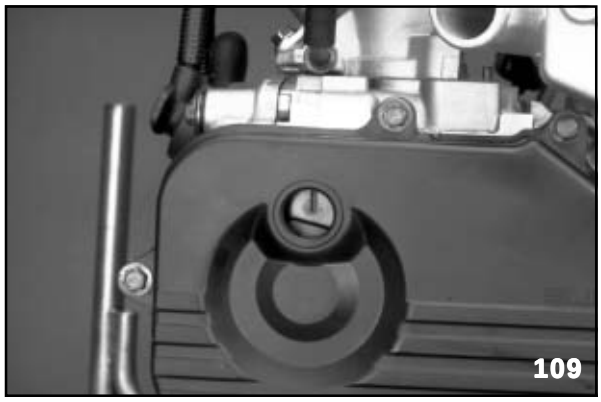
Bolt Tightening Sequence

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.



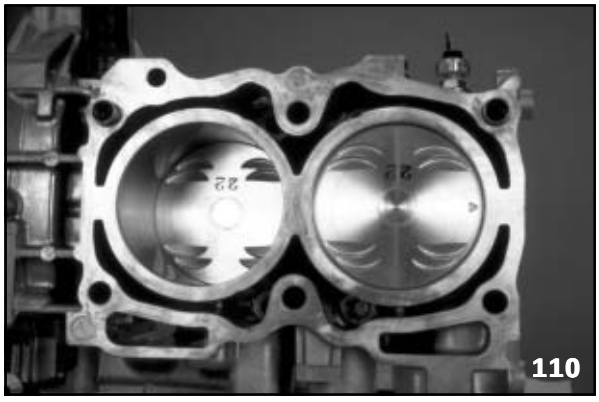
Engine Cam Belt Timing Marks Locations

Timing belt marks on the left bank will be made onto the inner timing belt cover and the edge of the camshaft sprocket. The crankshaft 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

The right bank timing mark can be checked with outer cover in place using the provided window.



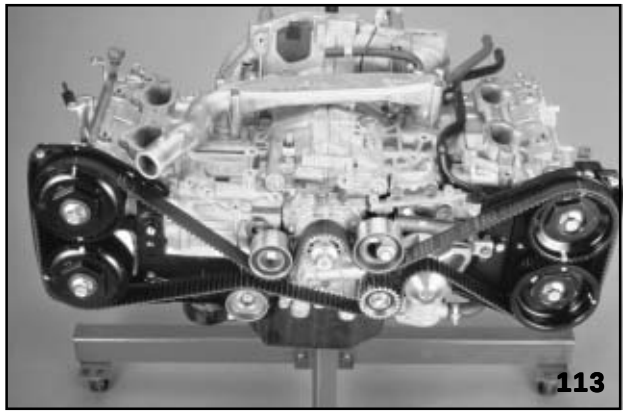
Open Deck Design



New Piston Design

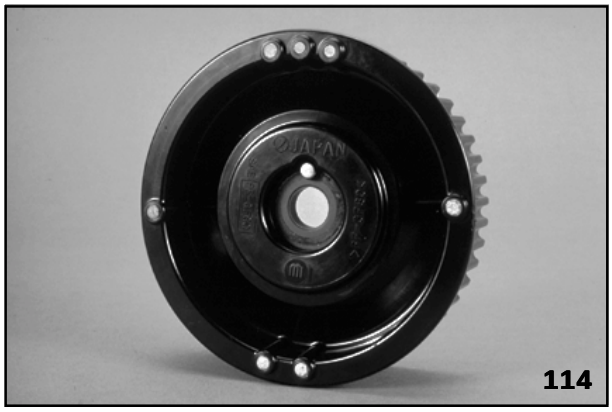
Pistons on the 2.2 liter engines will have a 0.5 mm offset with the engine having a compression ratio of 10.0 to 1. The horsepower has increased to 142hp @ 5600 RPM. Maximum torque 149 ft. lbs @ 3600 RPM.

2.5 Liter Engine Features

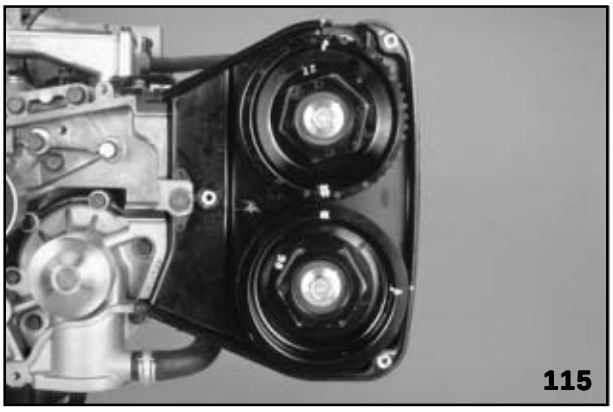


2.5 Liter Engine

The 2.5 liter engine uses double overhead camshafts that are belt driven. Belt tension is maintained through the use of the hydraulic tensioner which is also used on the 2.2 and 3.3 liter engine.



Camshaft Sprocket (Left Bank) (Rear)



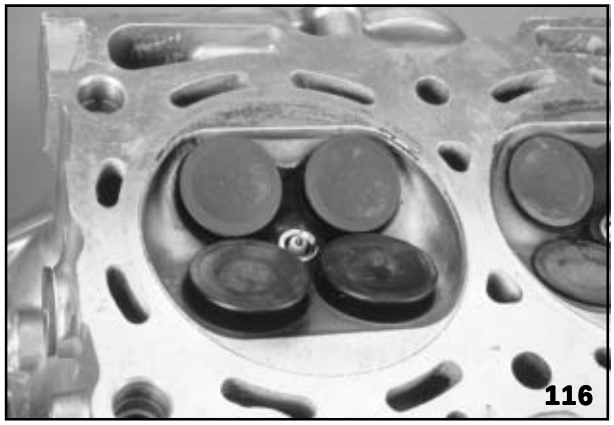
Camshaft Sprocket Timing Marks (Left Bank)

Camshaft sprockets are constructed from a resin type material with a metal key pressed into the sprocket for maintaining proper sprocket to shaft orientation.

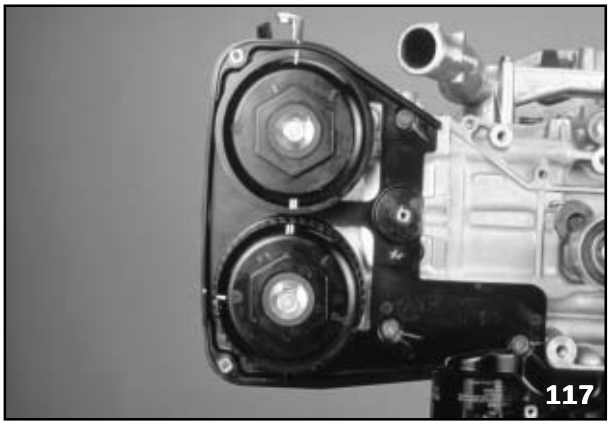
The timing marks on the left bank intake camshaft sprocket are positioned at 12:00 o'clock and 6:00 o'clock. The 12:00 o'clock mark, which aligns with a timing mark on the timing belt housing, is used for camshaft to engine timing. The 6:00 o'clock mark is used for timing the intake camshaft to the exhaust 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.

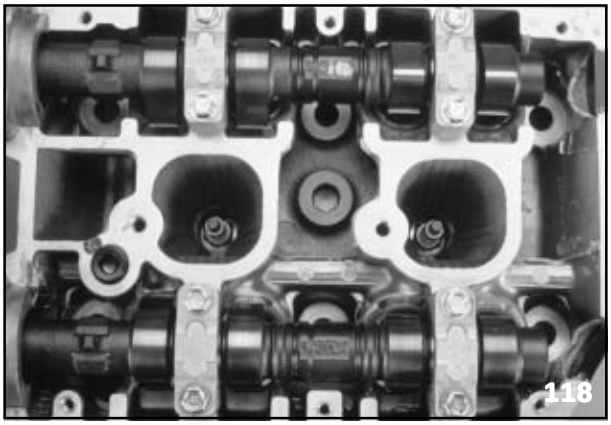


Valve Interference



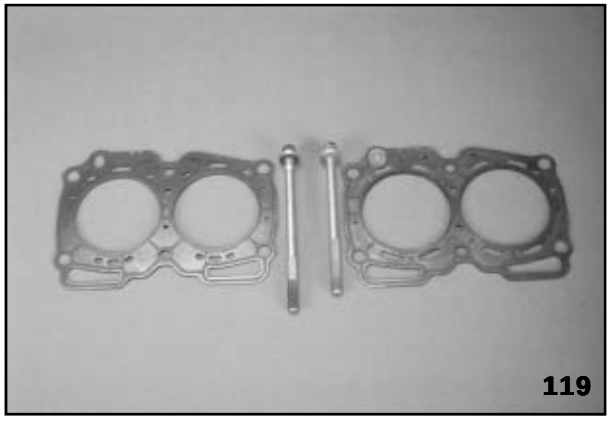
Camshaft Sprocket Timing Marks (Right Bank)

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 (Figure 58-2).



Camshafts

To access the cylinder head bolts, the camshafts must be removed. Follow the procedure outlined in the Subaru service manual for performing this task. The camshafts are held to the cylinder head with bearing caps that are marked (right side) I1TD, I3TD, E1TD, E3TD.

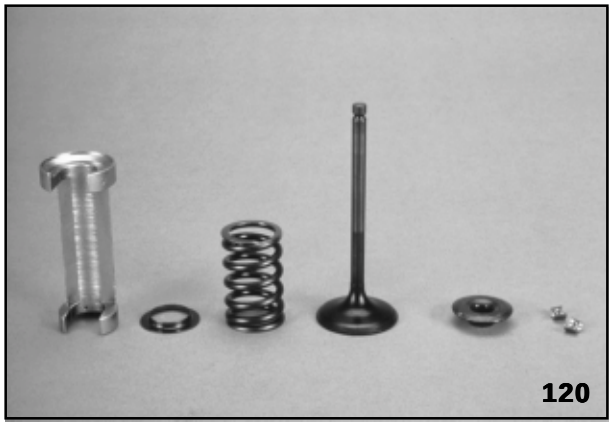


2.2 and 2.5 Liter Head Gaskets

2.5 liter engine head gaskets are identified by the 3 notches located along the gaskets edge, 2.2 liter N/A engine head gaskets have only 2 notches.

CAUTION: THE BOLT PATTERNS FOR BOTH GASKETS ARE THE SAME BUT ARE NOT INTERCHANGEABLE.

The cylinder head bolts for the 2.5 liter engine are much shorter than those of the 2.2 liter engine, and are not interchangeable.



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. (Same maintenance schedule as the SVX.) 2.2 liter engines will use Champion RC10YC4.

Engine oil viscosity for all '96 Legacy and Outback vehicles is 5W-30 to improve fuel economy.



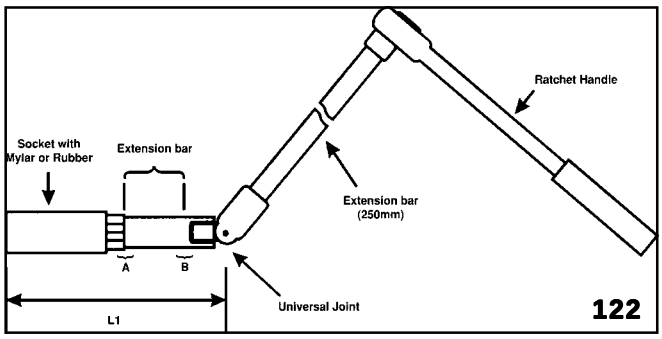
Direct Type HLA

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:

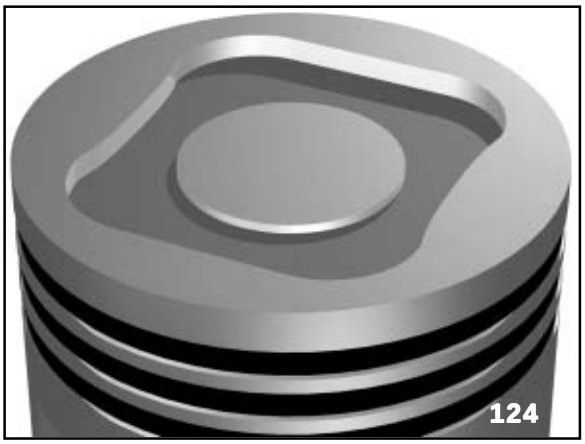
1. Length L1 (100mm, 3.94") is most important for ease of removal and installation.
2. Wrap points A & B with tape to prevent them from separating during work.
3. An approximate 250mm long extension bar is recommended to be used between the ratchet and the universal joint.

1997 2.5 Engine DOHC (Phase 1)

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 Molybendum. This thin coating not only allows a smoother travel through the cylinder but also reduces cylinder wall scuffing.

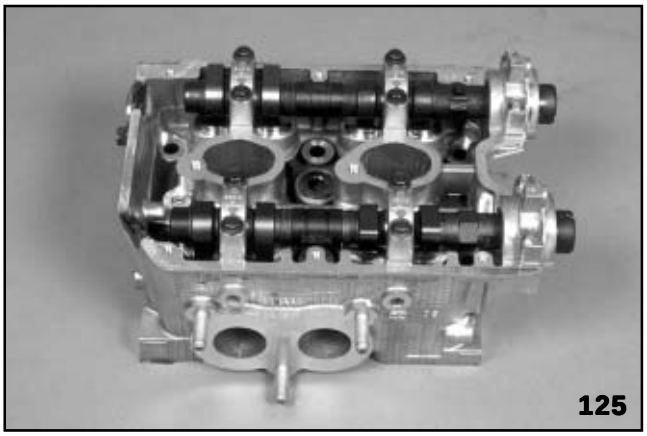
The skirt of the piston has been reshaped and the overall weight has reduced by approximately 100 grams. Compression ratio has been increased to 9.7 to 1 by reshaping the crown of the piston. This eliminates the clearance that was available between the piston at TDC and a fully opened valve. Piston pin 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.

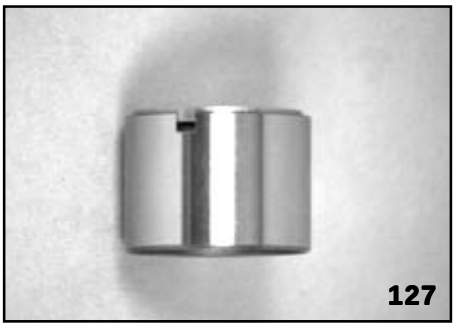
The scheduled service of these valve trains is set at **100,000 miles and is not required during the PDI**. The DOHC engine uses an adjustment shim. There are 94 shim sizes.



2.5 Liter Valve Assembly



2.5 Liter Head on the car



Bucket and Shim Assembly

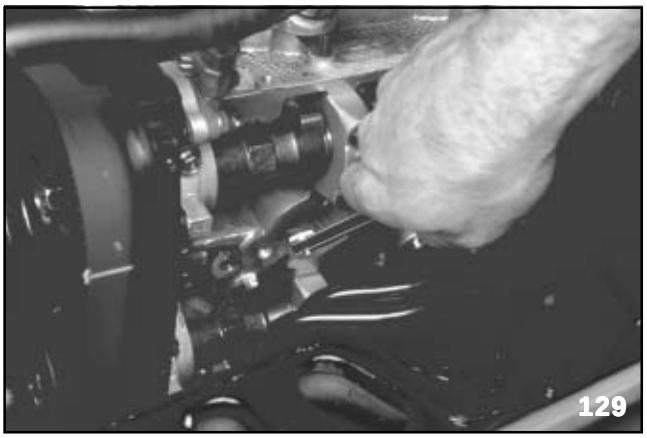
NOTE: USE A THIN NONMAGNETIC TOOL PLACED IN THE NOTCH OF THE LASH ADJUSTER TO REMOVE SHIM. (SPECIAL TOOL J-43979)



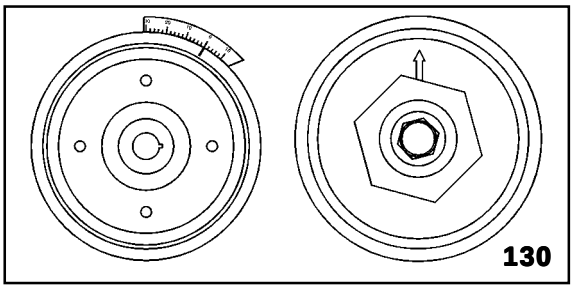
Identifying Shim Size

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 Service Manual Supplement (Volume 6. (2.2 [07B2])



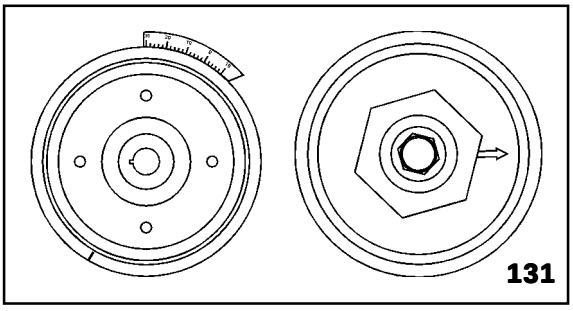
Checking Valve Clearance on the Car



Exhaust Valve Clearance on Cylinders 1 and 3

Step 1

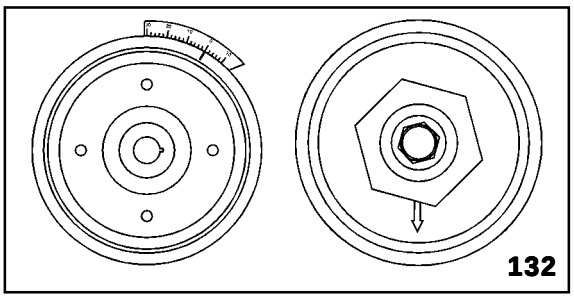
- Set the crankshaft sprocket at 0 degrees. (use crankshaft wrench)
- Set the left intake camshaft sprocket arrow at 12 o'clock (Please remember that the camshaft sprocket has an arrow and a mark used for belt timing. Make certain to use the arrow and not the mark for valve clearance check.)
- The engine 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

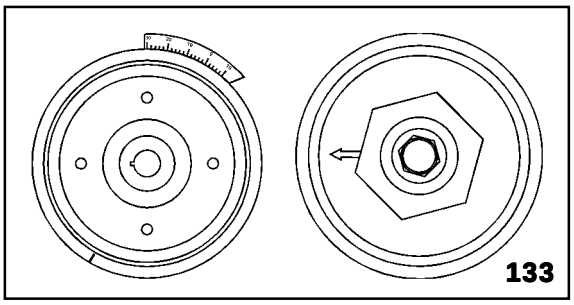
- Rotate the crankshaft 180 degrees
- The left intake camshaft arrow should now be at 3 o'clock (Figure 7).
- Check the clearance of the **intake valves on cylinders 1 and 3 only**.
- Record the measurement



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)

Example:

To solve for the new shim or "T"

- Cylinder 1 intake measured valve or clearance is 0.22 mm no adjustment needed
- Cylinder 1 exhaust measured valve or clearance is 0.15 mm adjustment needed
- Cylinder 3 intake measured valve or clearance is 0.31 mm adjustment needed

The shim in use on cylinder 1 exhaust is marked 240. This refers to the shim having a thickness of 2.40 mm

T = 2.40 S = V + T (0.25 mm)
V = 0.19 S = .19 + 2.4 - (0.25mm)
SVC = 0.25 +/- 0.03 S = 2.59 - 0.25mm
(Standard valve clearance) S = 2.34

The shim in use on cylinder 3 intake is marked 245. This refers to the shim having a thickness of 2.45 mm

T = 2.45 S = V + T (0.20mm)
V = 0.31 S = .31 + 2.45 - (.20mm)
SVC = 0.20 +/- 0.03 S = 2.76 - .20mm
(Standard valve clearance) S = 2.56

Step 6

- Current method of shim replacement is accomplished by removing the camshafts.

CAUTION: (FOLLOW THE DIRECTIONS PROVIDED IN THE APPROPRIATE SERVICE MANUAL FOR CAM-SHAFT REMOVAL AND BELT INSTALLATION.)

Refer to 2-2 [07B2] of the 1997 Service Manual Supplement (Volume 6).

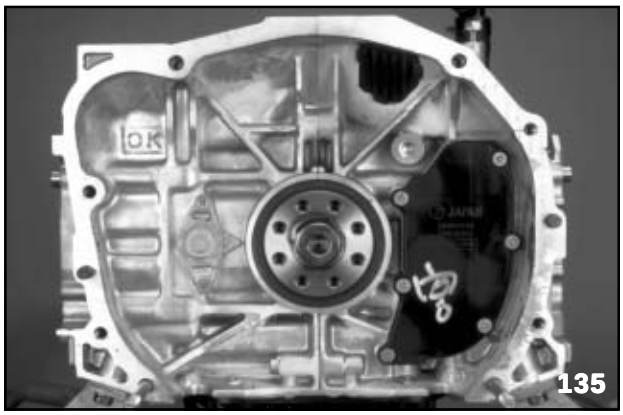
NOTE: SPECIAL TOOL 498187100 MAY ALSO BE USED FOR THIS PROCEDURE.

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.

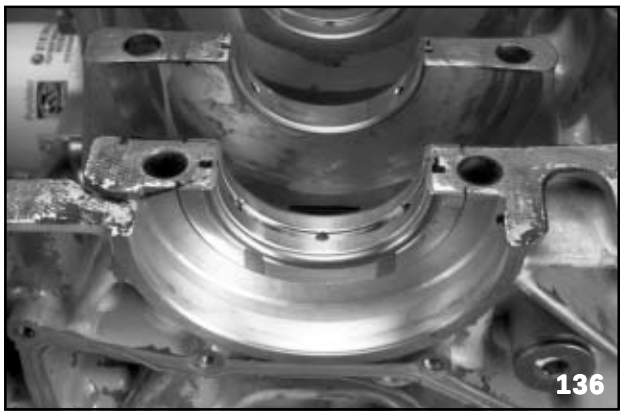
The 2.5 liter phase 2 engines are SOHC engine with a newly designed cylinder head. The (phase 1) 2.5 liter engine uses the same cylinder head configuration that it has used on prior year models with the crankcase and bell housing sharing the same characteristics of the new phase 2 engines.

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

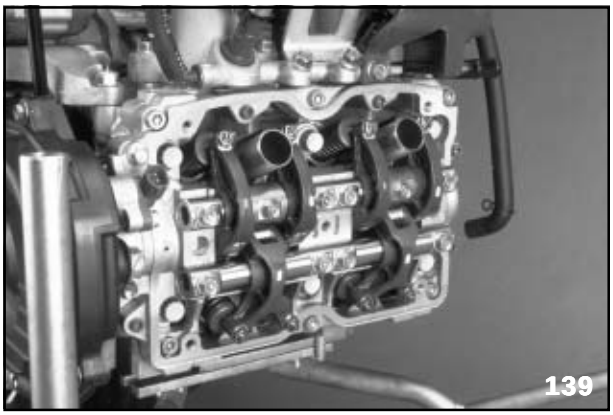
The thrust bearing has been moved to the number 5 position.



Main Bearing Oil Grooves

Oil groove in the number 1 and 3 have been changed to supply additional lubrication to the crank journal.

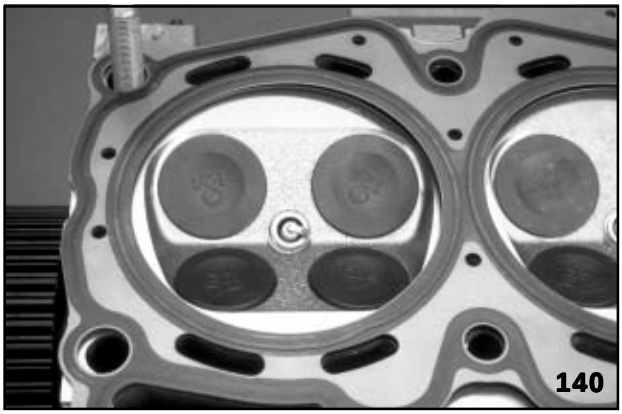
New Features of the 2.5 Liter (Phase 2) SOHC Engine



2 Rocker Shaft Assembly

The cylinder head will be a 2-rocker shaft roller solid type 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.

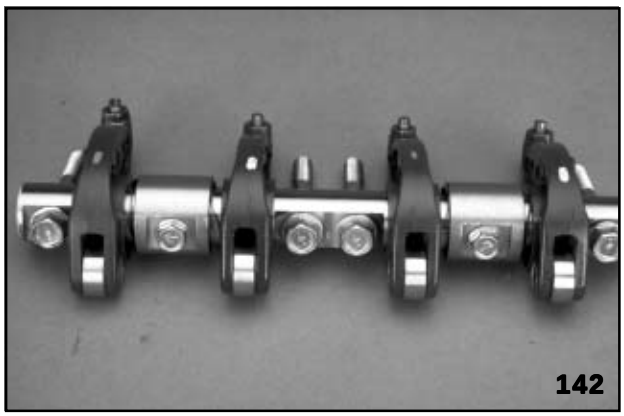


New Head Gasket Design

Head gasket thickness is 0.7 mm.



Rocker Arm Identification

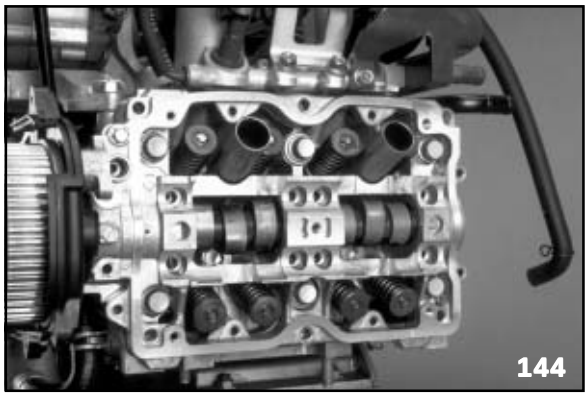


Roller Rockers and Wave Washers

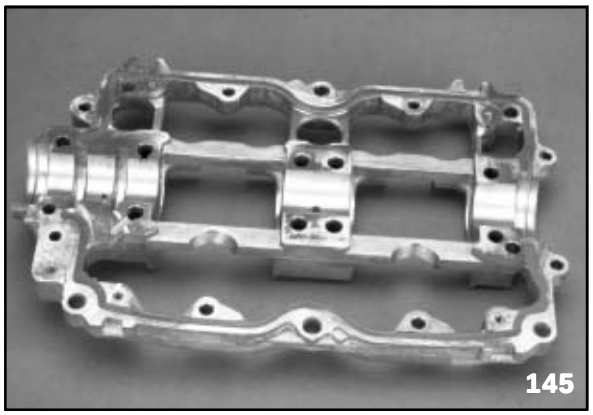


Adjustment Screw and Nut

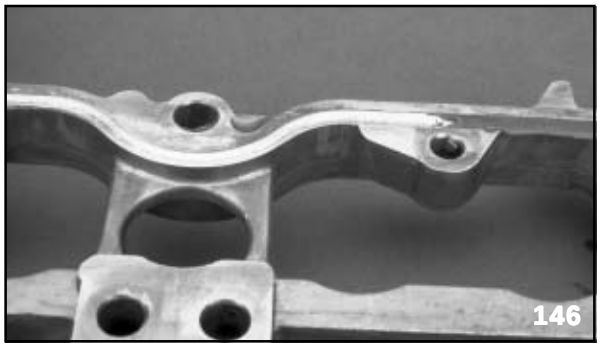
The intake rocker arms are marked so they are correctly placed on the rocker shaft when servicing. An IN1 or IN2 will be embossed on each rocker arm. As viewed from the front of the engine the Number 1 intake valve of each cylinder and the number 2 intake valve have an IN1 marked and IN2 marked rocker 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

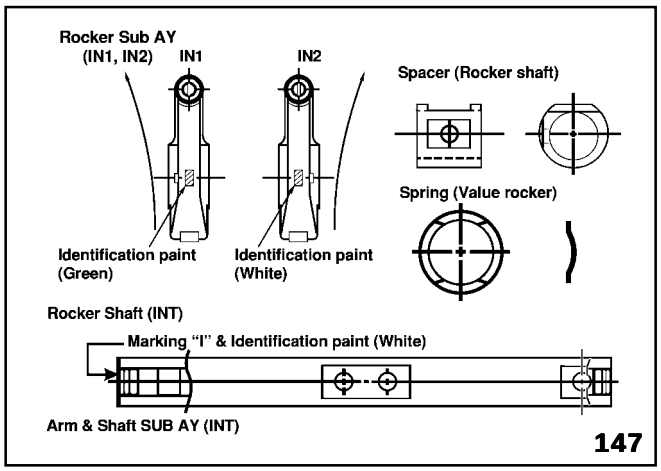


Sealing Groove

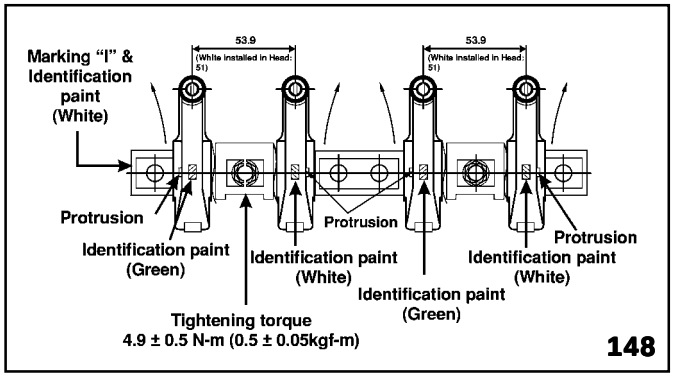
The camshaft is secured to the cylinder head with the camcase. An oil passage in the cylinder head provides the passageway in the camcase with oil that leads to the intake rocker shaft. Oil from the camshaft is collected on the opposite side of the passageway leading to the intake rocker shaft to provide 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.

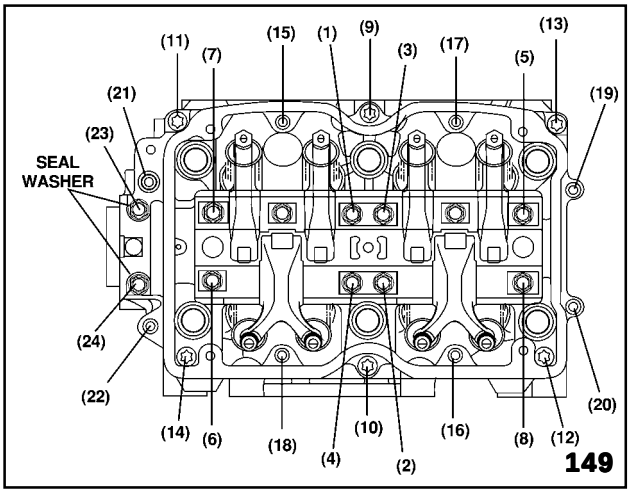
NOTE: CYLINDER HEAD AND CAMCASE MUST BE REPLACED TOGETHER. (LINE BORED)



Rocker Identification

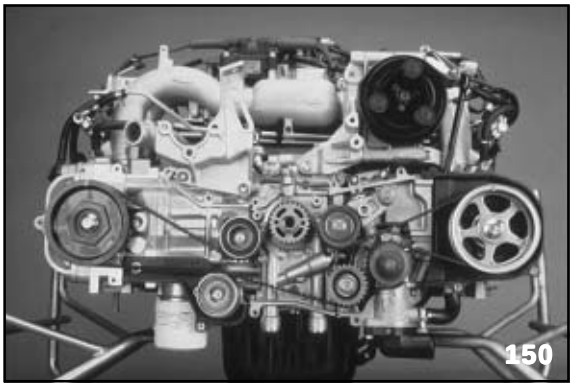


Rocker Arm Measurements



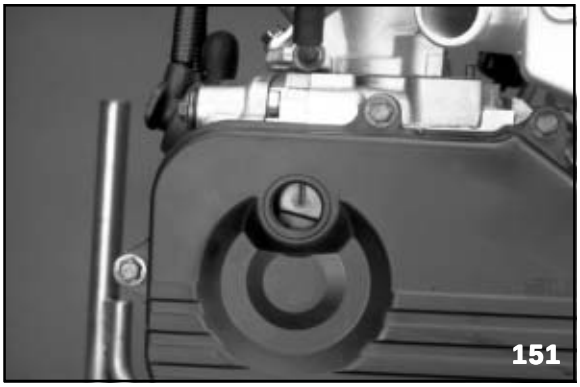
Camcase Tightening Sequence

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.



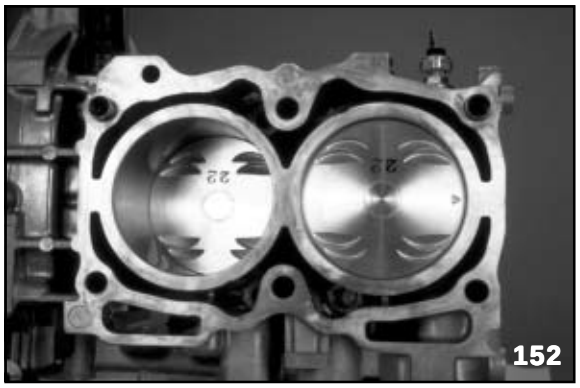
Timing Belt Marks

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.



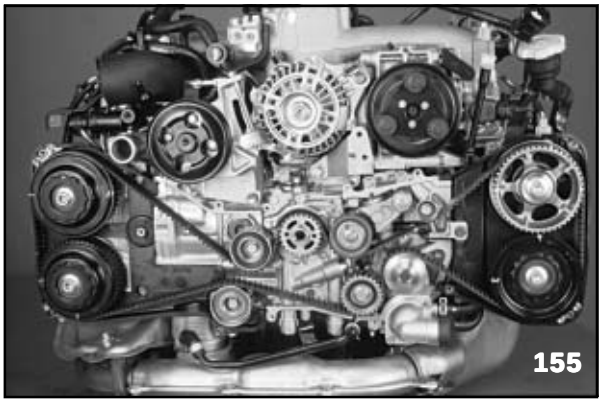
Open Deck Design



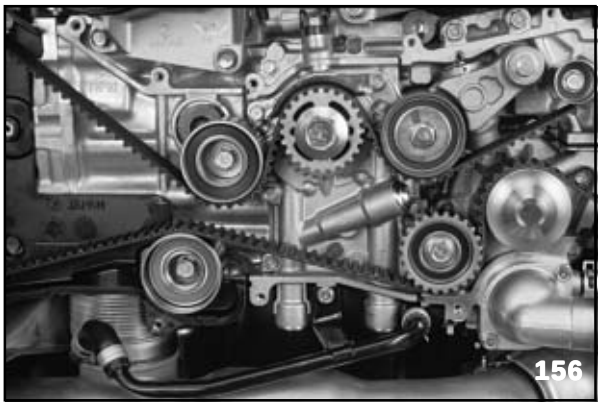
Piston With Valve Reliefs

Piston design on the 2.5 liter engine will remain the same as the 2.2 liter. The compression ratio is 9.7 to 1.

2.0 Liter Engine Features



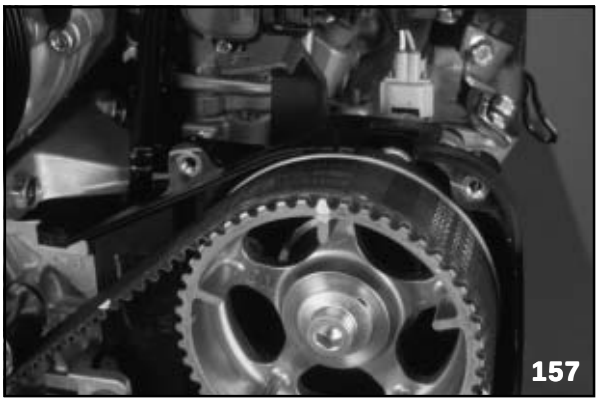
2.0 Liter Engine



Cam Belt and Idler Pulleys

The EJ-2.0 engine is a double over head camshaft engine equipped on all turbo charged Impreza vehicles. 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)

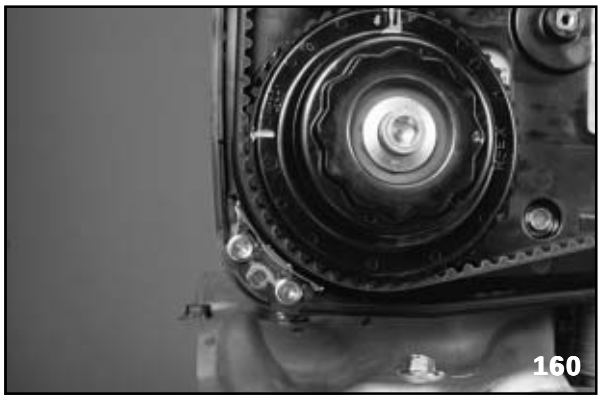
The left bank intake camshaft sprocket is metallic and the camshaft reluctor is made onto the backside. The timing marks for belt installation are at 12:00 (❙) and 6:00 (❙❙).

The left exhaust sprocket is made of a resin material with its timing marks during belt installation at 12:00 (❙❙) and 3:00 (❙). The exhaust 12:00 (❙❙) mark lines up with 6:00 (❙❙) 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 (❙) and 6:00 (❙❙). (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 (❙) and 12:00 (❙❙). The exhaust 12:00 (❙❙) mark lines up with 6:00 (❙❙) 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.



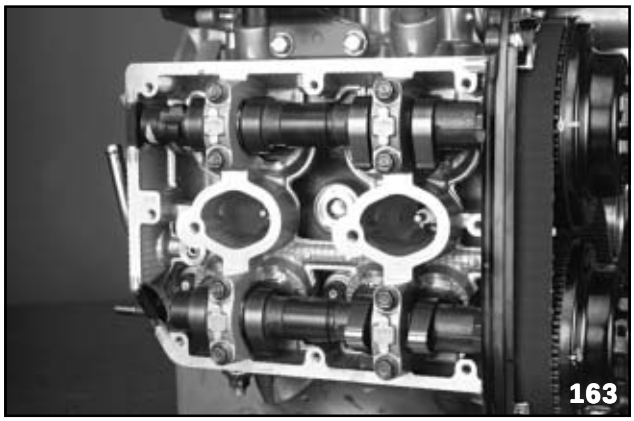
Engine Designation Number

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.

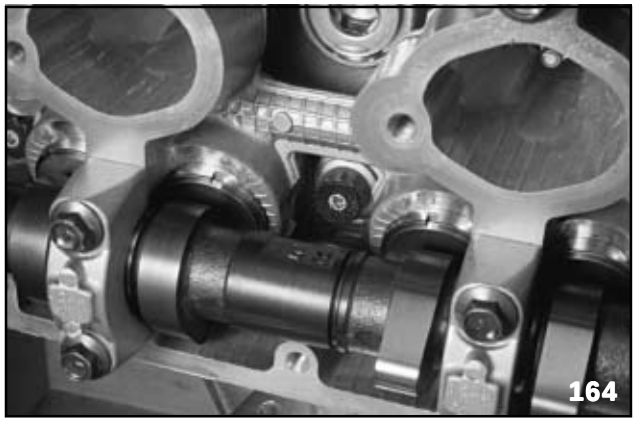


Factory Coolant Pipe Plug

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.

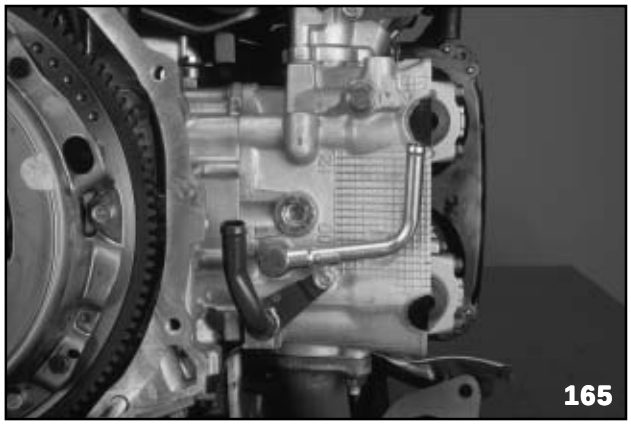


2.0 Liter Valve Train Assembly



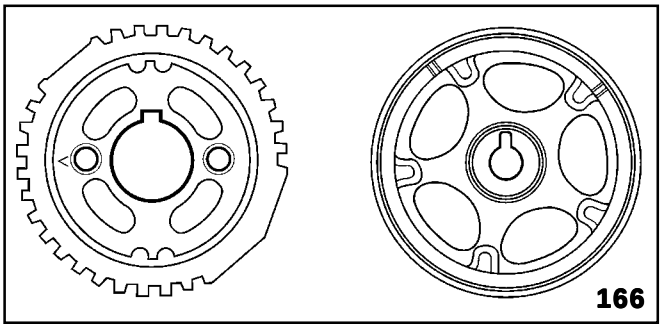
2.0 Liter Head Bolt Access

The valve train for the EJ 2.0 is the same design used on other DOHC engines. A new shim tool 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.



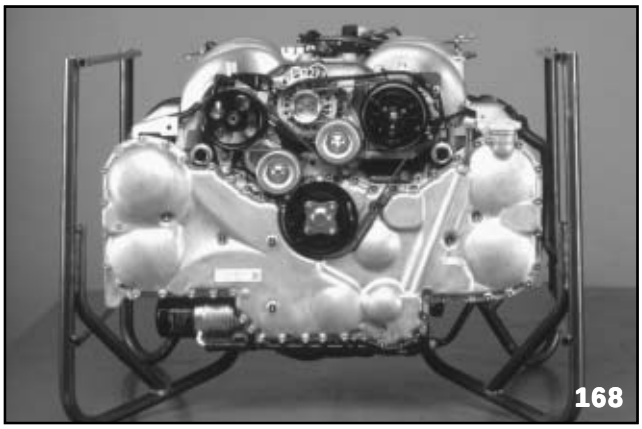
Turbo Oil and Coolant Passages (Right Bank)

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

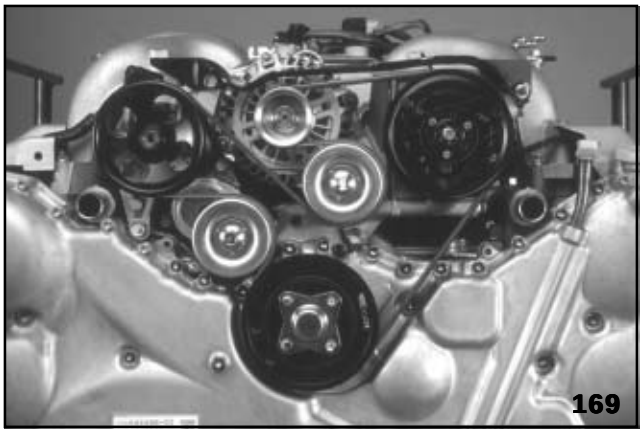
3.0 Liter Engine



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

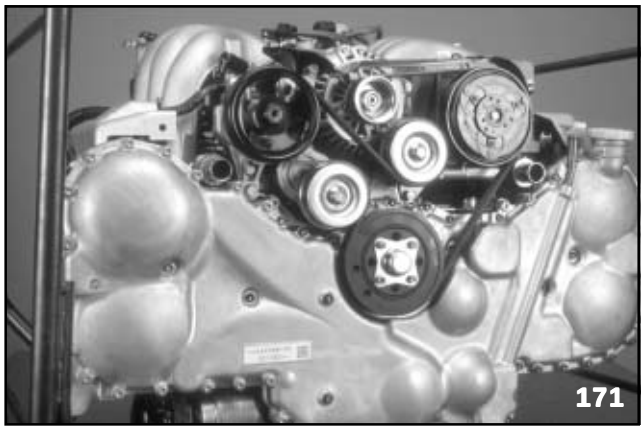
The front of the engine displays the large front timing chain cover. It is secured to the inner cover with 59 bolts. There are 4 different lengths used and is sealed to the inner cover with Three Bond (1280B). Special care must be used when servicing the timing chain covers to ensure the proper length 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.

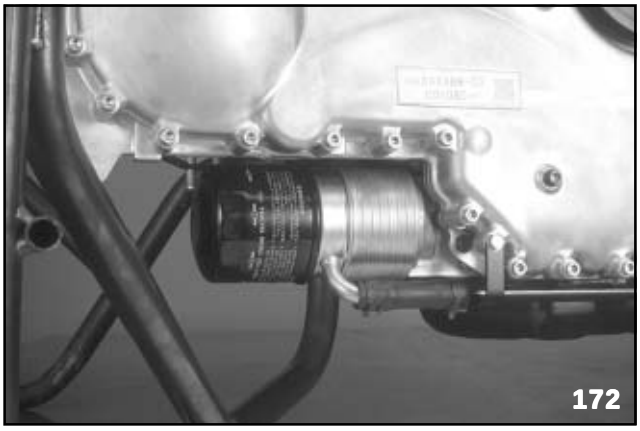
3.0 Specifications

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



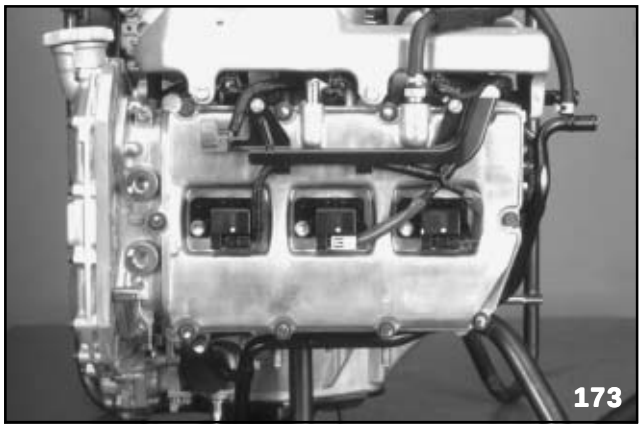
Upper Radiator Hose Connections

Two radiator hose connections are located at the top of the engine block connecting to each of the cylinder heads.

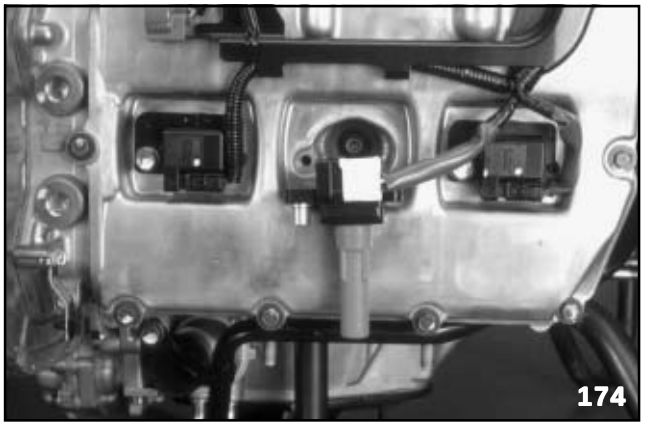


Oil Cooler

An oil cooler is used to assist with bringing the oil to operating temperature.

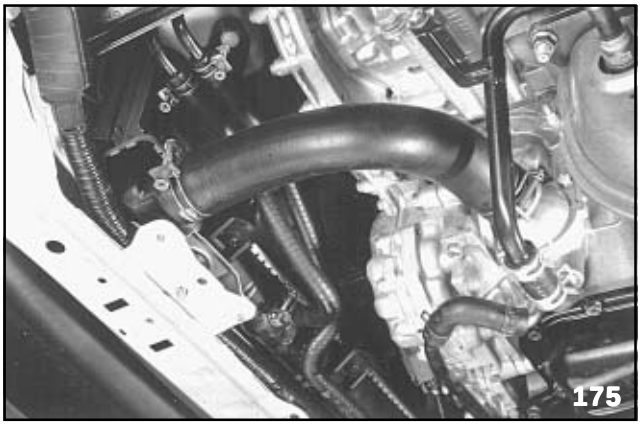


Individual Coils



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.



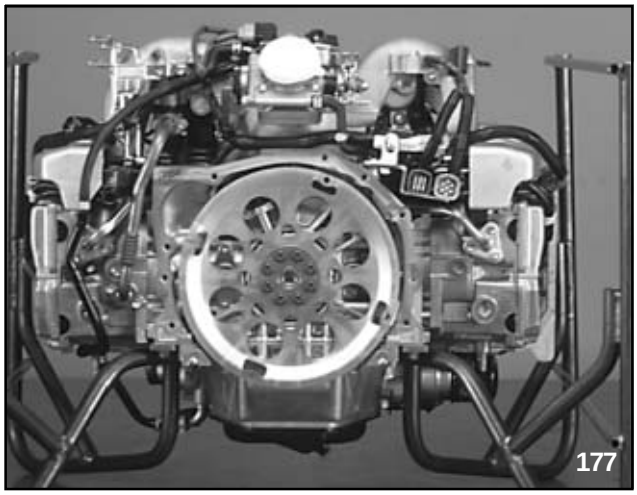
Lower Radiator Hose

The lower hose is located on the thermostat housing, connecting to the lower section of the radiator.



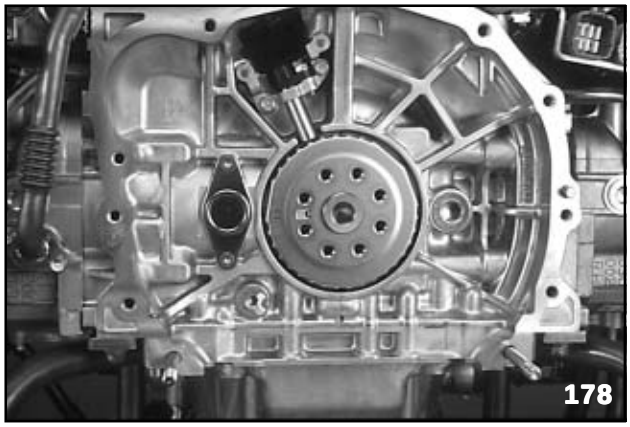
Oil Pan and Extension Case

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

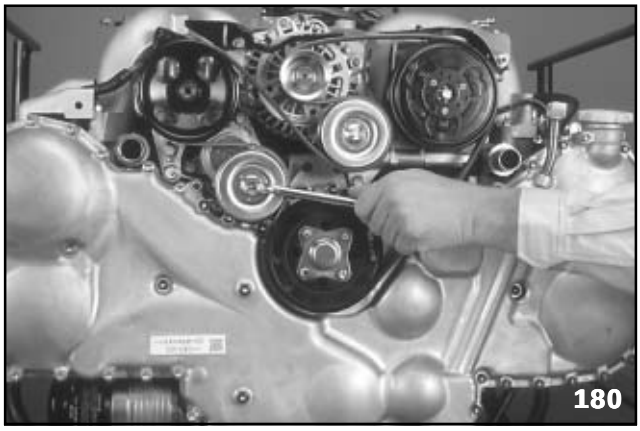
Connections for the crankcase ventilation system are located at the top of the valve cover. Pressure is equalized from the right bank with a cross over tube.



Crank Angle Sensor with Reluctor

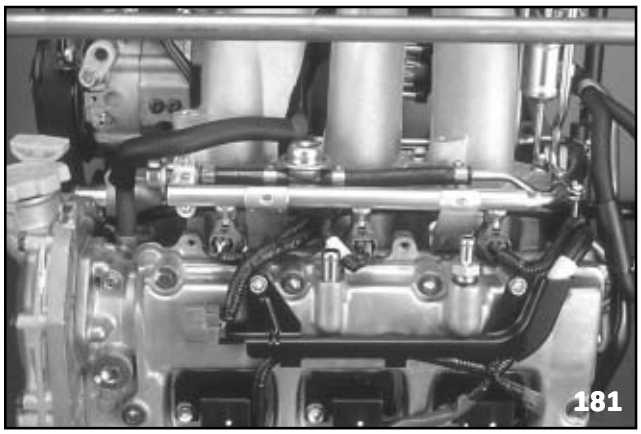
The new crank angle sensor, reluctor, and EGR pipe. The crank angle sensor and reluctor have been moved to the rear of the crankshaft. The EGR pipe has a new design and is mounted on the left bank of the engine.

3.0 Liter Engine Disassembly



Unloading Tensioner

Begin disassembly by unloading and removing the serpentine belt.



Fuel Rail Assembly

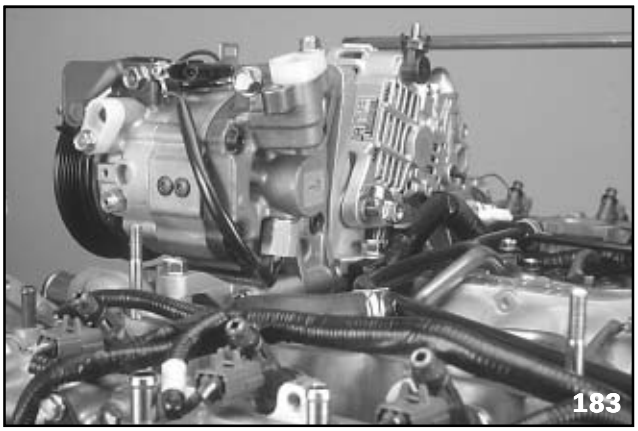
Remove the fuel rail protectors from both sides.



Lower Alternator Bolt

The lower alternator bolt must be backed out before the manifold can be removed.

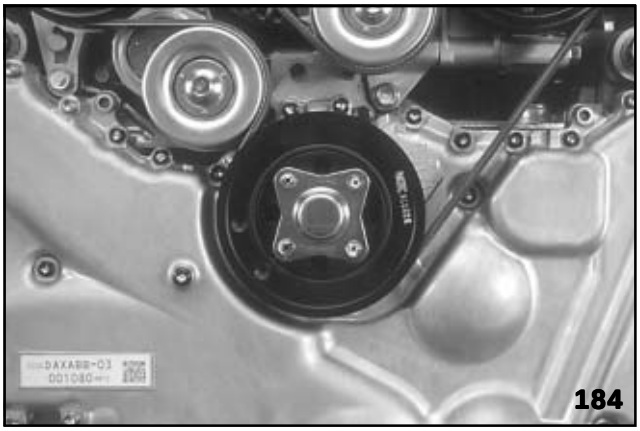
Remove the intake manifold.



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.

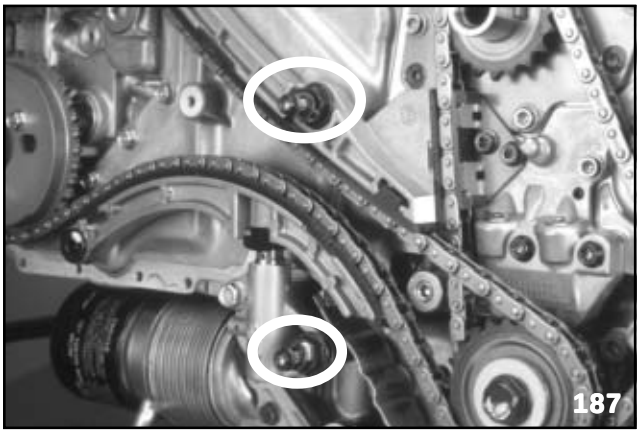
Begin removing the outer cover bolts. Keep them organized to ease reassembly. The bolts must be removed in the proper sequence to avoid warping the outer case.



Outer Cover Seals

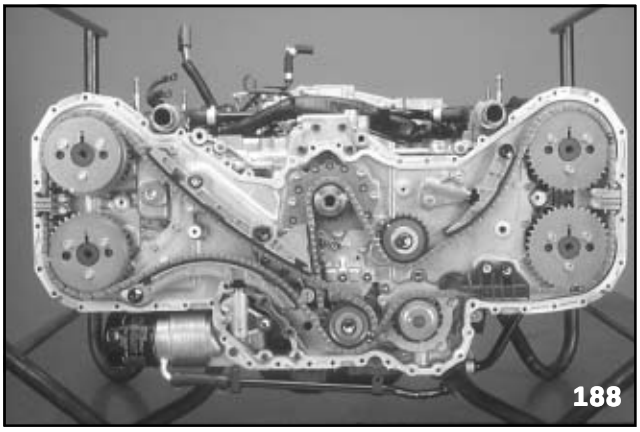
These two bolts use sealing washers to prevent engine oil from leaking to the outside.

The seals are not reusable.



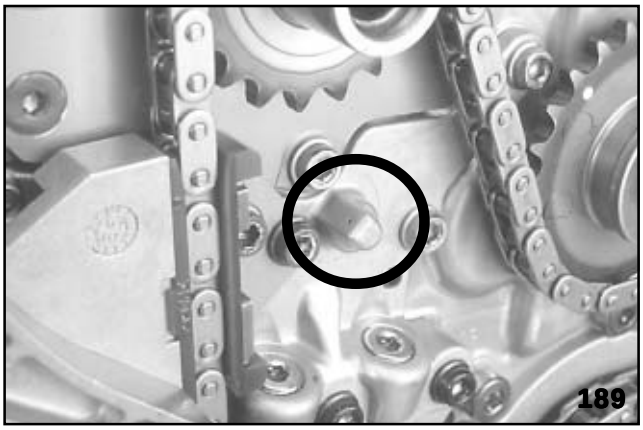
Outer Cover Bolts

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

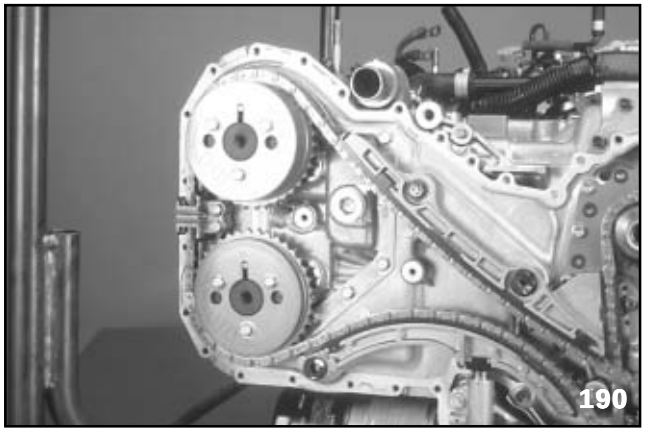
The timing chain on the EZ-3.0 is designed to last the life of the engine. Proper engine oil maintenance is necessary to ensure it lives up to its design. Two chains are used. Four (4) camshaft sprockets, one (1) crankshaft sprocket, two (2) idler sprockets and the water pump complete the timing chain routing.



Timing Chain Oil Jet

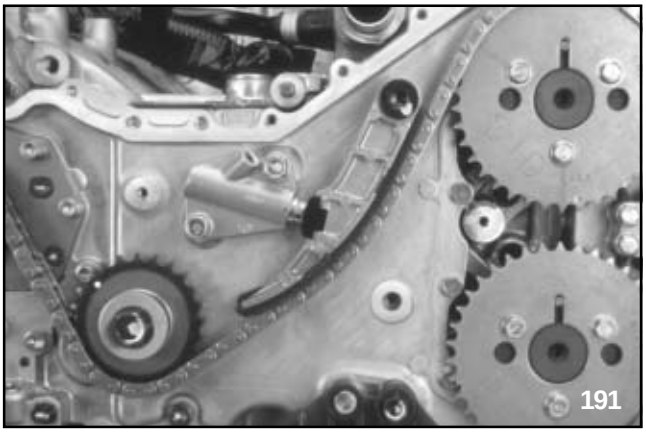
The timing chain is sprayed with oil from this jet located on the oil pump relief valve housing.

CAUTION: THE SPROCKET TEETH ARE SHARP SO USE EXTREME CARE WHEN WORKING NEAR OR AROUND THEM.



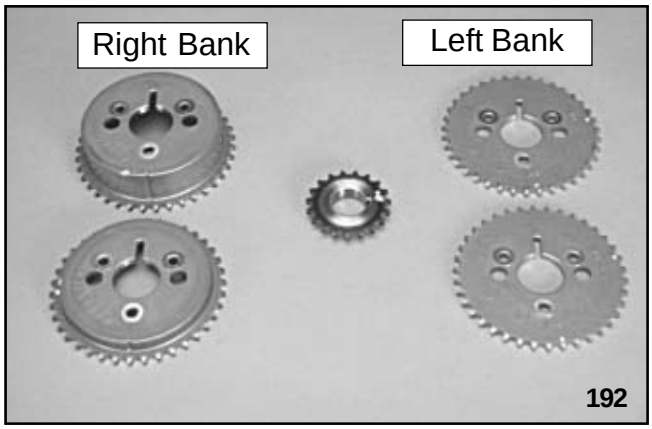
Right Bank Camshafts

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.



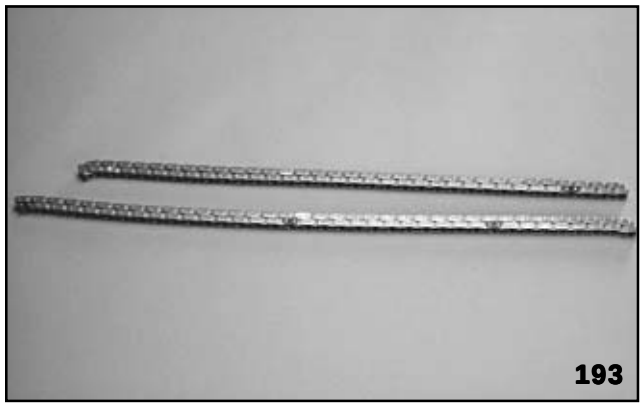
Left Bank Timing Marks

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.*



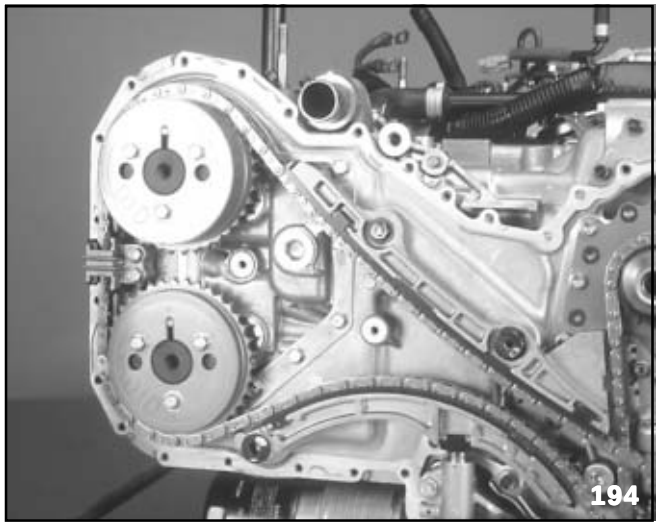
Camshaft Sprockets

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.



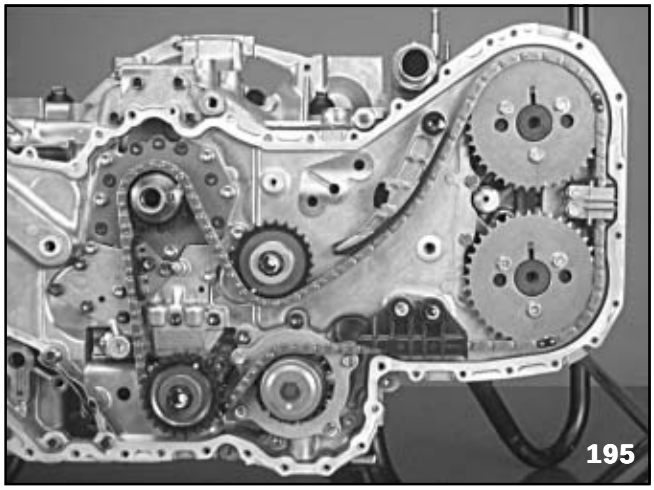
Timing Chains

The left timing chain is the longer of the two with 148 links. The right chain has 134 links.



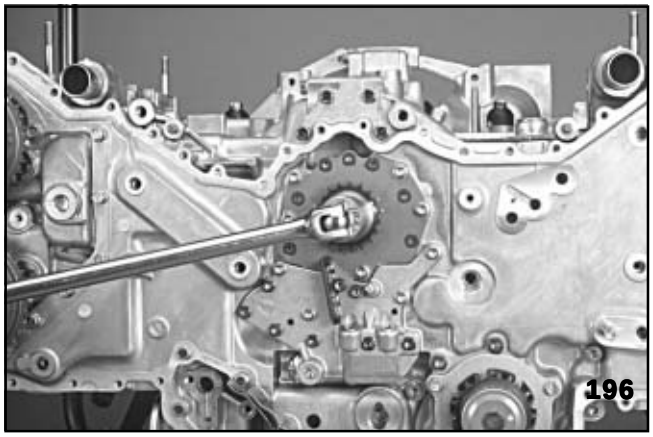
Removal of Right Bank Timing Chain Components

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.



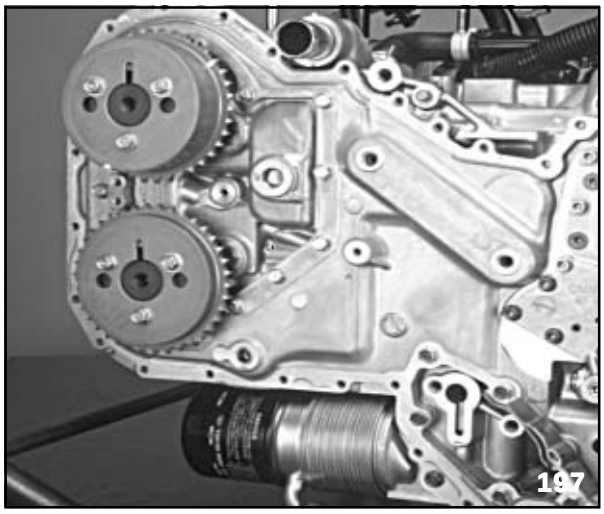
Removal of Left Bank Timing Chain Components

Remove the left bank tensioner, chain and chain guides..



Turn Crankshaft to Prevent Piston and Valve Damage

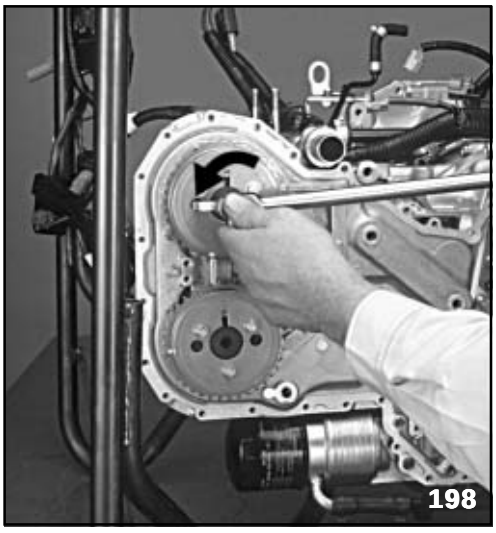
NOTE: TURN THE CRANKSHAFT 90 DEGREES COUNTER CLOCKWISE TO REDUCE THE CHANCE OF ACCIDENTAL DAMAGE TO THE PISTONS AND VALVES IN THE EVENT THE CAMSHAFTS SUDDENLY UNLOAD.



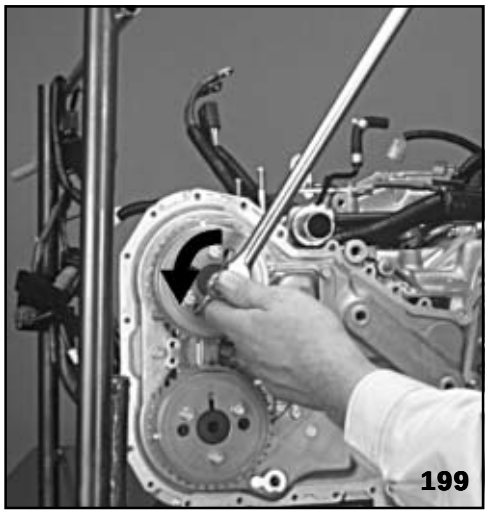
Right Bank Camshafts in Loaded Postion

The left bank is currently unloaded. The right bank is loaded and must be unloaded using the procedure depicted below.

Unloading Cam Sprockets

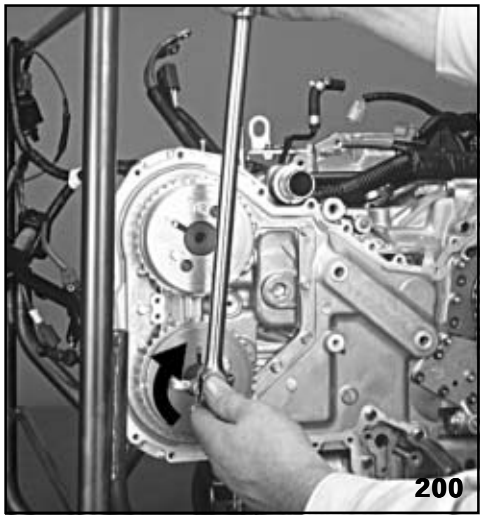


Unloading Intake Camshaft

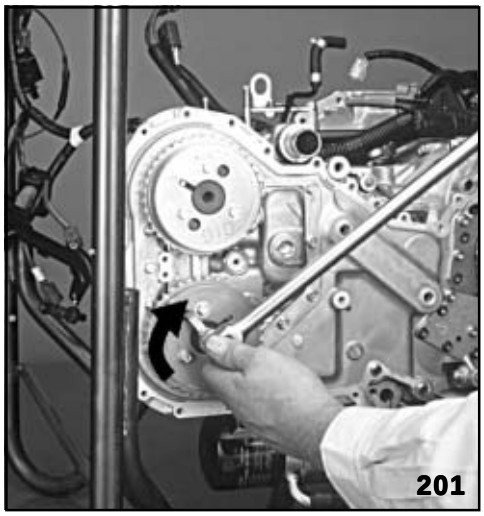


Unloading Intake Camshaft

Position the camshaft sprocket wrench on the **right bank intake** sprocket and turn 90 degrees **counter clockwise.**

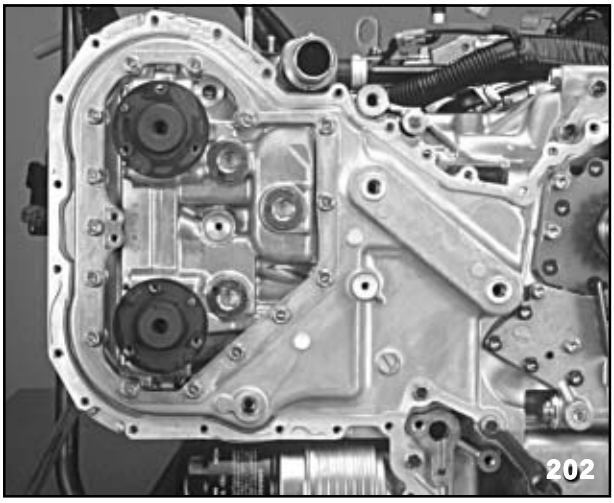


Unloading Exhaust Camshaft

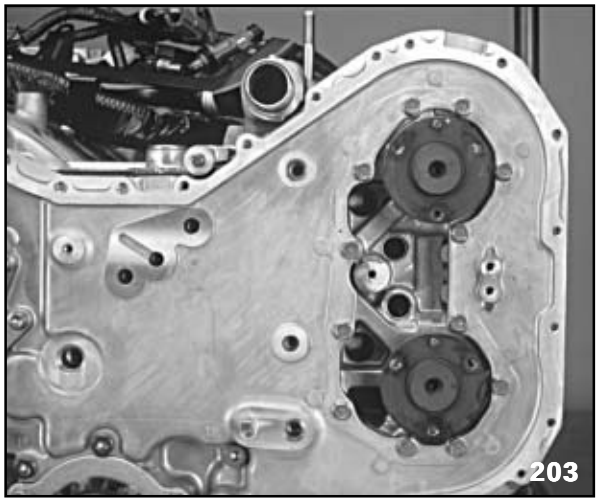


Unloading Exhaust Camshaft

Position the camshaft sprocket wrench on the **right bank exhaust** sprocket and turn 90 degrees **clockwise**. Both camshafts are now unloaded.

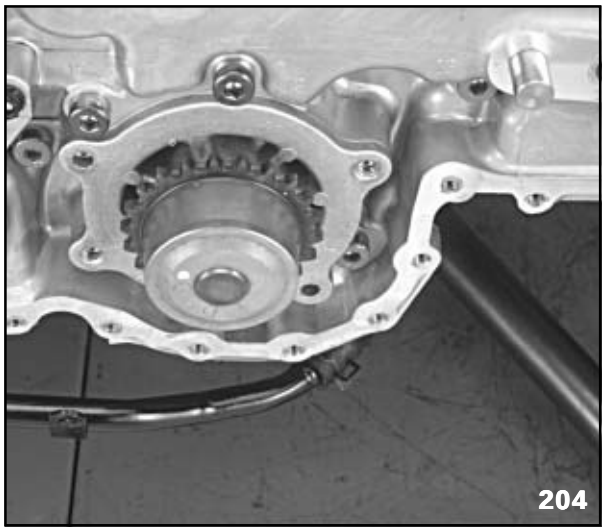


Remove Camshaft Sprockets (Right Bank)



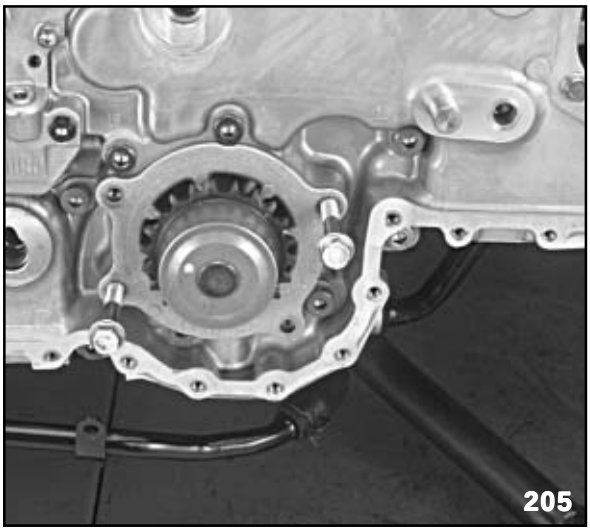
Remove Camshaft Sprockets (Left Bank)

Remove both the intake and exhaust camshaft sprockets on the left and right banks.



Water Pump Assembly

Remove the bolts from the water pump.

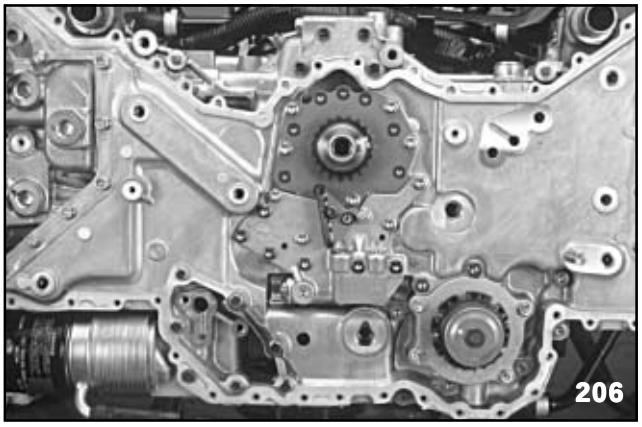


Insert Bolts for Pump Removal

Thread two eight millimeter bolts as shown and equally turn them in. This will assist with the removal of the pump.

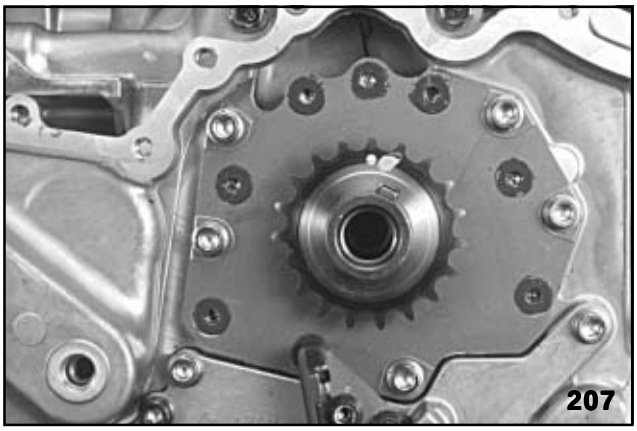
Remove the o-ring that seals the water pump to the inner cover.

Removal of Oil Pump



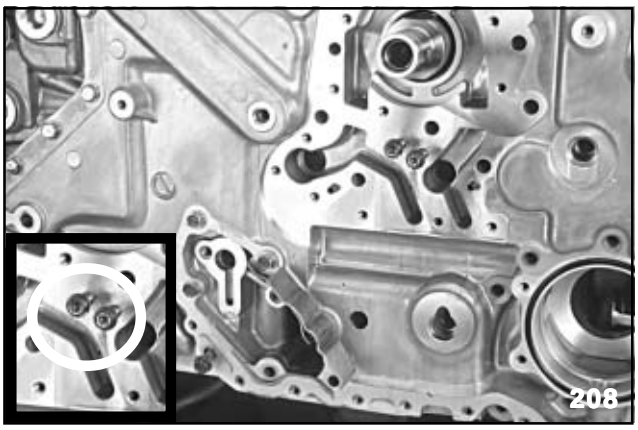
Oil Pump Cover

Remove the oil pump cover and oil pump gears.



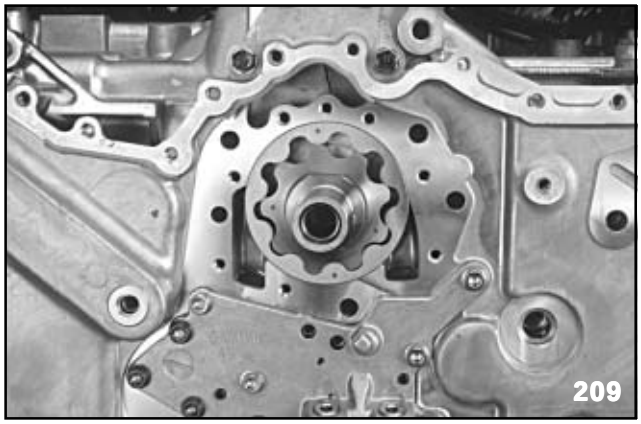
Chain Guide

NOTE: THE CHAIN GUIDE MUST BE REMOVED BEFORE REMOVING THE OIL PUMP COVER.



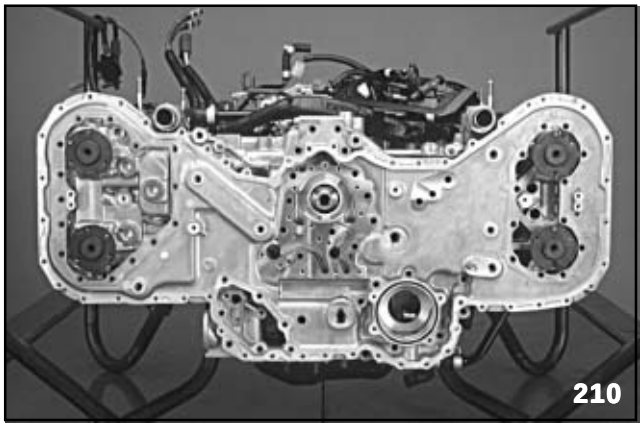
Chain Guide Bolts

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.

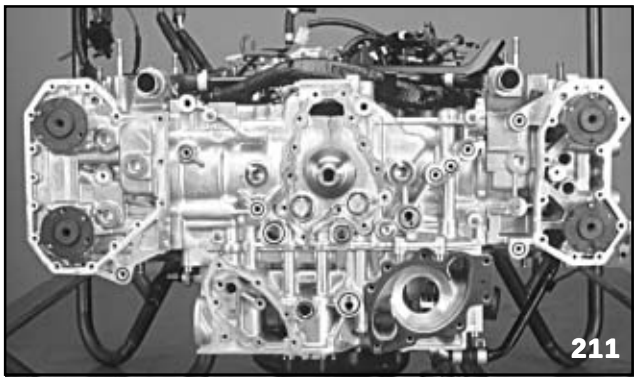


Inner Cover

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



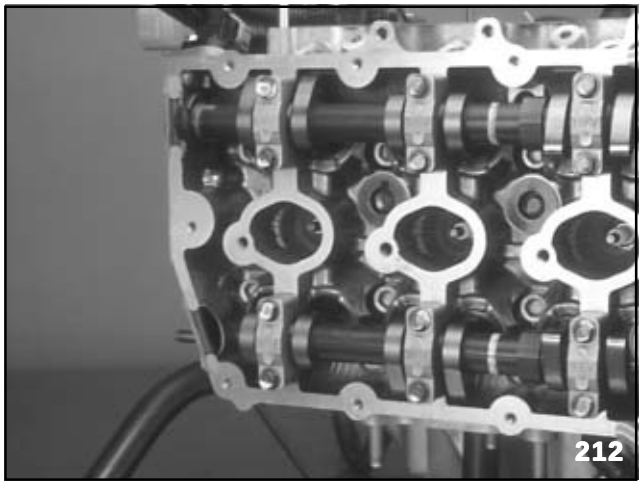
O-Ring Locations

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



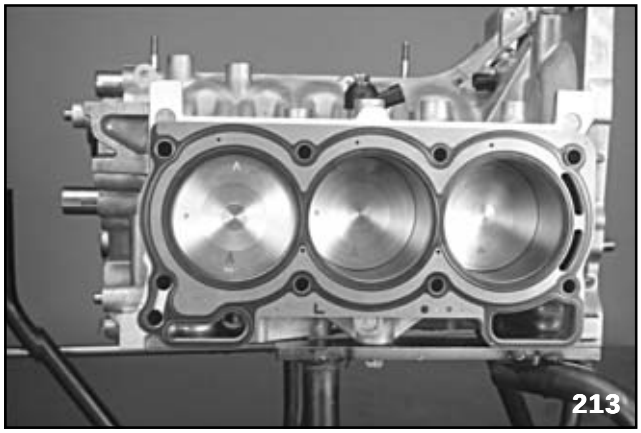
Valve Train Assembly

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.

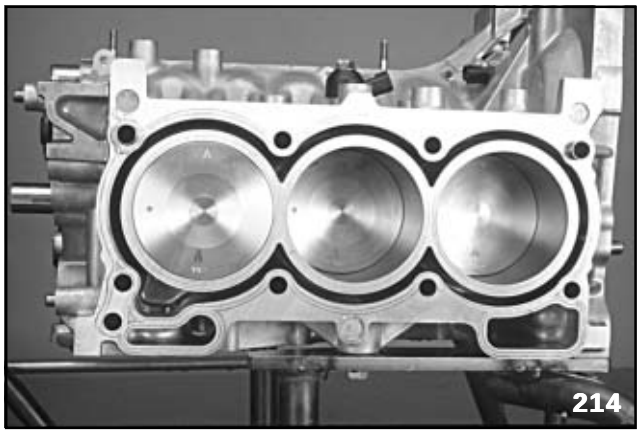
Remove the cylinder head and gasket.

Repeat this procedure on the opposite side.



Cylinder Block with Head Gasket

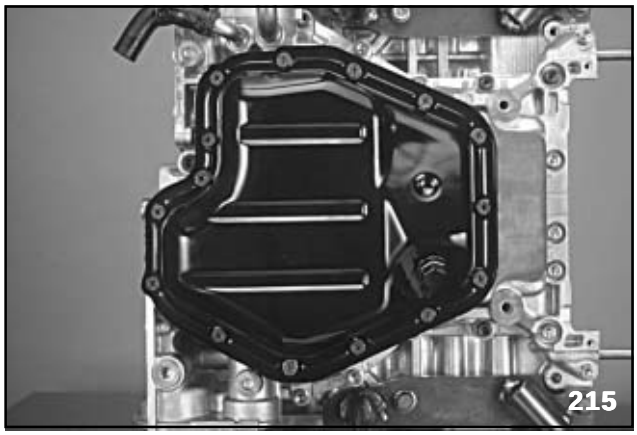
The cylinder block is made from aluminum die casting with monoblock casting cast iron cylinder liners. Water jackets are independent for the RH and LH block halves.



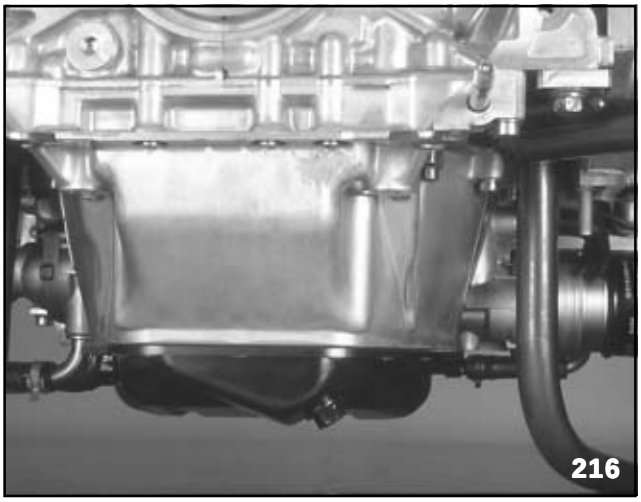
Open Deck Design

The block utilizes open deck design.

Removal of Oil Pan

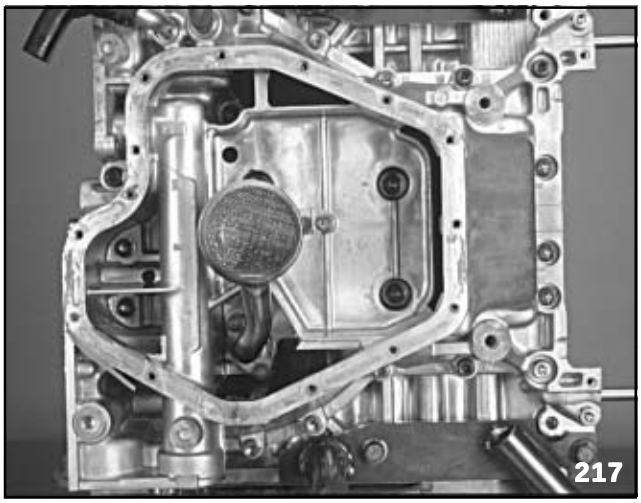


Oil Pan (Lower)



Oil Pan (Upper)

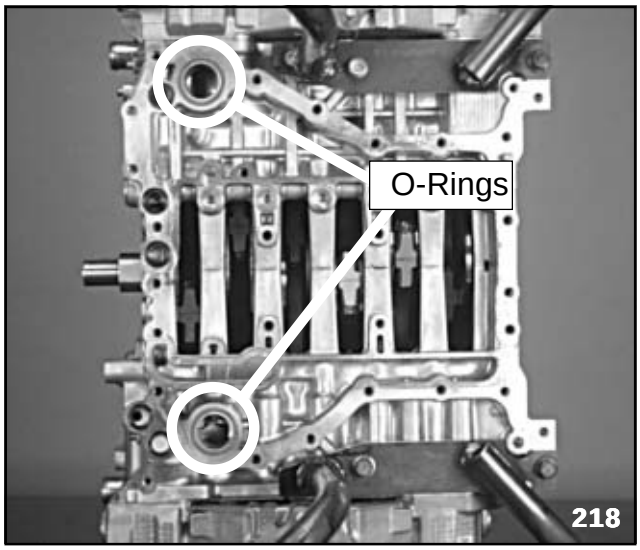
Remove the oil pan bolts and oil pan. Observe that the Oil Pan has a different design from 4 cylinder Subaru engines.



Oil Pan Bolt Locations

NOTE: PLACEMENT OF BOLTS.

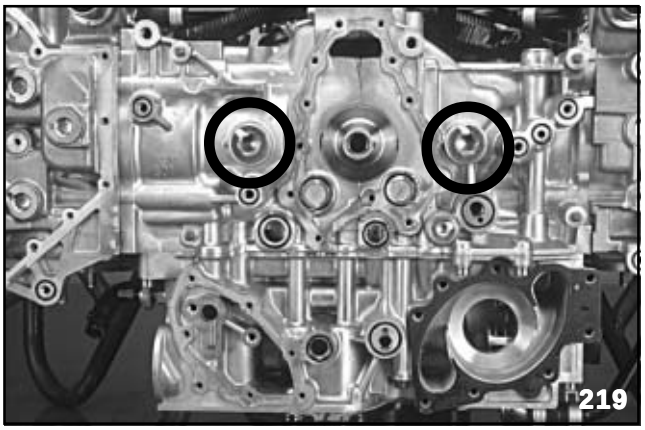
Remove the oil pan extension housing bolts. There are 28 bolts with five different lengths. Follow the proper sequence to prevent warping the case.



Block O-Ring Locations

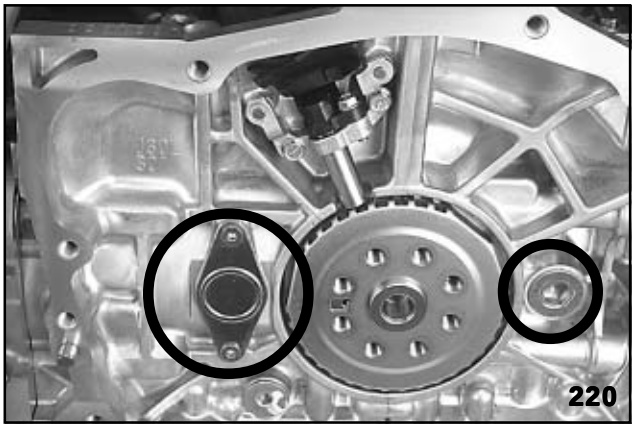
NOTE: CONFIRM PLACEMENT OF O-RINGS

Piston Pin Access



Piston Pin Access (Front View)

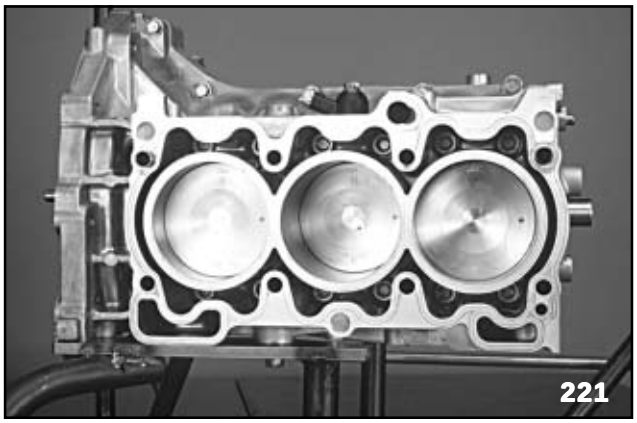
The piston pin access is gained from the front at these two positions.



Piston Pin Access (Rear View)

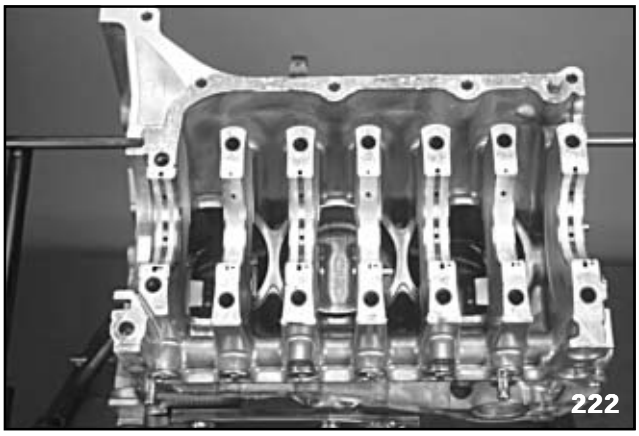
Rear piston pin access is gained at these two points. Remove the piston pins and organize them for assembly to their original positions.

Spliting Block Halves

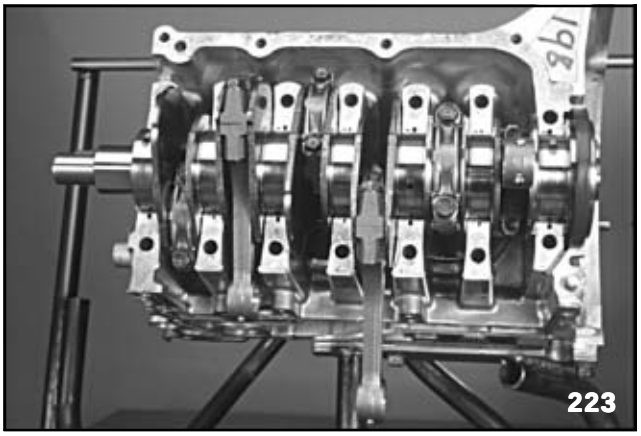


Engine Block Assembly Bolts (Right Bank)

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.

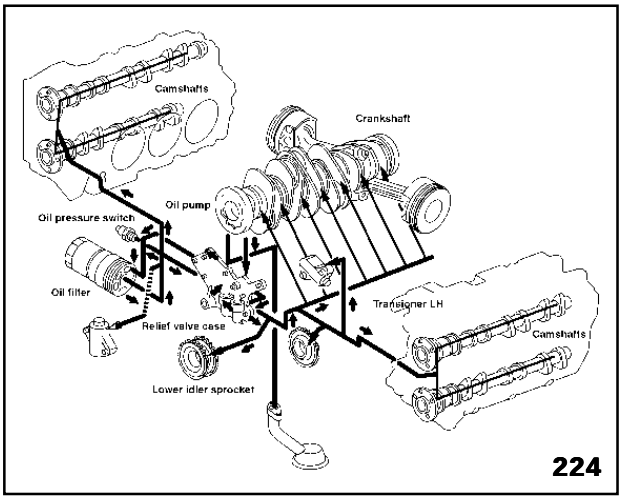


Main Bearings



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

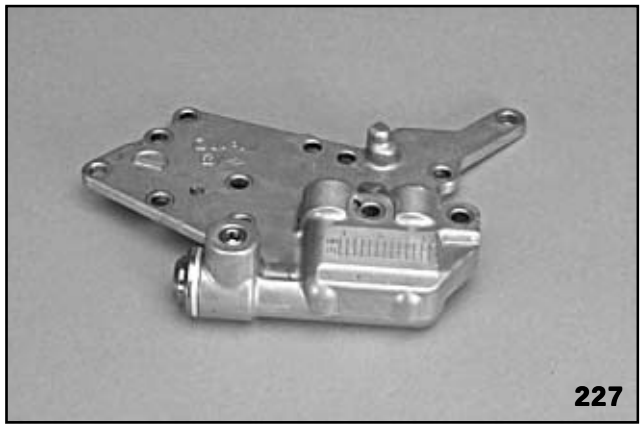
NOTE: FOR FURTHER INFORMATION CONSULT THE LUBRICATION (LU) SECTION OF THE 6 CYLINDER SUPPLEMENT.



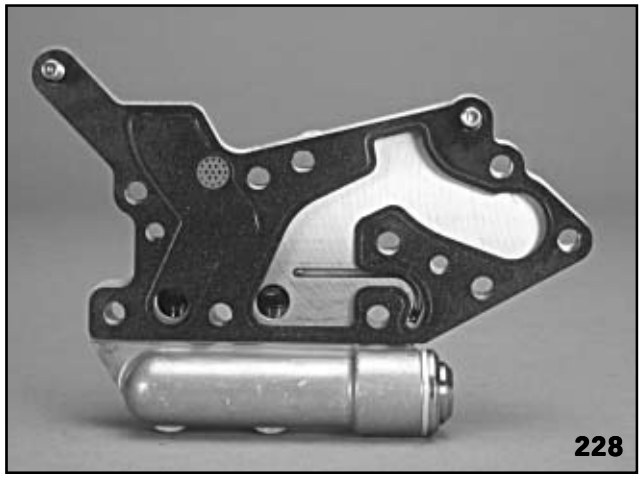
Pump Gears (Front Side)



Pump Gears (Back Side)



Relief Valve Case (Front Side)

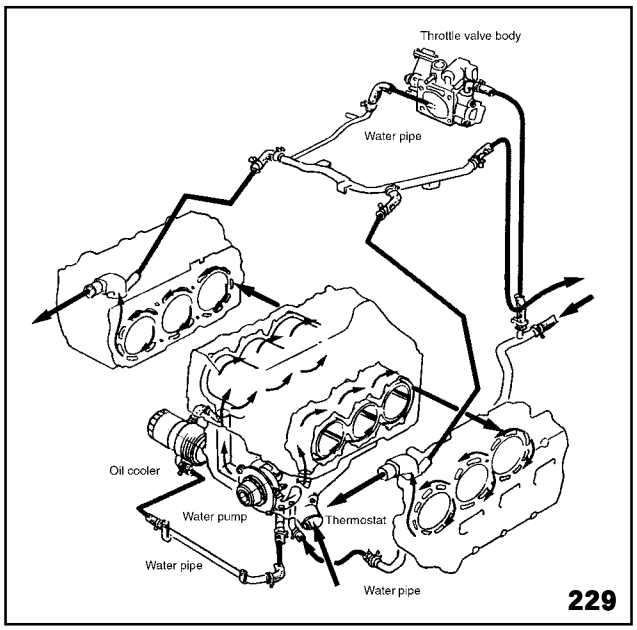


Relief Valve Case (Back Side)

A new gasket must be used upon installation.

NOTE: THE SCREEN OR FILTER IN GASKET. CONFIRM THAT IT IS NOT RESTRICTED.

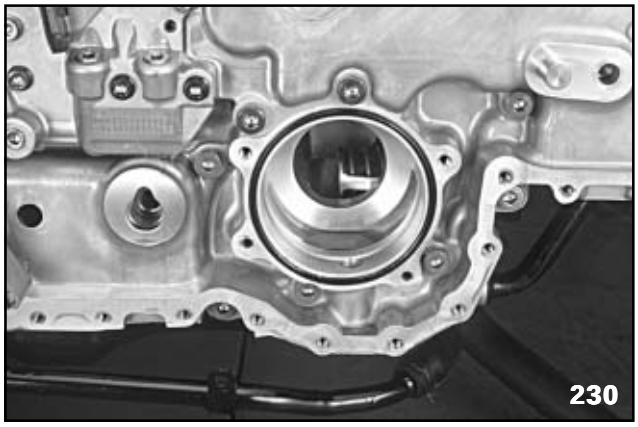
Coolant System



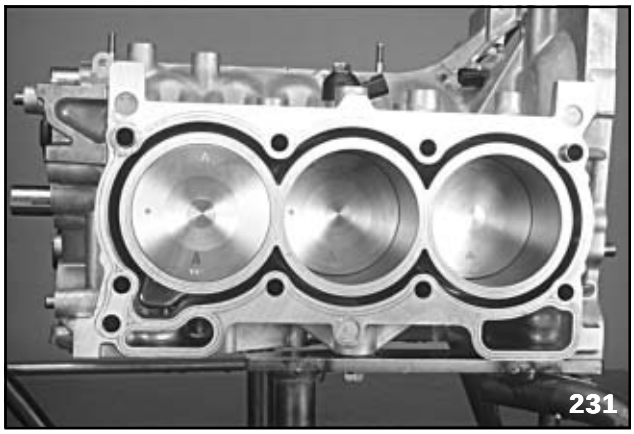
Coolant Flow

The coolant flow begins at the lower radiator hose and continues to the following:

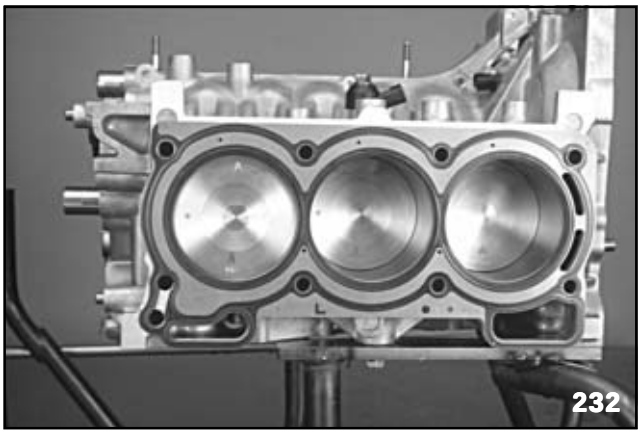
- Thermostat
- Water pump
- Internal block passages that carry coolant through the front of the block halves continuing on to the rear of the block halves.
- From around the rear cylinders of the block halves to the head gasket of the rear cylinders. A passage in the head gasket allows coolant to the cylinder heads.
- Around the cylinder heads to the upper radiator hose connections.



Water Pump Housing



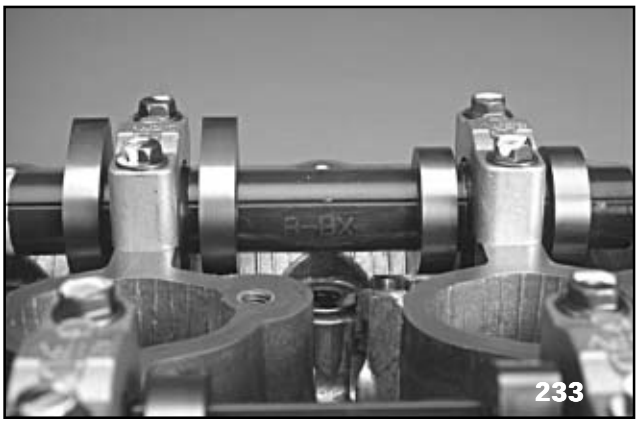
Water Jackets (Left Bank)



Head Gasket Coolant Passages

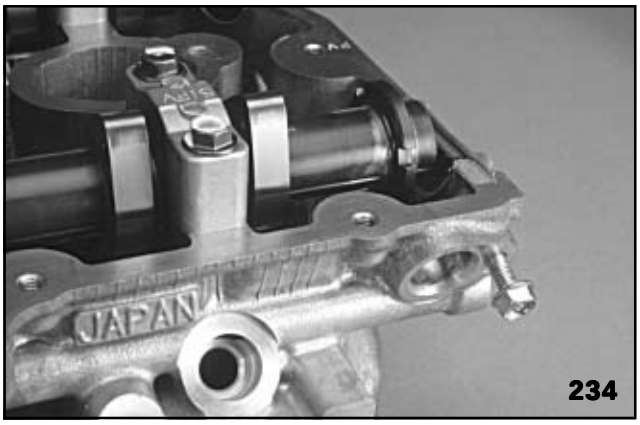
NOTE: FOR FURTHER INFORMATION, CONSULT THE COOLING SECTION (CO) OF THE 2001 LEGACY AND OUTBACK 6 CYLINDER SUPPLEMENT.

Valve Adjustment



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.



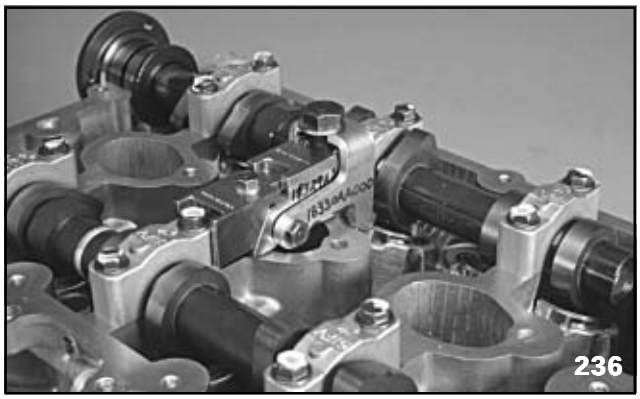
Camshaft Sensor Reluctor

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.



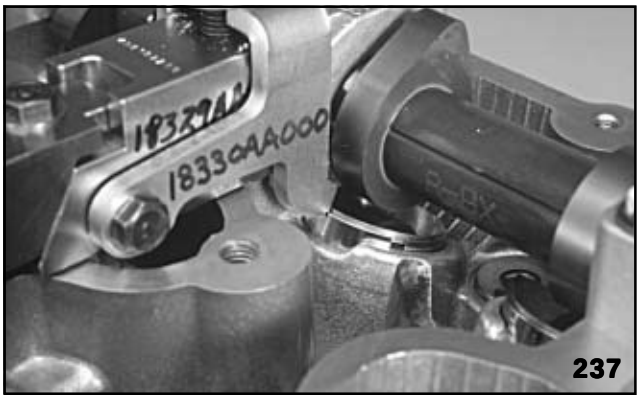
Valve Adjustment Tool

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

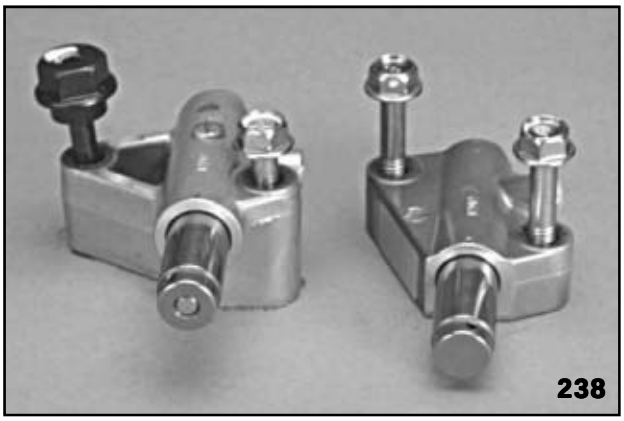
The tool is wedge fitted into place over the two shims requiring removal.



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.

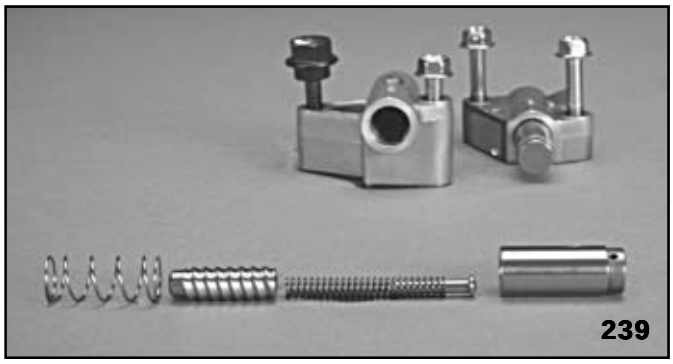
Chain Tensioners



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.

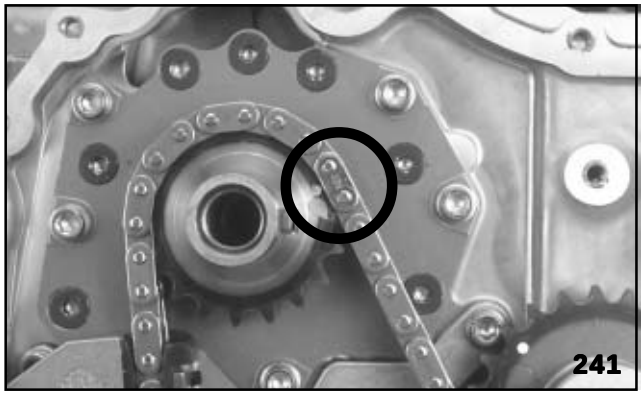


Worm Gear Assembly

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.

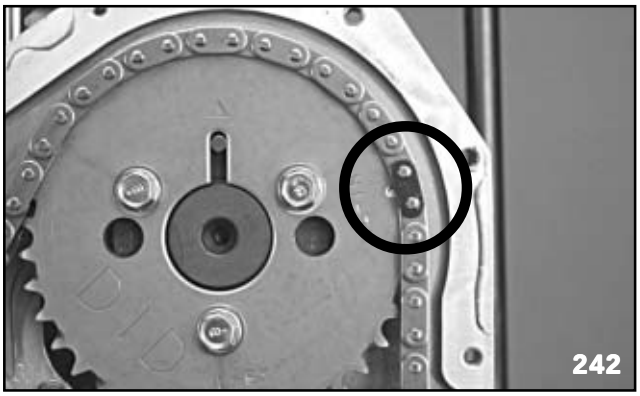
The tensioners are turned in by hand for reassembly. Observe the order of the worm gear assemble. Make sure your hands are dry when depressing the tensioners. A rivet or large paper clip will hold tensioner in place. Do not use a press to depress tensioner.

3.0 Liter Engine Reassembly

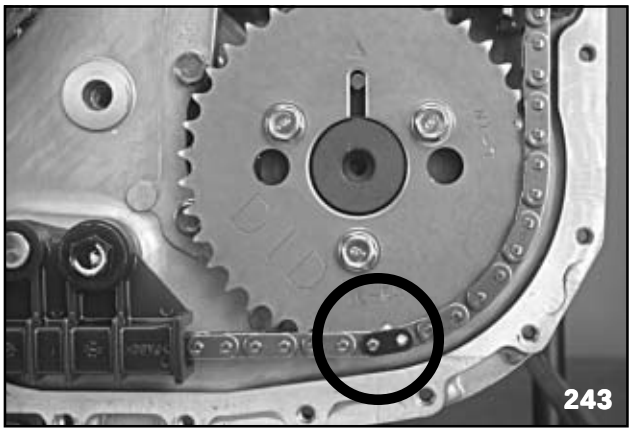


Crankshaft Timing Mark Location

Position the crankshaft sprocket to TDC. Indicated by the triangle mark. Place the chain over the water pump and lower idler sprocket.

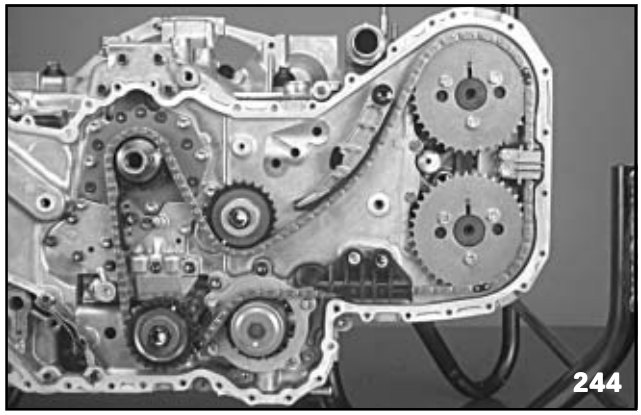


Left Bank Intake Camshaft Timing Mark

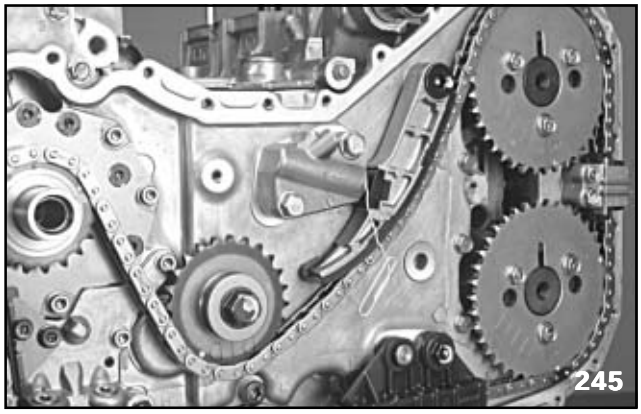


Left Bank Exhaust Camshaft Timing Mark

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.



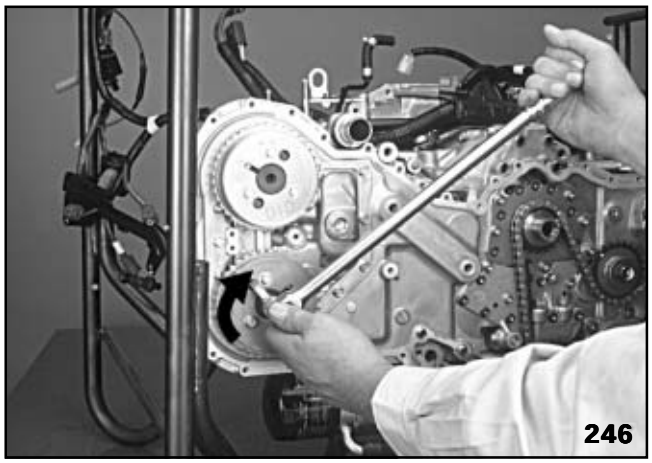
Matching Links to Timing Marks (Left Bank)



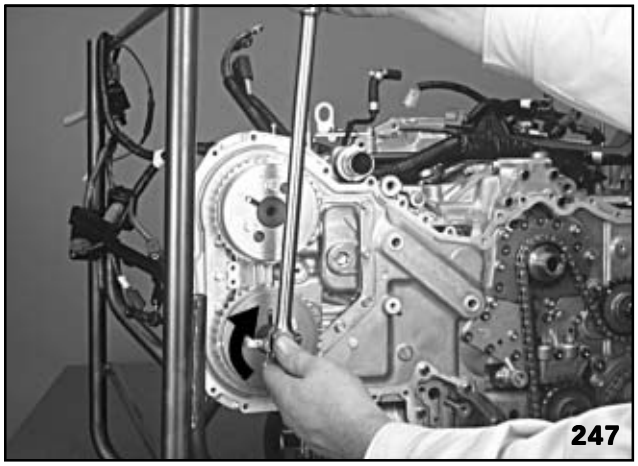
Installing Guides and Idlers (Left Bank)

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.

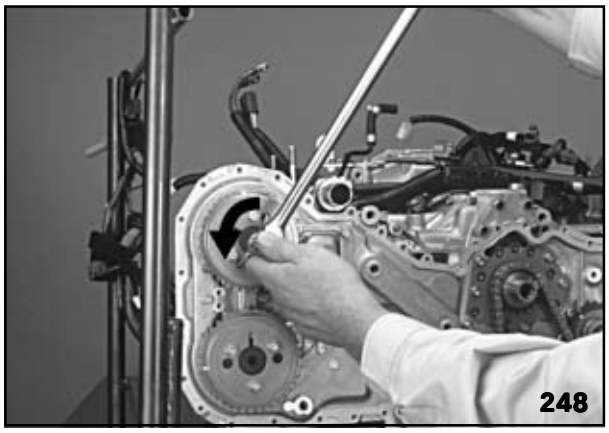


Loading Exhaust Camshaft (Right Bank)

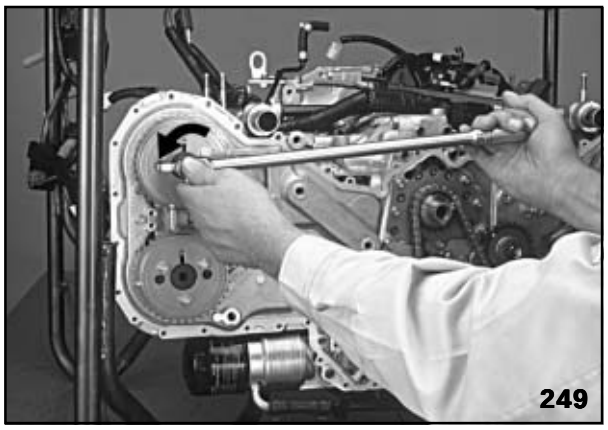


Loading Exhaust Camshaft (Right Bank)

Return the key way for the **right bank exhaust** camshaft to 12:00 by turning the sprocket **counter clockwise**.



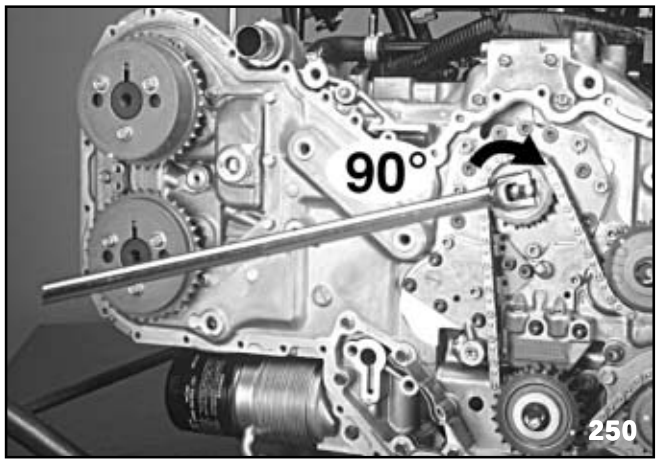
Loading Intake Camshaft (Right Bank)



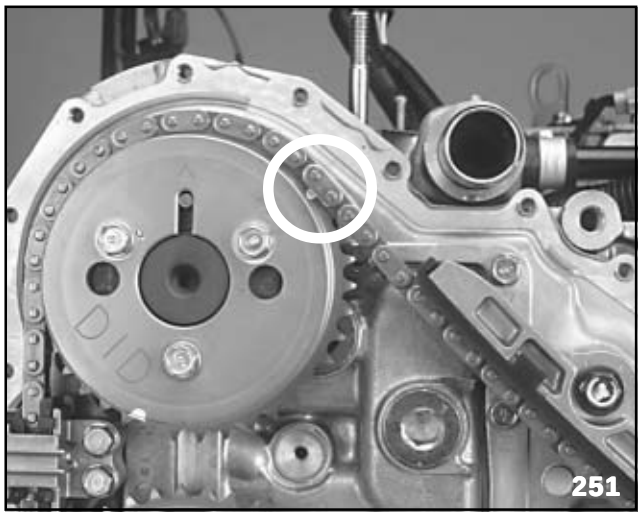
Loading Intake Camshaft (Right Bank)

Return the key way for the **right bank intake** camshaft to 12:00 by turning the sprocket **clockwise**.

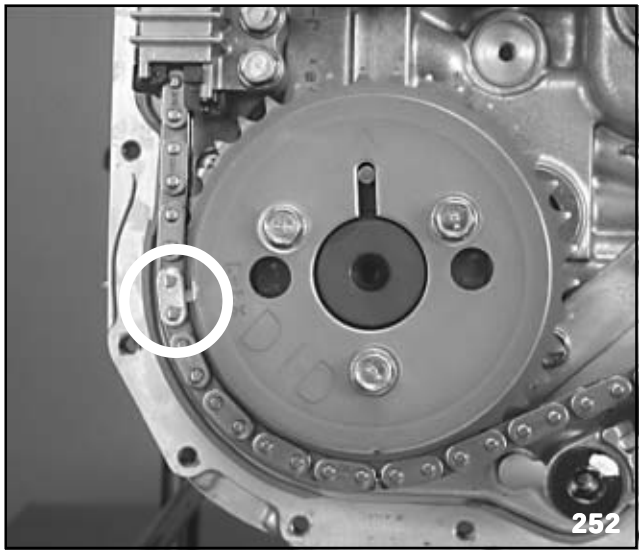
Both right bank camshaft sprockets should now be in the correct position for timing chain installation. **Do not forget to turn the crank shaft TDC mark back to 12:00.**



Aligning TDC Mark



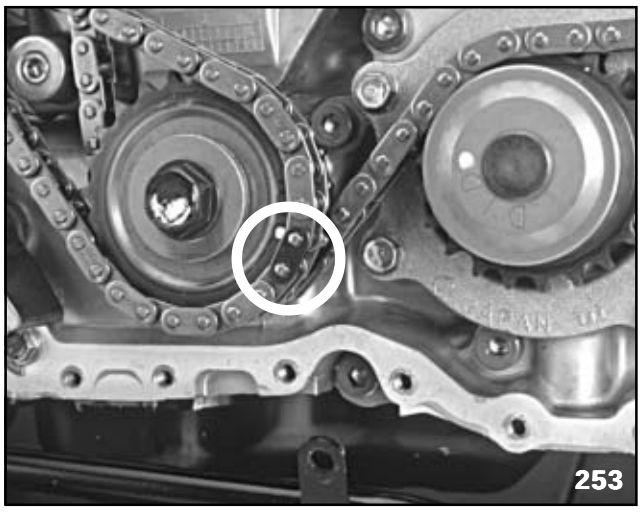
Intake Camshaft Timing Marks (Right Bank)



Exhaust Camshaft Timing Marks (Right Bank)

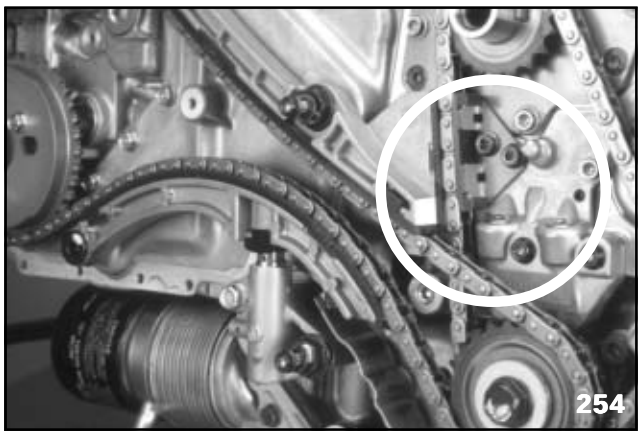
Place the lower gold link on the small circular mark of the exhaust cam sprocket and the upper gold link on the small circular timing mark of the intake camshaft sprocket.

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.



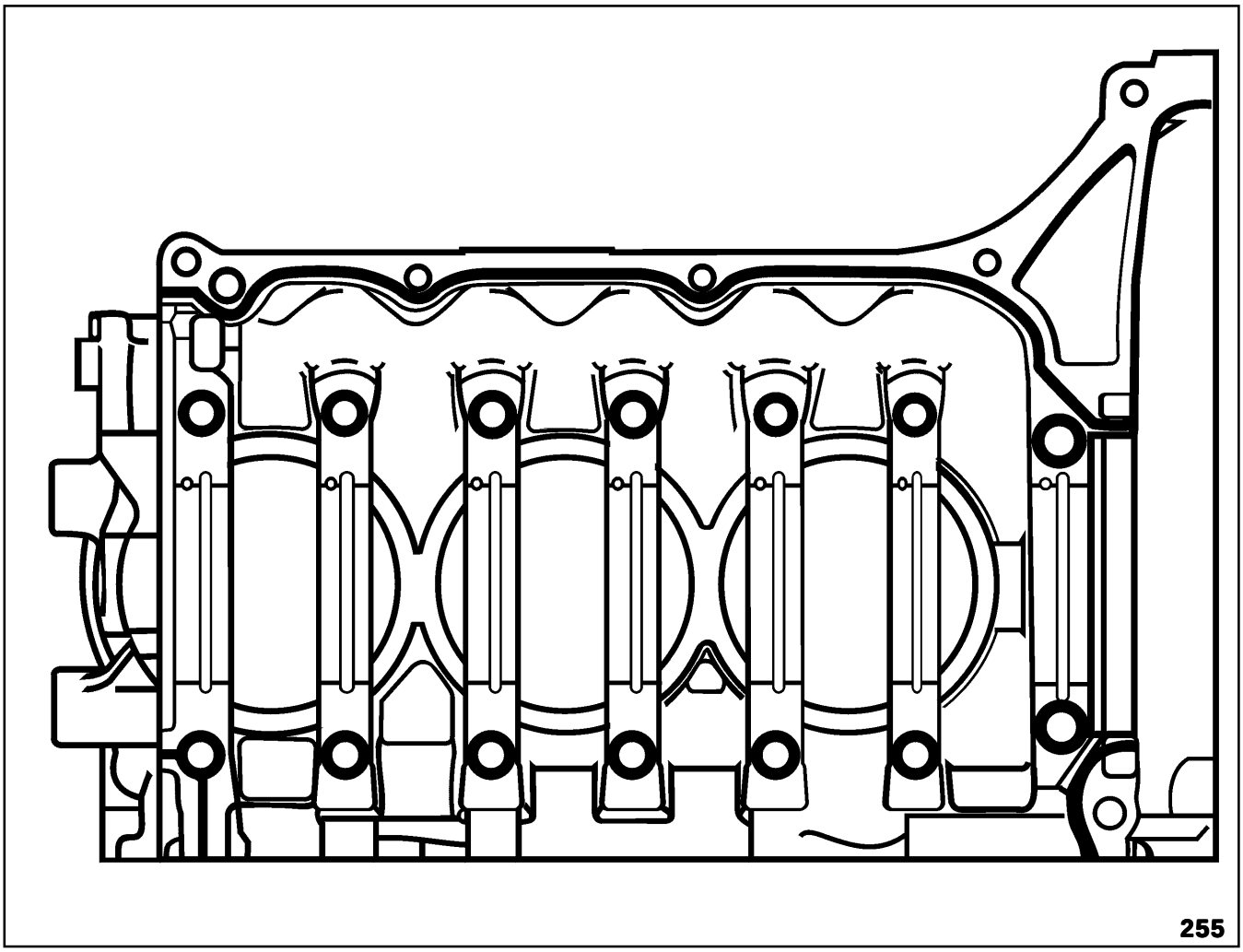
Chain Guides and Idlers (Right Bank)

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 service manual during reassembly and for checking chain guide clearances.

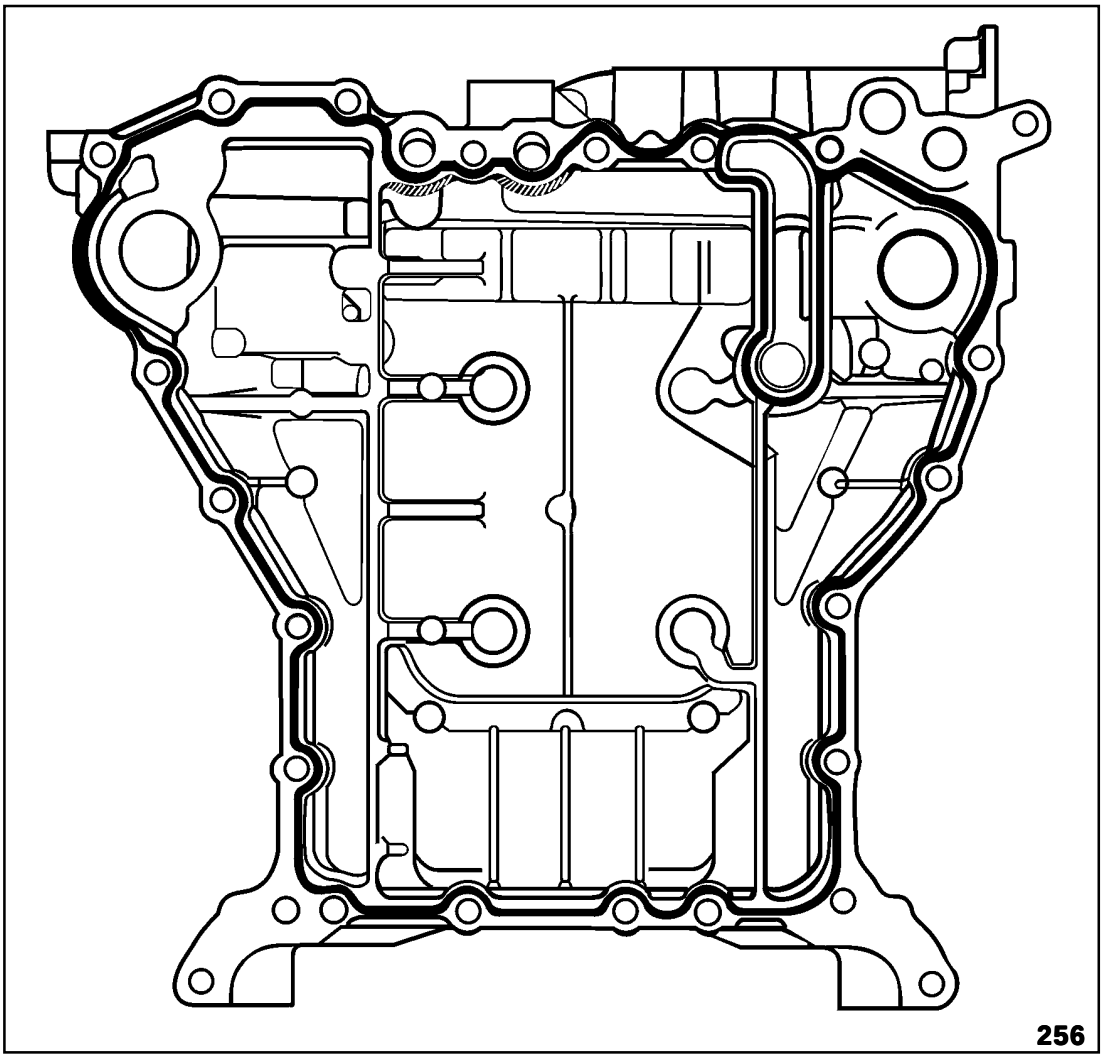
Fuji Bond Application Guide for Block Halves



Refer to the Legacy and Outback 2001 Service Manual 6 Cylinder Supplement.

ME (H6) 65 to 69 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

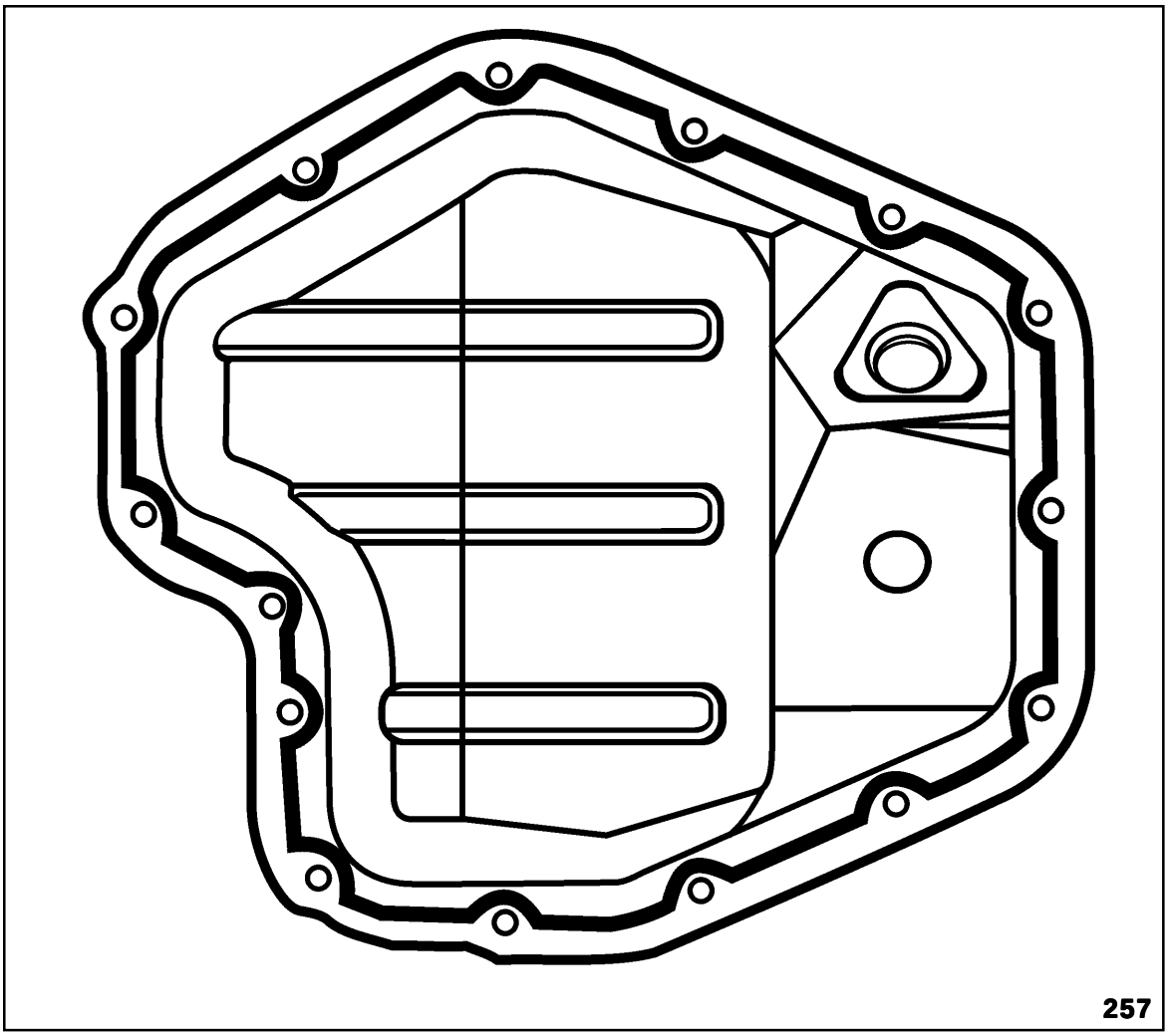
Oil Pan Extension Housing (Upper Oil Pan)



Refer to the Legacy and Outback 2001 Service Manual 6 Cylinder Supplement.

ME (H6) 65 to 69 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

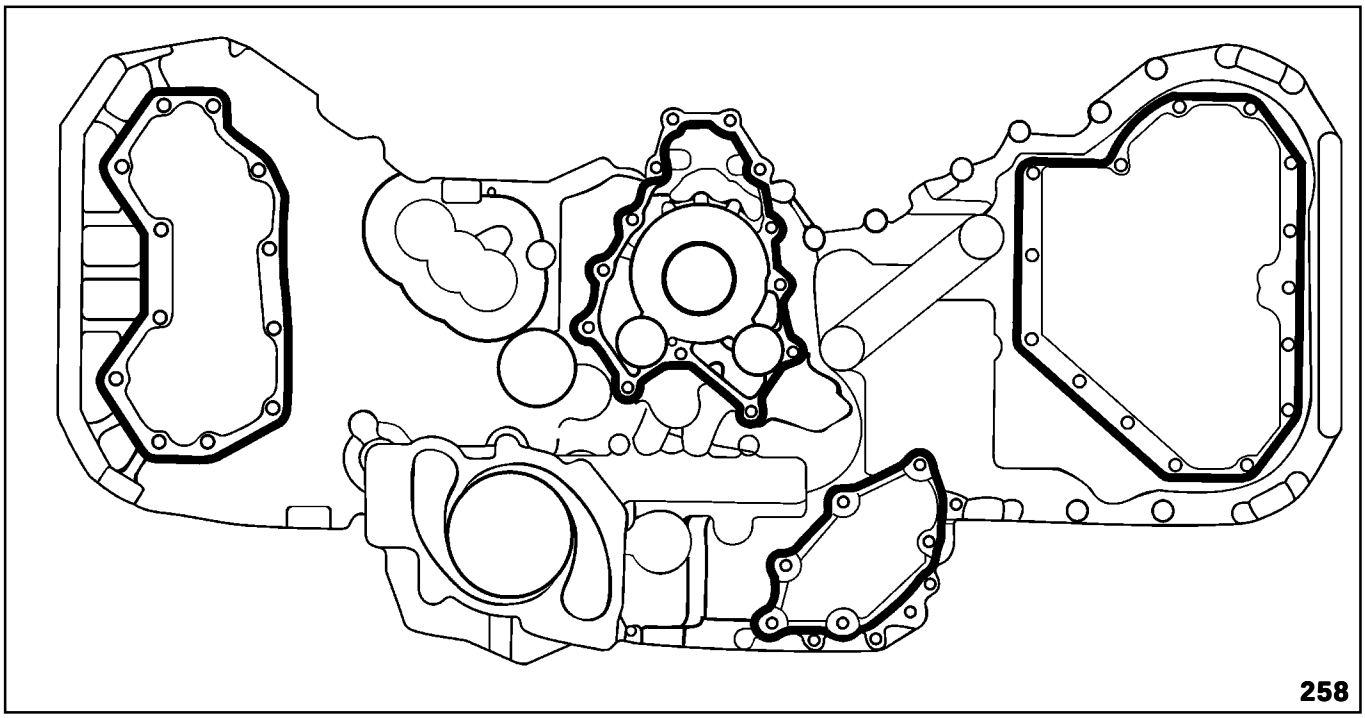
Fuji Bond Application Guide for Oil Pan (Lower)



Refer to the Legacy and Outback 2001 Service Manual 6 Cylinder Supplement.

ME (H6) 65 to 69 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

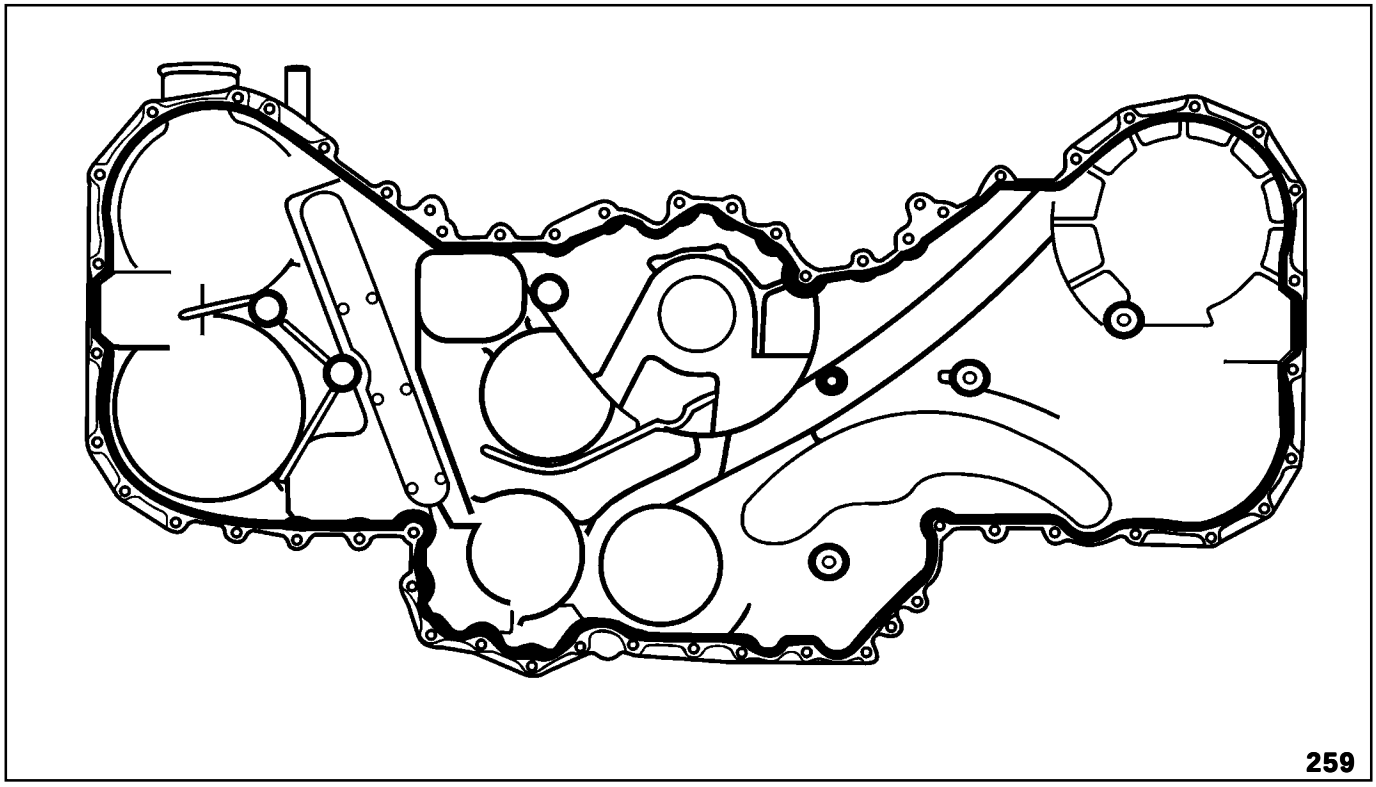
Fuji Bond Application Guide for Inner Cover



Refer to the Legacy and Outback 2001 Service Manual 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)



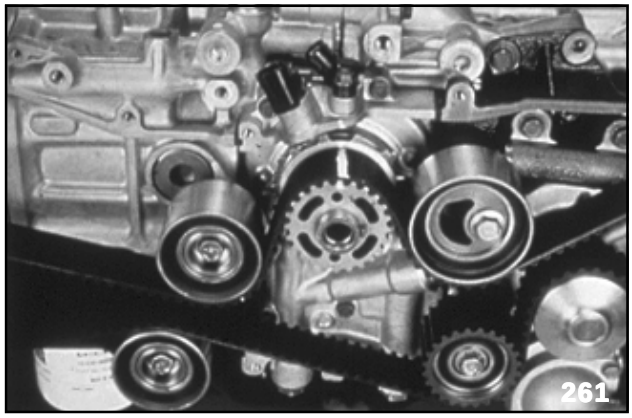
Refer to the Legacy and Outback 2001 Service Manual 6 Cylinder Supplement.

ME (H6) 43 for proper sealing, bolt sizes and sequence. Torque to proper specifications.

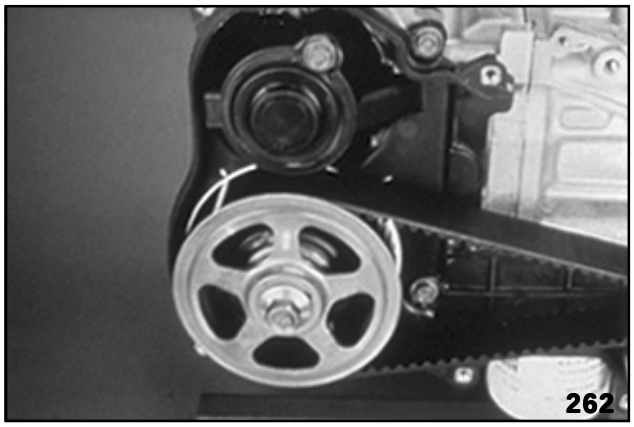
3.3 Liter Engine Service Procedures

Remove the left, right and the center cam belt front covers.

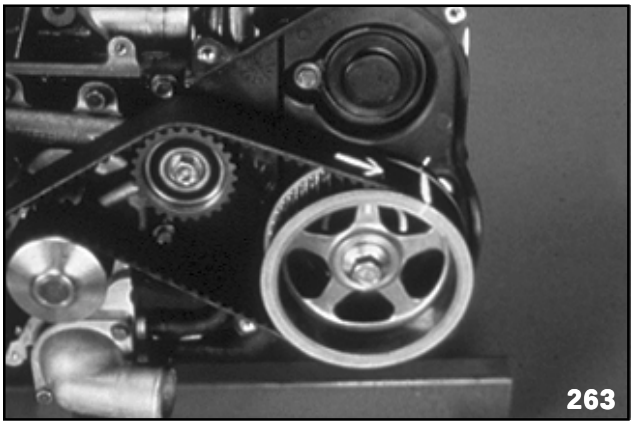
NOTE: THE CENTER CAM BELT COVER USES SHOULDER TYPE BOLTS. THESE BOLTS ARE NOT INTERCHANGEABLE WITH THE STANDARD BOLTS USED IN THE LEFT AND RIGHT CAM BELT COVERS.



Crankshaft Sprocket Alignment



Camshaft Sprocket Alignment (Right Bank)



Camshaft Sprocket Alignment (Left Bank)

Use the crankshaft pulley to rotate the crankshaft clockwise to properly align the timing marks. There are two timing marks on each of the cam sprockets, a notch and an arrow. There is an alignment notch on the crank sprocket. Align the notch on the outer rim of each camshaft sprocket with the notch on the inner cam belt covers. Align the notch on rear flange of the crankshaft sprocket with the notch on the oil pump housing. The crank and cam sprocket arrows should be at 12 o'clock.

When the camshaft and the cam belt timing marks are properly aligned and the crankshaft timing mark is at the 12 o'clock position, the engine is at TDC for the number 1 cylinder compression stroke. The alignment marks must be aligned with the marks on the cam belt covers.

When the belt is going to be reinstalled, use a crayon or paint marker to mark the belt and the cam and crank sprockets at the three timing notches and to indicate the belt rotation direction. The remaining belt removal procedures are the same as the 2.2L engine.Remove the left, right and the center cam belt front covers.



Camshaft Sub-Gear Servicing

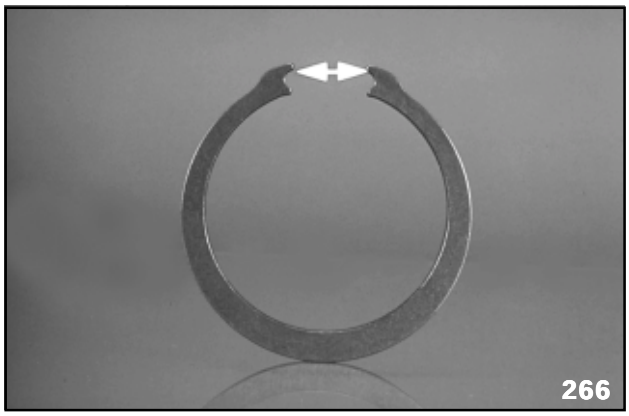
NOTE: THE FOLLOWING INFORMATION OUTLINES THE STEPS LISTED IN THE SUBARU SVX SERVICE MANUAL, SEC 2-3, [W3B1] TO DISASSEMBLE AND SERVICE THE INTAKE CAMSHAFT SUB-GEAR. REFER TO THE APPROPRIATE MY SERVICE MANUAL AND REVIEW THE DISASSEMBLY STEPS.

Pad the vice jaws with soft jaws or a shop cloth and then secure the shaft portion of camshaft in the vice. Do not clamp the vice to the cam lobe or journal surfaces. Use camshaft gear wrench **499207200** to slightly rotate the sub-gear "clockwise", and remove the service bolt. Next use a snap ring pliers to remove the snap ring.



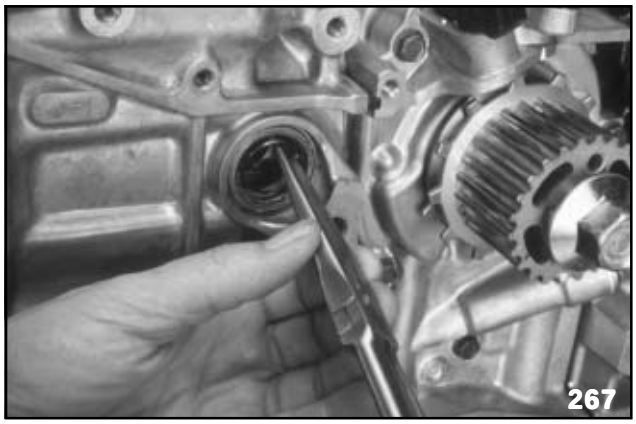
Two Piece Gear

Remove the wave washer, the sub-gear and sub-gear spring.



Sub-Gear Spring

Check the free distance between the camshaft gear spring ends. The proper tolerance (free distance) should be: 0.980 - 1.137 in (24.88 - 28.88 mm). Be sure to position the components in the order of removal to ease reassembly. Assembly is the reverse of the disassembly steps. Use the camshaft gear wrench **499207200** to reset the sub-gear tension and to reinstall the service bolt to the sub-gear.



Piston Pin Circlip Removal

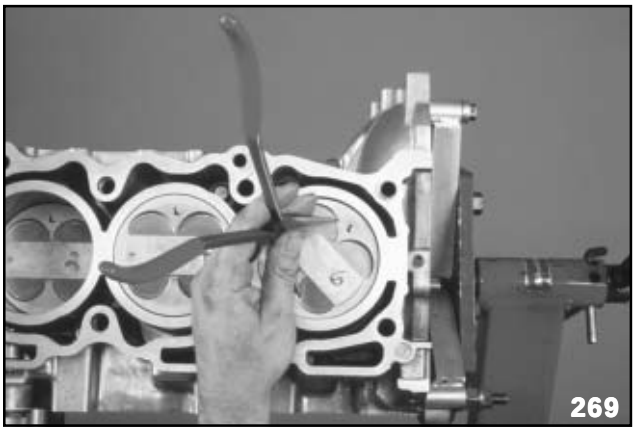
NOTE: REMOVAL OF THE WATER PUMP, OIL PUMP, OIL PAN, PCV BAFFLE PLATE, PISTON PIN ACCESS PLUGS AND PISTON PINS ARE SIMILAR TO THE 2.2L AND 2.7L ENGINES.

Follow the appropriate MY service manual procedure to remove each piston pin. First remove the access plugs and then the piston pin retaining circlips. Use circlip pliers **499897200** (or SNAP-ON 911CP).



Piston Pin Removal

Use piston pin remover **499097500** to remove the piston pins through the service holes located in the front and back of the crankcase. Removal of the center piston pins requires the removal of one of the outer pistons. Removal of the center piston pin is similar to the procedure for the 2.7L engine.

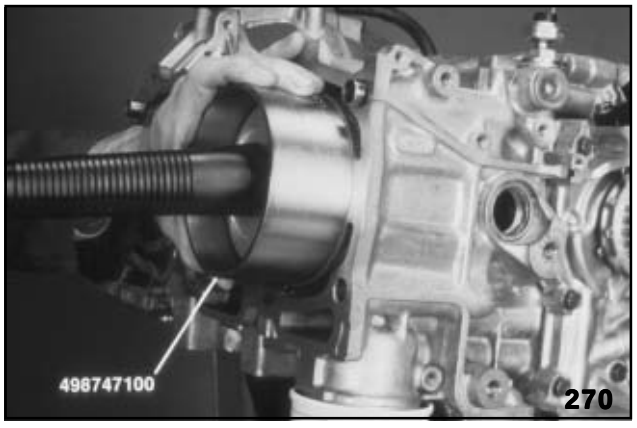


Piston Removal

Number the pistons prior to removal as the pistons must be returned to the original cylinders. The pistons are marked "L" for left and "R" for right, with arrows which must point towards the front of the engine.

TIP: TO REMOVE THE PISTONS, SLOWLY ROTATE THE CRANKSHAFT TO BRING THE PISTON TO THE TOP OF THE BORE. CONTINUE TO ROTATE THE CRANKSHAFT TO BRING THE ROD TO THE BOTTOM OF THE STROKE. USE NEEDLE NOSE PLIERS TO CAREFULLY ROTATE THE PISTON EITHER DIRECTION 90 DEGREES. DO NOT SCRATCH THE PISTON. SLOWLY ROTATE THE CRANKSHAFT, THE CONNECTING ROD WILL PUSH THE PISTON OUT OF THE CYLINDER.

NOTE: USE CARE NOT TO JAM THE CONNECTING ROD LARGE END INTO THE CYLINDER BORE WHILE ROTATING THE CRANKSHAFT DURING PISTON REMOVAL.



Piston Installation

NOTE: THE INSTALLATION OF PISTONS, PISTON PINS AND CIRCLIPS, PISTON PIN PLUGS, PCV BAFFLE, OIL PICK-UP TUBE, OIL PUMP, WATER PUMP, AND OIL PAN ARE SIMILAR TO THE 2.2L ENGINE.

Return the pistons and pins to the original cylinders. Install the piston and pin first. The installation procedures are similar to the 2.7L engine. The arrows on the pistons must point to the front of the engine. Confirm the pistons marked R for the right side and L for the left side are installed in the correct crankcase half. The complete piston installation procedures are listed in the appropriate service manual, section 2-3 [W5D4]-[W5D6].

NOTE: THE "EXHAUST" AND "INTAKE" CAMSHAFTS THRUST CLEARANCES ARE MINIMAL, CAREFULLY INSTALL EACH CAMSHAFT SLOWLY WHILE KEEPING THE CAMSHAFT PARALLEL TO THE CYLINDER HEAD. DAMAGE TO THE THRUST BEARING WILL OCCUR IF THE CAMSHAFT IS NOT PARALLEL TO THE HEAD DURING INSTALLATION. ALWAYS FOLLOW THE INSTALLATION SEQUENCE DEFINED IN SECTION 2-3, [W3E1] OF THE APPROPRIATE MY SUBARU SVX SERVICE MANUAL.



Install Intake Camshaft

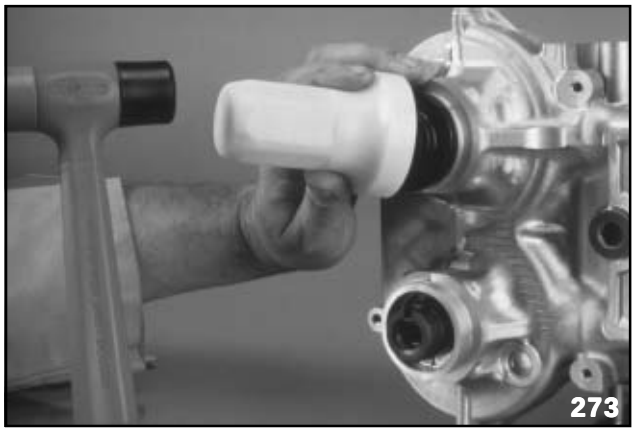


Install Intake Camshaft

Install the intake camshaft. First center the match (punch) mark on the back of the intake camshaft gear between the two match (punch) marks on the back of the exhaust camshaft gear. The front notch on the L/H side should be at 6 o'clock and the front notch on the R/H side should be at 12 o'clock. Next, install the intake camshaft bearing caps to the original locations, tighten in the proper sequence, and torque to specifications. Remember to remove the service bolts from both intake camshaft sub-gears.

CAUTION: FAILURE TO REMOVE THE SERVICE BOLTS MAY CAUSE THE CAMSHAFTS TO PRODUCE A KNOCKING SOUND. IF THE BOLT LOOSENS IT COULD DAMAGE THE CAMSHAFT GEARS AND THE CYLINDER HEAD.

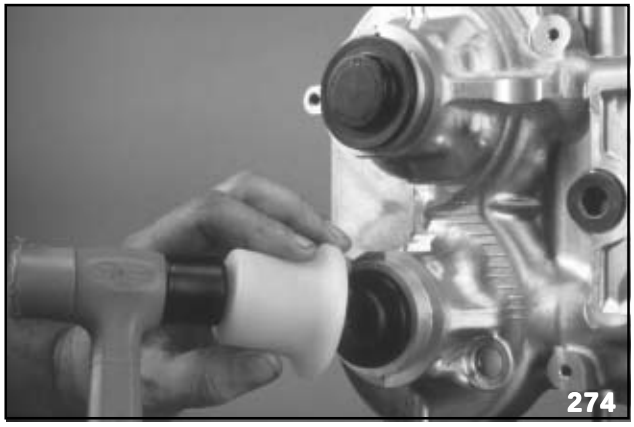
NOTE: FAILURE TO KEEP CAMSHAFT PARALLEL TO THE HEAD DURING INSTALLATION MAY DAMAGE THE CAMSHAFT OR BEARING CAPS. TORQUE SPECS FOR BEARING CAPS IS VERY LOW DO NOT OVER TORQUE OR USE AIR TOOLS.



Front Camshaft Cover Installation

Sparingly use FUJI Bond 1215C or the equivalent to install the front camshaft covers. Install the intake camshaft plug using intake installer **499587300**.

CAUTION: EXCESSIVE USE OF SEALANT CAN CAUSE BLOCKAGE OF THE CAMSHAFT OIL FEED HOLES.

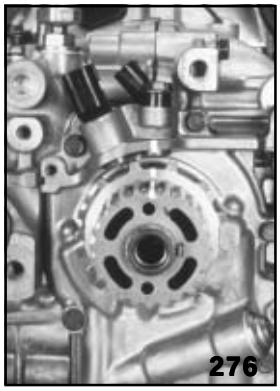


Exhaust Camshaft Oil Seal Installation

Use camshaft oil seal installer **498037100** to install the exhaust camshaft oil seal. Then install the camshaft cover gasket and camshaft cover. Then install the left and right inner cam belt covers.



Left Camshaft Sprocket

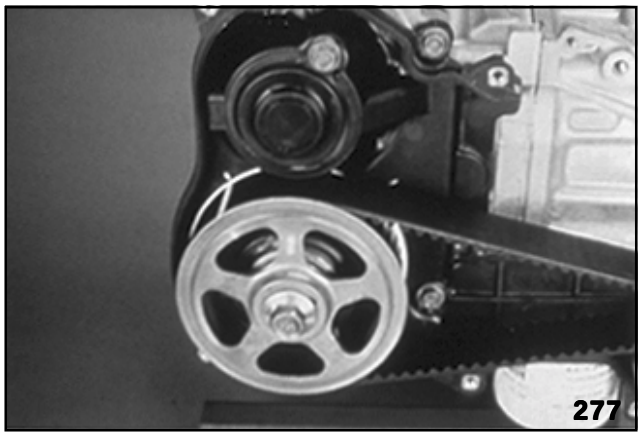


Crankshaft Sprocket Installation

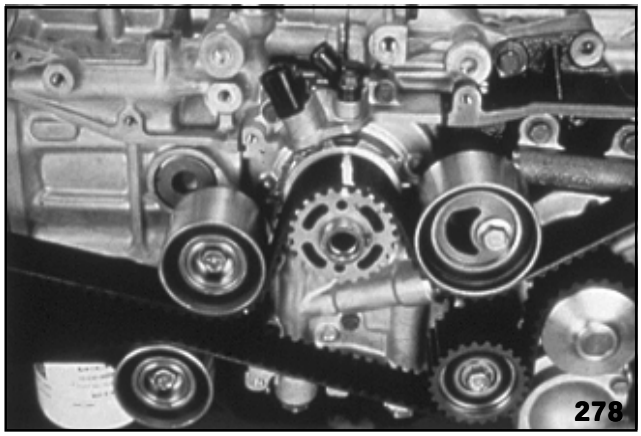
Notice the cam angle reluctor located behind the left camshaft sprocket and the locating pin on the back of each of the sprockets. Install the camshafts sprockets and the crankshaft sprocket.

NOTE: LOCATING PINS SHOULD BE LOCATED AT 6 O'CLOCK ON LEFT HAND SIDE AND AT 12 O'CLOCK ON THE RIGHT HAND SIDE CAMSHAFT SPROCKET.

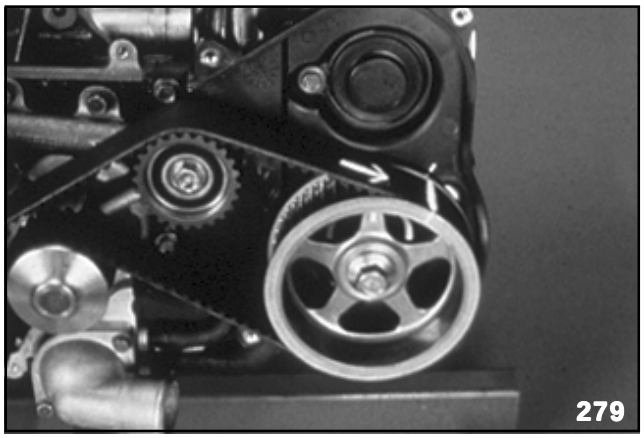
Align the crankshaft sprocket arrow in the 12 o'clock position which corresponds to the mark on the crank sensor casting.



Cam Belt Installation (Right Bank)



Cam Belt Installation (Crankshaft)



Cam Belt Installation (Left Bank)

The camshaft sprockets are stamped with timing marks, the right sprocket timing mark should be at 11 o'clock with the arrow at 12 o'clock while the left sprocket timing mark should be at 1 o'clock with the arrow at 12 o'clock. The timing marks on the sprockets should align with the timing marks on the inner cam belt covers.

Prior to installing the timing belt, install the following:
*Tensioner bracket
*Cam belt tensioner

Then install the camshaft timing belt. The belt is directional and must be installed with the arrows pointing in the direction of rotation. When you are replacing the original belt, be sure to align the match marks on the belt with the marks on the sprockets and belt covers and the crankshaft sprocket. New belts have alignment marks to insure proper camshaft timing.

NOTE: THERE SHOULD BE 53 TEETH BETWEEN THE CRANKSHAFT SPROCKET MARK AND EACH OF THE CAMSHAFT SPROCKET MATCH (PUNCH) MARKS.

NOTE: THE REMAINING ENGINE ASSEMBLY STEPS ARE THE REVERSE OF THE PROCEDURE FOR ENGINE DISASSEMBLY. ALWAYS REFER TO THE APPROPRIATE MY SERVICE MANUAL FOR A DETAILED DESCRIPTION OF THE ENGINE ASSEMBLY STEPS.

Notes

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.)
Vernier calipers

Reference Materials

Subaru Service Manuals
Technician Reference Booklets

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) 2.5L	3.0
399094310	Piston pin remover (1800cc tool)		X				
479587300	Oil seal installer		X				
498037100	Camshaft journal plug installer		X				
498267200	Cylinder head table		X				
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	
499037100	Connecting rod bushing remover & installer	X	X		X	X	
499097500	Piston pin remover		X		X		X
499207100	Camshaft sprocket wrench		X		X	X	
499587100	Camshaft oil seal installer	X	X	X	X	X	X
499587200	Crankshaft oil seal installer	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	

Boxer Engine Series Module

		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
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
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
18252AA00	Crankshaft socket						X
499587500	Oil seal installer					X	X
18329AA000	Shim replacer assemble						X
18233AA000	Piston pin circlip pliers						X
398744300	Piston guide	X					
499097700	Piston pin remover assembly	X				X	
499207400	Camshaft sprocket wrench	X				X	
499977300	Crank pulley wrench	X			X		
499987500	Crankshaft socket	X			X		
499587600	Oil seal guide	X					
499597200	Oil seal guide	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		

Service Bulletins

No.	Date	Title	Remarks
01-143-96	12/23/96	Recommended sealants and adhesives	

104 Module Service Help-Line Updates

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

Notes:



Subaru of America, Inc.

Technicians Reference Booklet

Brake Systems Series Module

Module 501

MSA5P0170C

Technical Training

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Table of Contents

Introduction 8
General Overview 8
General ABS Operation 19
Teves Mark IV with ABS/TCS 24
Vehicle Dynamic Control (VDC) 42
Sensors 45
Service Bulletins 53
501 Module Service Tech TIPS 54

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (Brakes System)	
2	Created By	
3	Teaching Aids	
4	Introduction	
5	Title Slide (General Overview)	
6	Dual Diagonal Brake System (artwork)	8
7	Front Disc Brake	9
8	Rear Disc Brake	9
9	Front Disc Brake	9
10	Depressing Caliper Piston (older)	10
11	Hill Holder ™ System	10
12	Pressure Hold Valve	10
13	Clutch Pedal Free Play	11
14	Clutch Lever Free Play	11
15	Adjusting the PHV	11
16	Master Cylinder Cross Section	12
17	Master Cylinder	12
18	Reed Switch Schematic (artwork)	12
19	Reed Switch Construction	12
20	Typical Proportioning Valve	13
21	2001 Legacy Rear Drum Brake and VDC Model (artwork)	13
22	2001 Legacy Rear Disc Brake Model (artwork)	13
23	Brake Booster	14
24	Booster Check (artwork)	14
25	Measuring Rotor Thickness (artwork)	15
26	Measuring Rotor Run out	15
27	Rotor Resurfacing	15
28	Piston Removal	16
29	Removing Pistons	16
30	Front Caliper Lubrication Points	17
31	Pads Assembled	17
32	Locating Brake Vibration Source (artwork)	17
33	Self-Adjuster Operation (Brakes Applied)	17
34	Drum Brake Lubrication Points	18
35	Legacy Parking Brake System	18
36	Title Slide (General ABS Operation)	19
37	Hydraulic Control Unit	19
38	Valve Relay Circuit	20
39	Motor Relay Circuit	21
40	Speed Sensor Operation (artwork)	22
41	Speed Sensor Components	22
42	Title Slide (Teves Mark IV with ABS/TCS)	24
43	Master Cylinder - Traction Control	24
44	Teves Mark IV Hydraulic Control Unit	25
45	Brake Pedal Stroke Sensor	25
46	Wheel Speed Sensor / Tone Wheel	25
47	Combination Meter	25
48	TCS Off Switch	26
49	ABS/TCS Control Module	26
50	Normal Braking (artwork)	27
51	ABS Braking Pressure Drop (artwork)	28

Slide Sequence

Slide No.	Description	Page No.
52	ABS Braking Pressure Hold (artwork)	29
53	ABS Pressure Rise (artwork)	30
54	TCS Logic-Engine Control (artwork)	31
55	TCS Logic- Engine Control & Brake Control (artwork)	31
56	TCS Logic / Wheel Slip Recognition (artwork)	32
57	TCS Logic - One Wheel Slip (artwork)	32
58	TCS Logic - Two Wheel Slip (artwork)	32
59	TCS Logic - One Wheel Slip (artwork)	33
60	TCS Logic - Two Wheel Slip (artwork)	33
61	TCS Pressure Rise (artwork)	34
62	TCS Pressure Hold (artwork)	35
63	TCS Pressure Drop (artwork)	36
64	TCS Logic / Valve Control (artwork)	37
65	Title Slide (Vehicle Dynamic Control (VDC))	42
66	VDC Logic Chart	42
67	Understeer	42
68	Oversteer	42
69	Cornering Force	42
70	Oversteer While Accelerating	43
71	Understeer While Accelerating	43
72	Oversteer While Braking	44
73	Understeer While Braking	44
74	Title Slide (Sensors)	45
75	Steering Position Sensor	45
76	Steering Position Sensor Construction	45
77	Steering Position Sensor Waveform	45
78	Degrees of Turn	45
79	Wheel Speed Sensor	46
80	Yaw Sensor	46
81	Yaw Sensor (artwork)	46
82	Hydraulic Control Unit	46
83	VDC CM Connector	47
84	VDC CM Location	47
85	Pressure Reducing Mode (artwork)	47
86	Pressure Holding Mode (artwork)	48
87	Pressure Increasing Mode (artwork)	48
88	Pressure Increasing Mode (artwork)	48
89	Pressure Holding Mode (artwork)	49
90	Pressure Reducing Mode (artwork)	49
91	Copyright	
92	The End	

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.

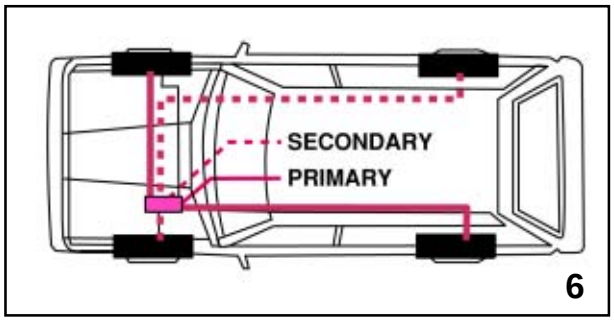
The text and illustrations are derived from and follow the classroom lectures and slide presentations. They are intended to supplement and reinforce classroom instruction and to serve as a home-study reference source. Lists of applicable Service Bulletins, important notes and cautions, and Special Tools 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

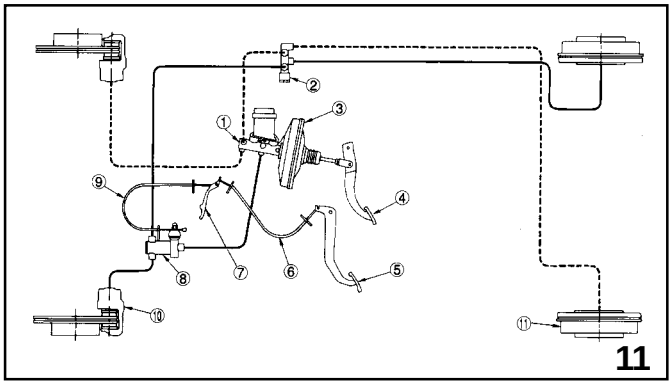
NOTE: IF THE PAD FITS TIGHTLY IN THE PAD HOLDER, RAPID PAD WEAR CAN OCCUR.



Depressing caliper piston (older)

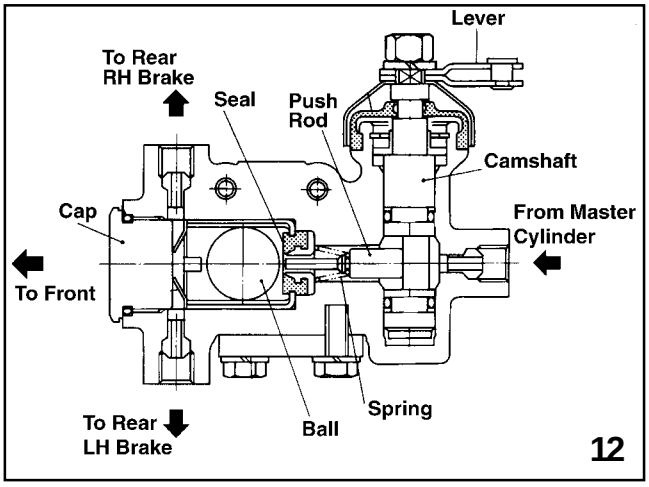
Because the new pads will be thicker than the old ones being replaced, the caliper piston needs to be retracted in the caliper body. Before pushing the piston back into the caliper, loosen the bleeder screw. After the pads are replaced and the brake calipers are reassembled, depress the brake pedal several 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

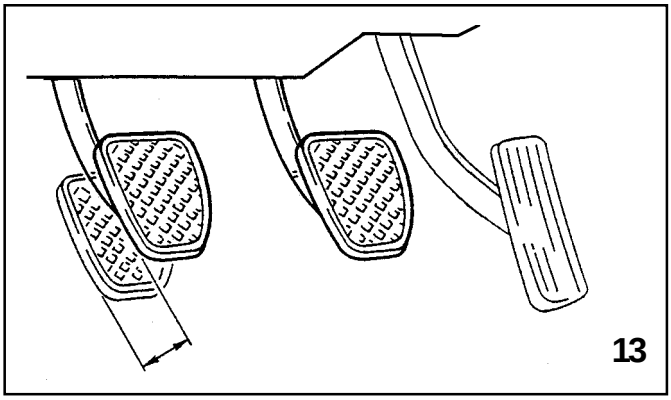
When the vehicle comes to a stop on an uphill grade greater than or equal to 3 degrees, a push rod inside the PHV retracts when the clutch is depressed. This permits a ball in the PHV to roll backwards to seal hydraulic pressure in the primary circuit. When the brake pedal is released, the pressure trapped 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.

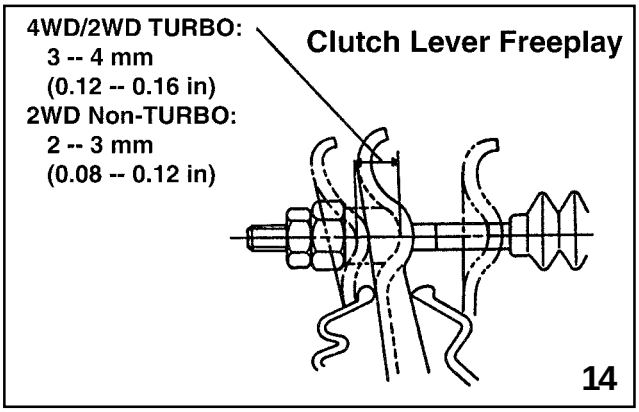
Hydraulic Servicing Precautions

When servicing any of the hydraulic components, follow these precautions carefully.

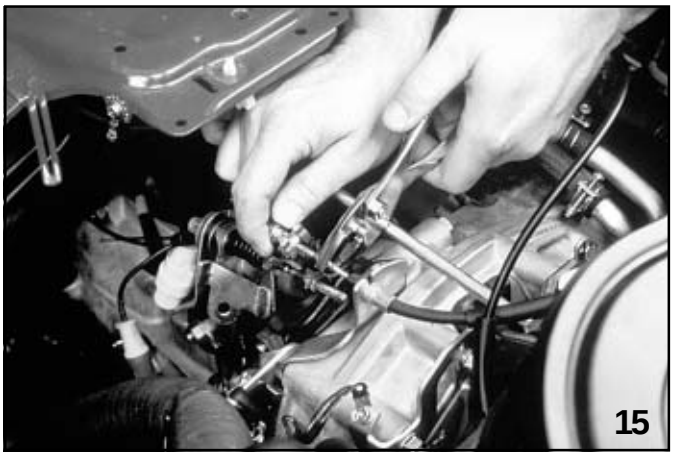
1) Use DOT 3 or DOT 4 brake fluid.
2) Clean internal brake components with alcohol. External brake components may be cleaned with brake clean type solvents.
3) Use specified lubricants.
4) Do not hone aluminum cylinders.
5) Do not use silicone type brake fluids



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.

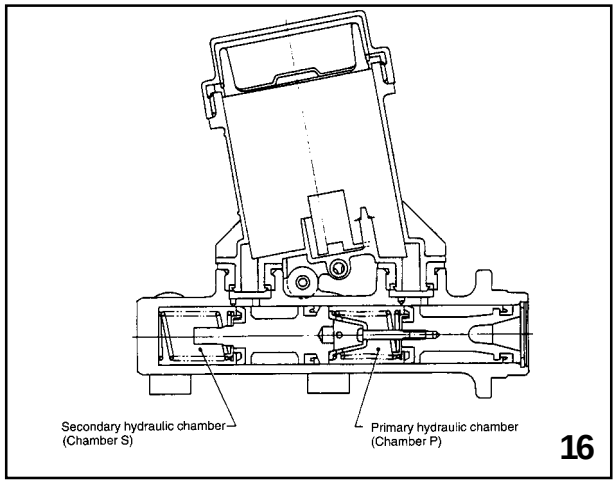
NOTE: CONFIRM PROPER OPERATION BY ROAD-TESTING THE VEHICLE.

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



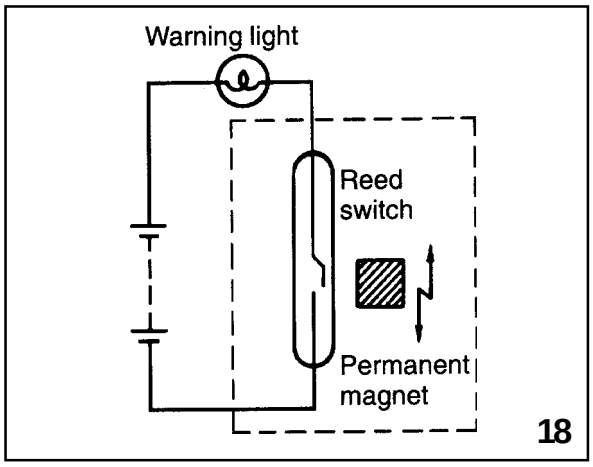
Master cylinder cross-section

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).

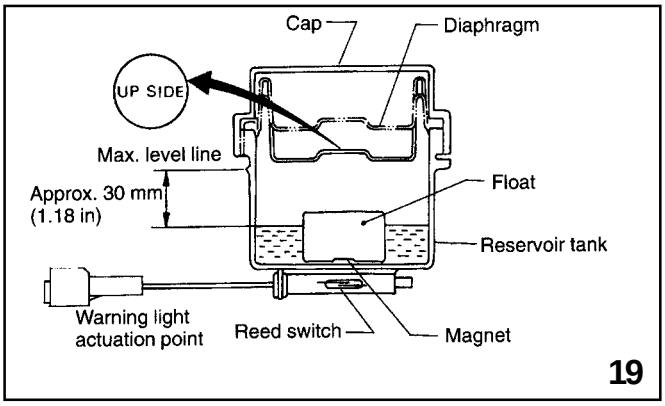


Master Cylinder

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

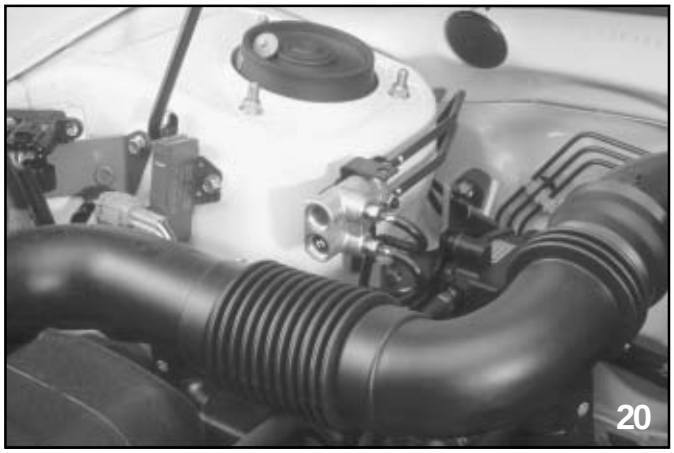
Components consist of a reed switch which mounts below the brake fluid reservoir and a permanent magnet housed in a float inside the brake fluid reservoir. When activated, the reed switch completes a ground circuit to turn on the brake warning lamp in the combination meter. Under normal conditions, the 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.

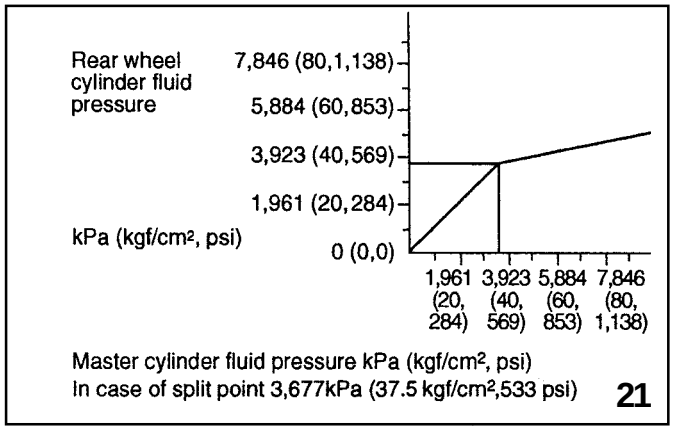
(95 LEGACY WITH TEVES MARK IV ABS/TCS)

Typical Proportioning Valve

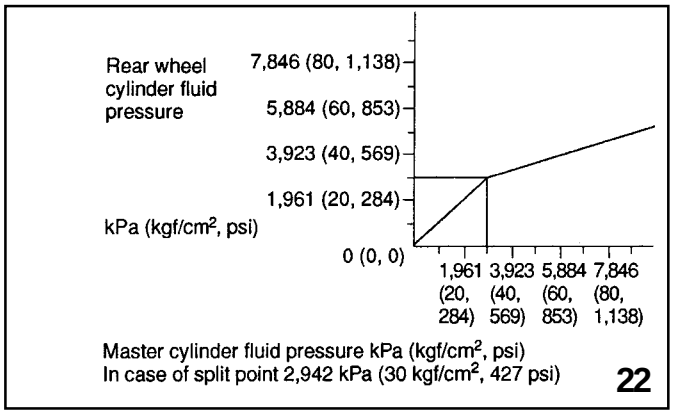


Typical proportioning valve

Another hydraulic component in Subaru brake systems is the proportioning valve.



2001 Legacy Rear drum brake and VDC model

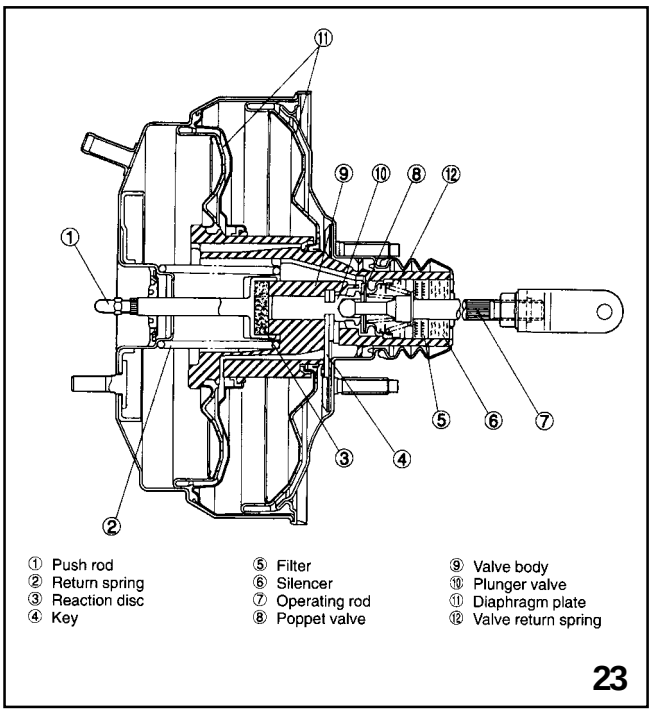


2001 Legacy Rear disc brake model

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

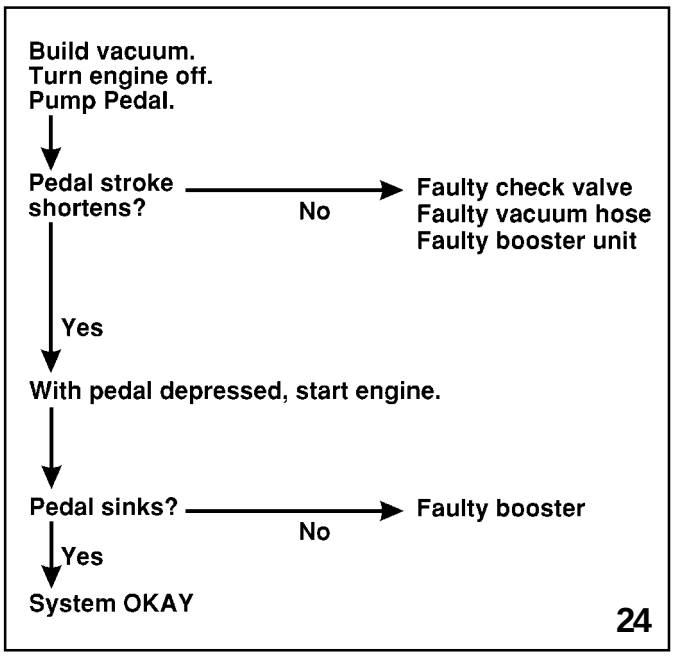


Brake booster

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

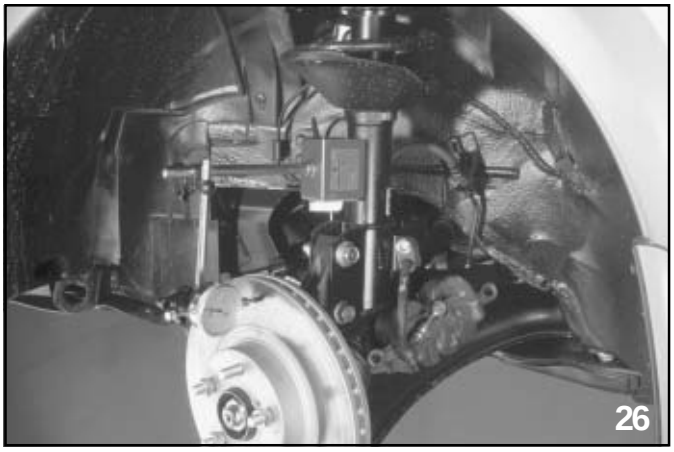


Measuring rotor thickness

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 ≤ .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:

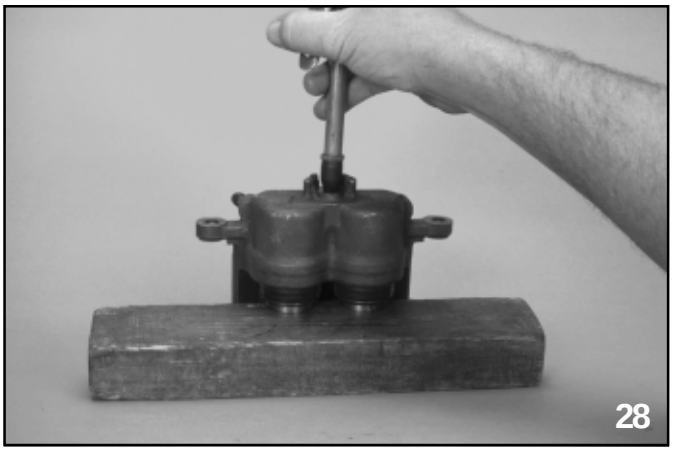
1. Remove rotor and remove any corrosion on the inner and outer hat surfaces. (Only on non-trapped design).
2. Remove any corrosion on the hub surface that mates with the rotor.
3. If the rotor must be removed after resurfacing, mark the rotor and hub so that their relative positions remain unchanged 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

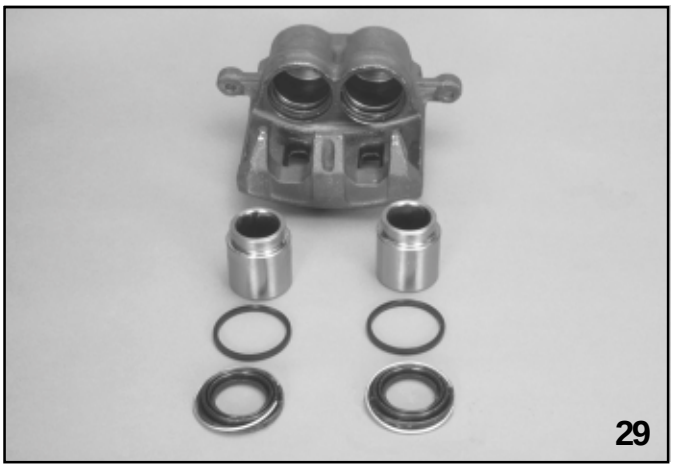
Whenever the brake system is inspected, the inspection should include checking the condition of the calipers. Calipers in need of repair can cause numerous brake problem including pulling to one side, reduced pad life, ABS not operating at optimum performance, and loss of brake fluid.

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

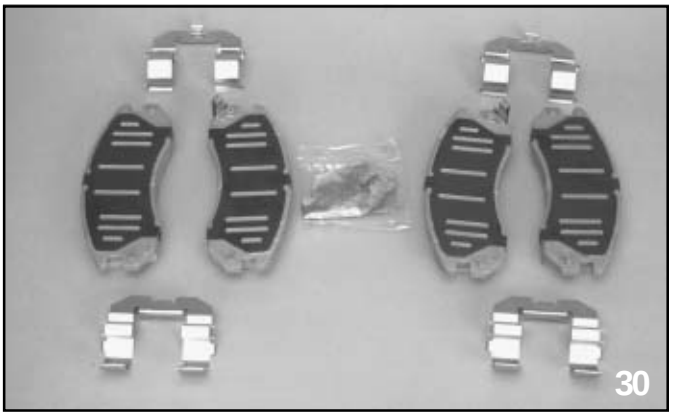
NOTE THE FOLLOWING PRECAUTIONS WHEN OVERHAULING DISC BRAKES ON A SUBARU VEHICLE:

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.

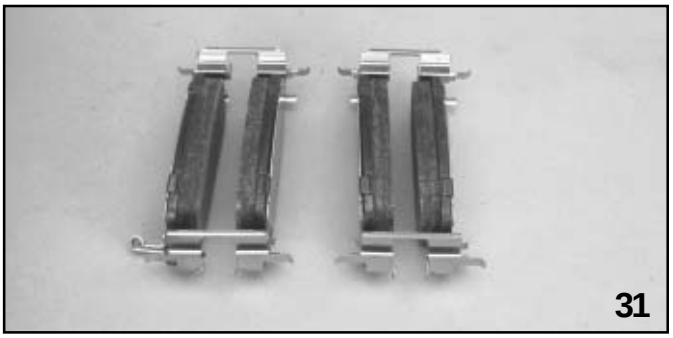
AFTER DISASSEMBLING THE CALIPER, MAKE THE FOLLOWING INSPECTIONS:

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.



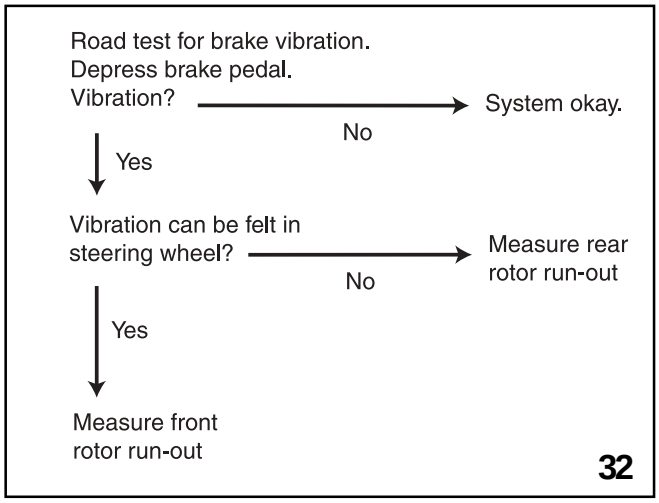
Front caliper lubrication points



Pads assembled

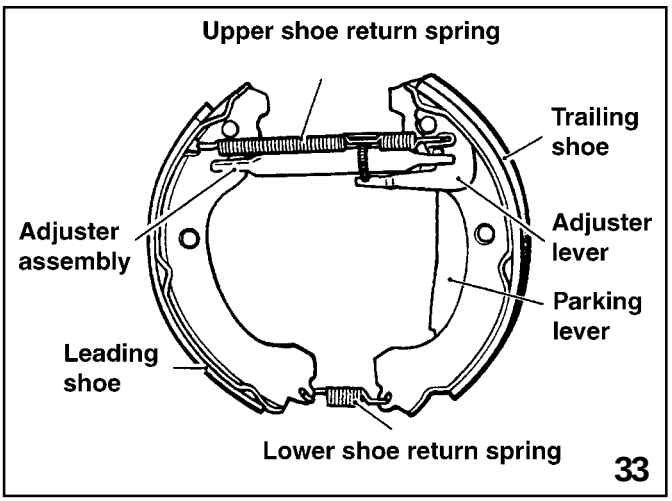
Brake System Inspection

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

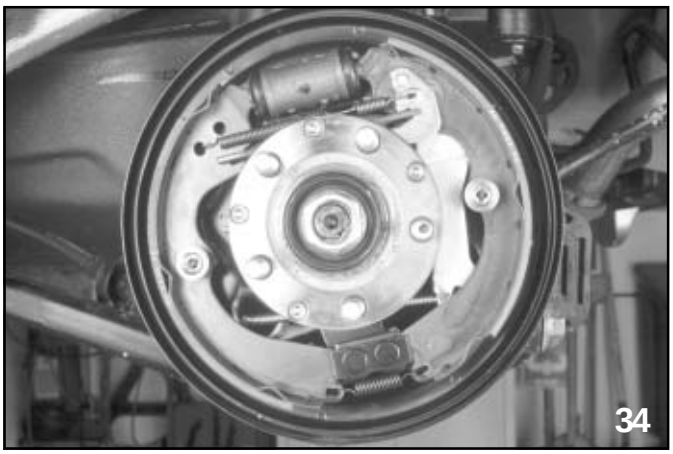


Self-adjuster operation (brakes applied)

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.

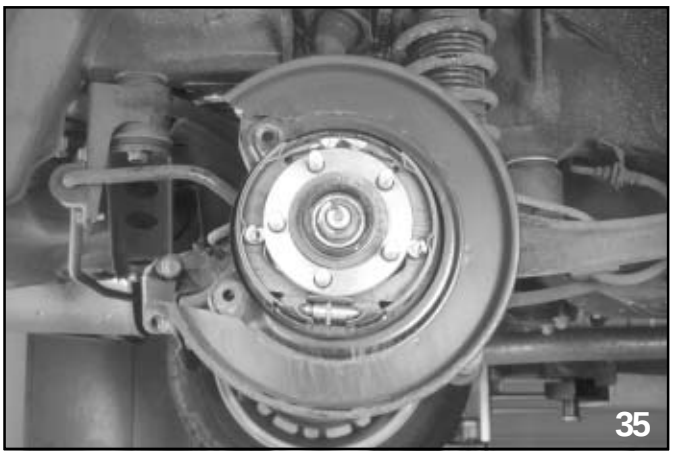
NOTE: ALWAYS RELEASE THE SELF-ADJUSTING MECHANISM BEFORE REMOVING THE DRUM.



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.

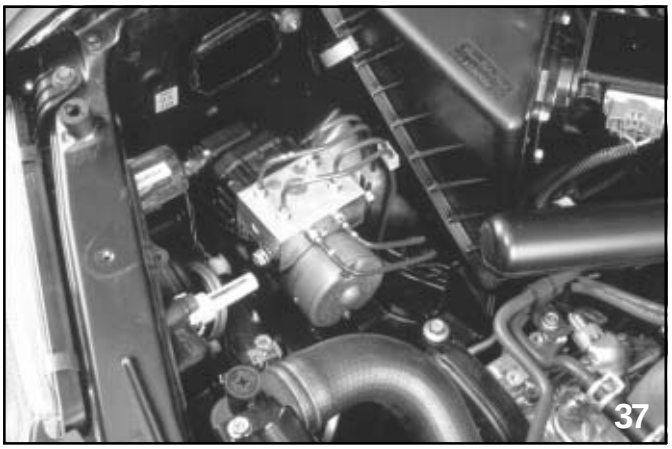
Test drive the vehicle to confirm proper operation of the brake system and also to "break-in" the parking brake linings. Maintain 15 to 20 MPH and lightly pull on the parking brake lever and release. Repeat at least five times.

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.

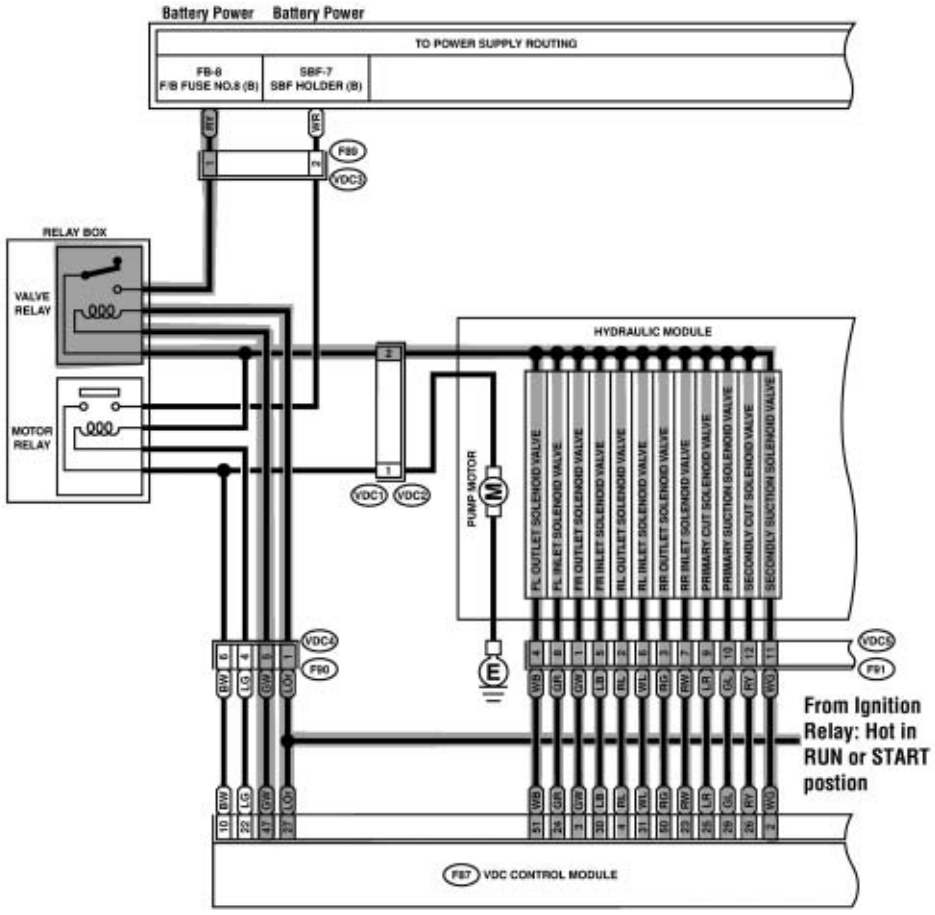
General ABS Operation

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.



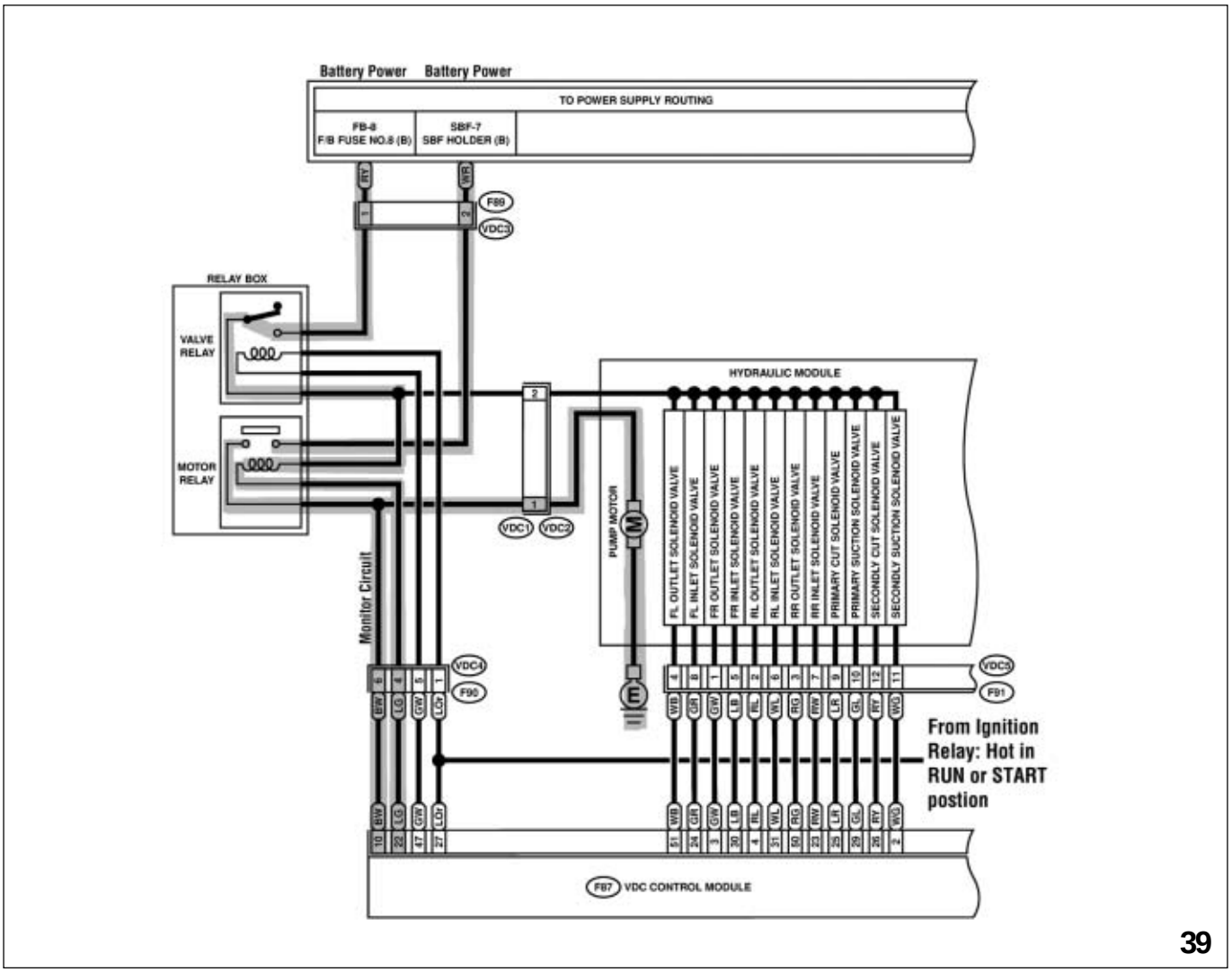
Hydraulic control unit

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).



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.

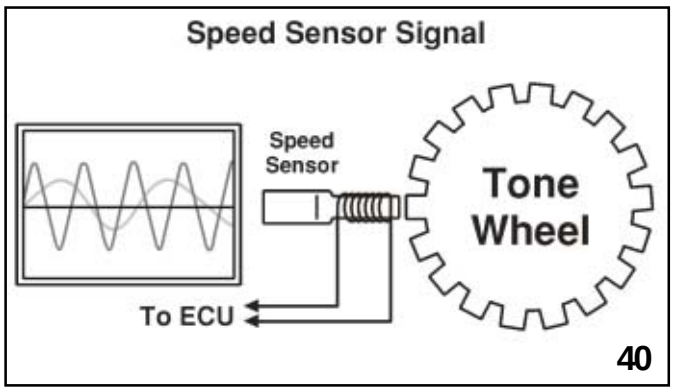


Motor relay circuit

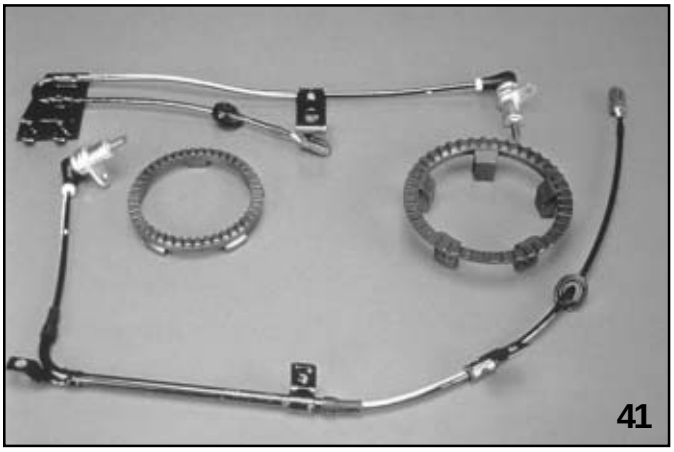
The HCU's on Subaru ABS systems contain a pump motor which operates a hydraulic pump inside the HCU. The pump motor has a constant ground and receives power from a motor relay. The motor relay is energized by the ABSCM. The only time the ABSCM will energize the motor relay is when ABS is controlling 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

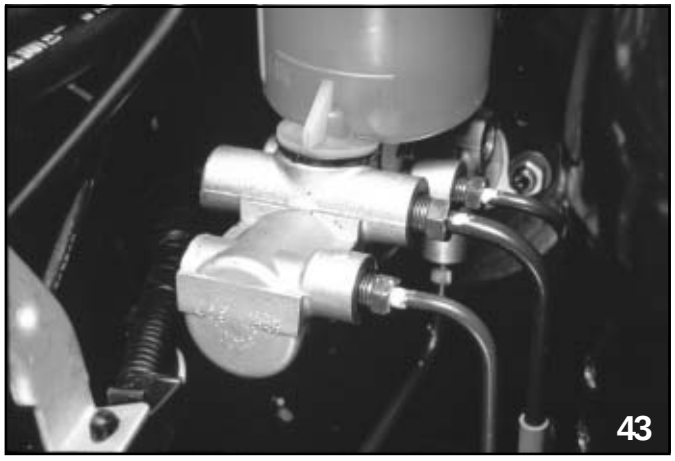
- Electrical faults indicated by ABS or VDC warning lamp.
- Long term memory
- Stores up to three trouble codes
- Special bleeding procedure
- Communicates with SMII
- Select Low Control
- Separate ABS and VDS sequence control procedures
- Special procedure to calibrate steering sensor

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

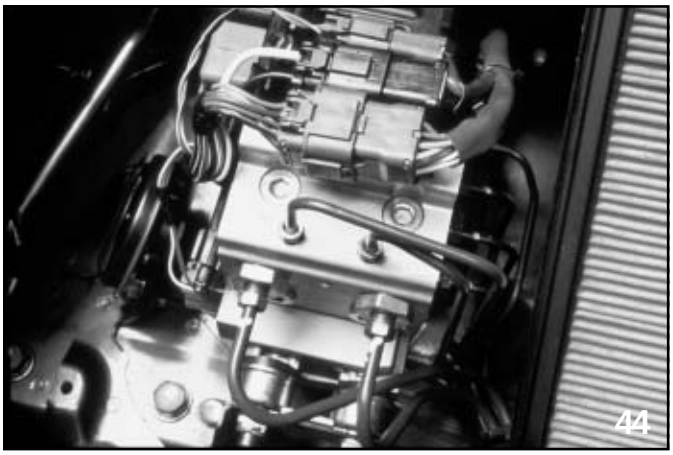
During normal braking and ABS operation SV1 and SV2 remain off (open). During TCS operation, SV1 and SV2 will turn on (closed). Each solenoid has a check valve connected in parallel with it to aid in the flow of fluid. (The solenoid design restricts flow.)

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)

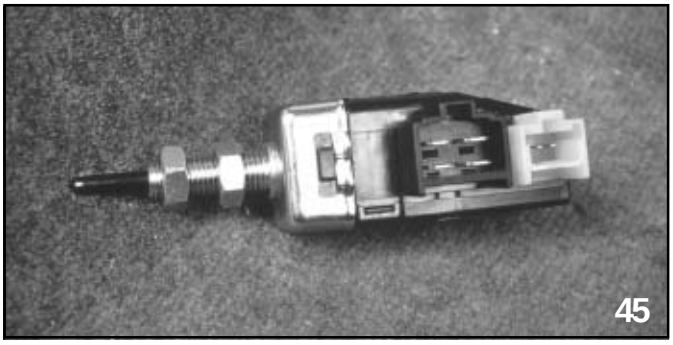
The motor relay controls motor operation via the control module.



Teves Mark IV Hydraulic Control Unit

The valve relay controls the power supply to the ten solenoids inside the hydraulic control module.

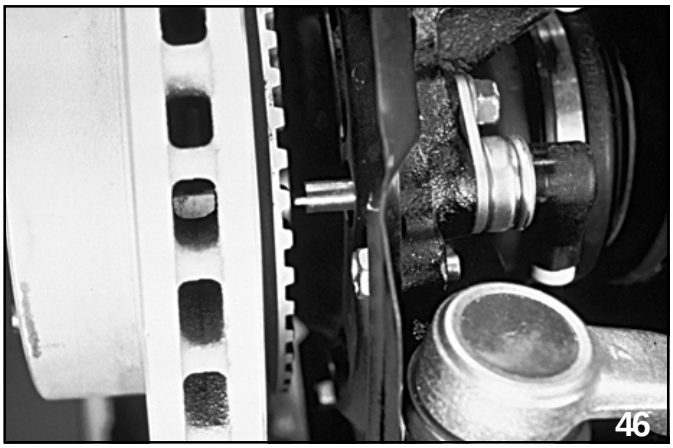
Brake Pedal Stroke Sensor



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.)

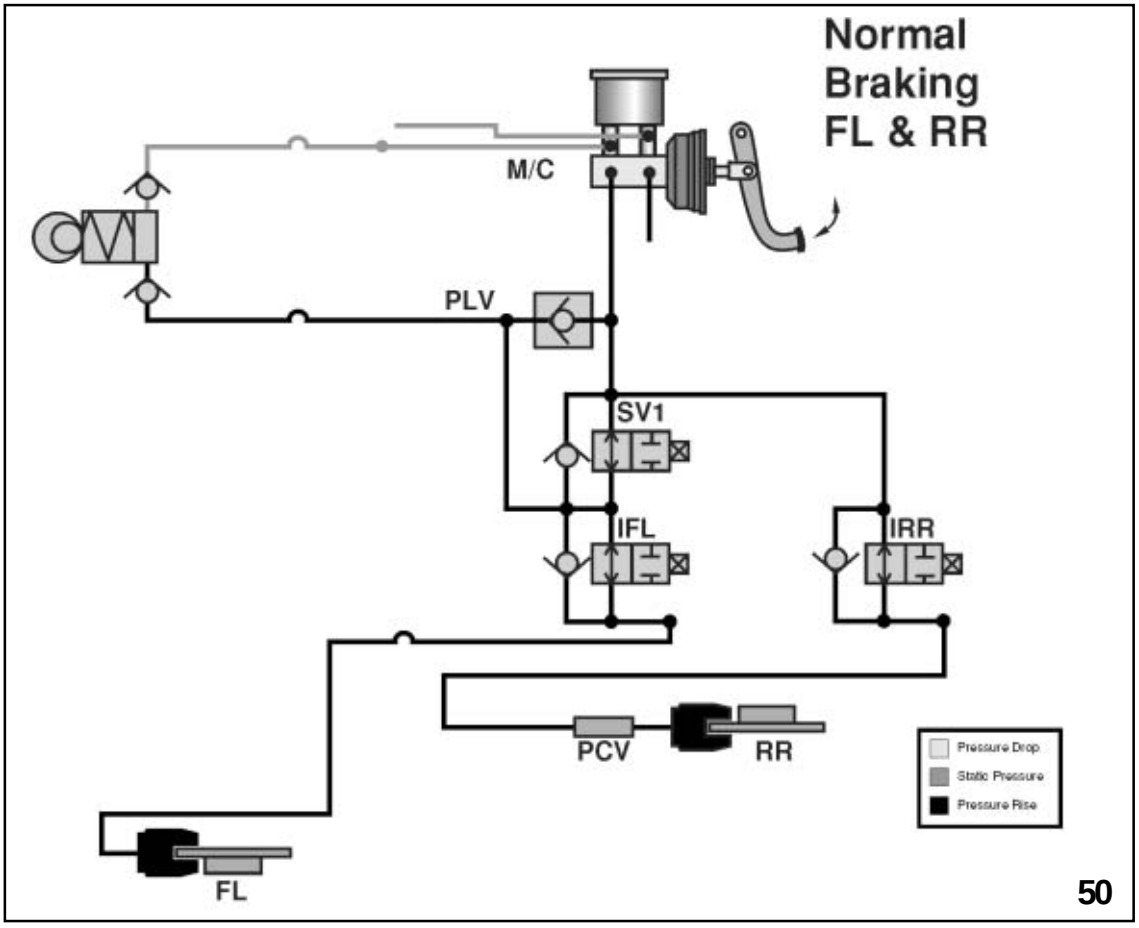
ABS/TCS Control Module



ABS/TCS control module

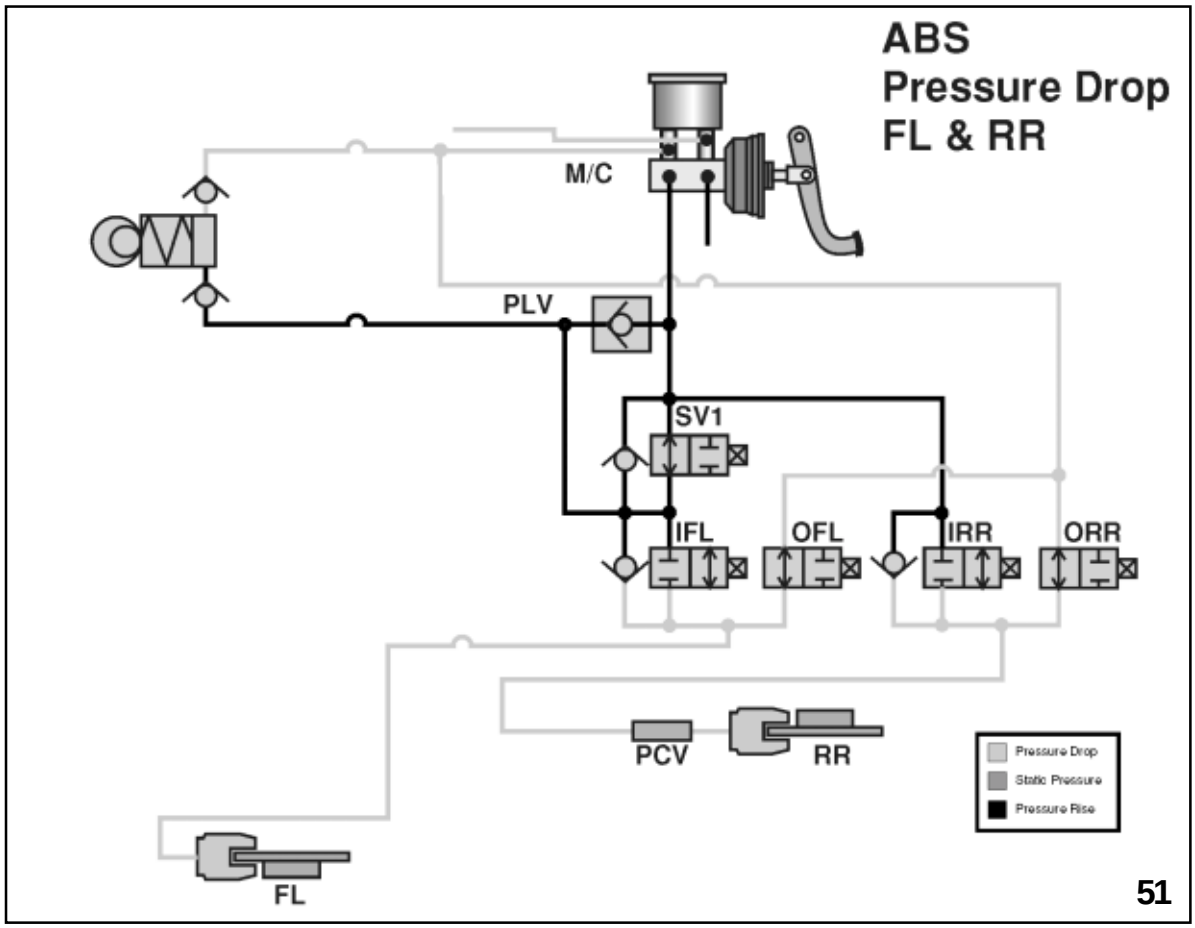
The ABS/TCS control module controls the application of ABS and TCS vehicle functions. It also networks with the engine control module during TCS operation and networks with the transmission control module during ABS operation.

Hydraulic Flow



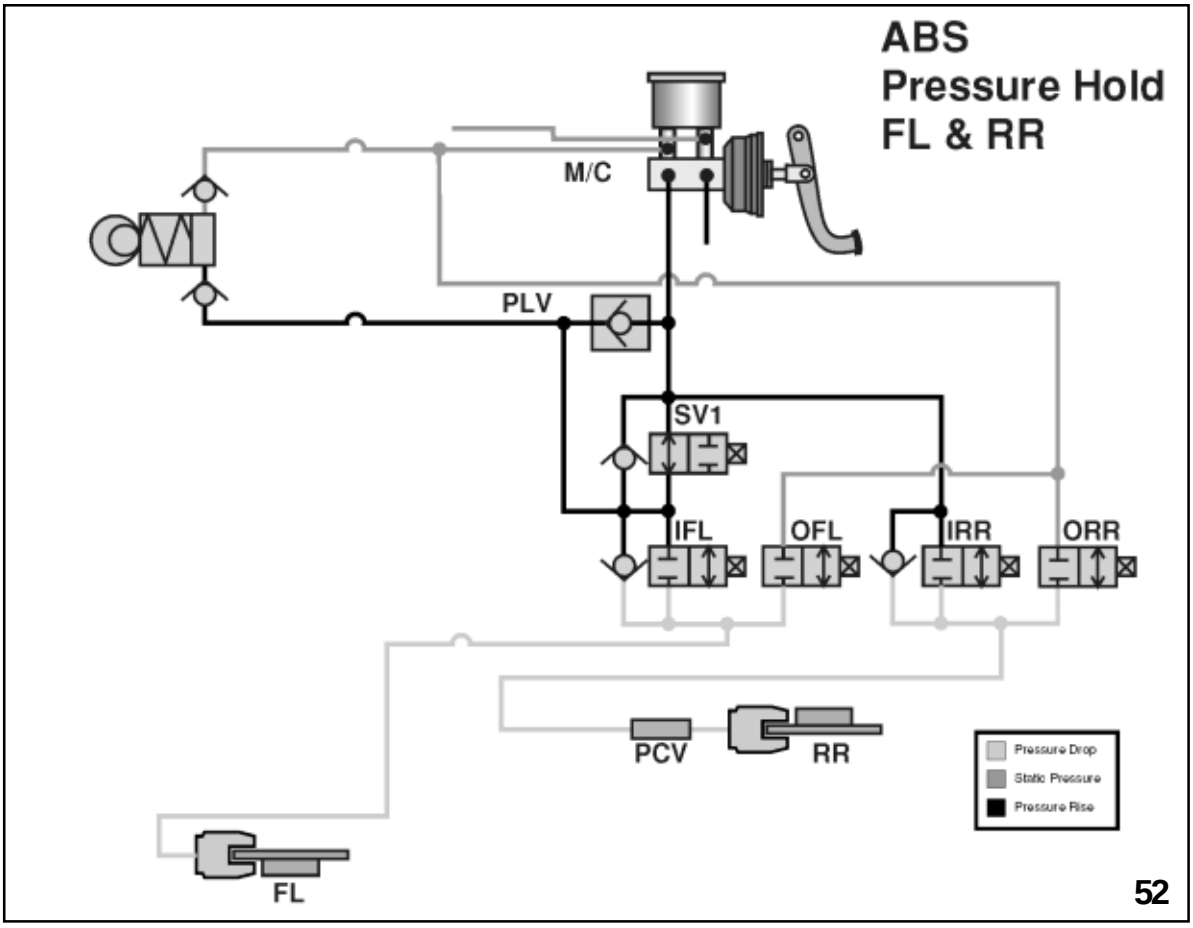
Normal braking

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.



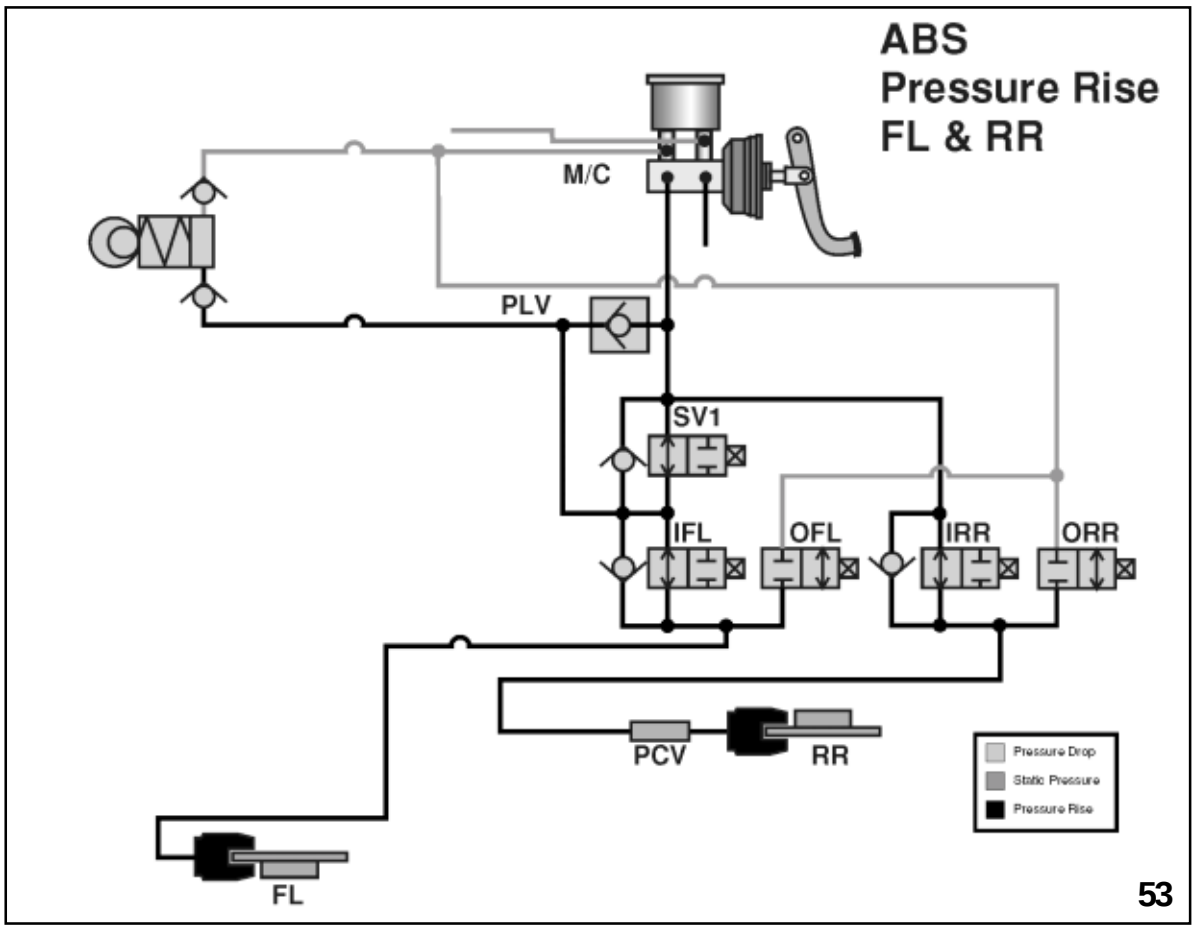
ABS braking pressure drop

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

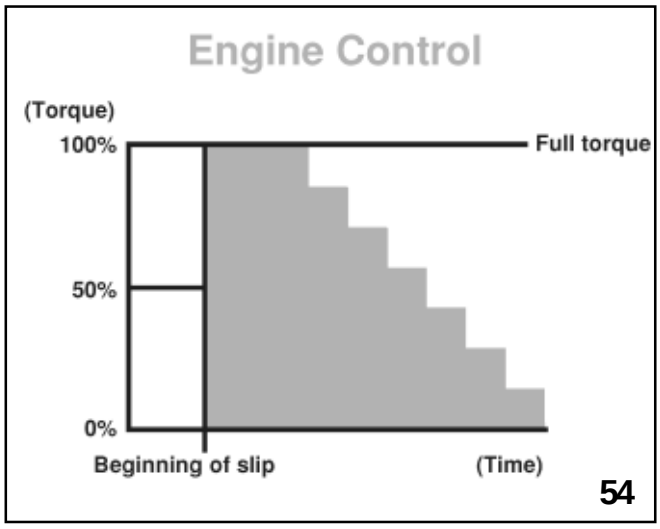
Pressure Hold – The IFL and OFL close, trapping the remaining pressure in the brake caliper. Wheel speed is then reevaluated, and the ABS/TCS will enter pressure rise or drop, depending on whether the wheel need to accelerate or decelerate.



ABS pressure rise

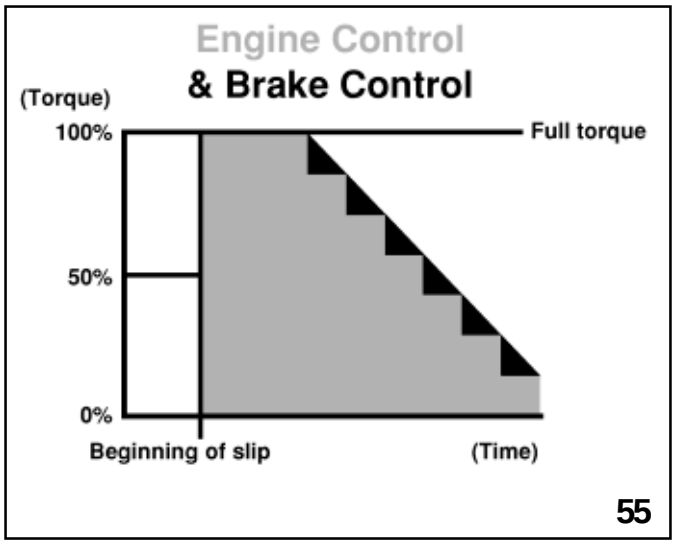
Pressure Rise – The OFL remains closed, IFL opens and the brake pedal begins to move toward the floor. The motor pump assembly activates and pressurizes the hydraulic circuit from the caliper to the master cylinder. At this point the pump output pressure is approximately 150 kgcm2, which overcomes the 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.

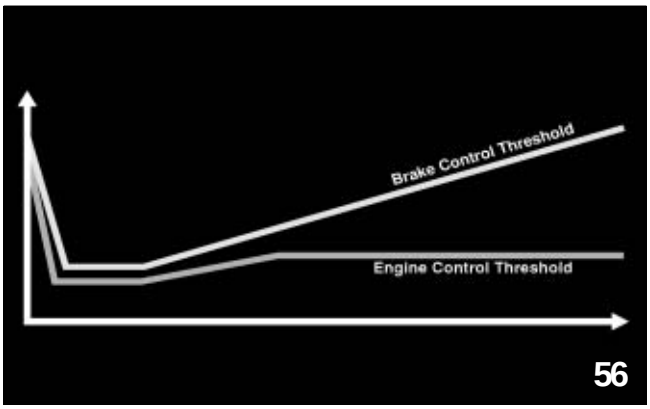


TCS Logic - Engine Control & Brake Control

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

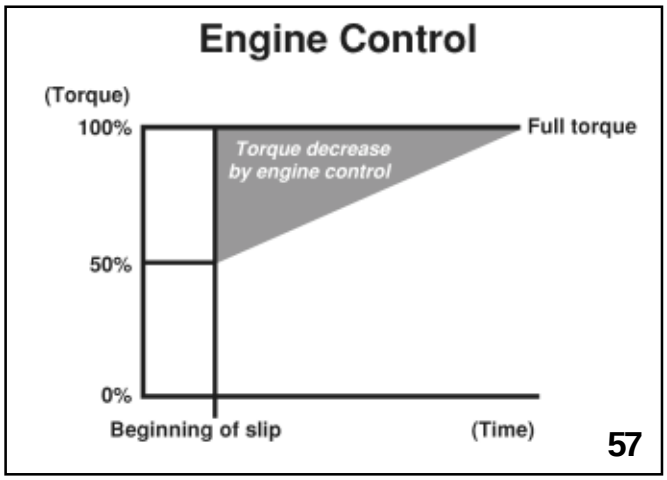


TCS Logic / Wheel slip recognition

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.

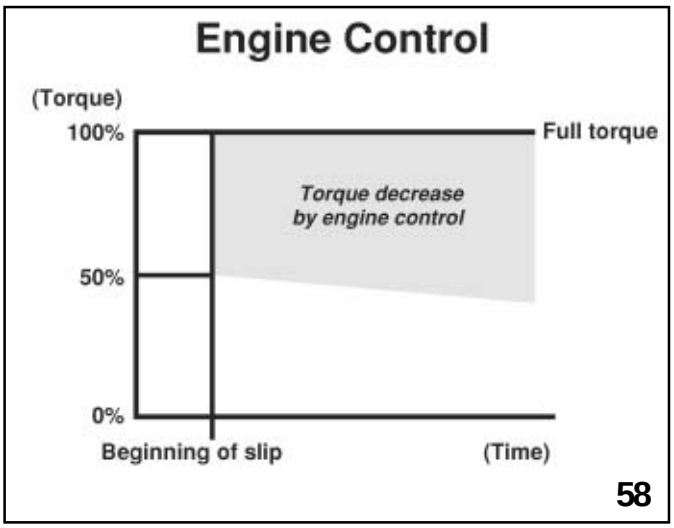
One-Wheel Slip



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.

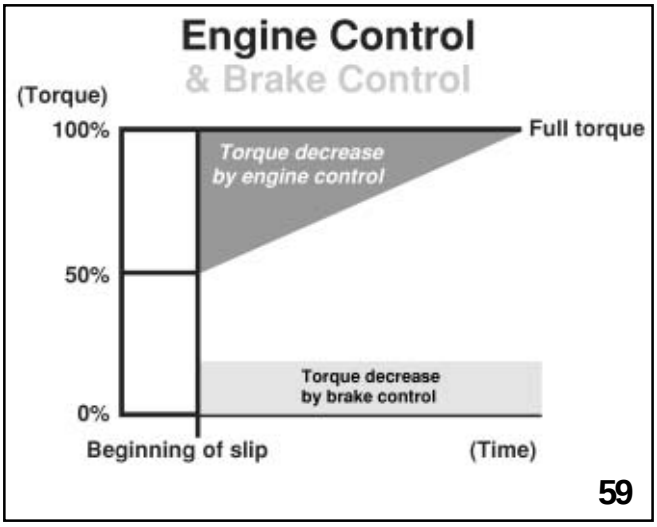
Two-Wheel Slip



TCS Logic - Two wheel slip

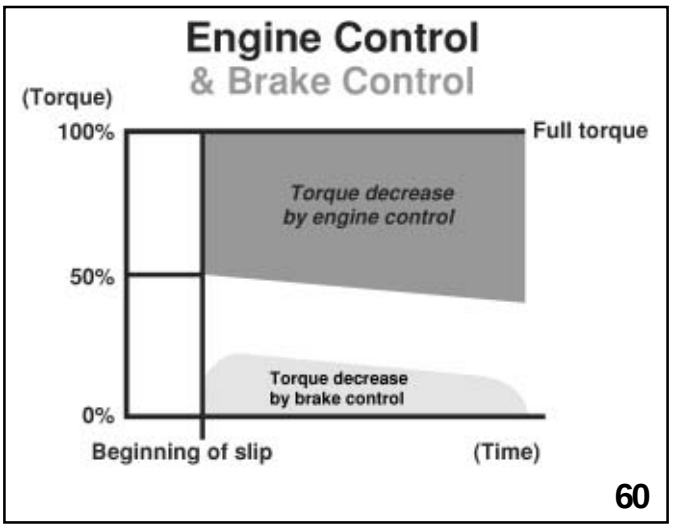
Two wheel slip results in a large fuel cut at first and increases if the slip does not decrease and decreases if the wheel slip decreases. This concentrates on stability.

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.

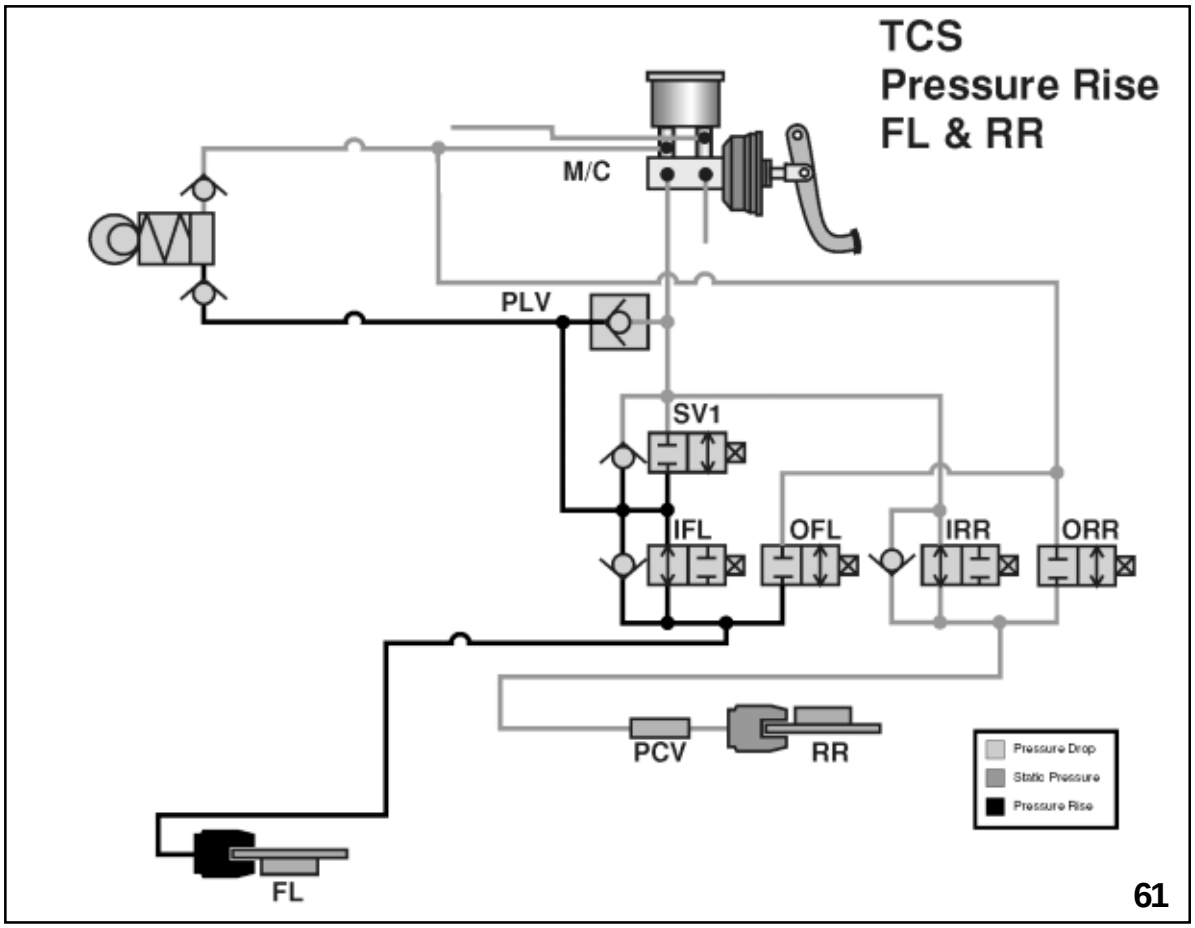


TCS Logic - Two wheel slip

NOTES:

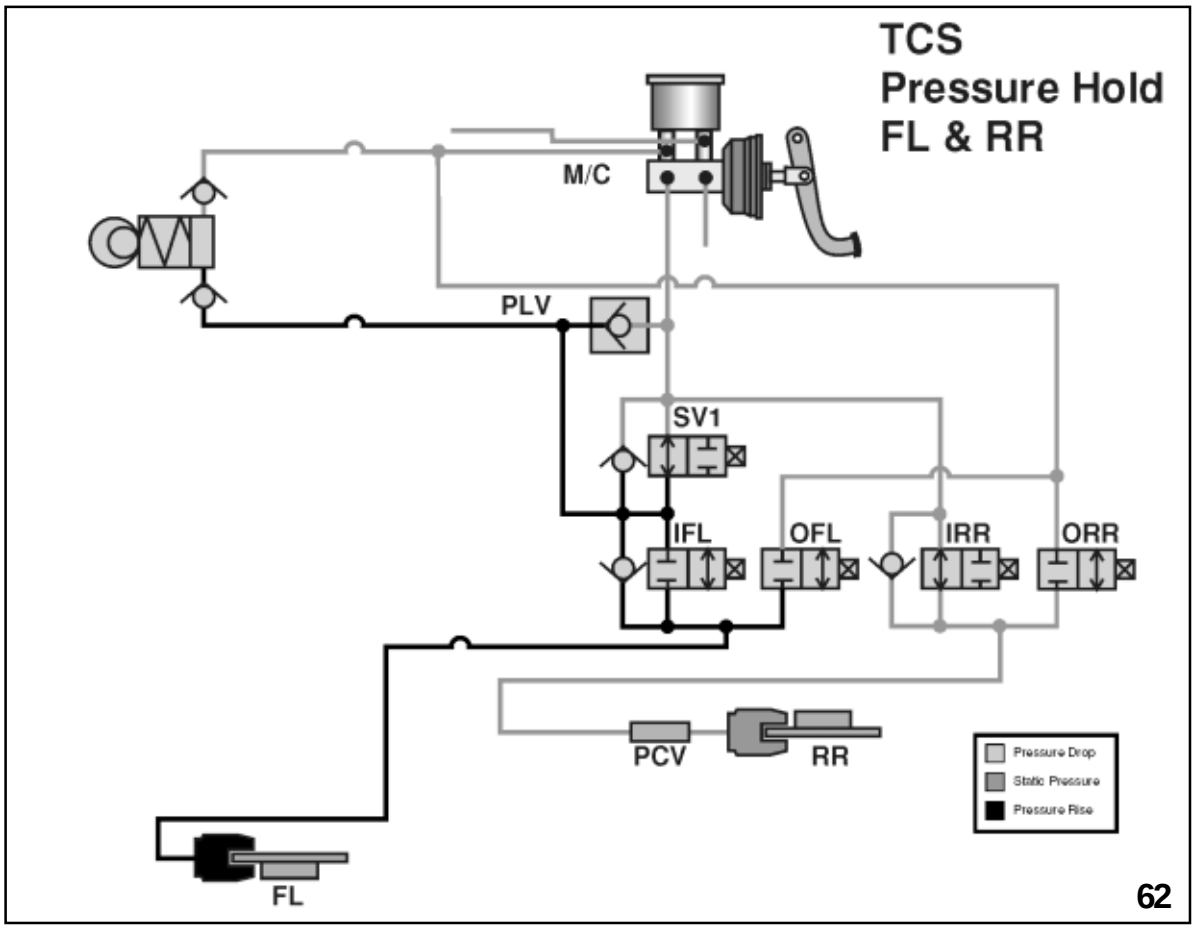
TCS Hydraulic Control

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.

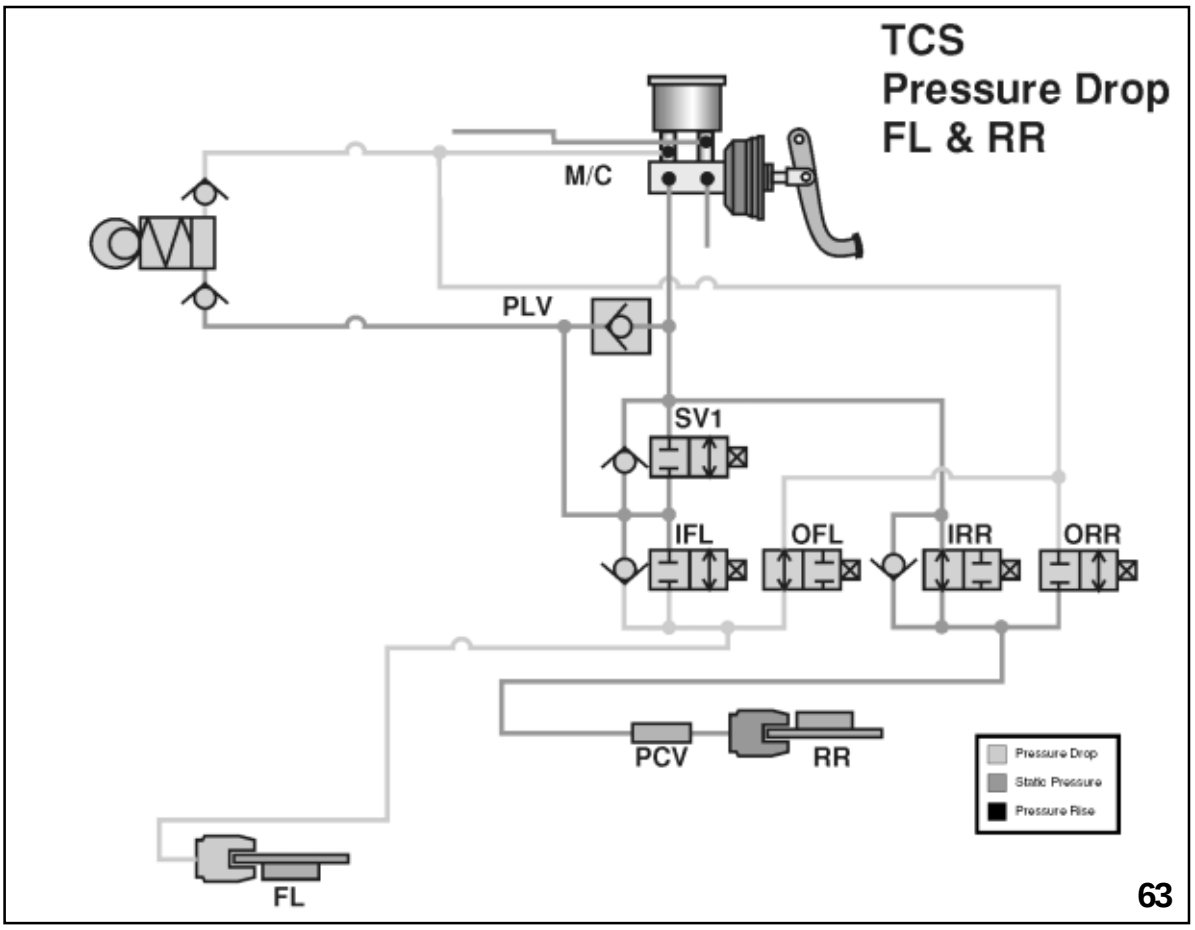


TCS pressure rise

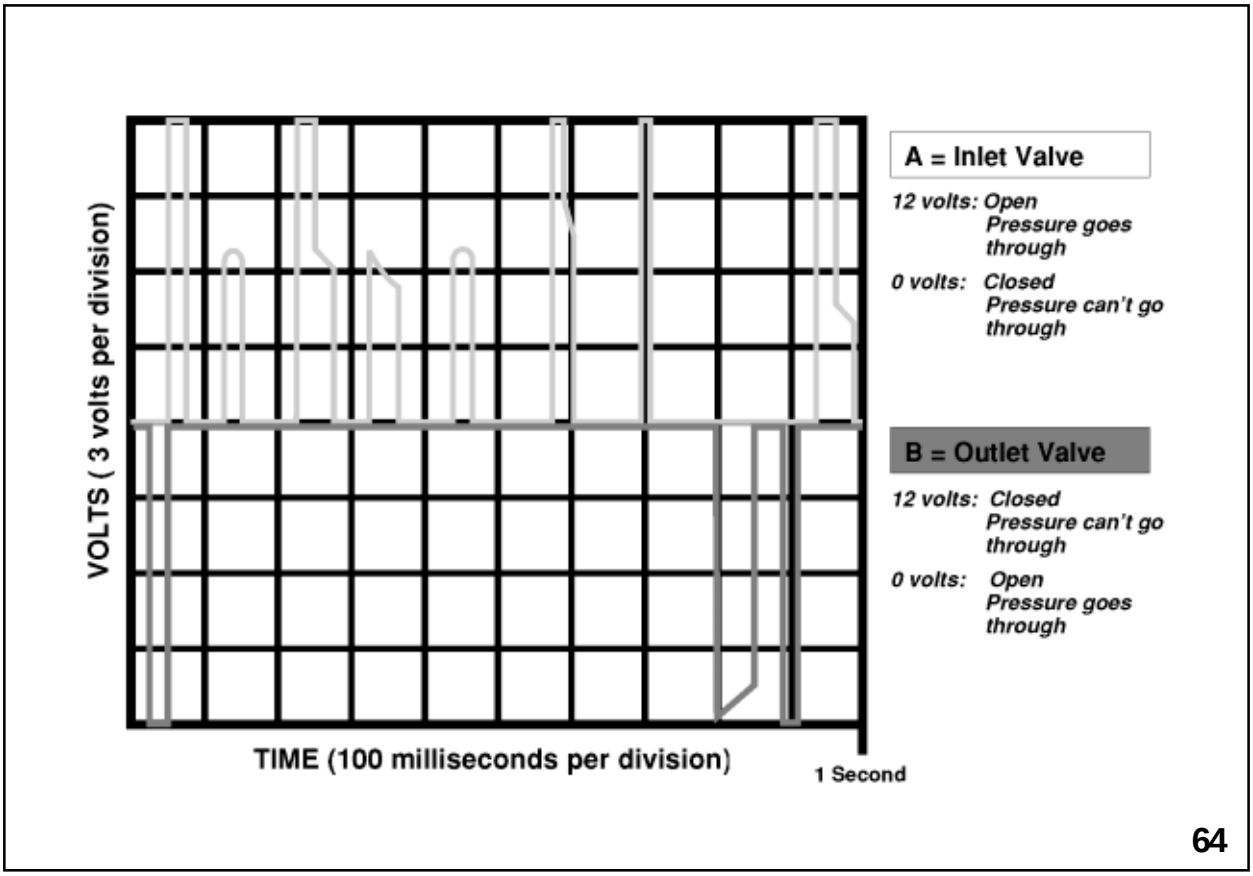
Two wheel slip will result in both inlet valves remaining open, allowing braking on the FR and FL wheels. When braking occurs during one wheel slip, the driving torque that would otherwise go to the slipping wheel is transmitted through the differential to the wheel with traction, creating a **Limited 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

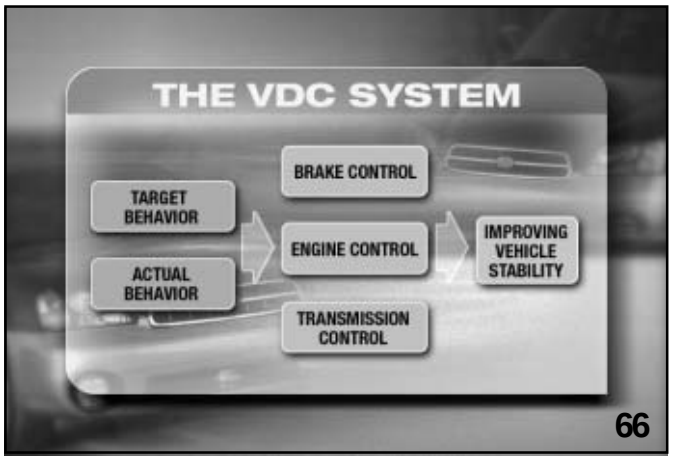
15. Disconnect the select monitor

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.

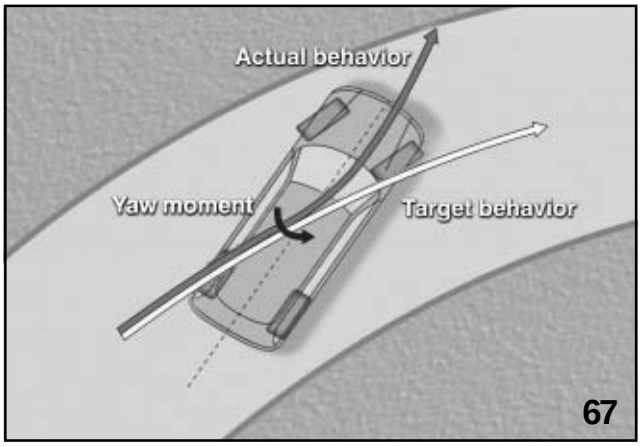
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Vehicle Dynamic Control (VDC)



VDC Logic

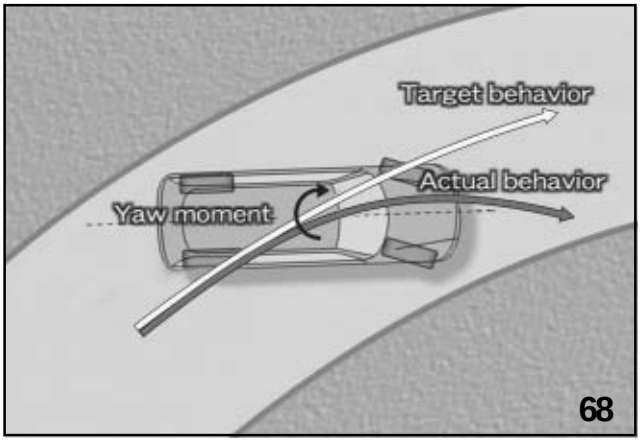
Vehicle Dynamic Control or VDC combines Anti-lock Brakes, Traction Control and new vehicle stability logic. The VDC system is designed to keep the vehicle behavior in the driver's expectations when the actual vehicle behavior may divert from what is expected.



Understeer

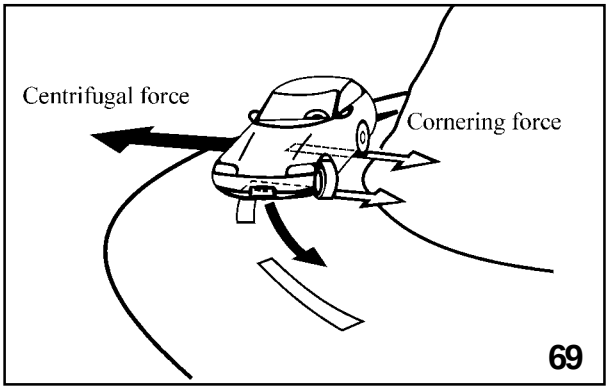
VDC operation comes into use during periods of driving when understeer or oversteer conditions are encountered. Four wheel TCS and ABS functions become active any time the VDC CM determines they are needed.

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.

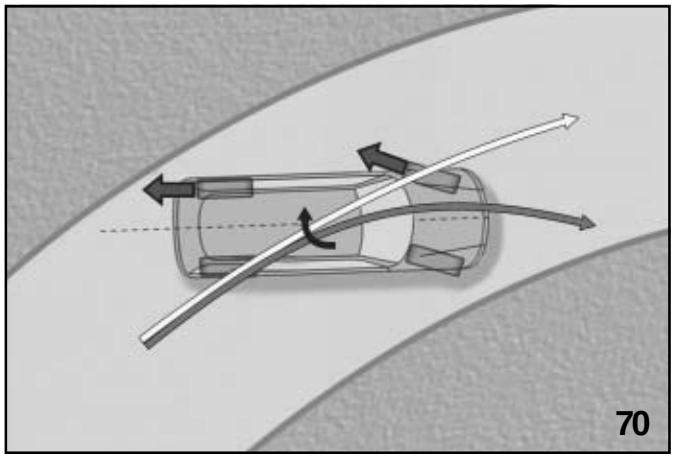
There are two ways to control slip: Produce a force or yaw moment of the reverse direction in the case of oversteering or produce a yaw moment of the same direction as the turning direction in the case of understeering.

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.



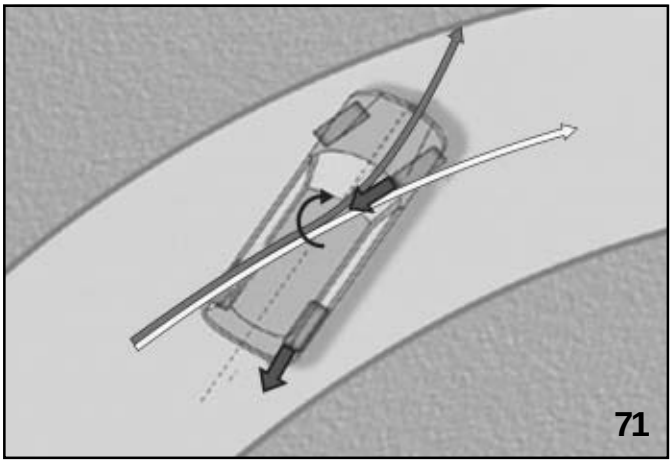
Oversteer While Accelerating

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.



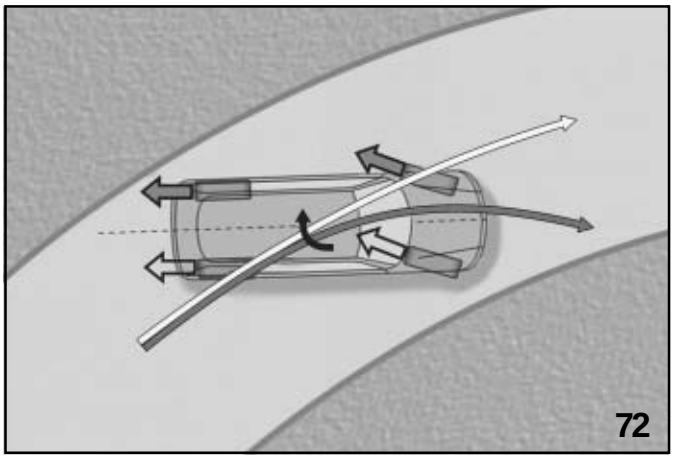
Understeer While Accelerating

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

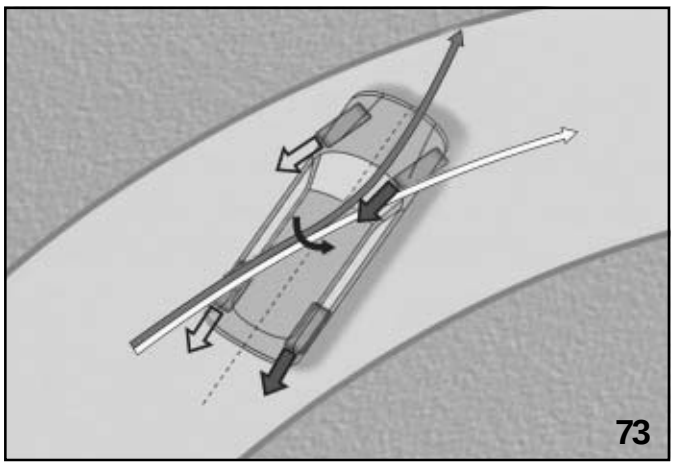
Oversteering while applying the brake.

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.

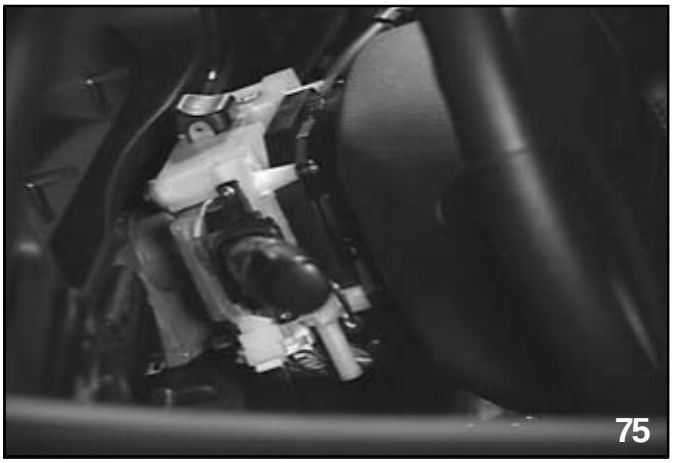
Actions taken:

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.

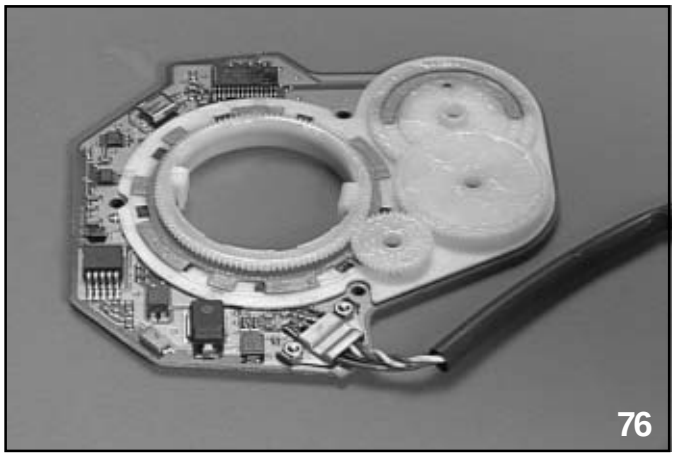
Sensors

Steering Position Sensor



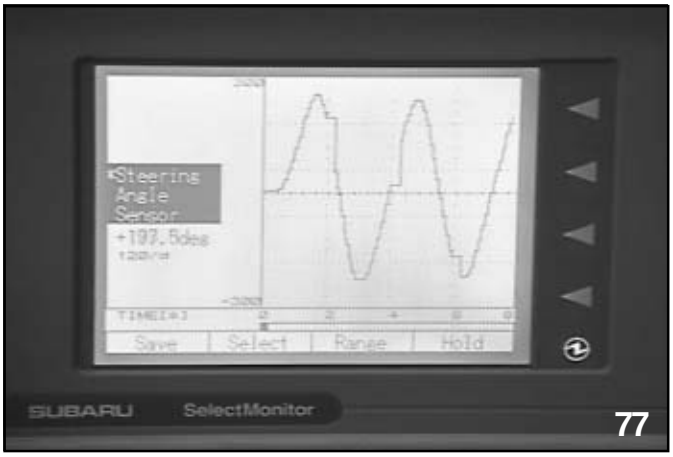
Steering position sensor

This sensor is located under the steering wheel and is indexed with it to create signals as the steering wheel is turned.



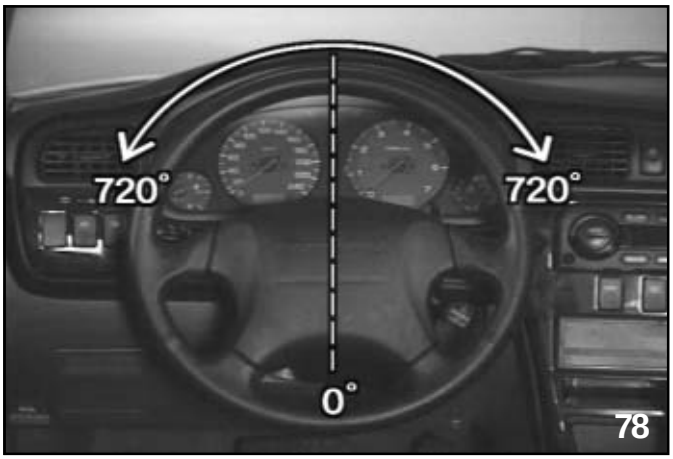
Steering position sensor construction

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.



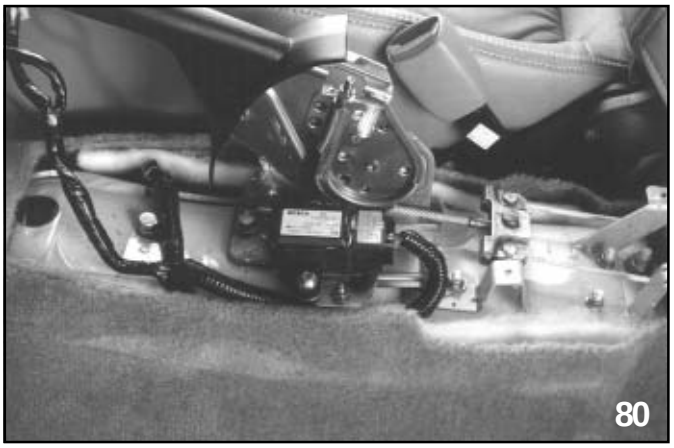
Degrees of turn

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.



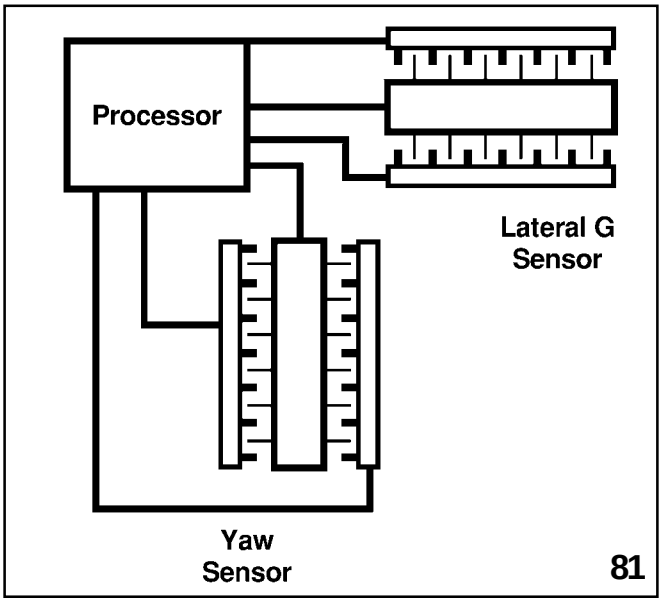
Wheel Speed Sensor

Wheel Speed Sensor-Detects wheel speed by each wheel.



Yaw Sensor

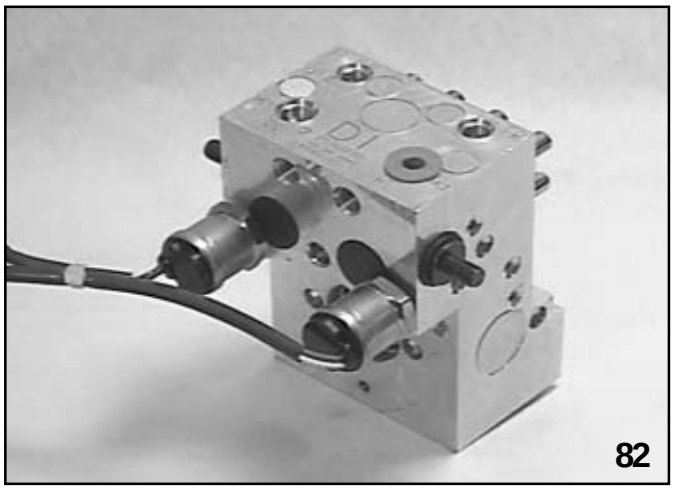
Yaw Rate Sensor- Detects the rotating velocity of the vehicle body during turning.



Yaw Sensor (artwork)

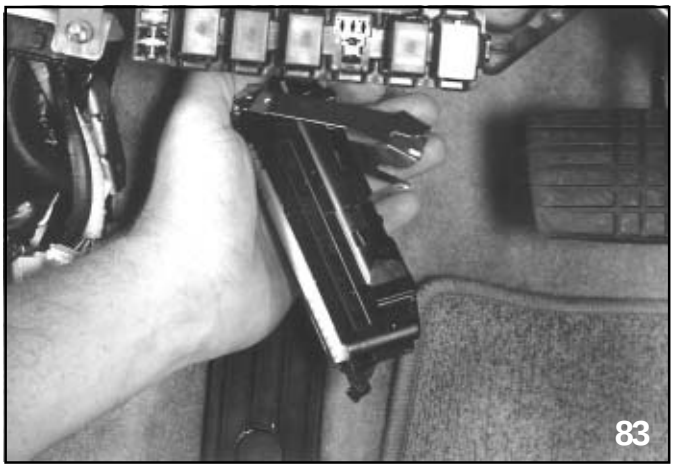
Lateral G Sensor- measures the centrifugal force exerted on the vehicle.

These two sensors are housed in a single unit and is located in the center console near the hand brake.



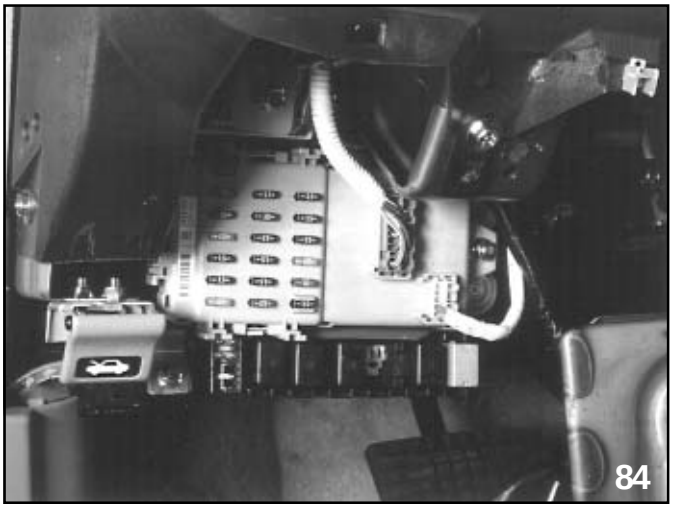
Hydraulic Control Unit

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.

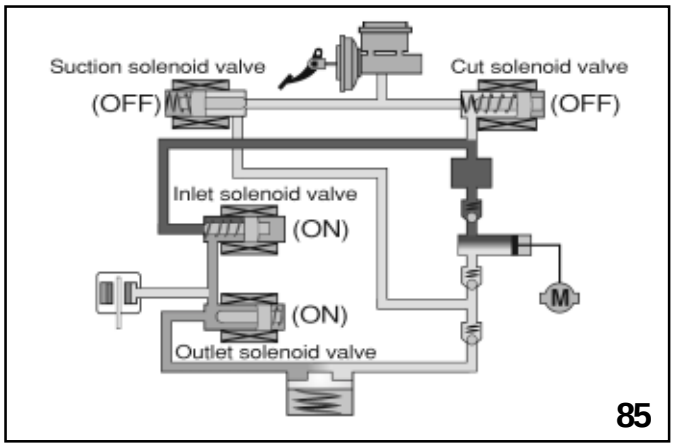


VDC CM location

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.

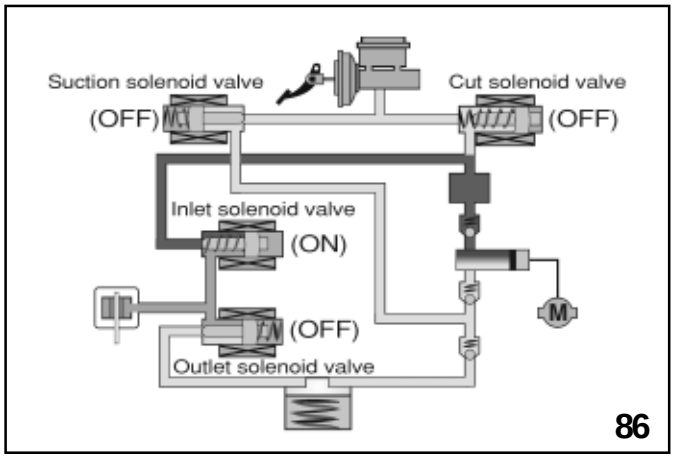
Pressure reducing mode



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.

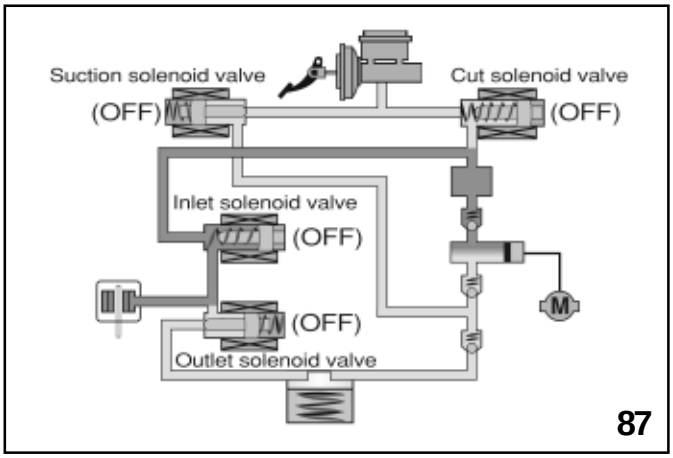
Pressure holding mode



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

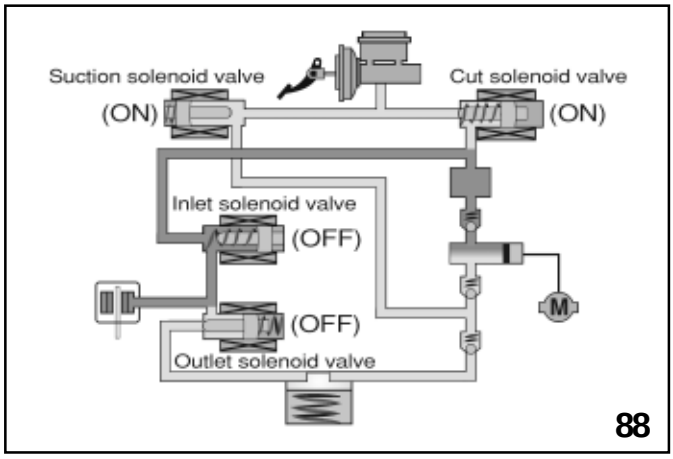


Pressure increasing mode

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

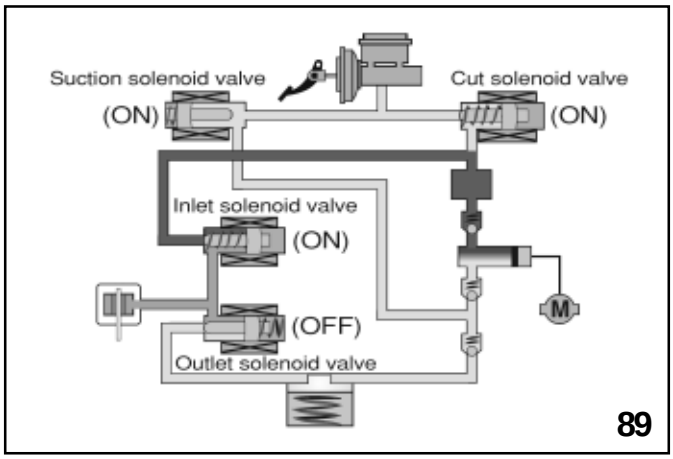
Pressure increase mode



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.

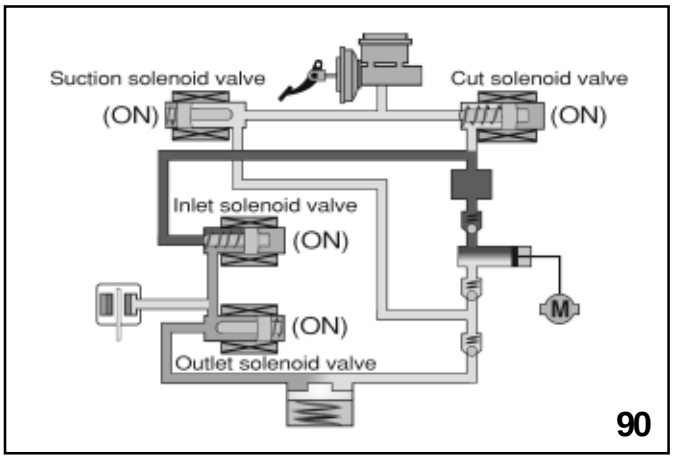
Pressure holding mode



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:

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Technicians Reference Booklet

Fuel Injection and Engine Management

Module 406

MSA5P0161C

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Technical Training

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Fuel Injection and Engine Management

Table of Contents

Slide Sequence 5
Introduction 10
Air Induction System 10
Fuel Supply 13
Sensors 15
Fuel Injection Logic 16
Learning Control 17
Ignition System Control 17
Power Supply 19
Self Diagnosis System 19
Impreza 1.8 Liter 20
SVX 22
Inertia Resonance Induction System (IRIS) 23
SVX Ignition 24
SVX Fuel Delivery System 25
Fuel Tank Components 26
Fuel Tank Servicing 26
    Sub Assemblies 27
Radiator Fan Control 27
    Relay Control Circuit 28
    Motor Control Circuit 28
    Torque Reduction System 28
1999 Enhancements 28
D MPI 28
    Crankshaft and Camshaft Reluctors 30
L MPI 31
2000 Enhancements 32
2001 Legacy Enhancements 37
2002 Impreza Enhancements 42
Turbocharger 44
Turbocharger Testing 46
    Wastegate Control 46
Intercooler 47
    External Influences On Boost Pressure 49
        Ambient Air Temperature and Pressure 49
        Exhaust Diameter 49
        Fuel Octane Rating 49
        Turbo Lag 49
Service Bulletins 52
406 Module Service Help-Line Updates 53

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (Boxer Engine Series Module)	
2	Created By	
3	Teaching Aids	
4	Title Slide (Introduction)	10
5	Current Models	10
6	Title Slide (Air Induction System)	10
7	Air Flow Meter	10
8	Fail-safe Schematic	11
9	Mass Air Flow Sensor Circuit	11
10	Idle Air Control Valves	11
11	Throttle Body with Accel Cable & TPS	11
12	Potentiometer Operation	12
13	Throttle Position Sensor Circuit	12
14	Idle Air Control Valve	12
15	Turbo Idle Air Control Valve	13
16	IAC Schematic	13
17	Fuel Supply	13
18	Fuel Supply System	18
19	Fuel Pump	14
20	Fuel Pressure Regulator	14
21	Fuel Injector	14
22	Tip Design	15
23	Fuel Injector Circuit	15
24	Sensors	15
25	Crank Angle Sensor	15
26	Crank Angle Sensor Reluctor Construction	15
27	Cylinder Discrimination Signal	16
28	Cam Angle Sensor and Reluctor	16
29	Cam Angle Sensor Air Gap	16
30	Fuel Injection Logic	16
31-37	Injection Duration	16
38	Learning Control	17
39	Basic Duration	17
40	Ignition System Control	17
41	Ignition Circuit	17
42	Ignition Coil Construction	17
43	Ignition Coils	18
44	Ignitor	18
45	Timing Advance Logic	18
46	Power supply	19
47	Ignition Relay Coil Power	19
48	Ignition Relay Power Distribution	19
49	Self Diagnosis System	19
50	Select Monitor and Service Connector	19
51	Impreza 1.8 Liter	20
52	Throttle Position Sensor	20
53	Control Soft Operation	20
54	Idle Air Control Valve	20
55	Throttle Body with Wax Pellet	21
56	A/C IAC	21
57	1.8 Impreza Fuel Supply System	57
58	SVX	22
59	Throttle Body and Manifold	22
60	Auxiliary Air Valve	22
61	Inertia Resonance Induction system (IRIS)	23

Slide Sequence

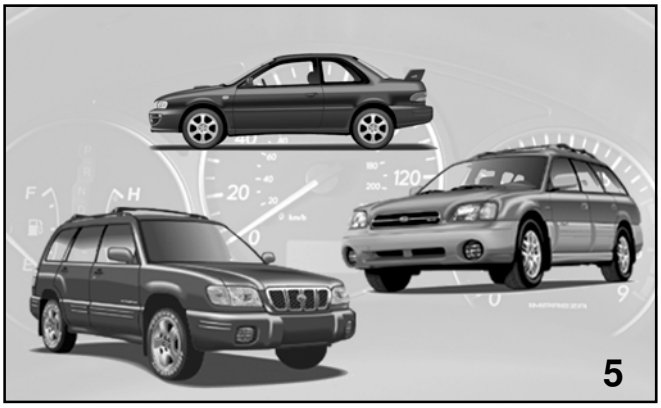
Slide No.	Description	Page No.
62	Intake Manifold (Underside)	23
63	IRIS Valve (Closed)	23
64	IRIS Valve (Open) with Resonance Tube	23
65	Resonance Tube	23
66	SVX Ignition	24
67	Ignition coil and Spark Plug	24
68	Knock Sensor Locations	24
69	Oxygen Sensors	24
70	Crank and Cam Angle Sensors	24
71	Throttle Sensor	25
72	SVX Fuel Delivery System	25
73	Fuel Delivery System	25
74	Fuel Tank components	26
75	Sending Units Assemble and Pump	26
76	Fuel Tank Servicing	26
77	Removing Spanner Ring	26
78	Sub Assembly Retaining Clamp	26
79	Removing Fuel Pump	27
80	Removing Sending Unit	27
81	Radiator Fan Control	27
82	Fan Control Schematic	27
83	Torque Reduction System	28
84	1999 Enhancements	28
85	D MPI	28
86	Fuel Supply Rail	28
87	Air Assist Injector	29
88	Idle Speed Control Valve	29
89	Air Assist Supply Rail	29
90	Injector AA Camber Tip	29
91	AA Camber (Air Inlets)	30
92	Idle Speed Control Valve	30
93	D MPI (Artwork)	30
94	L MPI (Artwork)	30
95	Ignitor coil	31
96	ECM to Coil Signal	31
97	Ignition Coil construction	31
98	L MPI	31
99	Idle Air Control Solenoid Valve	31
100	Enhancements	32
101	Vent Control Piping	32
102	Fuel Pump (Under Seat)	33
103	Fuel Drain	33
104	Fuel Pump (Top View)	33
105	Fuel Pump (Float Arm View)	33
106	Fuel Pump (Static Strap View)	33
107	Static Strap Close-up	34
108	Fuel Level Sensor	34
109	Engine Compartment	34
110	Air Assist Solenoid Valve	35
111	Intake Air Temperature And Pressure Sensor (Bottom View)	35
112	Intake Air Temperature And Pressure Sensor (Top View)	35
113	Air Induction Housing	35
114	TPS	36
115	AFR Sensor	36
116	AFR Sensor Harness	36

Slide Sequence

Slide No.	Description	Page No.
117	2001 Legacy Enhancements	37
118	Variable Intake Control Valve Closed	37
119	Variable Intake Control Valve Open	37
120	Variable Intake Control Valve Chart	37
121	Variable Intake Control Valve	38
122	Variable Intake Control Valve Location	38
123	Component Location	38
124	Intake Manifold	38
125	Ignition Coil Complete	38
126	Ignition Coil and Spring Contact (Apart)	39
127	Crankshaft Reluctor	39
128	Crank Angle Graph	39
129	Cam Angle Signal Pattern	40
130	EGR Pipe	40
131	EGR Valve	40
132	EGR Harness	40
133	Muffler	40
134	Muffler By-pass Valve	41
135	By-pass valve Operation (High Engine Speed)	41
136	By-pass valve Operation (Low Engine Speed)	41
137	2002 Impreza Enhancements	42
138	Tumble Generator Valve Rail	42
139	Tumble Generator Valve Motor	42
140	Vent Hose	42
141	Tumble Generator Valve Position Sensor	42
142	Bottom View of Intake	43
143	TGV Channel	43
144	Tumble Generator Valve Operation	43
145	Injector	43
146	Turbocharger	44
147	Turbocharger	44
148	Turbocharger Housing	44
149	Coolant Connection and Oil Return	44
150	Oil Supply and Connection	44
151	Wastegate	45
152	Wastegate Operation	45
153	Wastegate Actuator	45
154	Wastegate Valve	45
155	Wastegate Duty Solenoid	46
156	Turbocharger Testing	46
157	Pressure Gauge Connection	46
158	Radial Movement Check	47
159	Axial Movement Check	47
160	Intercooler	47
161	Effects of Intercooling	47
162	Intercooler (Bottom View)	47
163	Inlet to Throttle Body	48
164	Intercooler Location	48
165	By-pass Valve connection	48
166	Air By-pass Valve Operation	48
167	By-pass Valve	50
168	Fuel Pump Controller Terminal Layout	50
169	Copyright	
170	The End	

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.



Current Models

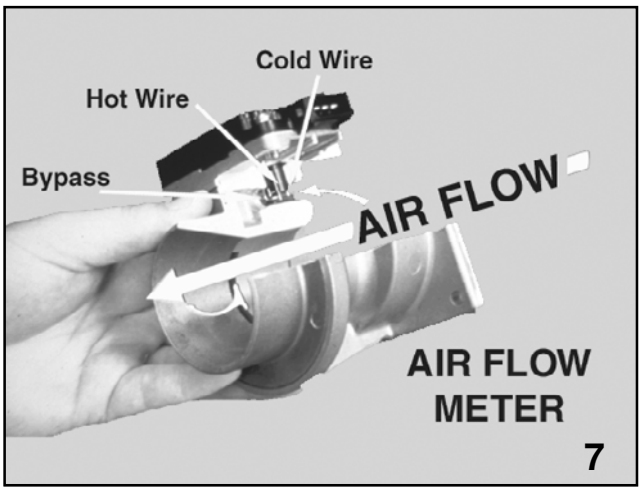
Only the differences of other models will be reviewed and supplemental information will be provided for you to take back to the dealership.

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

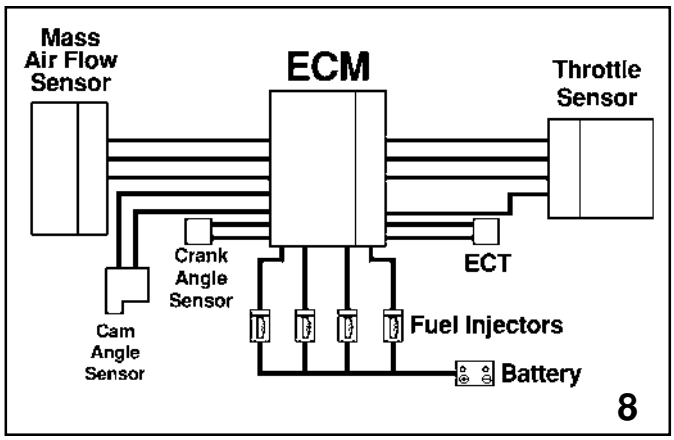
The Air Induction Piping delivers air from the air filter to the Throttle body , Idle Air Control Valve and the PCV system. Fitting to the components of the Air Induction System must be air tight to prevent unmetered air from entering the intake manifold.



Air Flow Meter

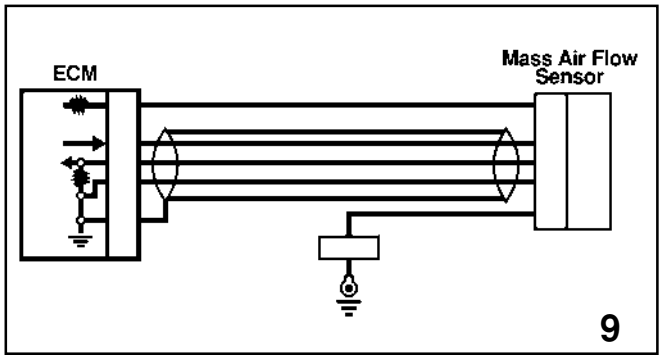
Monitoring the amount of air inducted is the main function of the Mass Air Flow Meter. Described as a "Hot Wire" type air flow meter containing no moving parts, the Subaru Mass Air Flow Meter obtains information by monitoring the voltage of a single wire which is exposed to the incoming air flow. There 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.



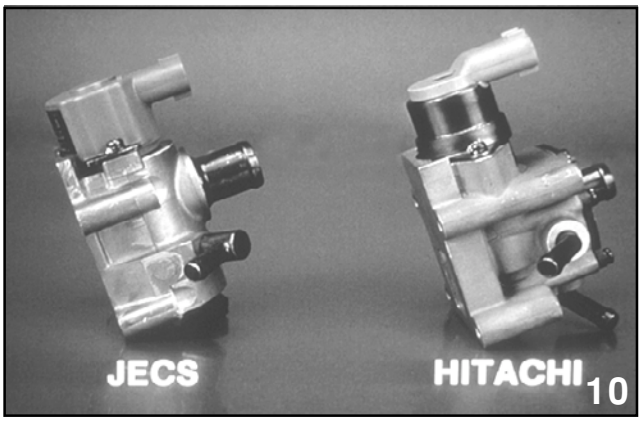
Fail-safe Schematic

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.



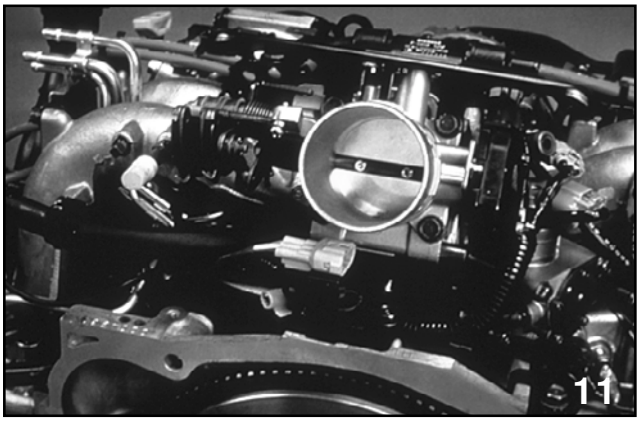
Mass Air Flow Sensor Circuit

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.



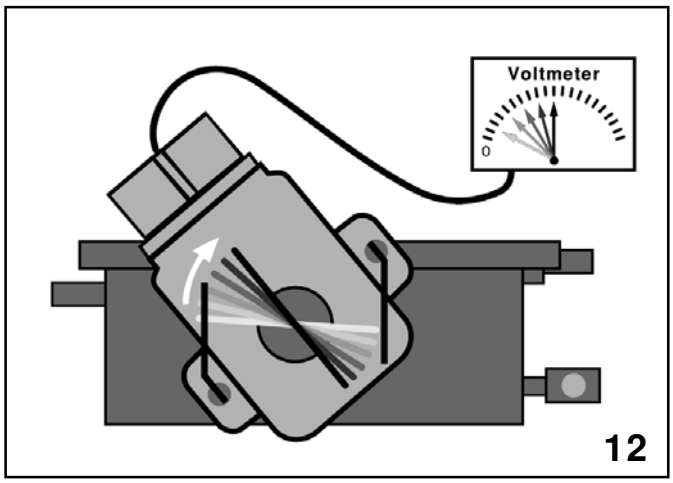
Idle Air Control Valves

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.



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.



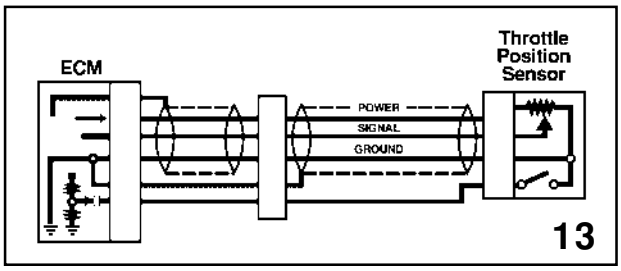
Potentiometer Operation

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.

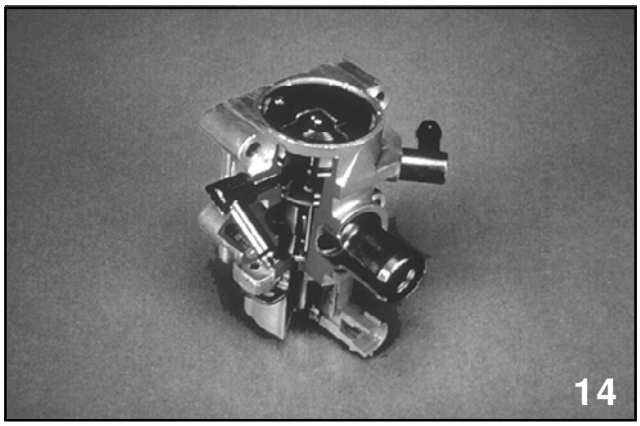
Adjustment is possible through the use of elongated mounting holes.

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

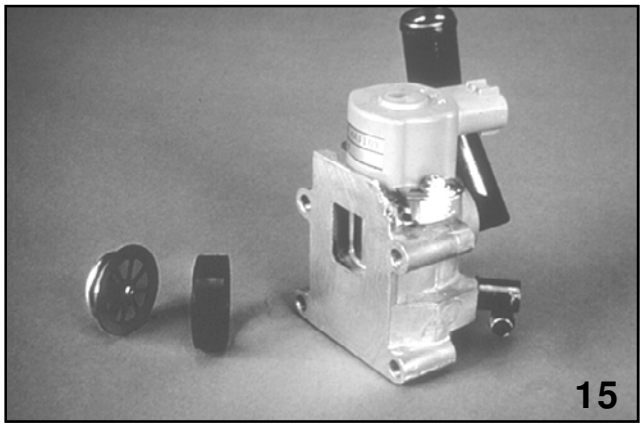
Testing is performed by observing voltage and resistance values. The Select Monitor on earlier models will display THV or throttle voltage and illuminate an LED when the idle switch signal is present. Newer models in addition will indicate throttle opening in degrees.



Idle Air Control Valve

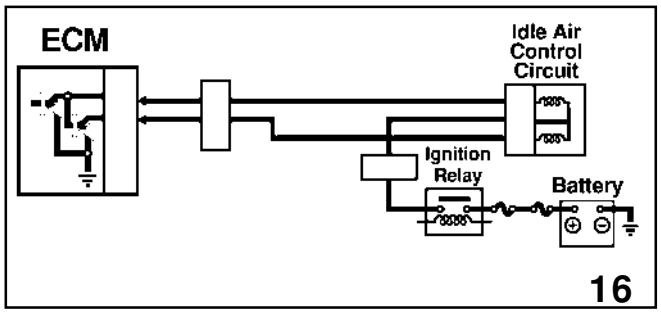
Idle Air Control Valve (IAC) operation controls all idle speeds. Construction includes an air cut valve, duty control valve, intake air passage and a coolant passage. These component parts create a dual control over the IAC. The air cut valve is influenced by the temperature of coolant flowing through the IAC. A bimetallic spring is utilized to act on the aircut 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.



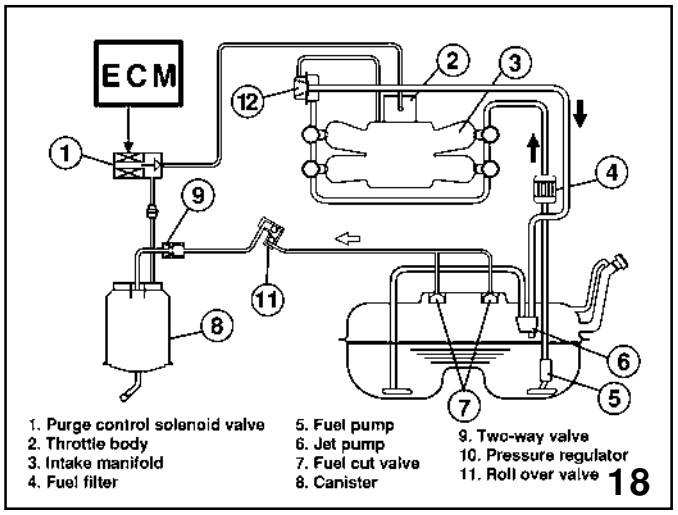
IAC Schematic

Fail-safe results of the IAC can be miss leading. Failure of the bimetallic spring with the aircut 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 service manual.

Fuel Supply

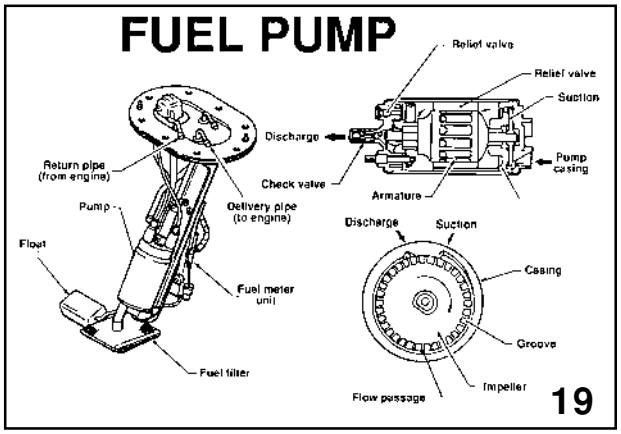


Fuel Supply System

The Fuel Supply system supplies, regulates and monitors gasoline to the injectors. Components include:

- Fuel Tank
- Pump
- Rollover valve
- Separator
- Regulator
- Injectors

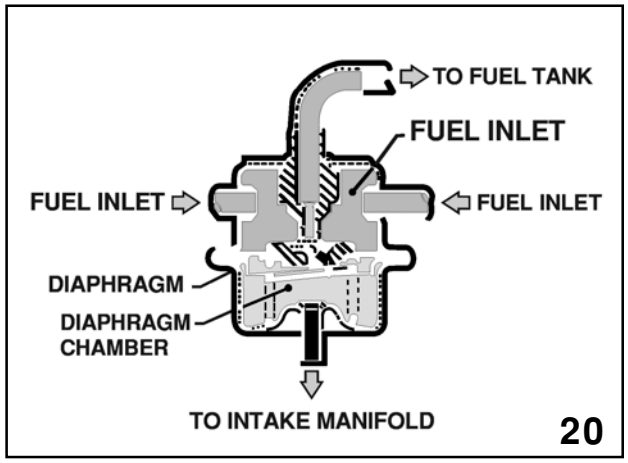
The Fuel Tank houses the fuel pump and on AWD models a jet pump. Interference with the rear differential is avoided by shaping the tank in a saddle type design. This design makes it necessary to supply a means of removing fuel from one side of the tank to the other. The fuel pump is on the right side 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.

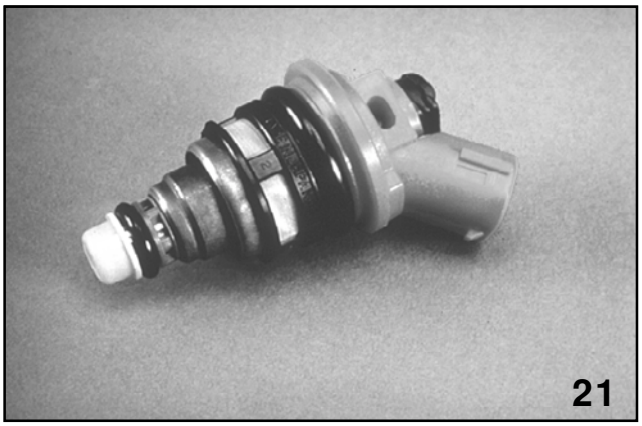
The fuel pump creates pressure by moving the fuel through a series of impeller vanes and centrifugal force. Pressurized fuel flows through the clearance between the armature and the magnet of the motor to the discharge port of the pump. If the pressure output is too high a relief valve opens and the 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.



Fuel Injector

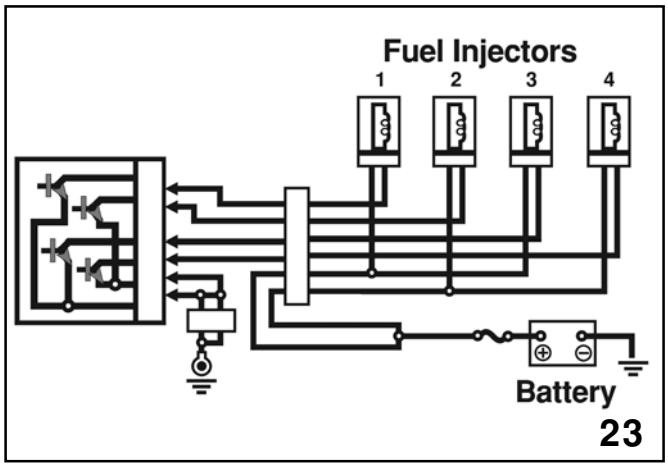
The fuel injector is described as a galley or side feed type, that delivers fuel to the intake manifold.

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

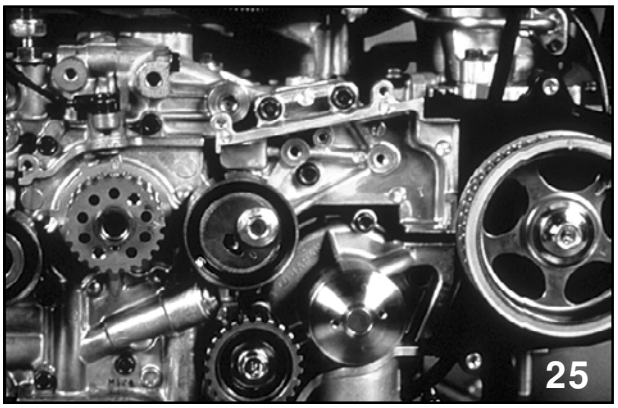
The time or length of grounding of the injector circuit is referred to as injection duration. The select monitor will display injection duration as "TIM". (Injection Duration)



Fuel Injector Circuit

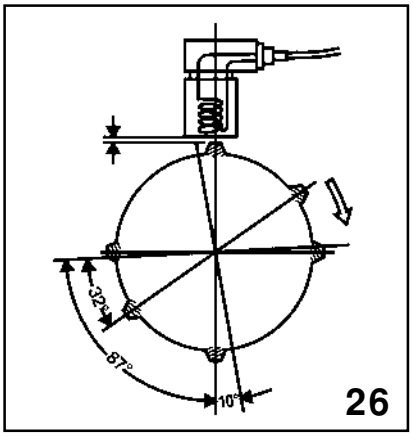
Sensors

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

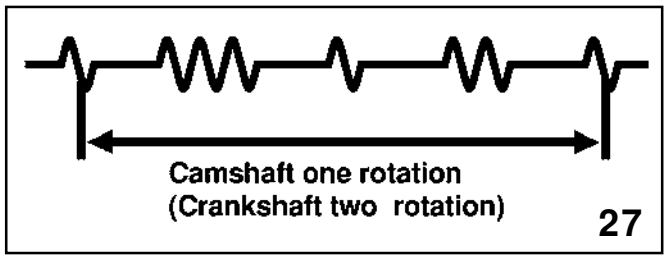
The crank angle sensor is made from a permanent magnet and a coil of wire. Do not drop the crank angle sensor as the magnet may be damaged or the shape of the sensor which can alter the signal generated.



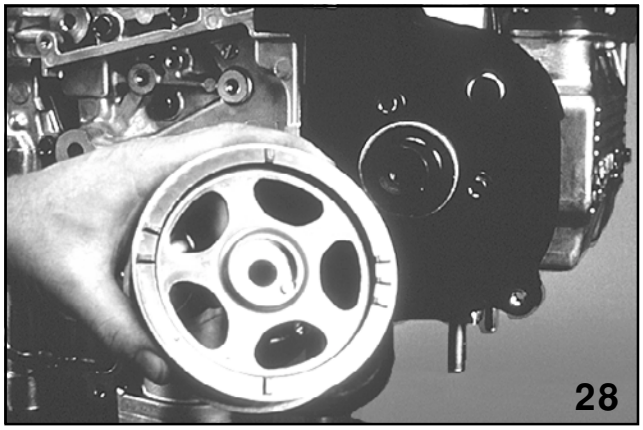
Crank Angle Sensor Reluctor Construction

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.)

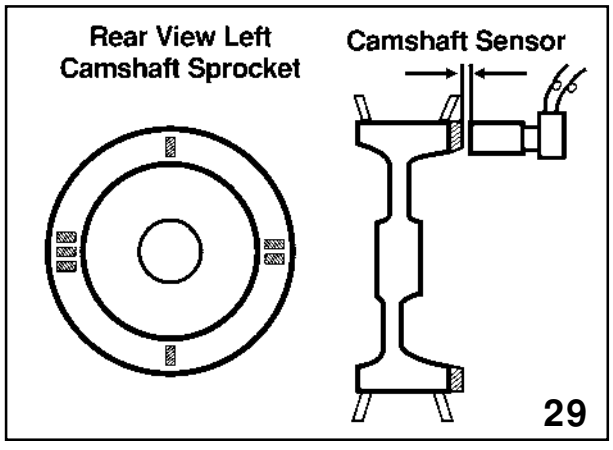


Cylinder Discrimination Signal



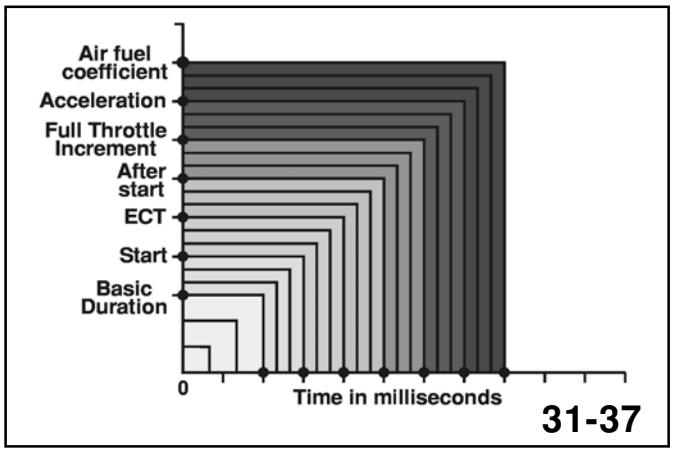
Cam Angle Sensor and Reluctor

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.



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

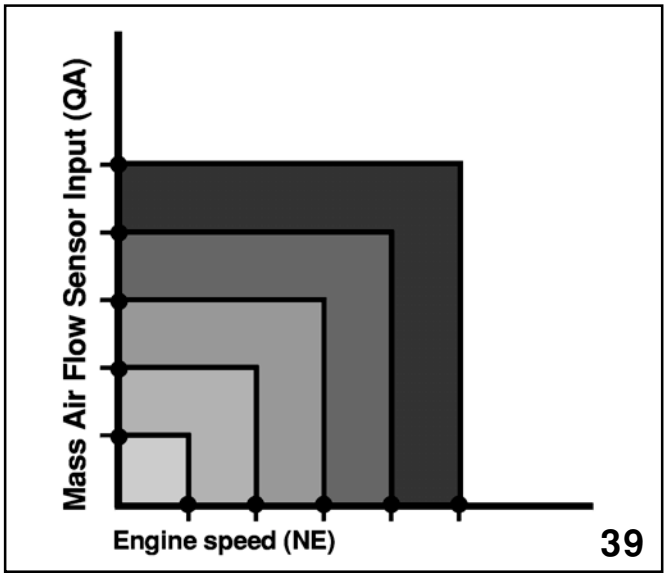
Basic duration is determined by comparing QA and engine speed.

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

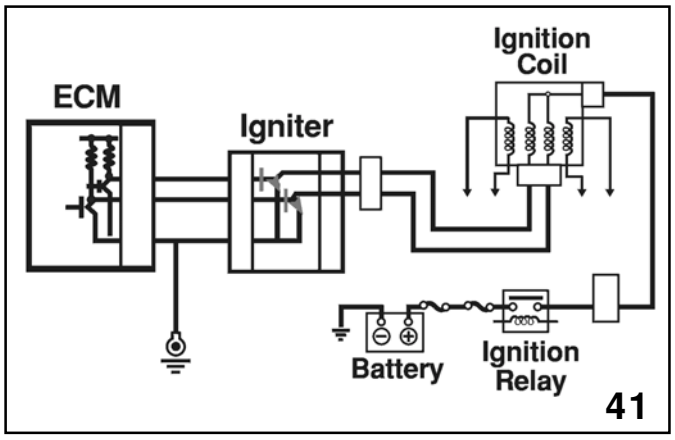


Basic Duration

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.

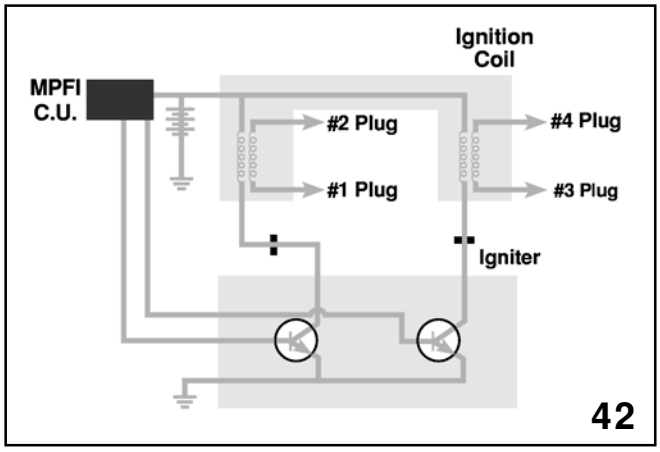
Engine load is used to update Basic duration.

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.

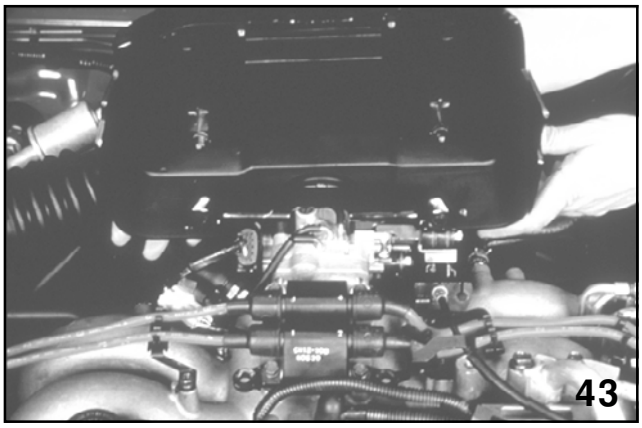


Ignition Coil Construction

Cylinders #1 & #2 - Forward coil
#3 & #4 - Rear coil

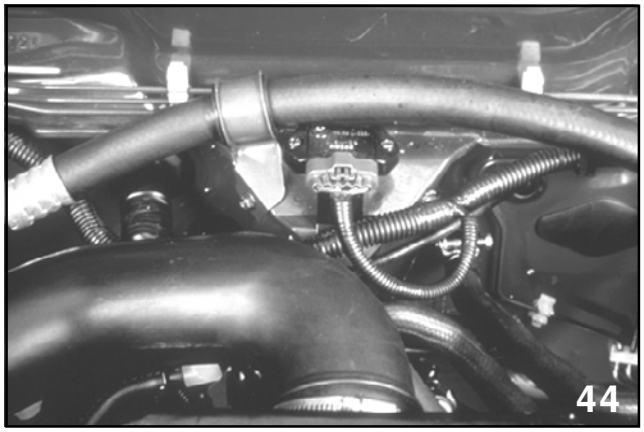
The secondary voltage is sent to the spark plugs of two cylinders simultaneously, one cylinder will be on the power stroke and the other on exhaust stroke.

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.



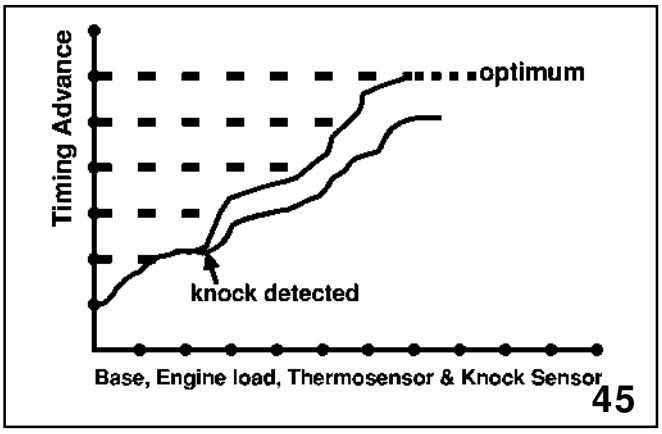
Ignition Coils

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.

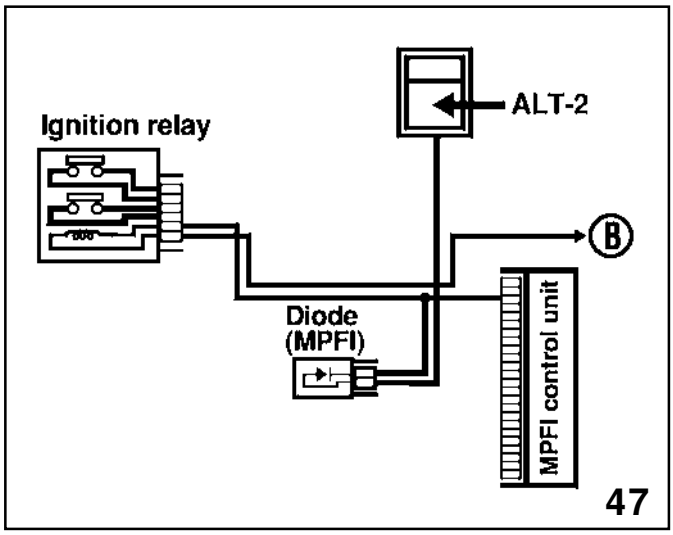


Timing Advance Logic

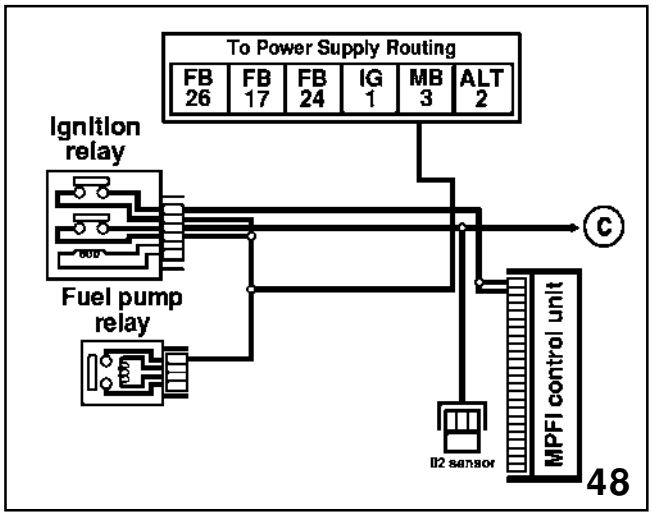
Optimum ignition timing is stored in the ECM. Timing is controlled to be just below the time of engine knock.

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 service manual.

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 service manual.

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 service manual.



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 service manual. Always refer to the appropriate MY service manual when identifying trouble codes.

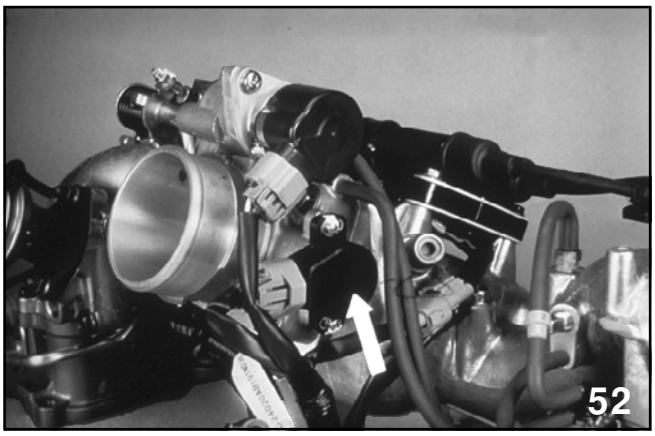
If the self-diagnostic system does not output trouble codes indicating a fault in the MPI system, suspect components may be checked using the check procedures found in the appropriate MY service manual.

Self Diagnosis for other Subaru models are similar, however, test connector shapes may be different. Consult the appropriate service manual for connector location and diagnosis procedures.

Impreza 1.8 Liter

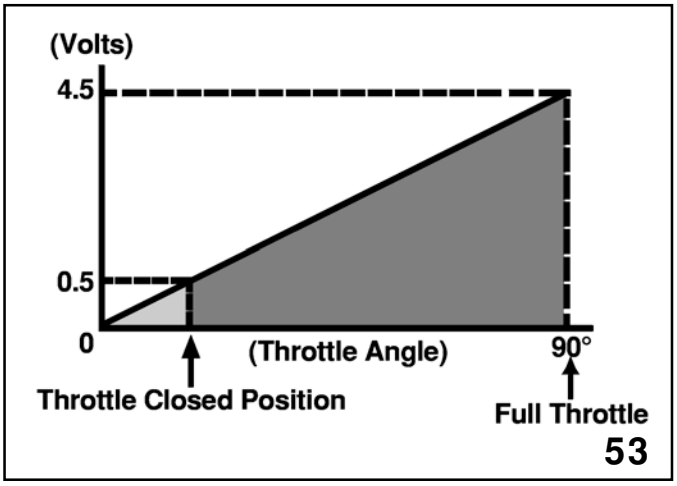
The Impreza 1.8 Fuel and Engine Management system differs from the Legacy in the following :

- TPS
- IAC
- Throttle Body
- Fuel Tank
- Power Supply

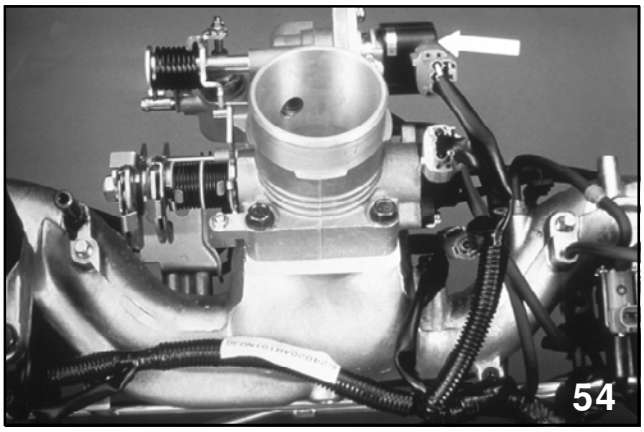


Throttle Position Sensor

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.

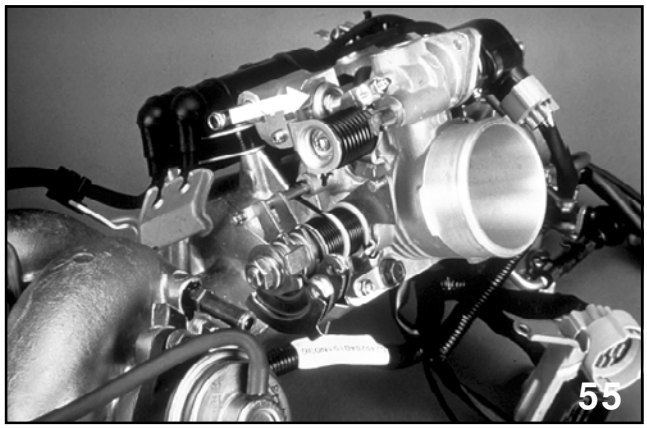


Control Soft Operation



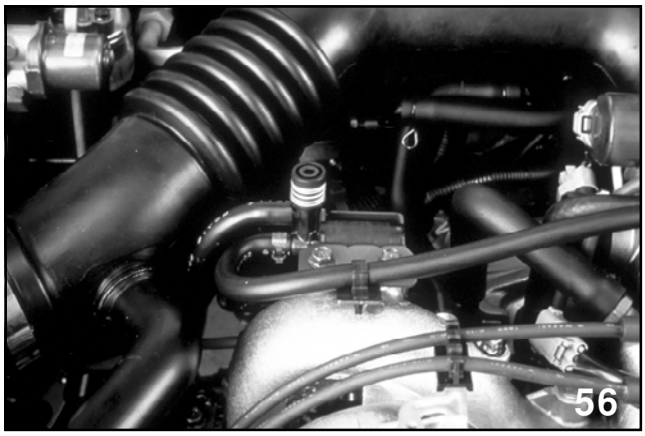
Idle Air Control Valve

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.

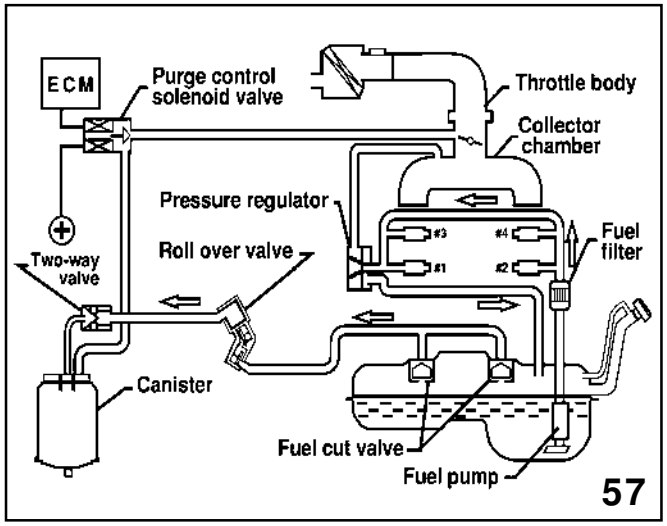


A/C IAC

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.



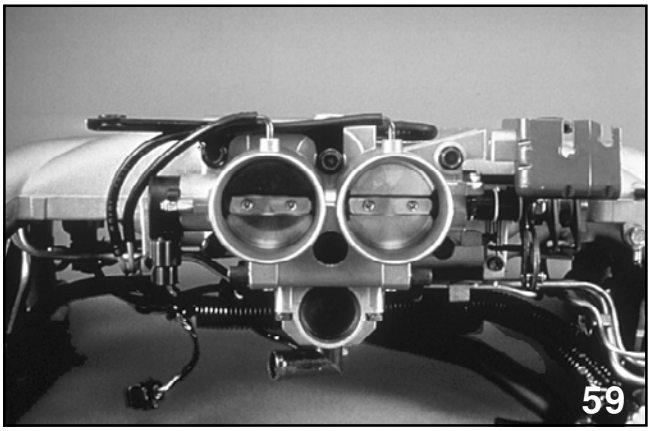
1.8 Impreza Fuel Supply System

SVX

Differences of the SVX fuel injection and engine management system include:

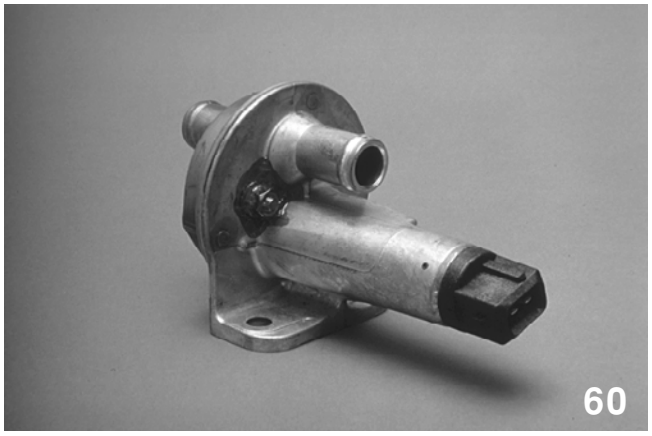
- Air Induction
- Ignition
- Sensors
- Fuel Supply
- Power Supply

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

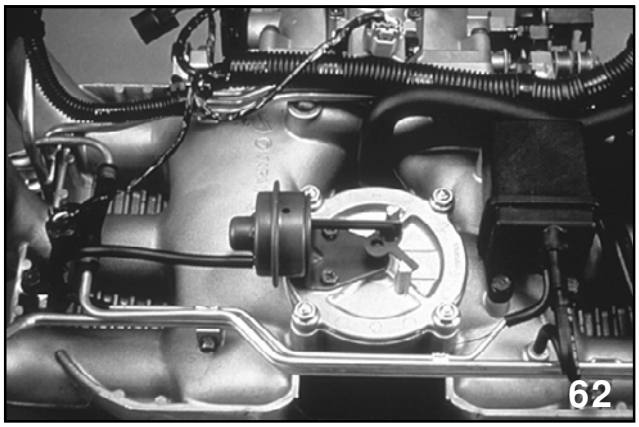
IAC valve operation is accomplished with a duty signal from the ECM which acts on the Duty control valve. The IAC controls base idle, compensates for additional engine load conditions, such as A/C operation, and assists the Auxiliary Air Valve with cold idle control. Auxiliary valve construction includes 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 by-passing 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)

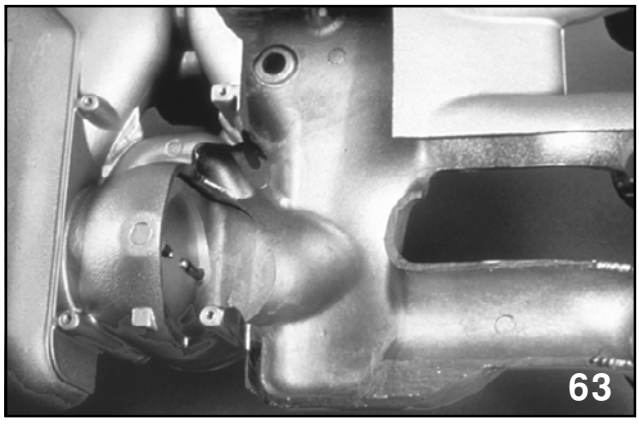


Intake Manifold (Underside)

Iris system components include:

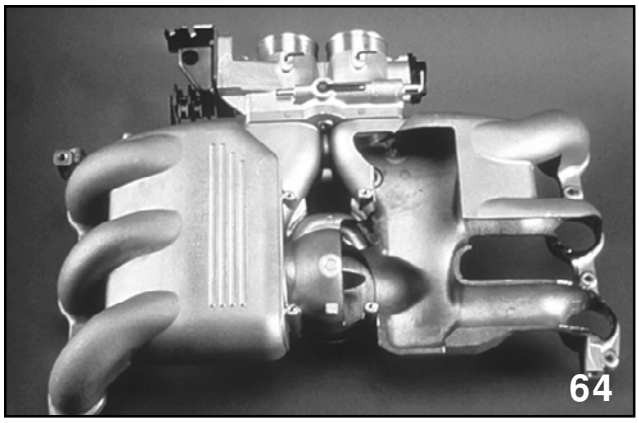
- IRIS Valve
- Vacuum Tank
- Check Valve
- Solenoid

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.



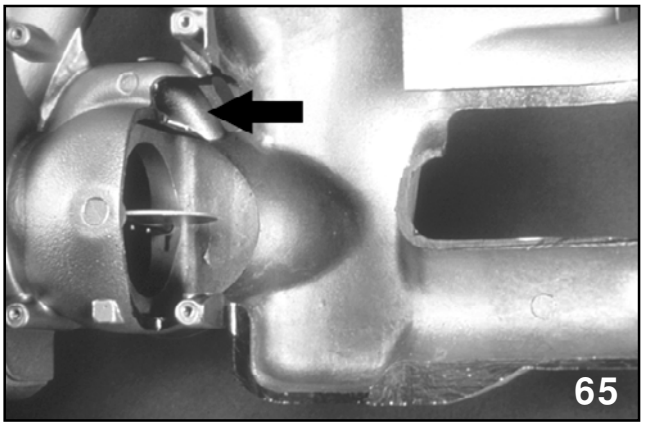
IRIS Valve (Closed)

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

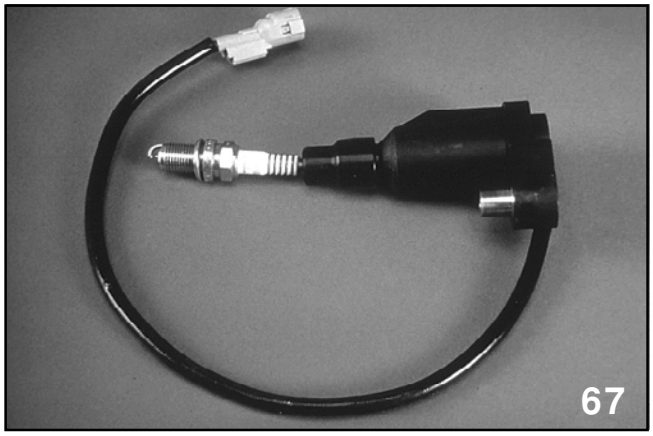
The IRIS valve is closed because the volume of air in mode one is moving too slow for the valve to be effective. Resonance tube operation maintains the speed of the moving air, keeping the pushing effect at maximum.



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

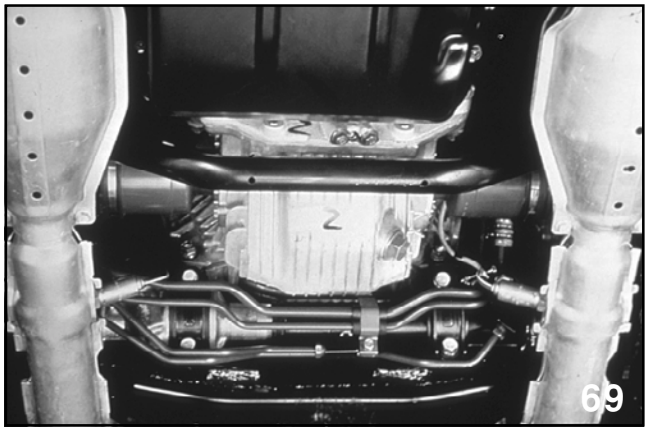
The ignition system of the SVX uses a coil for each of the six cylinders. Coil mounting is accomplished by a captured bolt that goes through the valve cover into the cylinder head. Primary and secondary windings are contained in the coil with a spring loaded contact that completes the secondary circuit to the spark plugs.

The primary circuit is controlled by an ignitor that pulses the ground circuit from a signal generated in the ECM.



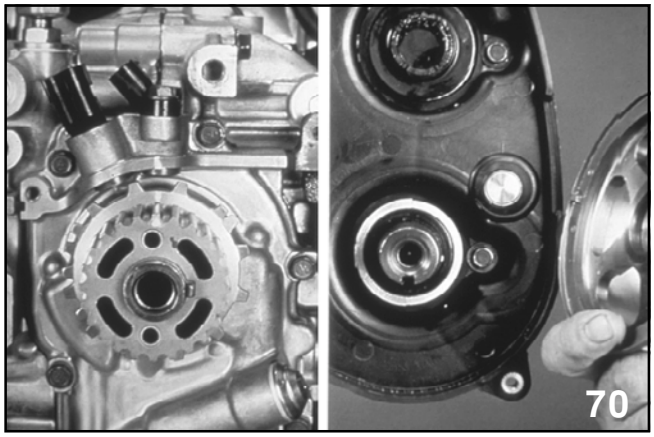
Knock Sensor Locations

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

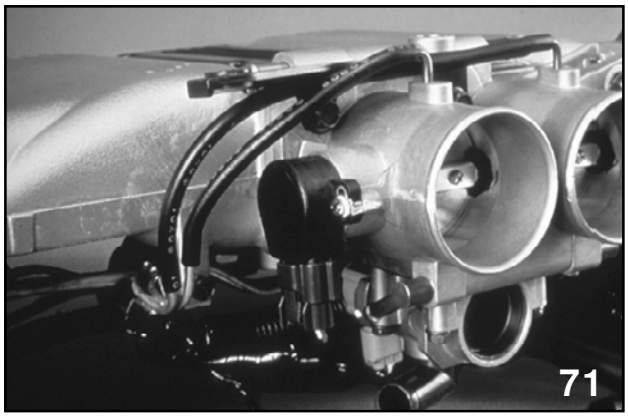
Oxygen sensors are located in the left and right side exhaust pipes ahead of the catalytic converters. Separate alpha readings are available for display on the select monitor.



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.

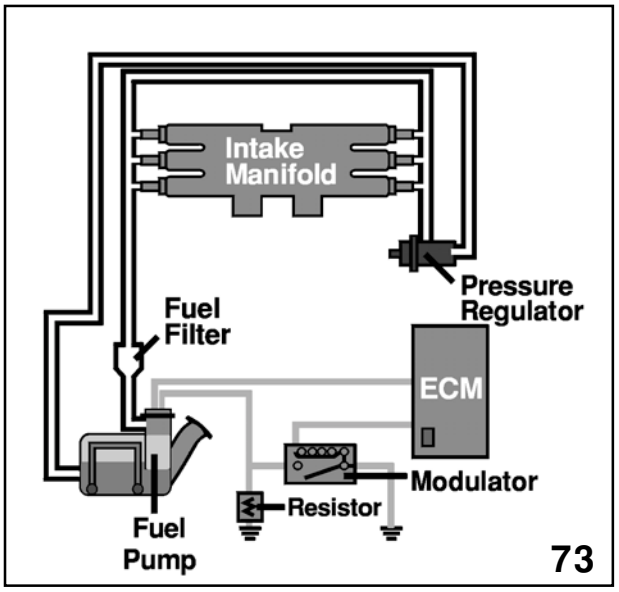


Throttle Sensor

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

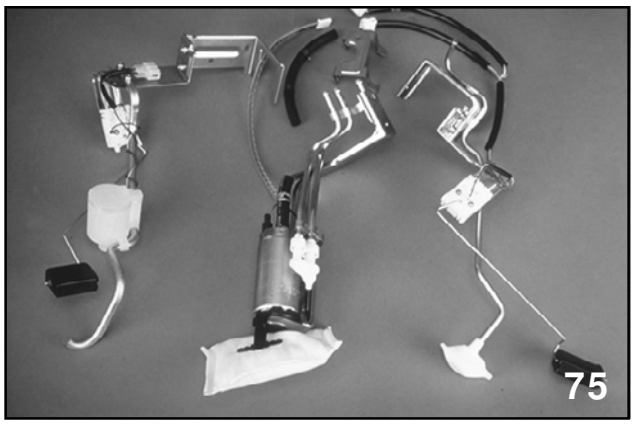
The fuel tank is a saddle tank design made of resin. This provides a weight savings as well as corrosion resistance. It is located under the rear seat area.

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

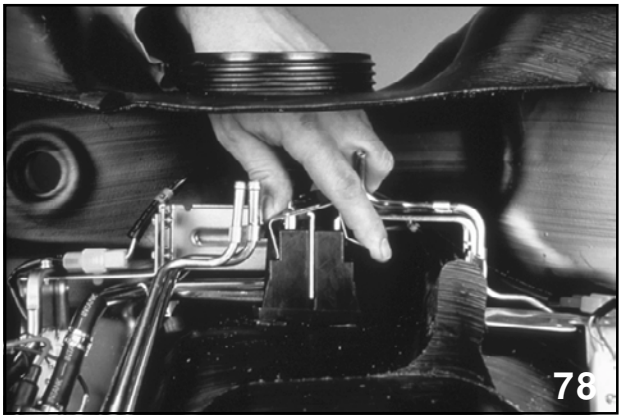


Removing Spanner Ring

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

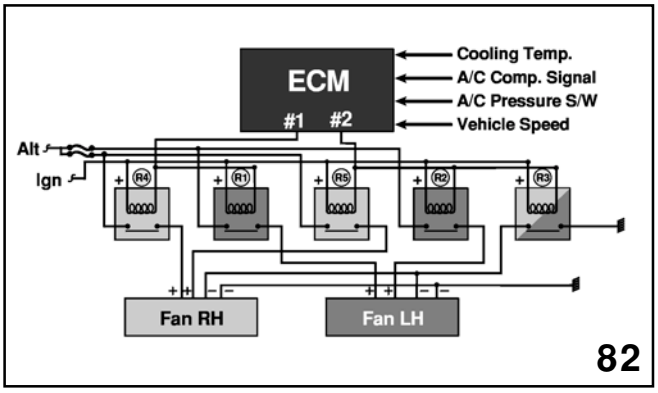
Gently rotate the left hand sending unit counter clockwise until it is upside down. Remove the assembly with the wiring harness attached.

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

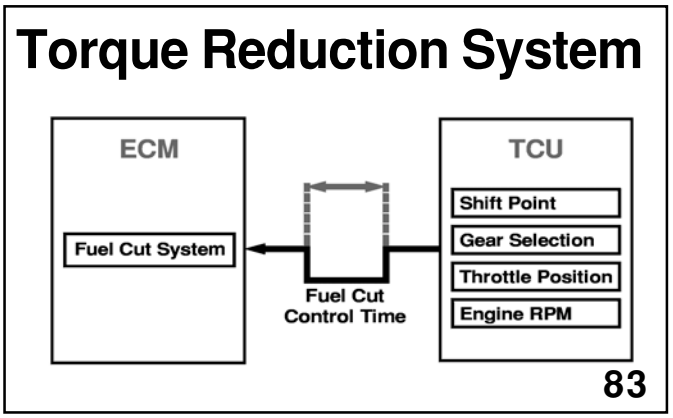
Battery B+ power is provided by the ignition switch to all of the relay coils. ECM signal #1 supplies grounds to relay coils #1 and #4 (low speed). Signal #2 grounds relay coils #3, #2 and #5.

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

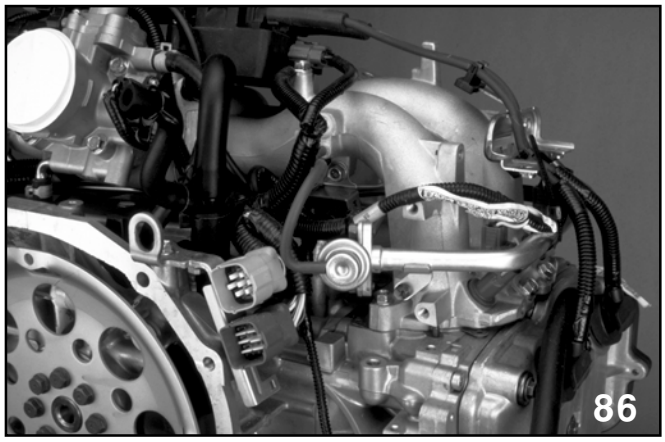
The 3.3L ECM differs from the 2.2L ECM in the following ways. It has a torque reduction system networked between the TCM and the ECM which reduces shift shock during upshifts when the engine is under a high RPM load (above 6000 RPM or at WOT). ECM momentarily activates fuel cut at the time of the shift. 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.



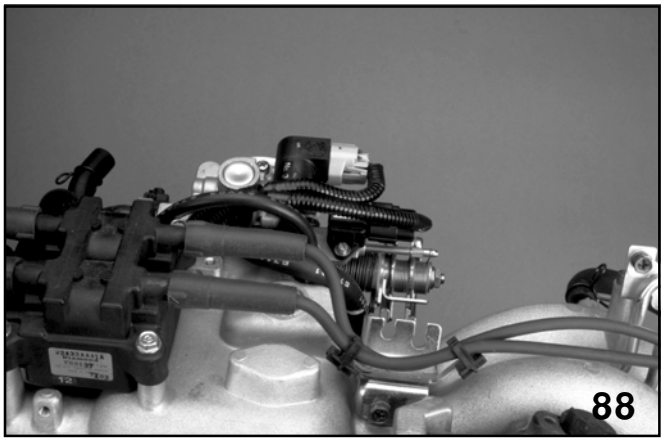
Fuel Supply Rail

Referred to as top feed, this style injector internally functions the same as injectors used on previous model years.



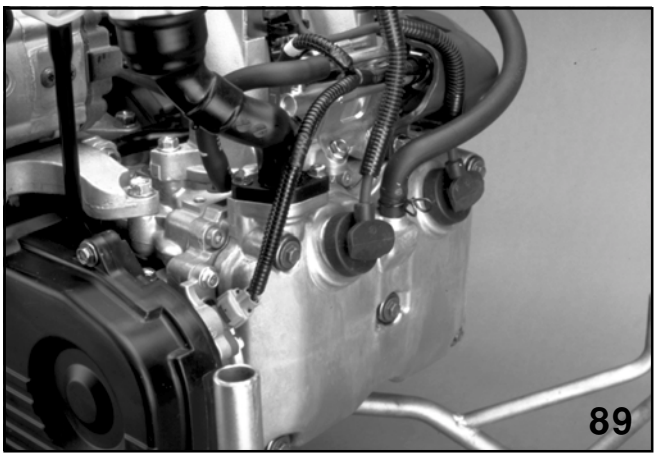
Air Assist Injector

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.



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.

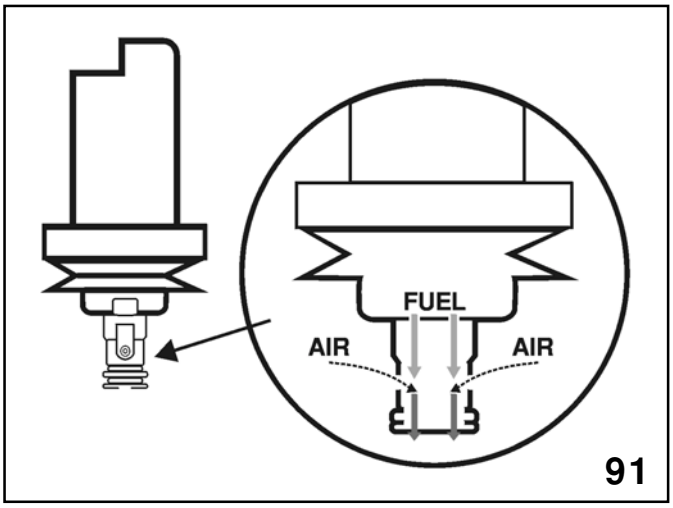


Air Assist Supply Rail

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.

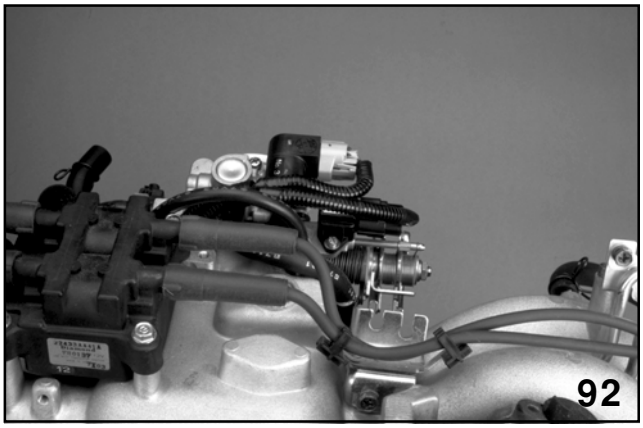


Injector AA Chamber Tip



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.



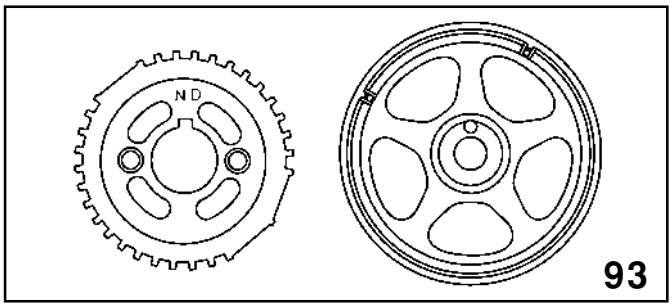
Idle Speed Control Valve

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 by-passes the throttle plate effecting idle speed. The remainder is delivered to the injectors.

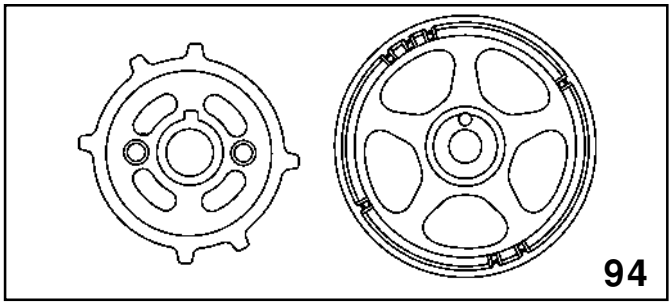
Off idle engine operation results in a larger amount of air delivered to the injectors.

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

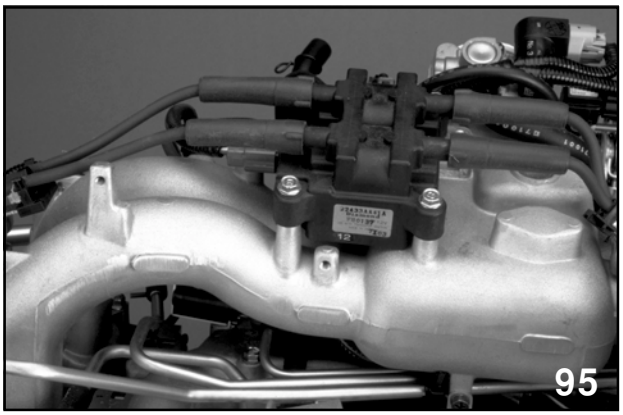


D MPI



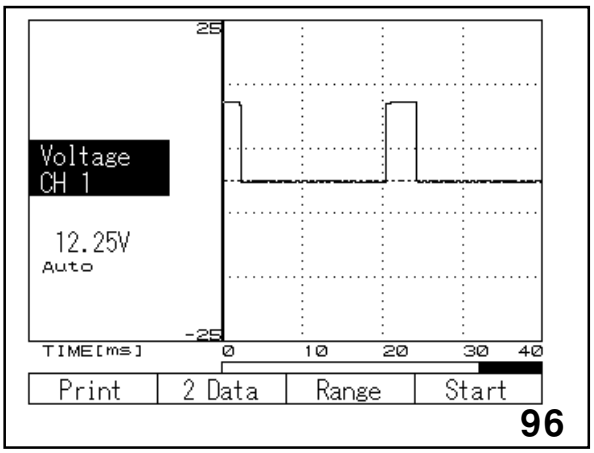
L MPI

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.

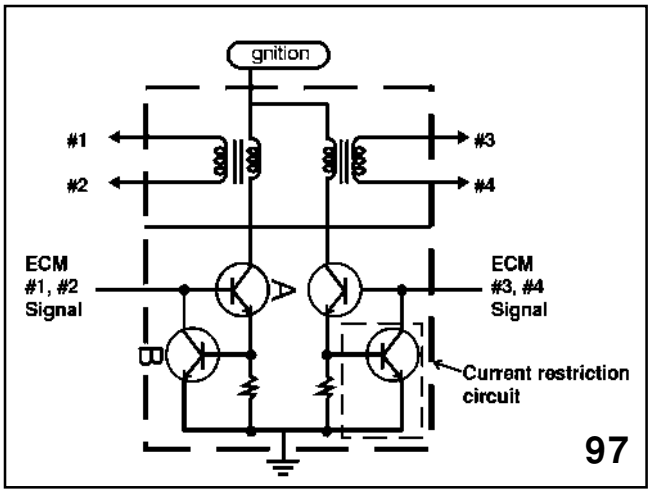


Ignitor Coil

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.

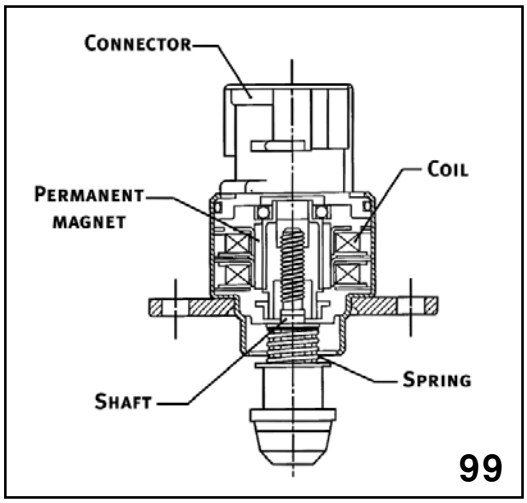


ECM to Coil Signal



Ignition Coil Construction

L MPI



Idle Air Contol 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

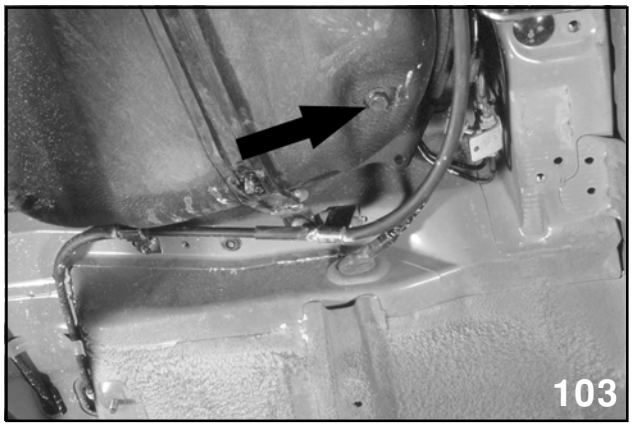
This hose is routed from the fuel neck to the vent control valve located on the driver's rear of the fuel tank. The routing carries the hose through the inner fender into the passenger compartment. The hose is protected by a metal cover, which must be removed to gain access to the quick connector. The 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.**



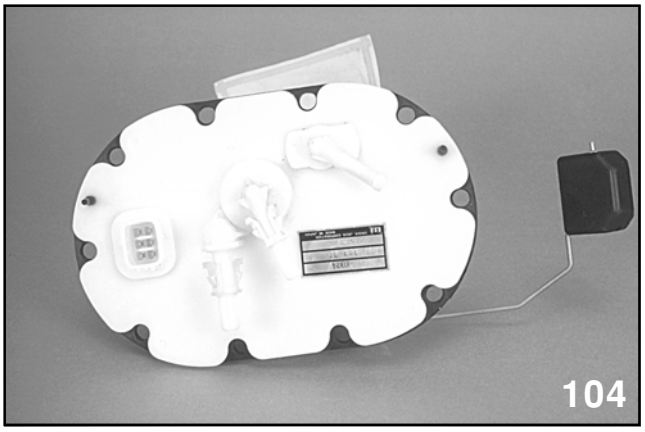
Fuel Pump (Under Seat)

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 proper procedure for draining all fuel from the fuel tank.

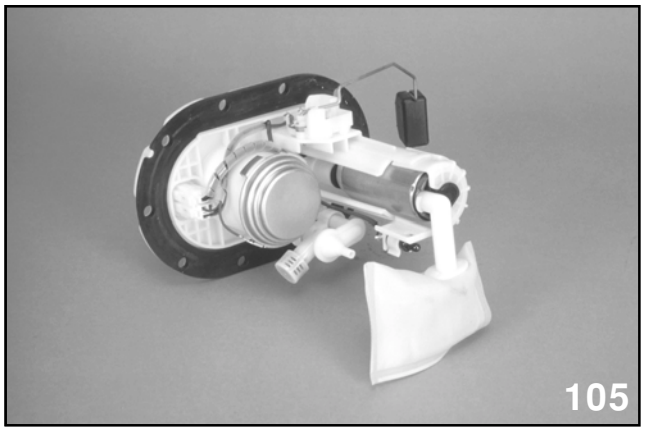


Fuel Drain

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.

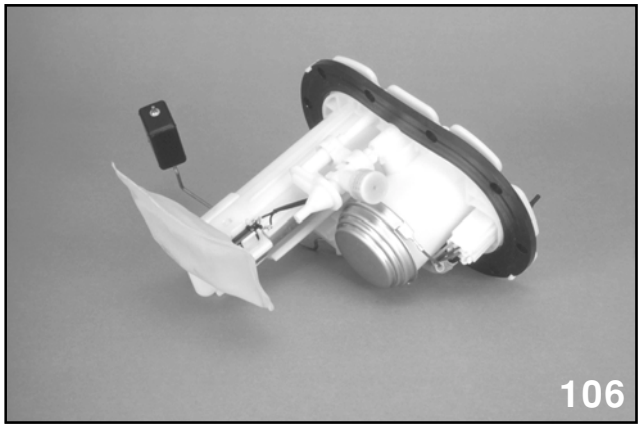


Fuel Pump (Top View)



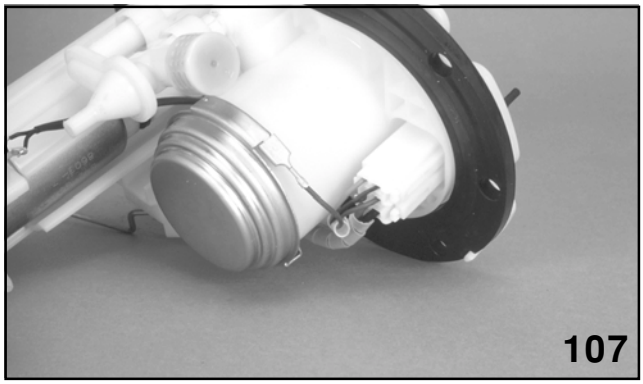
Fuel Pump (Float Arm View)

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.



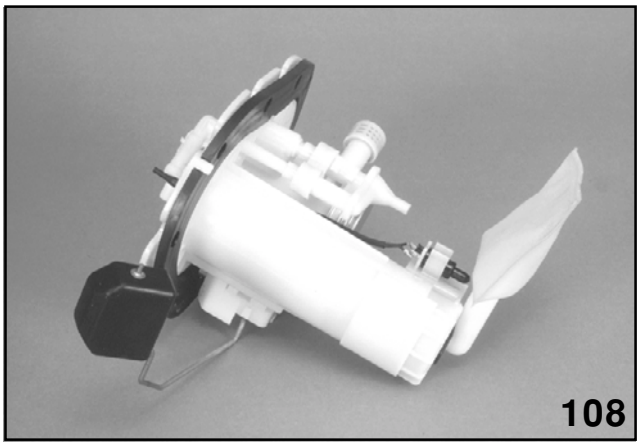
Fuel Pump (Static Strap View)

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.

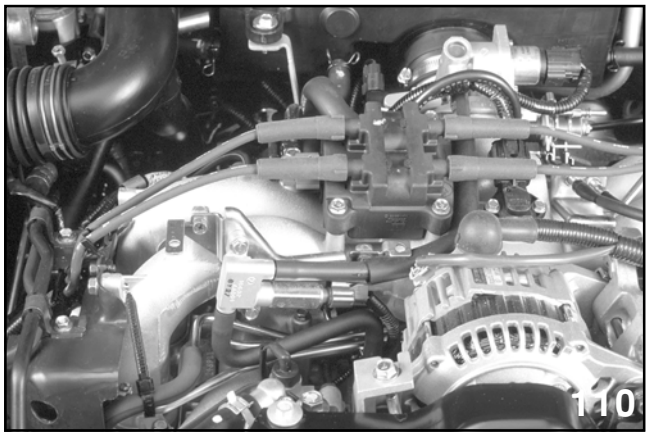
The AAI ND system will be equipped on the Legacy manual transmission and Impreza 2.2-liter models.

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.

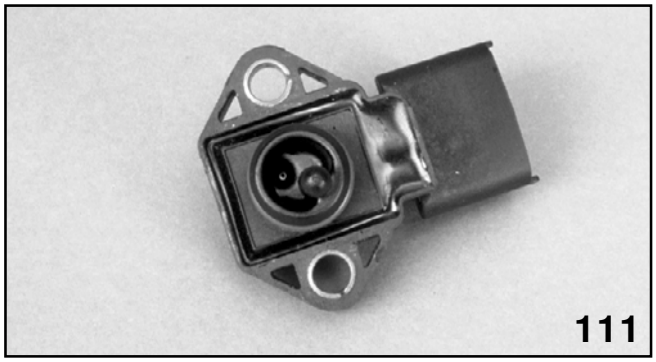
At idle the Air Assist Solenoid Valve is on allowing 20L/min per injector of air to flow. Off idle conditions result in the Air Assist Solenoid Valve turning off allowing only 5L/min per injector of airflow.



Air Assist Solenoid Valve

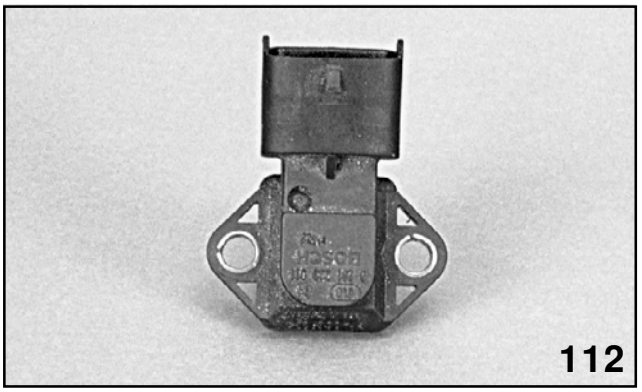
The new Intake Air Temperature and pressure sensor monitors the absolute pressure and the temperature of the air in the intake manifold. The measured temperature and pressure of the air is then converted into electrical signals and sent to the ECM. The ECM uses those signals from the sensor to control 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.



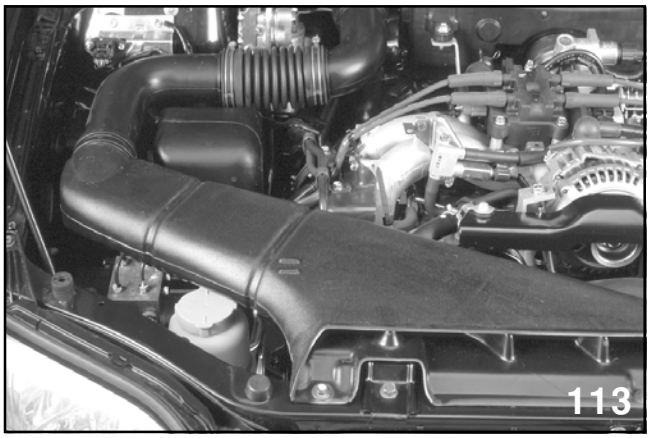
Intake Air Temperature and Presure Sensor (Bottom View)

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.



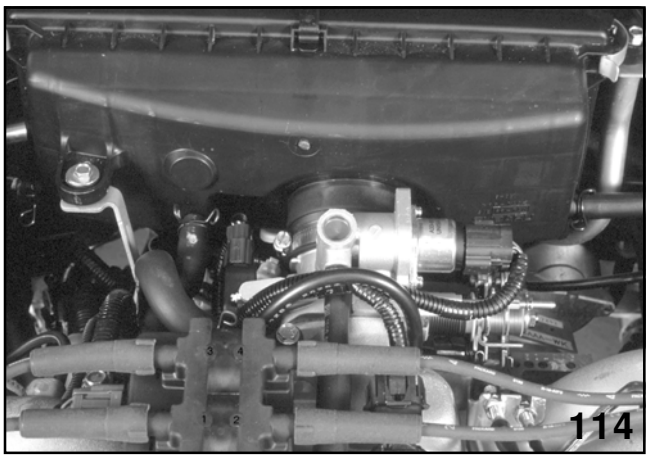
Intake Air Temperature and Presure Sensor (Top View)

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.



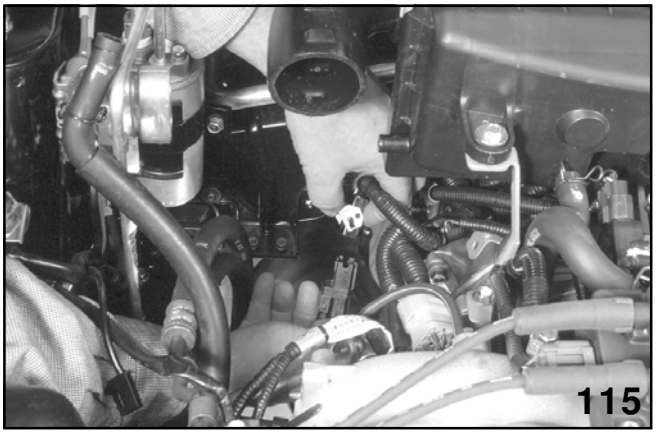
Air Induction Housing

The throttle position, idle speed control motor, and ignition coil have not been changed.



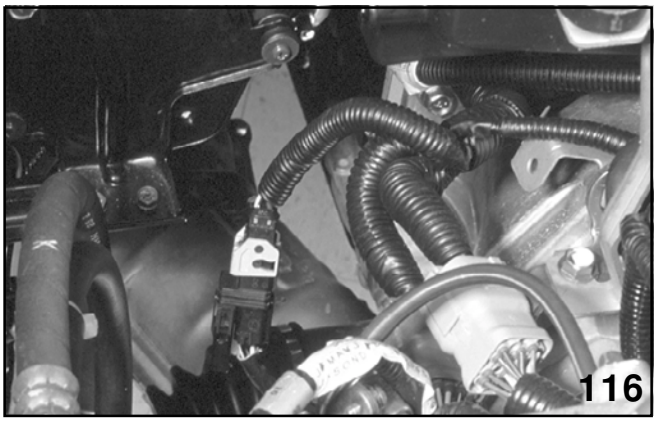
TPS

The throttle position, idle speed control motor, and ignition coil have not been changed.



AFR Sensor

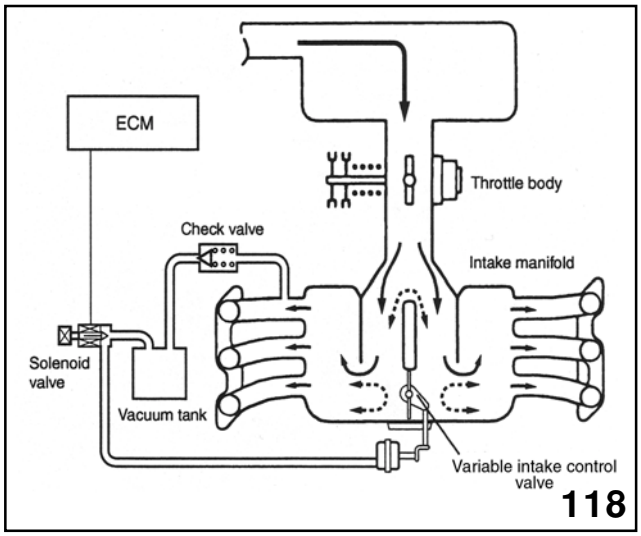
A new type air fuel ratio sensor is used on the UJ system. The harness includes a new-style locking mechanism. Position the locking mechanism as shown and gently separate the vehicle harness from the sensor harness.



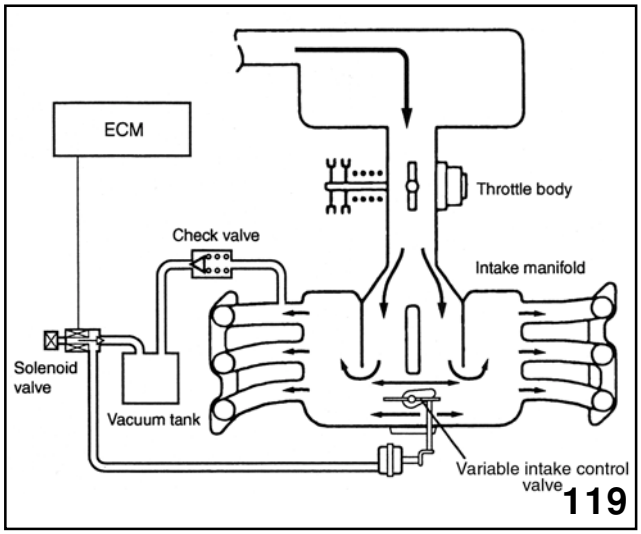
AFR Sensor Harness

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.

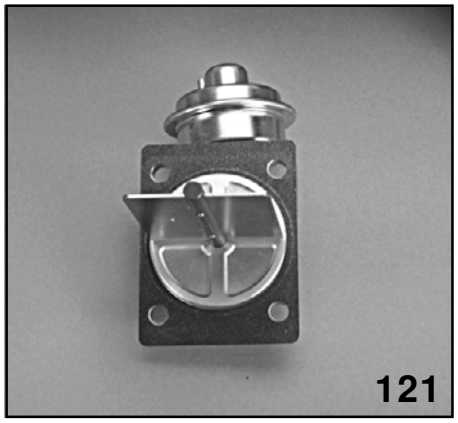
As the engine crosses beyond mid-range the inertia effect becomes strong enough to overpower the resonance effect and the airflow valve is opened. This will allow air moving on the LH side of the manifold to assist the RH side.

Variable Intake Control Valve Operation

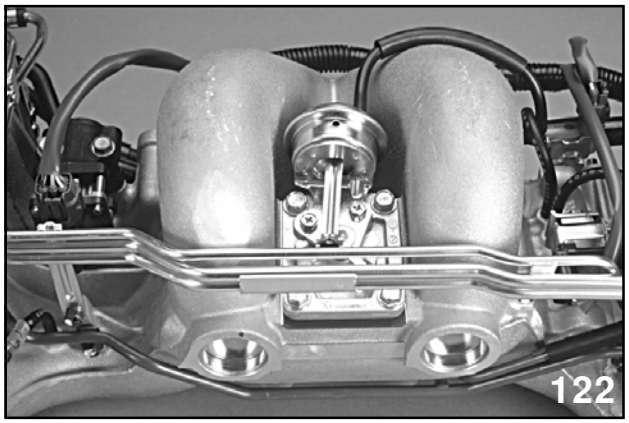
	Open	Closed
Engine Off	●	
Engine Idling	●	
Light Engine Load any RPM	●	
Heavy Load < 3600RPM		●
Heavy Load > 3600RPM	●	

120

Variable Intake Control Valve Chart



Variable Intake Control Valve

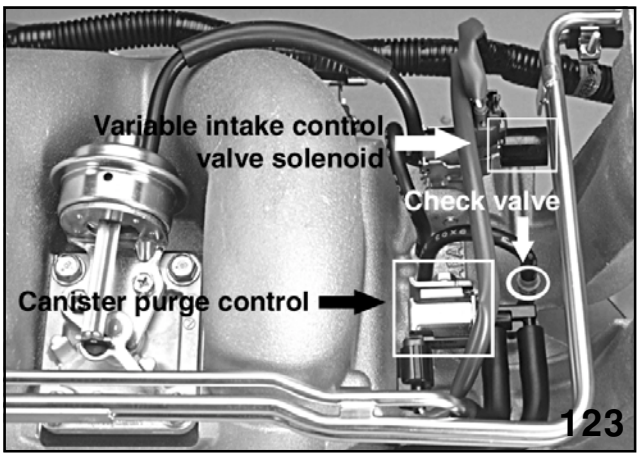


Variable Intake Control Valve Location

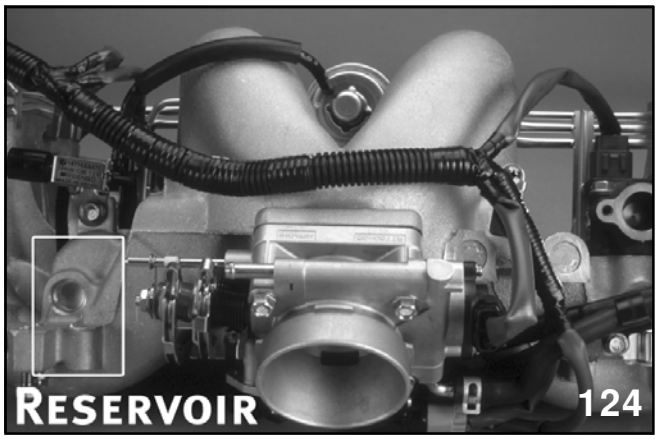
The variable intake control valve is positioned on the under side of the intake manifold.

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.

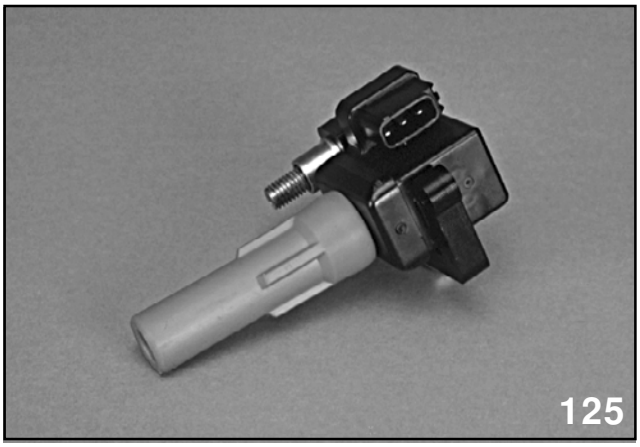
When a signal from the ECM is generated to the solenoid the vacuum in the reservoir tank (Figure 87) is routed from the solenoid to the variable intake control valve. This action will close the valve and in the event of low manifold vacuum, the check valve will keep the vacuum to the variable intake 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.



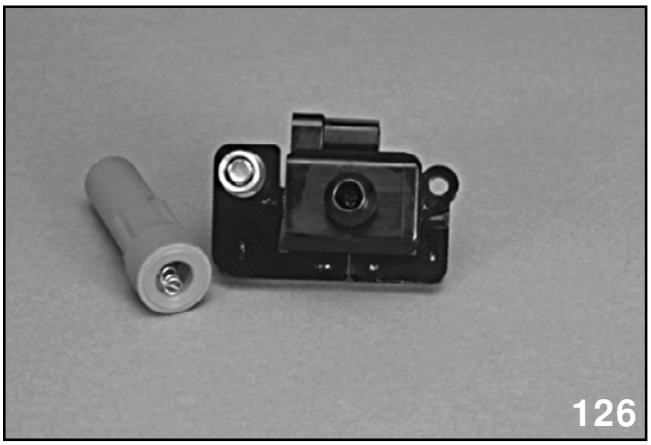
Component Location



Intake Manifold

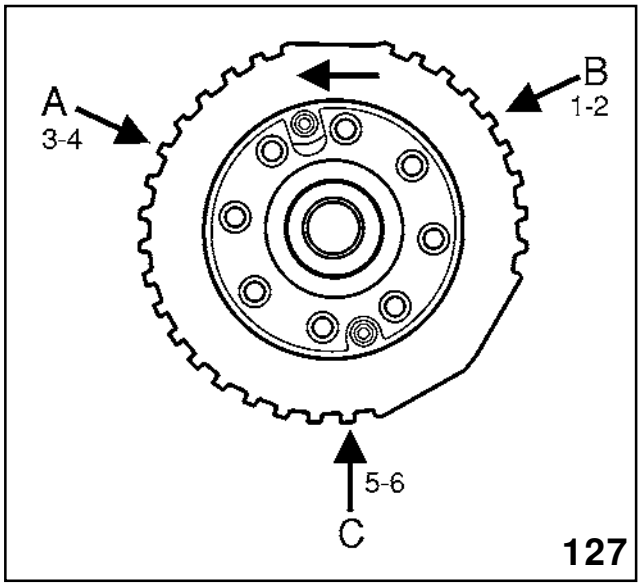


Ignition Coil Complete



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. (Figure 89-90)



Crankshaft Reluctor

Cylinder - Cam Signal

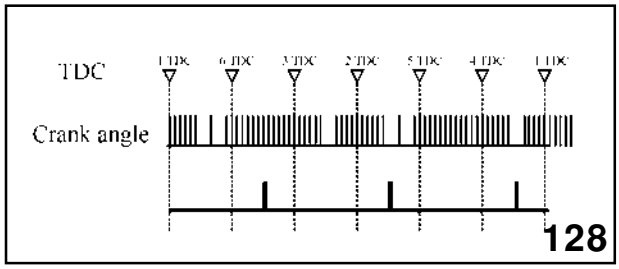
1-Yes
6-No
3-Yes
2-No
5-Yes
4-No

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.

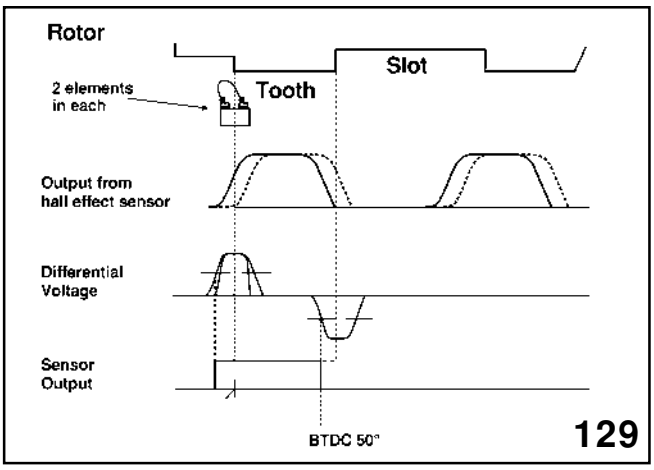
The right bank intake camshaft has a reluctor built onto the end. The new camshaft sensor uses this reluctor to help determine injection and ignition timing.



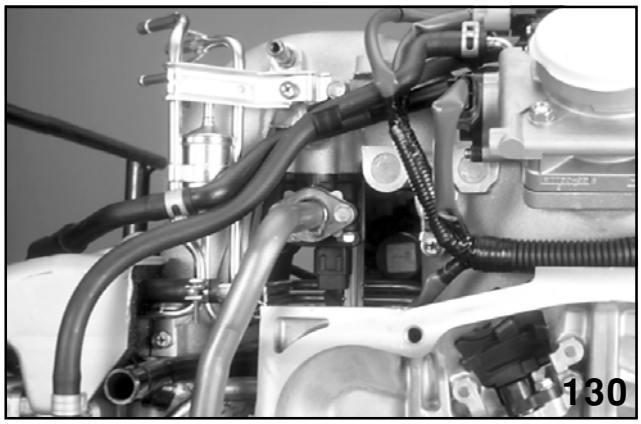
Crank Angle Graph

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).

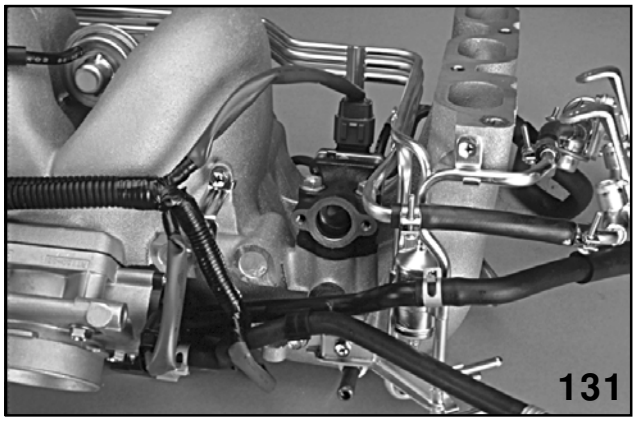
The integrated chip measures the time lag between the beginning and ending of the signals picked up by the two elements, (Hall effect) and converts this information into the output signal.



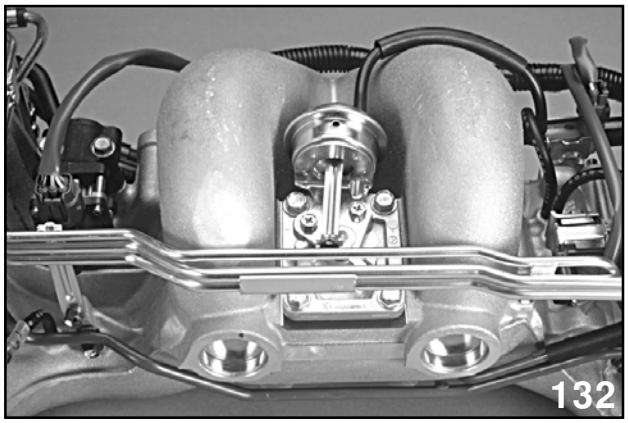
Cam Angle Signal Pattern



EGR Pipe

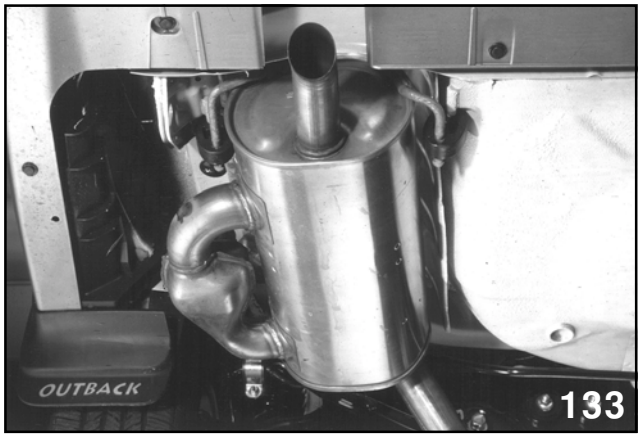


EGR Valve

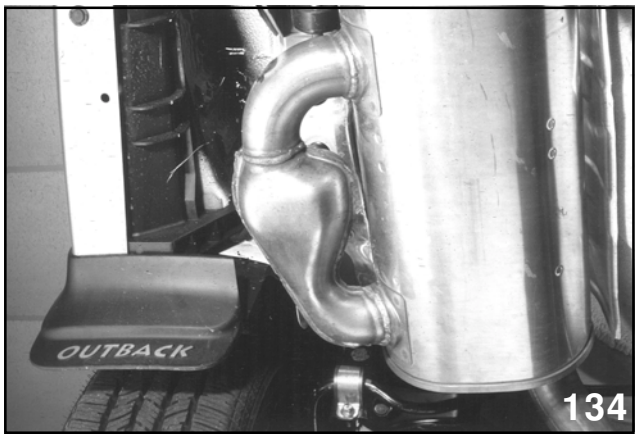


EGR Harness

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.

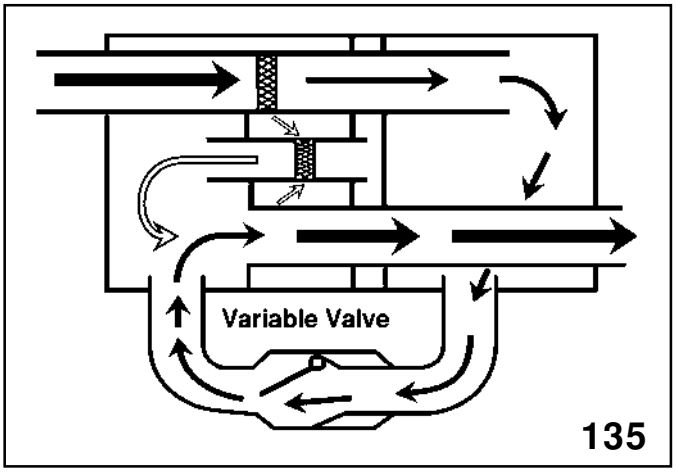


Muffler

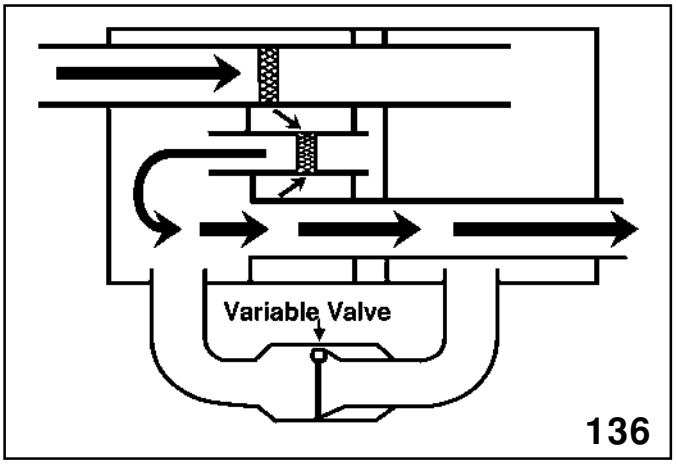


Muffler By-pass Valve

The muffler equipped on the EZ-3.0 Engine is designed with a by-pass valve that opens when the exhaust pressure exceeds 45 mm HG. This occurs around 2400 RPM. The by-pass 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.

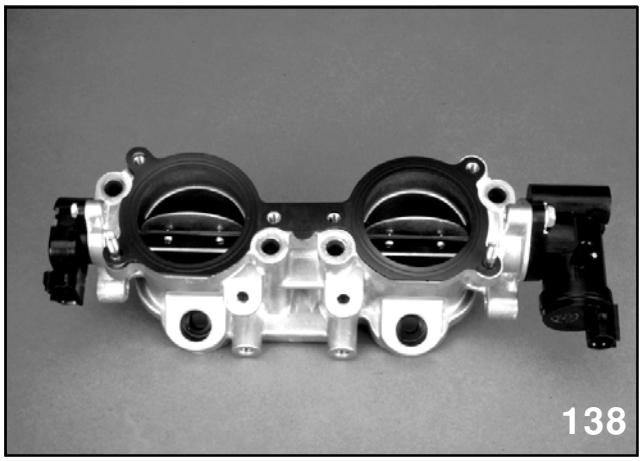


By-pass Valve Operation
(High Engine Speed)

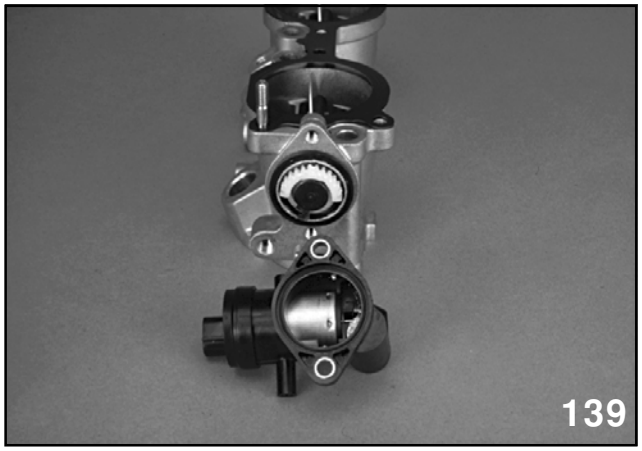


By-pass Valve Operation
(Low Engine Speed)

2002 Impreza Enhancements

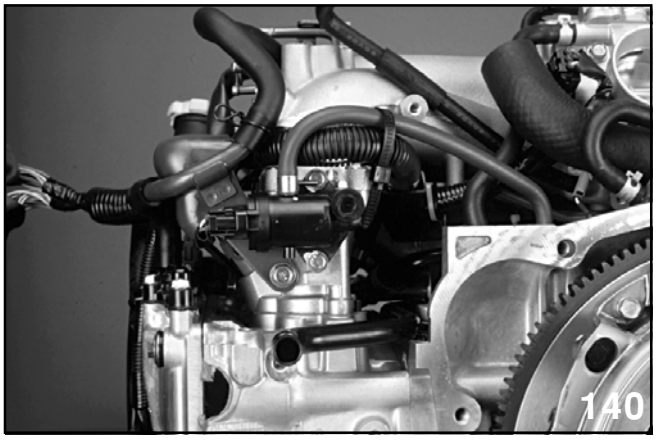


Tumble Generator Valve Rail

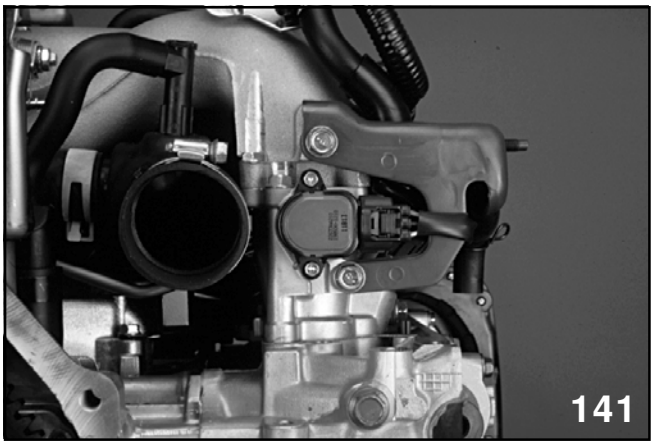


Tumble Generator Valve Motor

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.

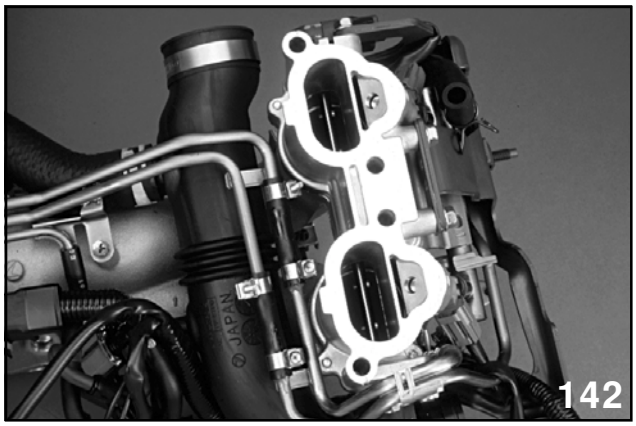


Vent Hose



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.

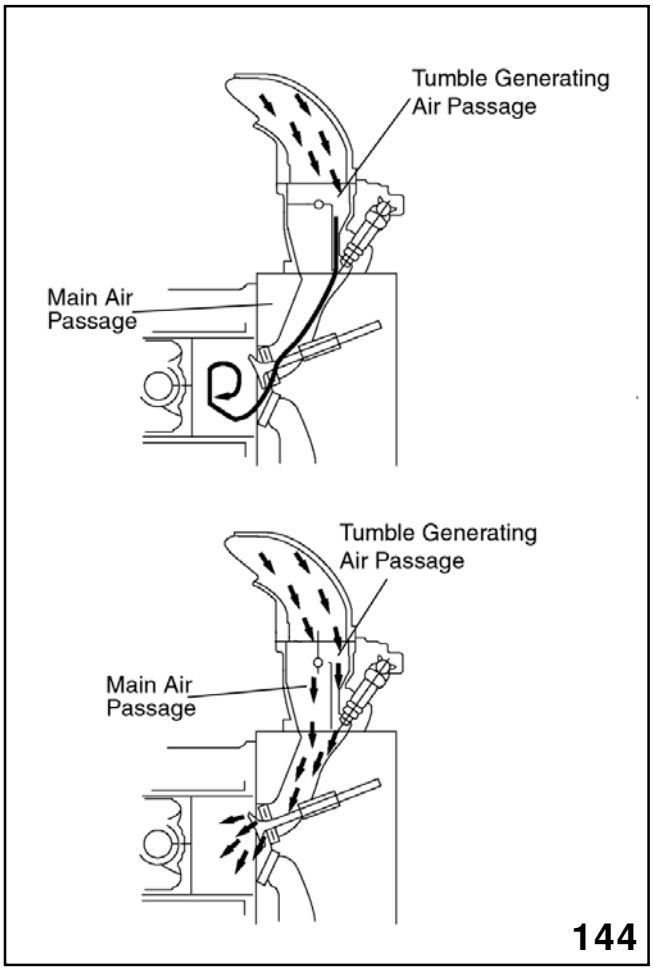


Bottom View of Intake



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 by-pass 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

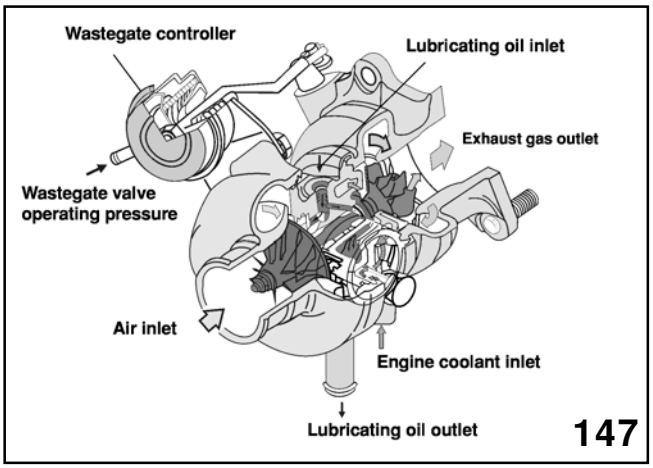


Injector

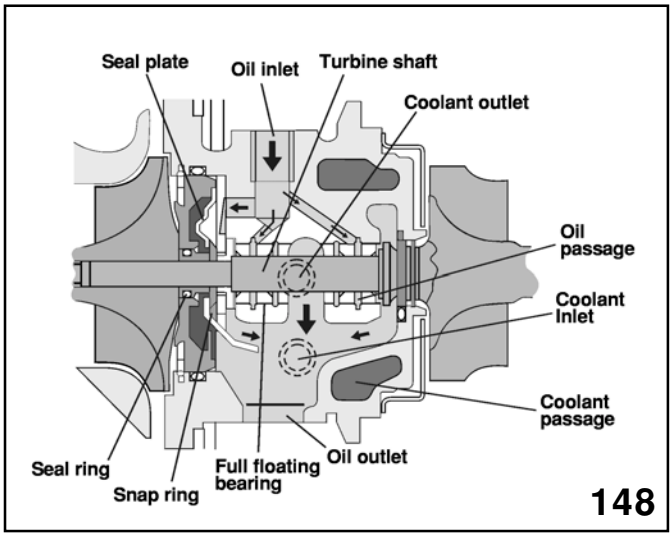
The new fuel injector is a top feed type with 12 holes. The new hole pattern produces a finer spray of fuel which assists with lowering the overall emission output of the vehicle. (No air assist on Turbo models.)

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.

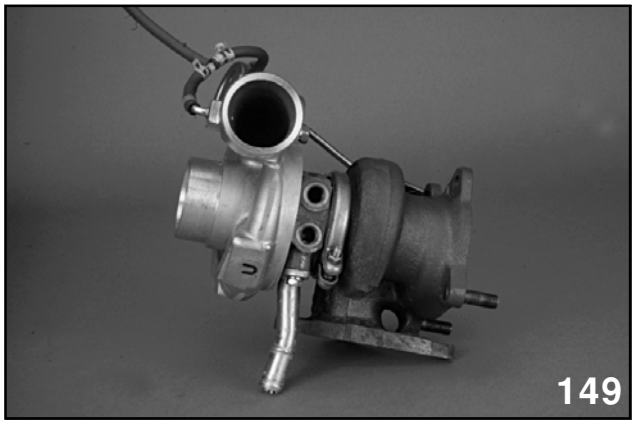


Turbocharger (Artwork)

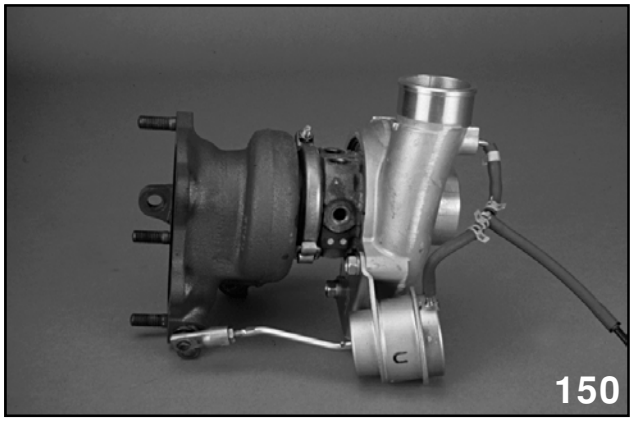


Turbocharger Housing

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.

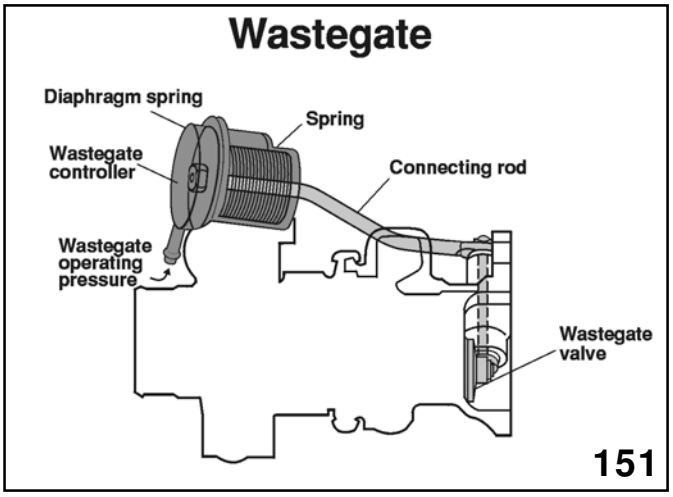


Coolant Connection and Oil Return

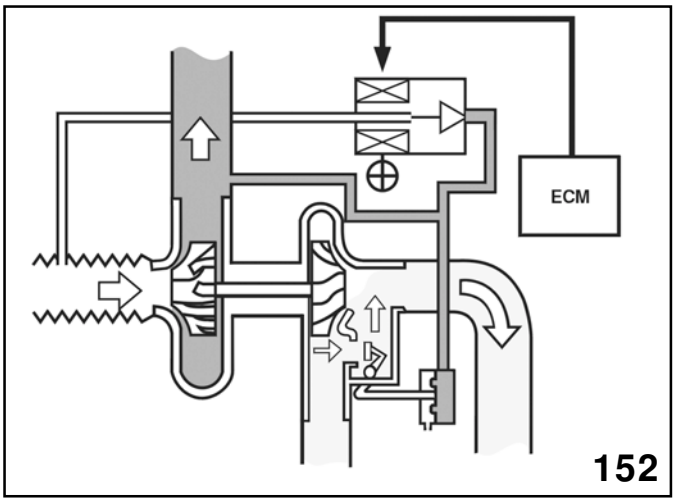


Oil Supply and Connection

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.

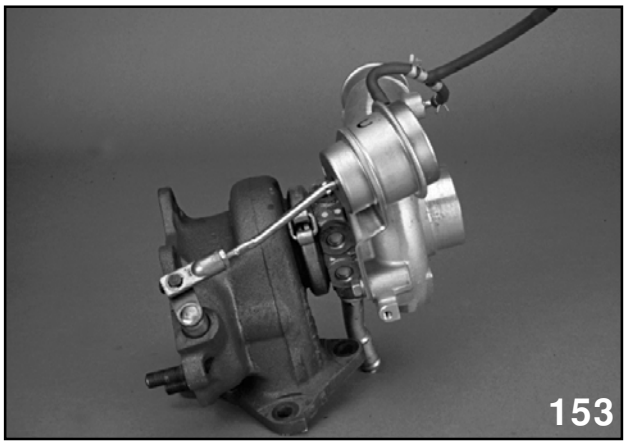


Wastegate

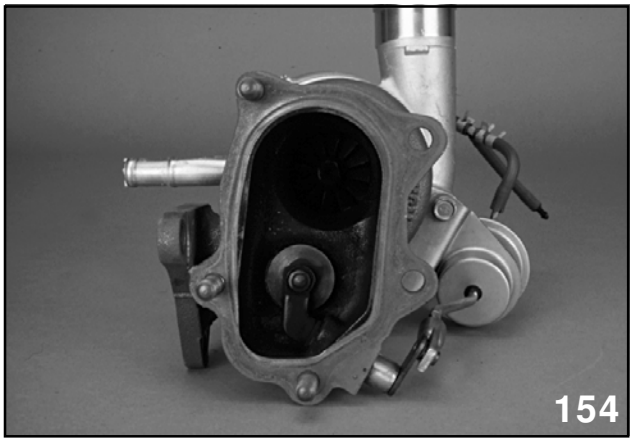


Wastegate Operation

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 by-passes the exhaust gas around the turbine wheel when the desired level of boost is reached.



Wastegate Actuator



Wastergate 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

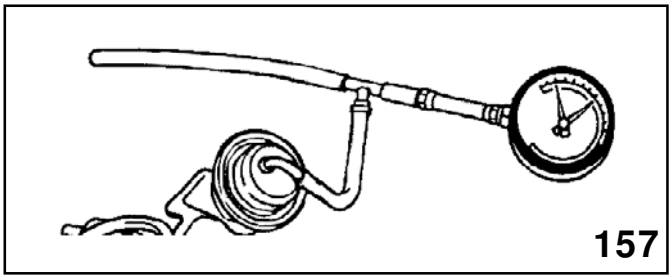
The wastegate controller (in response to the Duty Solenoid) opens the wastegate flap valve to by-pass exhaust gas and so decrease the rotating energy of the turbine keeping the boost pressure to the desired level.

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



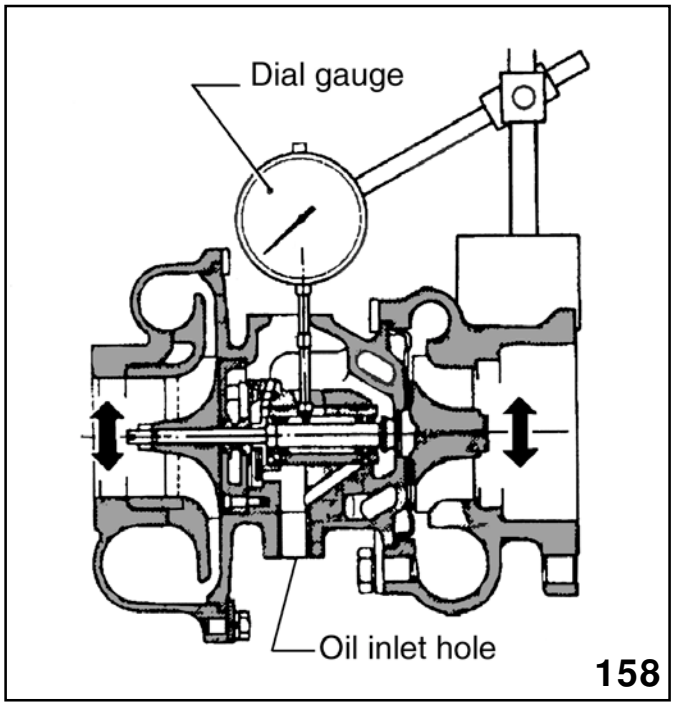
Pressure Gauge Connection

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.

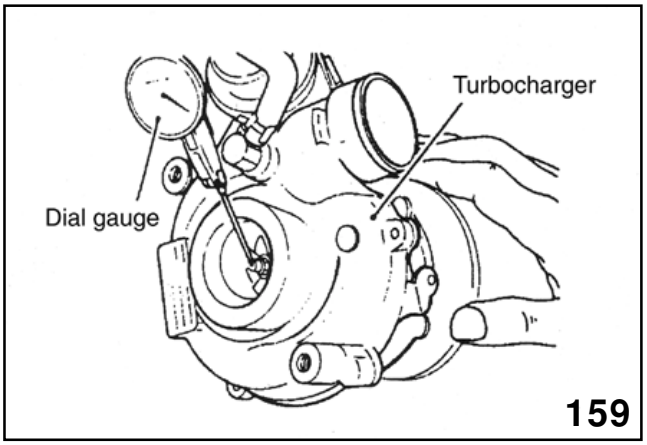


Radial Movement Check

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)



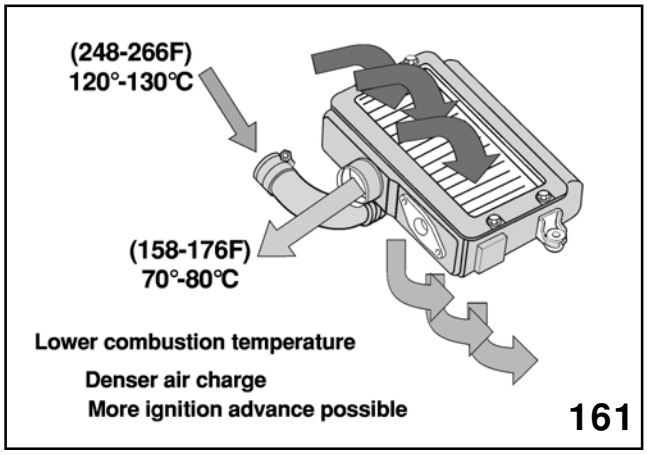
Axial Movement Check

Intercooler

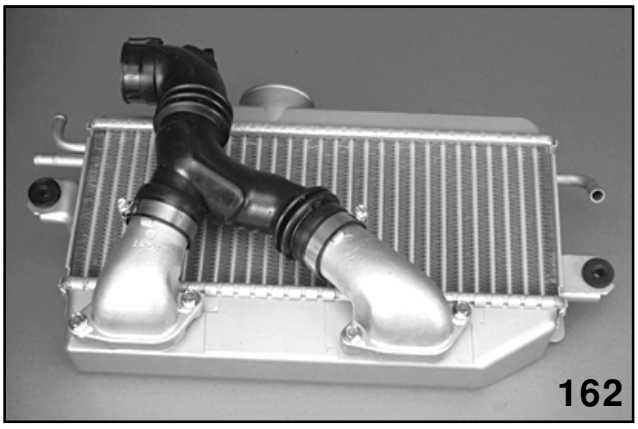
The Turbocharger compresses the intake air by using wasted exhaust gas energy. The Turbocharger turbine is driven by exhaust gas, causing the compressor wheel to rotate. By compressing the intake air, the volumetric efficiency of the engine is greatly improved.

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.

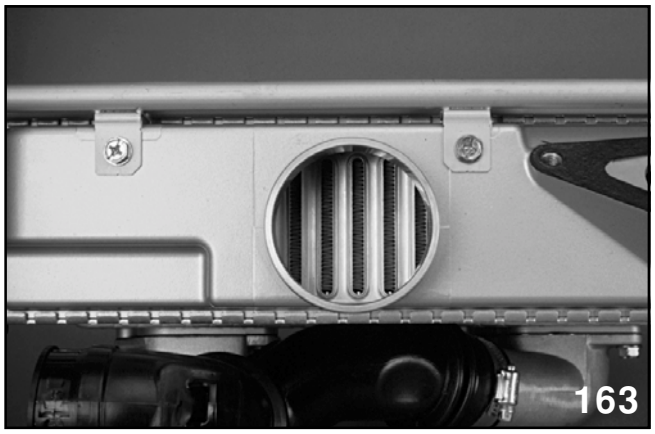
An Air By-Pass Valve redirects high pressures from the intercooler back to the inlet side of the Turbocharger under deceleration.



Effects of Intercooling



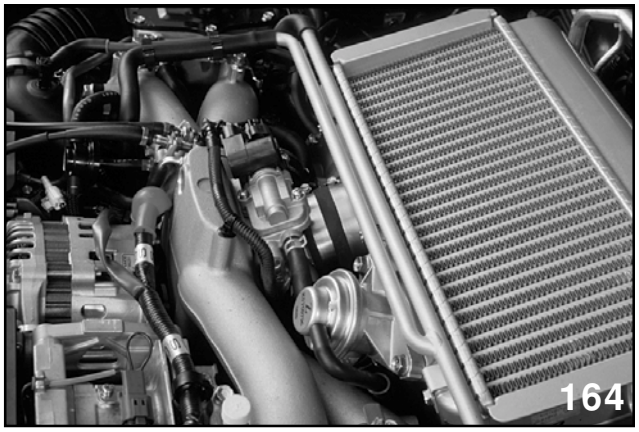
Intercooler (Bottom View)



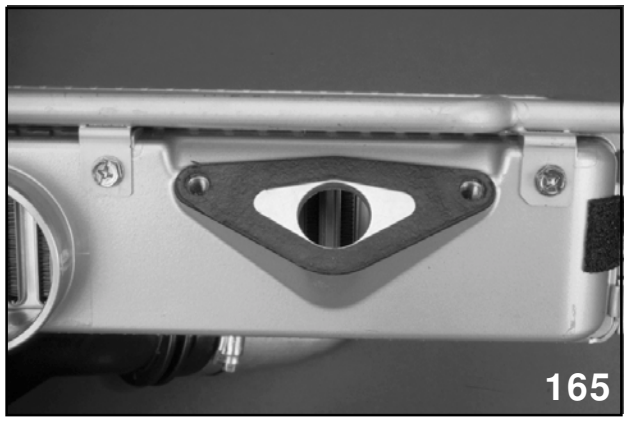
Inlet to Throttle Body

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.

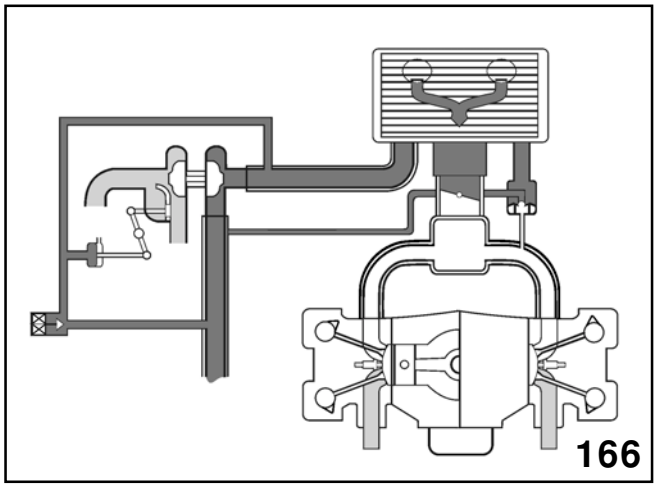


Intercooler Location

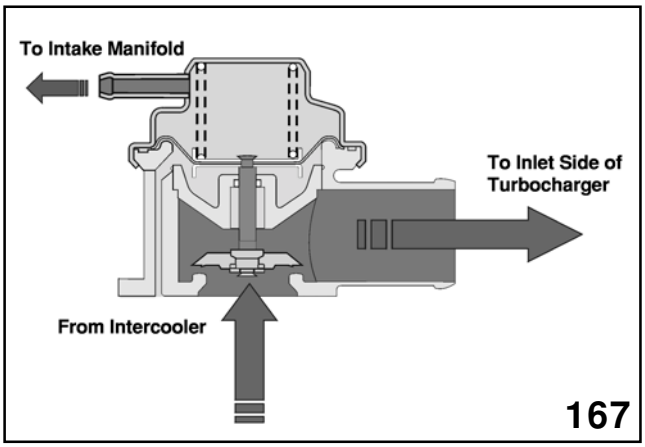


By-pass Valve Connection

The Air By-pass Valve is located after the Turbocharger, and provides a by-pass 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.



Air By-pass Valve Operation



By-Pass Valve

The upper chamber of the by-pass 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

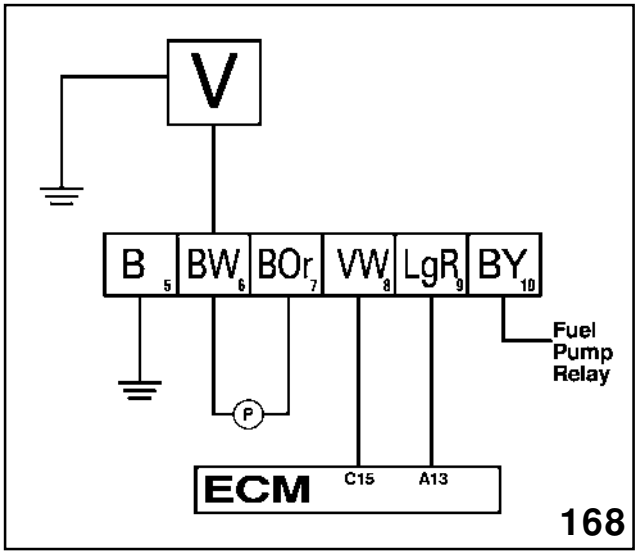
The diameter of the exhaust system will vary the pressure difference across the turbine. A larger exhaust allows the Turbocharger to rotate faster, which results in higher boost pressures. Any increase in boost pressures would require 're-mapping' of the ECM programs to accommodate different air flow 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.

Notes:

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 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

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 Loyales
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

406 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
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

406 Module Service Help-Line Updates

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



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Technicians Reference Booklet

On Board Diagnostics-II (OBD II)

Module 407

MSA5P0162C

AUTOMOTIVE Youth Educational Systems YES

Technical Training

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On Board Diagnostics-II (407)

Table of Contents

Introduction 6
Enabling Criteria 6
Confirmation Driving Pattern 7
Readiness Codes 8
OBD II Logic 9
Malfunction Indicat or Lamp Operation 10
    DTC Memory 10
    Warm Up Cycle 11
Freeze Frame 11
State I/M Program Advisories Bulletins 12
Service Bulletins 13
406 Module Service Help-Line Updates 14

Slide Sequence

Slide No.	Description	Page No.
1	Title Slide (Boxer Engine Series Module)	
2	Created By	
3	Teaching Aids	
4	Title Slide (Introduction)	6
5	Title Slide (Enabling Criteria)	6
6	OBD II Logic	6
7	Title Slide (Confirmation Driving Pattern)	7
8	Confirmation Driving Pattern	7
9	Title Slide (Readiness Codes)	8
10	Readiness codes after memory has been cleared	8
11	Readiness codes after meeting enabling criteria	8
12	Title Slide (OBD II Logic)	9
13	OBD II Logic	9
14	Accessing DTC's	9
15	DTC Structure P0440	10
16	Malfunction Indicator Lamp Operation	10
17	1 Hz	10
18	3 Hz	10
19	Title Slide (Freeze Frame)	11
20	Freeze Frame	11
21	Fuel Trim Map	11

On Board Diagnostics-II (407)

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

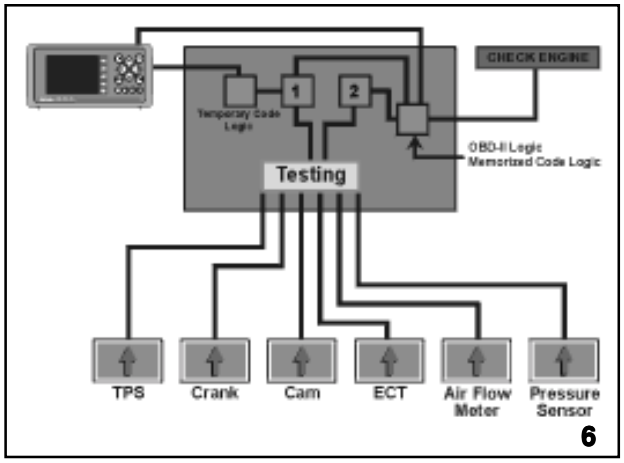
Before OBDII can begin to work the vehicle must meet the "Enabling Criteria". This is the vehicle operating condition that must exist for the Engine Control Module (ECM) to begin diagnostics. "Enabling Criteria" will not be the same for all diagnostics. For example; the ECM checks an EGR solenoid as 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

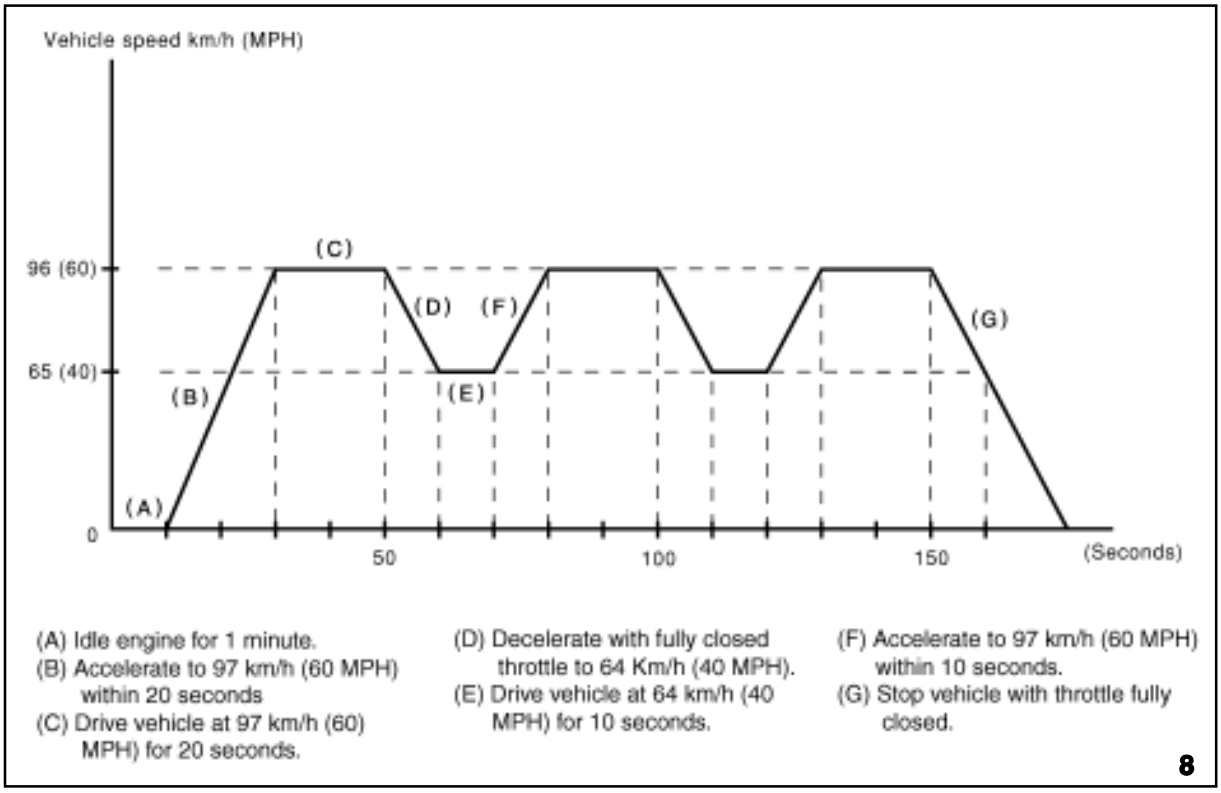
• **There can be no failures in the Following components or circuits;**

- 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:

On Board Diagnostics-II (407)

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
02 Heater Diagnosis	incomplete
EGR system	no support

10

Readiness codes after memory has been cleared

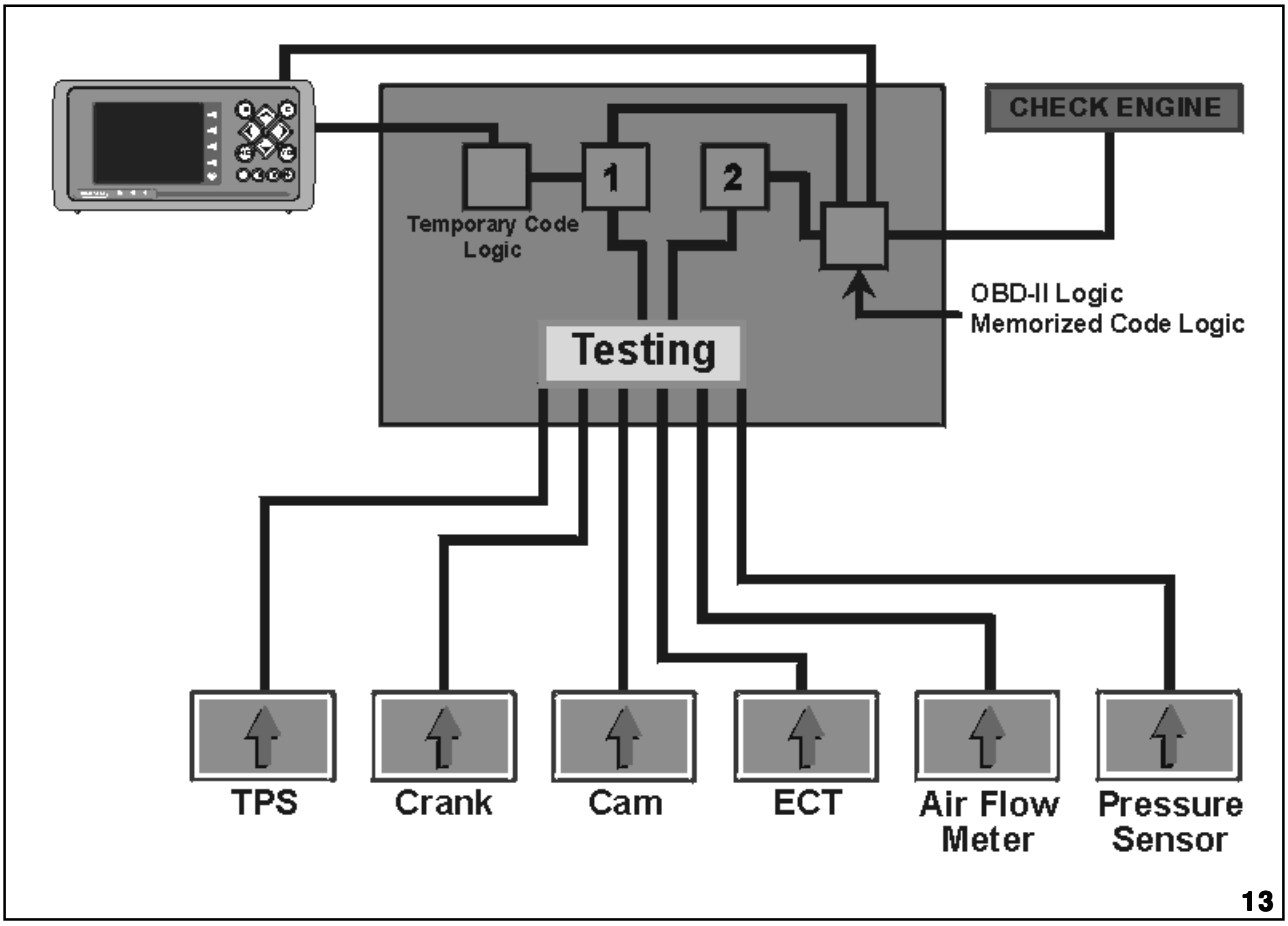
MI(MIL)	OFF
Misfire monitoring	complete
Fuel system monitoring	complete
Component monitoring	complete
Catalyst Diagnosis	complete
Heated catalyst	no support
Evaporative purge system	complete
Secondary air system	no support
A/C system refrigerant	no support
Oxygen sensor	complete
02 Heater Diagnosis	complete
EGR system	no support

11

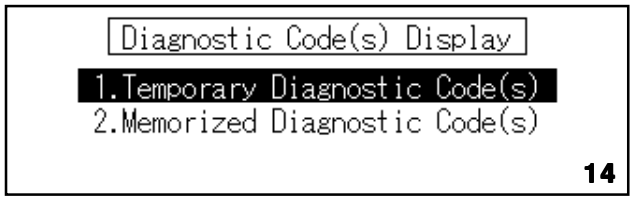
Readiness codes after meeting Enabling Criteria

Notes

OBD II Logic



OBD II Logic

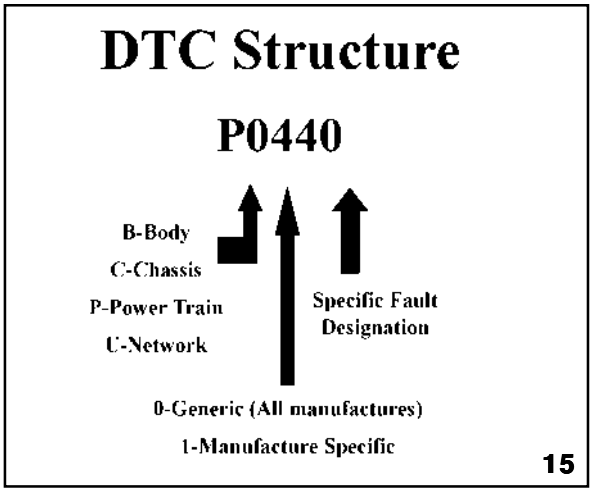


Accessing DTC's

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.

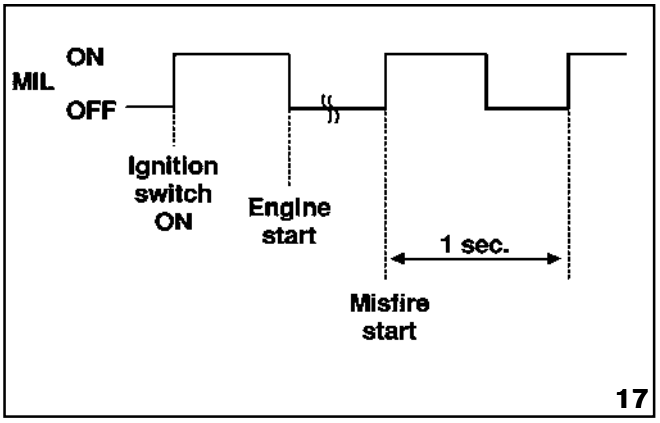
The exception to the second fault rule is any DTC that is related to Fuel Trim or Misfire. The second fault trip for these items must occur within 375 RPMs and 20% of the engine load of the first fault. At that point the Check Engine Light will illuminate and the DTC and Freeze Frame data will be memorized.



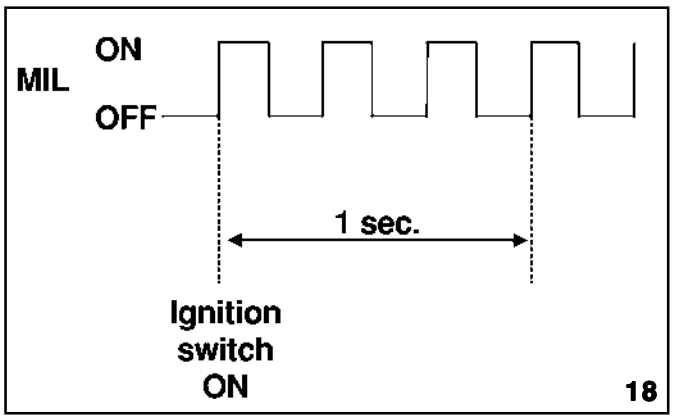
DTC Structure

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

20

Freeze Frame

Engine RPM

Engine Load

Fuel Pressure

Fuel Trim Values

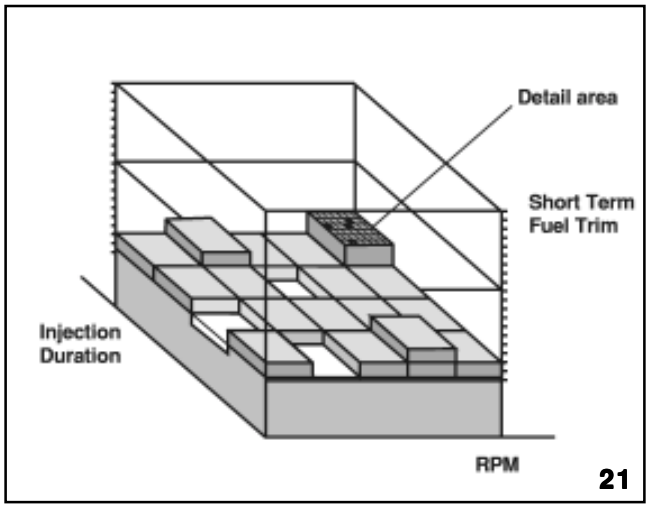
Coolant Temperature

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.



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.

On Board Diagnostics-II (407)

Notes:

On Board Diagnostics-II (407)

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.**

CAUTION
VEHICLE SERVICING PERFORMED BY UNTRAINED PERSONS COULD RESULT IN SERIOUS INJURY TO THOSE PERSONS OR TO OTHERS.
Subaru Service Bulletins are intended for use by professional technicians ONLY. They are written to inform those technicians of conditions that may occur in some vehicles, or to provide information that could assist in the proper servicing of the vehicle. Properly trained technicians have the equipment, tools, safety instructions, and know-how to do the job correctly and safely. If a condition is described, DO NOT assume that this Service Bulletin applies to your vehicle, or that your vehicle will have that condition.

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



Subaru of America, Inc.

SUBARU

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SERVICE

CERTIFIED SUBARU TECHNICIAN

Technicians Reference Booklet

Supplemental Restraint System (SRS)

Module 602-SRS

MSA5P0136C

Technical Training

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Table of Contents

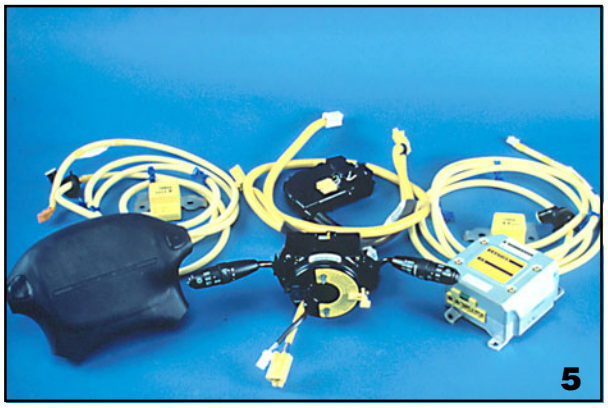
SRS Supplemental Restraint System (1992 SVX) ---------- 4
SRS System Precautions ---------- 4
Component Overview ---------- 5
Component Operation ---------- 7
Roll Connector Phasing ---------- 8
Connector Double Lock Sensors ---------- 9
Air Bag Module ---------- 10
Inflator Igniter ---------- 11
Air Bag ---------- 11
Air Bag Warning Lamps ---------- 11
Air Bag Deployment ---------- 12
Diagnostics and Servicing ---------- 12
SRS System Servicing ---------- 13

1995 Model Legacy ---------- 14
1996 Model Legacy and Outback ---------- 14
1998 Model Forester ---------- 15
2000 Model Legacy and Outback ---------- 17
2001 Model Legacy ---------- 19
2002 Model Impreza WRX ---------- 20

SRS SUPPLEMENTAL RESTRAINT SYSTEM

SVX System Overview

The SRS Air Bag 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.



The SRS System features built-in Self Diagnostics and a redundant Saftey Design with back-ups built into all of the circuits.

The system safeguards include double locking connectors with diagnostic sensors, a self-shorting inflator SRS air bag module connector to prevent accidental deployment during servicing, and a steering roll connector. A capacitor supplies back-up power.

Finally, for redundancy, there are two front inertia sensors and two safeing sensor circuits.

NOTE: THE SRS AIR BAG 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 Air Bag 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 air bag components. Always use gloves and eye protection. Although the residue is NOT toxic, it may cause minor eye and skin irritation.
8. Never place yourself or test equipment between the Air Bag Module and seat when serving the air bag system.

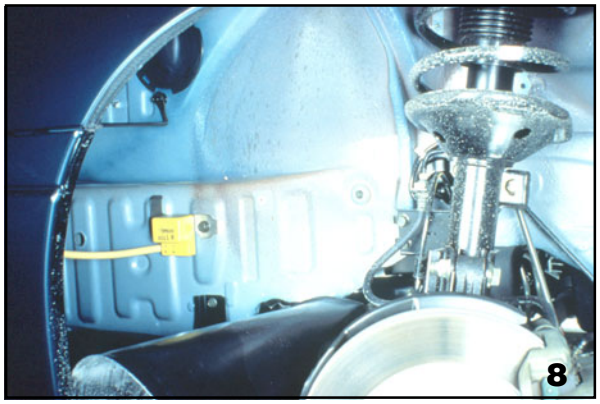
NOTE: REVIEW ALL CAUTIONS OUTLINED IN THE SERVICE MANUAL REGARDING SKIN AND EYE EXPOSURE TO DEPLOYED AIR BAG RESIDUES.

COMPONENT OVERVIEW

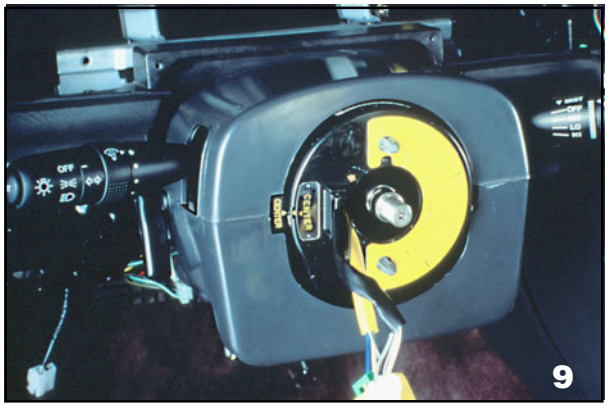
The Air Bag and Inflator Module is attached to the steering wheel and covered by the steering wheel pad. It contains the deployment module, air bag and cover pad.



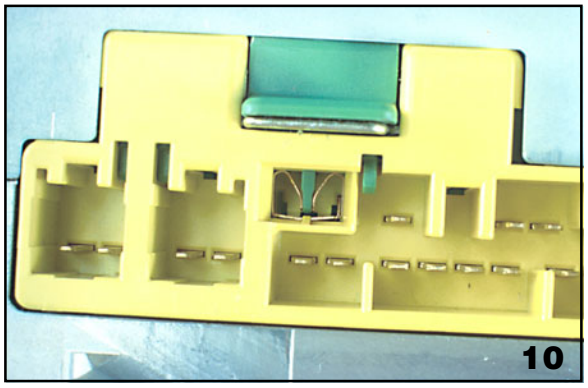
There are two (2) front sensors located inside the front fenders behind each inner fender liner. In addition, there are two Safeing sensors located inside the ECU.



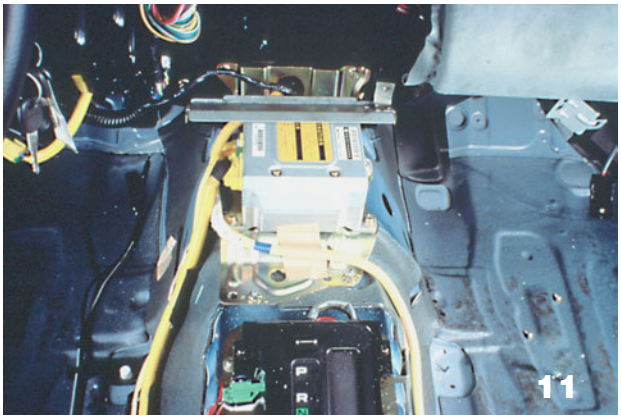
The steering roll connector is mounted between the steering wheel and the combination switch. It is an integral part of the combination switch assembly. The design of this assembly allows for steering wheel rotation. It also provides the hard wire connection between the air bag module and the SRS system harness.



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.

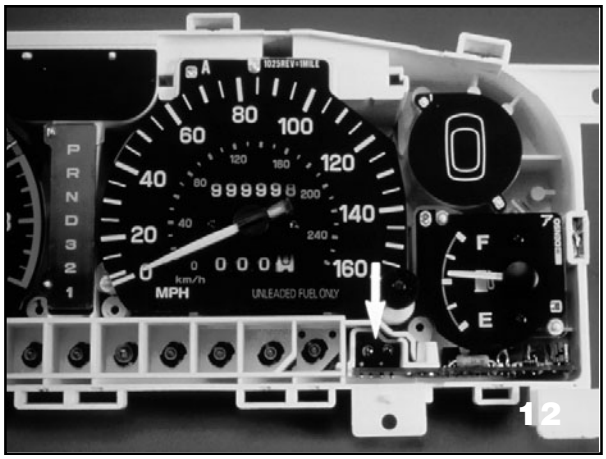


The ECU is located under the center console. It receives sensor input signals in the event of a frontal impact. It then sends a signal to trigger air bag deployment. The ECU features a self-diagnostic capability incorporating long term memory.



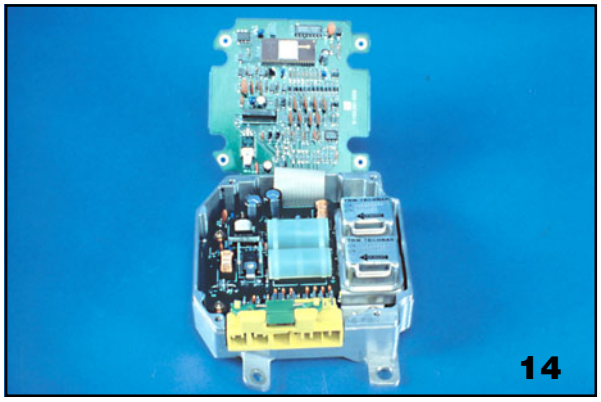
The ECU sends a continuous low voltage signal to monitor the sensors, the harness, the deployment module and to check for connector integrity.

There are two (2) air bag warning lamps located in the combination meter. For safety purposes, there are also two (2) independent drive circuits. Both lights and circuits illuminate only one light position in the combination meter.



COMPONENT OPERATION

The ECU controls the SRS Air Bag System by constantly monitoring the input signals from the front sensors, the safeing sensors and the double lock circuit. It also generates output signals to the warning lamps and to the inflator module.



Among other things, the ECU contains two safeing sensors which provide input signals, and two capacitors which supplement low battery voltage.

The capacitors also provide back-up 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 AIR BAG 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.



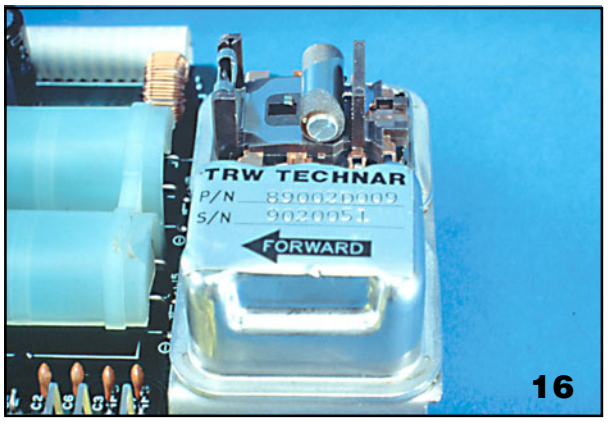
Redundancy is provided by the front left hand and right hand sensors. The hollow roller design provides a movable mass. The roller is mounted on a flat surface and held in place by a flat roller spring. The roller spring allows forward roller movement during frontal impacts of 12.5 MPH or greater. In 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 ECU. 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.

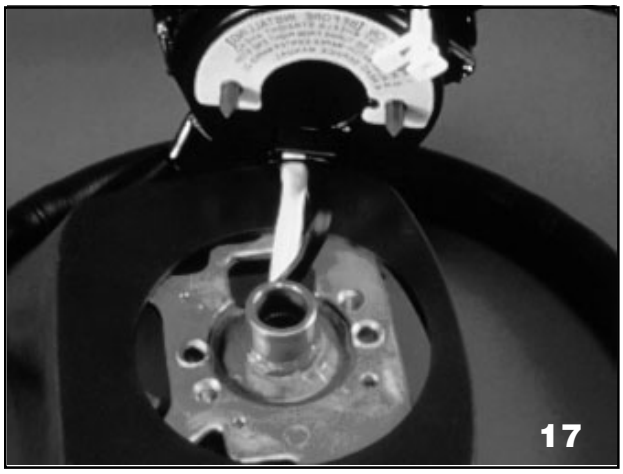
The continuous sensor harness is molded directly into the sensor body. The harness has only one sensor connector, which is located at the ECU. This provides a one-piece circuit path to the ECU. A damaged harness or sensor must be replaced as an assembly.



Two safing sensors located inside the ECU provide redundancy and safety. 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 safeing 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 ECU must be replaced if one of the safeing sensors fail.

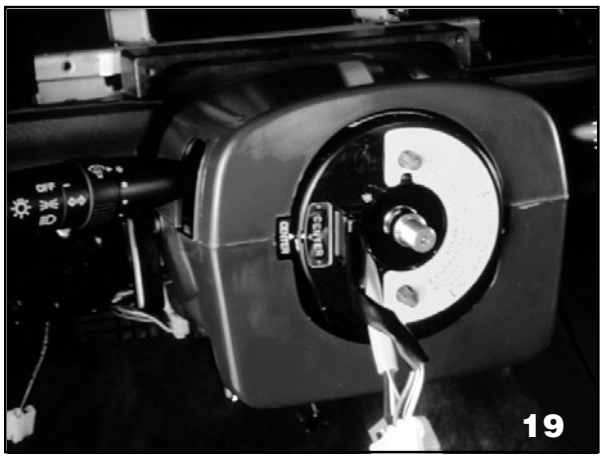
The steering roll connector is a continuous flat ribbon-type cable. The cable coils around the hub which allows 2.65 turns (either direction) from the center steering position. This provides a direct hard wire connection between the SRS air bag module and the ECU harness. It also includes the horn circuit. 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, aline 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.



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.

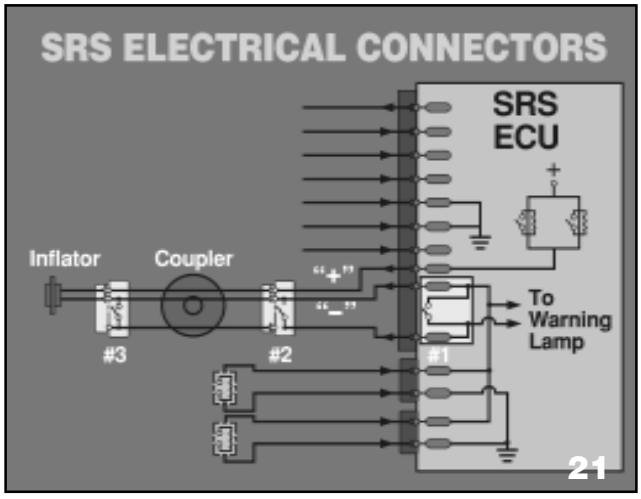
Similarly, if the indicator shows either "1L" or "2L", rotate the cover one or two left hand rotations.

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:

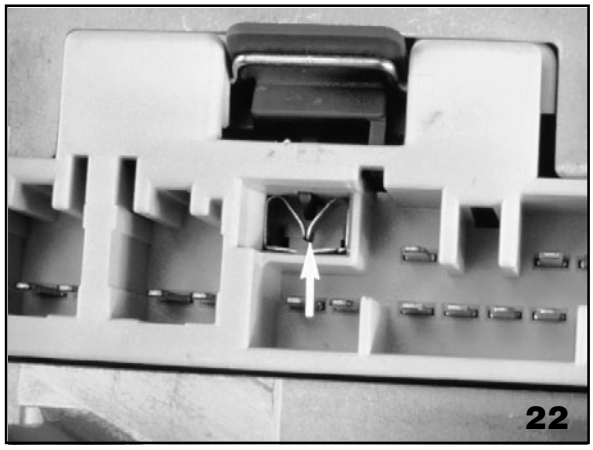
1. The system power supply and the warning light (Connector B58 to AB1)
2. The main ECU connection #1 (Connectors AB4, 5, & 6 to ECU)
3. The ECU harness and the roll connector # at the combination switch (Connector AB2 to AB7)
4. The roll connector and the air bag module #3 located behind the steering wheel pad (Connector AB7 to AB8)



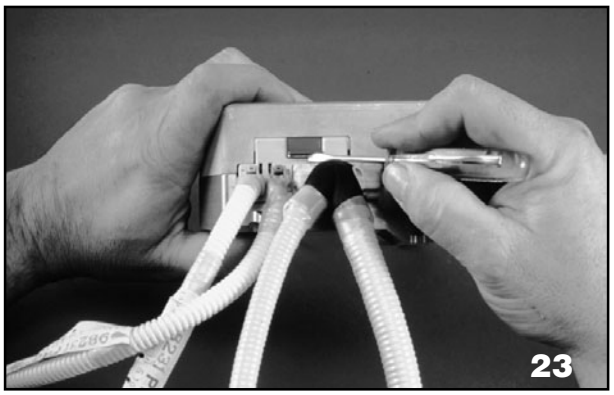
These sensors connect the double lock detecting circuit to the negative side of the igniter circuit. This provides a ground signal circuit for the warning light system.

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).

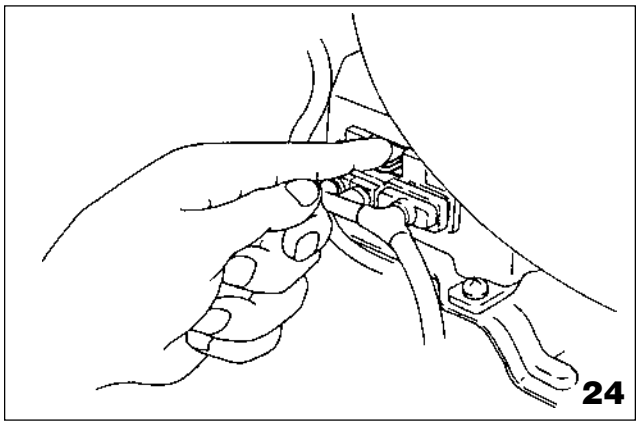
The double lock (#1) at the ECU secures the main harness connector as well as the two front sensor harness connectors.



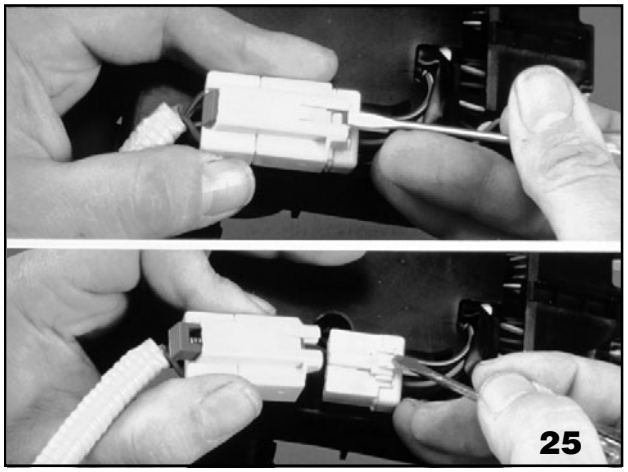
Double lock sensor terminals make contact when they are unlocked and they separate when they are locked. The green tabs mechanically prevent the connector from being removed. The double lock will not latch unless the connectors are completely inserted.



In order to release double lock #1, 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.



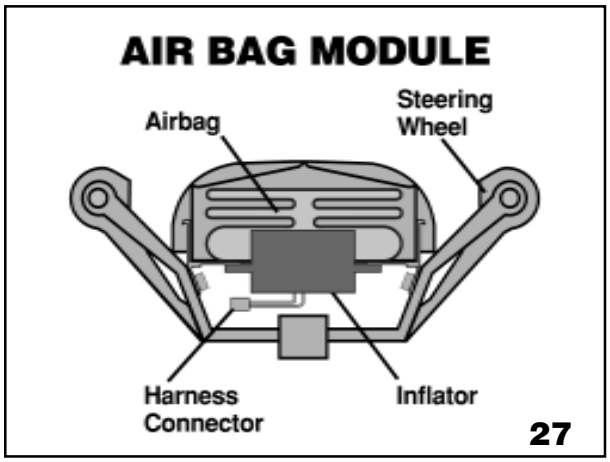
Secure the double lock by pressing the green latch down until a click is heard.



The procedure for locks #2 and #3 are similar to sensor #1 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.

AIR BAG MODULE

The air bag 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.



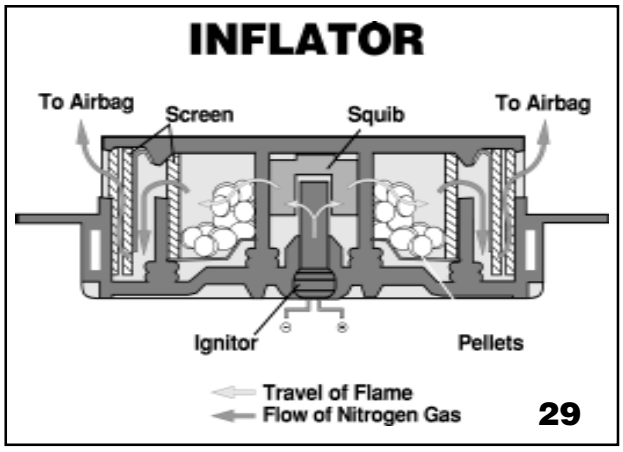
The air bag module consists of three sub-components:

1. Inflator
2. Air Bag
3. Inflator harness with connector

NOTE: THE AIR BAG MODULE IS SERVICED ONLY AS AN ASSEMBLY. DO NOT ATTEMPT TO DISASSEMBLE OR REPACK THE AIR BAG.

INFLATOR IGNITER

The inflator igniter is designed to ignite a squib after it receives an input from the ECU. The igniter is an electrically heater device with generates temperatures in excess of 300 degrees F. to ignite the squib.



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 with, in turn, inflates the air bag.

The built-in screen cools and removes hot cinders from the N2 before the N2 enters the air bag.

NOTE: FOR MORE SPECIFIC CHEMICAL CONTENT, PLEASE REFER TO THE SUBARU SVX SERVICE MANUAL.

AIR BAG

The air bag 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 coating produce the majority of the residue found after deployment.

AIR BAG 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 safeing sensors. The rollers then make contact with the circuit terminals. The front sensors provide a ground circuit while the safeing sensors provide a positive circuit.

In order for the ECU to activate the inflator, it must receive at least one collision signal from the front sensors and at least one collision signal from the safeing sensors.

After receiving a signal from the ECU, 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 air bag. The outer skin (steering wheel pad) of the inflator air bag module then ruptures as the air bag deploys. The Drivers forward movement is absorbed by the air bag as it vents the N2 through two 1.58 inch(40mm) holes.

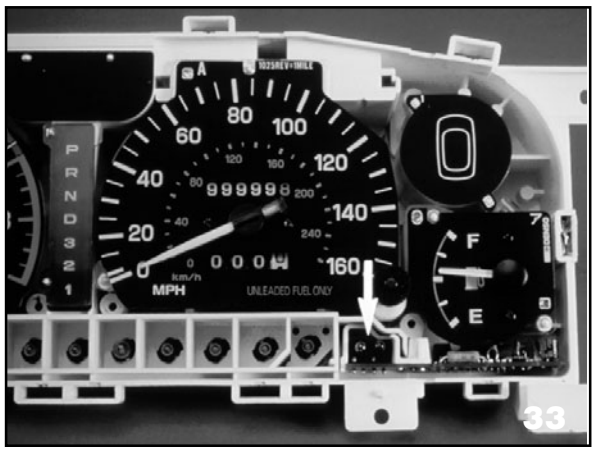
The Operational Time Sequence is almost instantaneous:

1. Collision: Zero seconds
2. Operation of the inflator: 3/100 second
3. Discharge of the N2: About 6/100 second
4. Completion: About 110/1000 second

NOTE: A VEHICLE WITH A DEPLOYED AIR BAG MUST BE TOWED TO THE DEALER FOR SERVICE.

AIR BAG WARNING LAMPS

Two (2) air bag 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.

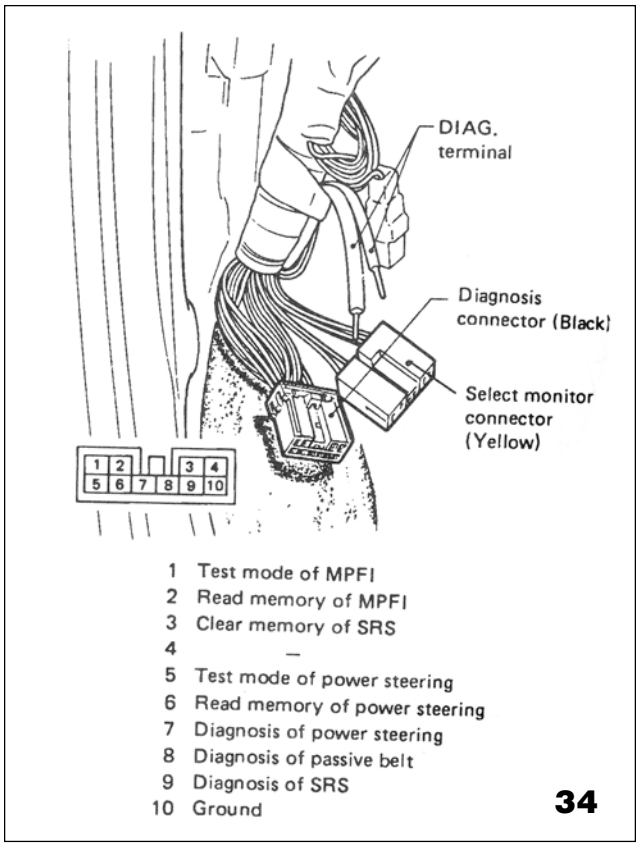


The lamp illuminates for 8 seconds after the key is turned to the "ON" position. It communicates to the operator when service is required and it communicates trouble codes to the technician.

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 "AIR BAG" 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 "AIR BAG" 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

There is also an additional factory long-term memory which can only be accessed by the factory. The purpose of this is for the ECU 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 SVX SERVICE MANUAL, SECTION 5-5.

CAUTION: DO NOT UNLOCK "DOUBLE LOCK" CONNECTORS OR DISCONNECT SYSTEM CONNECTORS WITH THE IGNITION "ON". THE ECU WILL SET A TROUBLE CODE IMMEDIATELY. THESE CODES WILL ALSO BE SET IN HIDDEN MEMORY AND CANNOT BE CLEARED FROM THE HIDDEN MEMORY.

SRS SYSTEM SERVICING

An SRS inspection is required every ten (10) years. Perform the Self-Diagnostic Checks and verify that the air bag 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, SECTION 1-5, AND REVIEW THE TEN YEAR SERVICE PROCEDURES.

NOTE: REFER TO THE SVX SERVICE MANUAL, SECTION 5-5, 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

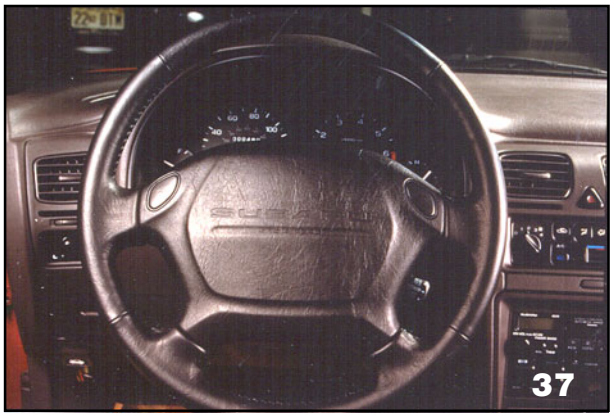
35

CAUTION: NEVER USE TEST HARNESS "C" TO CHECK THE RESISTANCE OF THE AIR BAG MODULE.

CAUTION: THE DEPLOYMENT HARNESS SHOULD NEVER BE CONNECTED TO THE AIR BAG MODULE WHILE THE MODULE IS IN THE VEHICLE.

CAUTION: ALWAYS US A DIGITAL TYPE OHM METER WITH AN OUTPUT SPECIFICATION OF 100 MILLE-AMPS OR LESS WHEN TESTING THE AIR BAG MODULE OR 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.

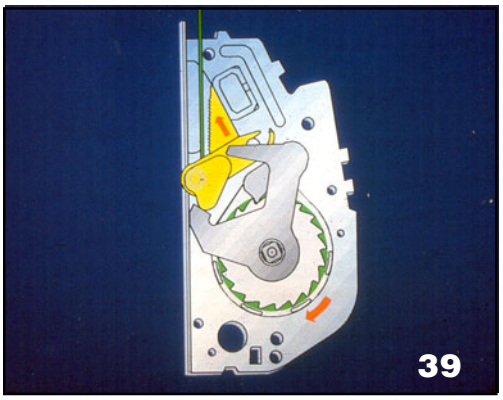
1995 MODEL LEGACY



Dual supplemental restraint system air bags will be standard equipment on all 1995MY Legacys and functions are similar to previous Model Year Legacys. The passenger side air bag module is wired in parallel with the driver's side. Both sides will deploy in the event of a frontal collision of 12.5mph or greater.



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.



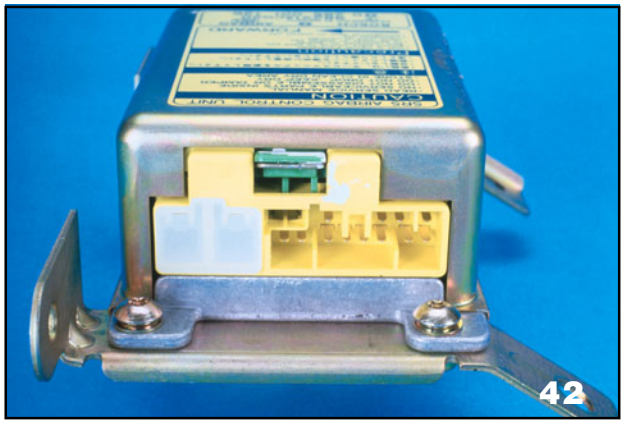
CAUTION: BEFORE SERVICING ANY SRS COMPONENT, DISCONNECT THE BATTERY AND WAIT 30 SECONDS FOR THE CAPACACITORS TO DISCHARGE.

1996 MODEL LEGACY AND OUTBACK

All 1996MY Legacy and Outback vehicles will have dual air bags. However, the electrical systems operating them will differ.



The Outback utilizes the same system as was used on the 1995MY Legacy 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.



Both models use a floating type SRS air bag module. The 1996MY Legacy steering wheel will no longer have horn buttons. To use the horn, press on the SRS air bag module, which activates a switch plate.





1998 MODEL FORESTER

The SRS air bag system for the 1998MY Forester employs both a driver and passenger side air bag. Please observe all warning precautions listed on the appropriate service publications and warning labels of the vehicle.

The driver side air bag is unchanged from that of the 1997 Impreza. Dashboard configuration for the passenger side requires a new air bag design. The air bag module can be removed or installed with the instrument panel in place.

The inflator of the passenger side air bag 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 air bag.

Gasses produced during burning include Argon and Helium.

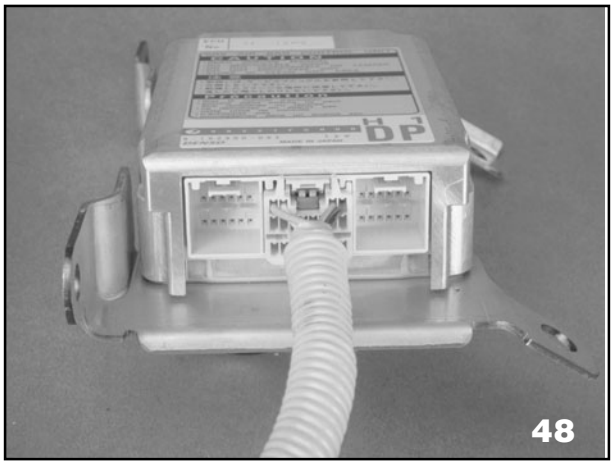


Control unit location is just forward of the shifter assembly.

The connector appearance and double lock feature have changed.

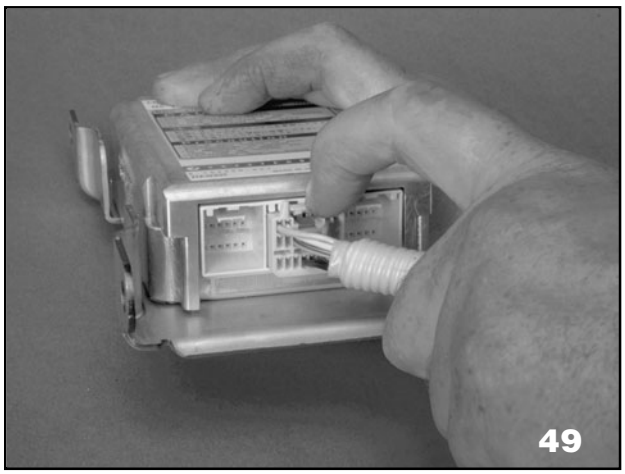
The control unit connector plate is designed for use with other Subaru SRS systems as well as the North American models. The connector is yellow with 20 pins.





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).



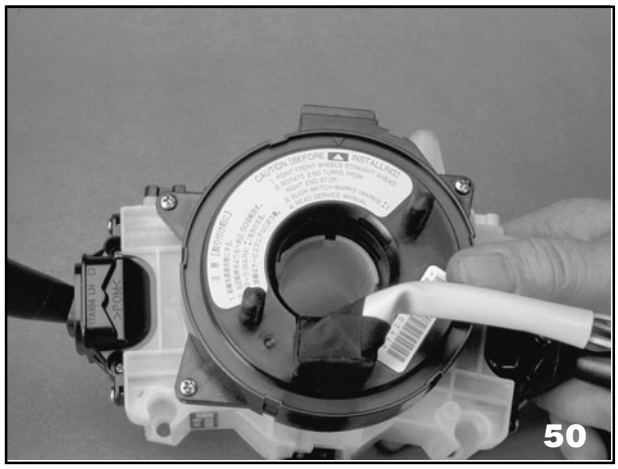
The connector "double-locks" for the driver side and passenger side air bag modules have also changed.

To disengage, push down on the yellow tab and slide the green tab in the direction of the arrow. Next, release the tab and pull gently on the connector. Failure to release the tab before attemplting separartion 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 side or passenger side air bag module integrity.

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.



The Legacy SRS air bag 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.

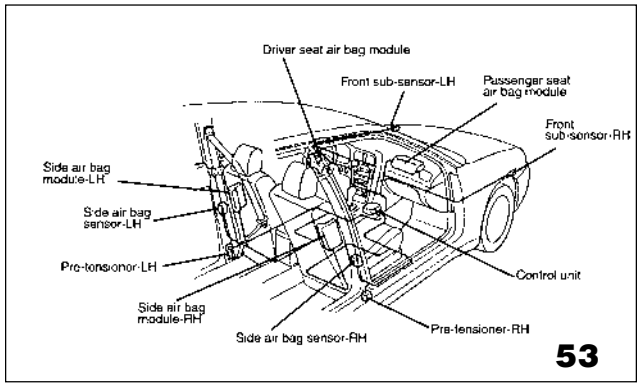
Side SRS airbags are equipped on GT Limited and Outback Limited models. They are designed to deploy on impact to the side of the vehicle. The severity of the impact is determined by the side air bag sensor located in the B-Pillar.



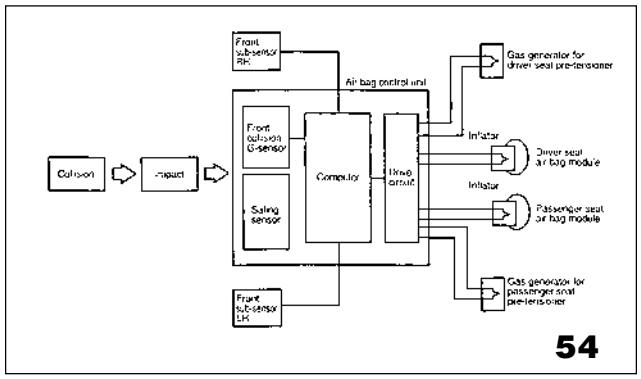
Side impacts to the rear door of the vehicle are absorbed by the door and body of the vehicle as well as to the shield under the rear passenger seat. The transferred force is then distributed through the shield and back in to the body of the vehicle.

2000 MODEL LEGACY AND OUTBACK

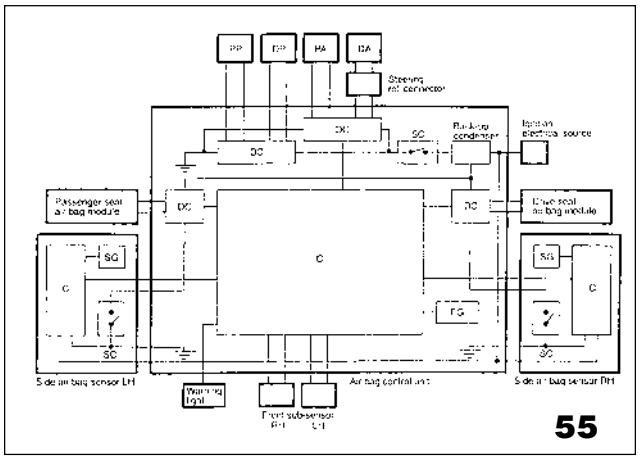
The SRS air bag control unit has been changed to include the addition of inputs and provide the output necessary for side air bag and seat belt pretensioner operation.



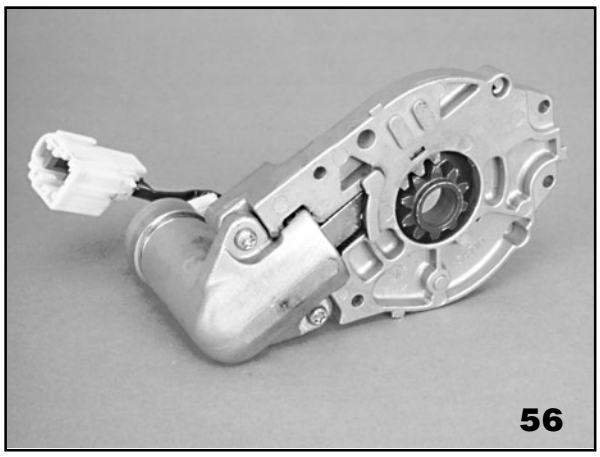
This diagram illustrates the electrical layout of the SRS air bag system without side air bags. The front sub-sensors are located in the front bumper area. The seat belt pretensioners will activate at the same time the front air bags activate.



This diagram illustrates the total SRS air bag 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 pre-established parameters, the front air bags, driver and passenger side, as well as both front seatbelt pretensioners activate.

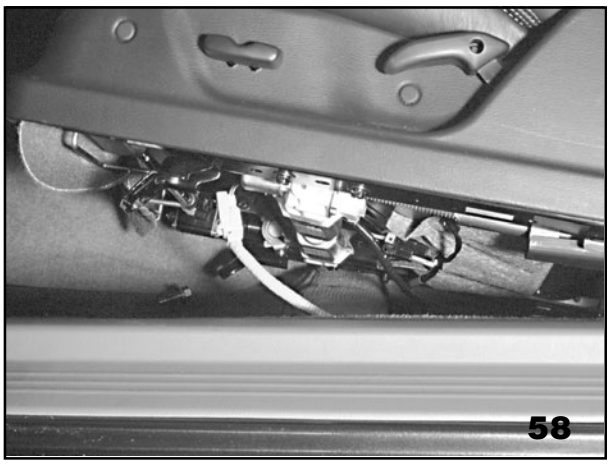


Seatbelt pretensioner operation winds the belt to restrain the occupant. The gas generator when activated pushes a piston, which is made onto a rack-type gear. This gear rotates the winding gear creating the motion and force necessary to wind the belt inward. When the force of the belt reaches a fixed value, the force limiter contained in the seatbelt assembly operates to control the restraint force so it does not increase further.



The GT and Outback models have a 6-way power driver seat. When serving this seat, disconnect the side SRS air bag connector after positioning the seat for mounting bolt removal and disconnecting the battery. (Wait 30 seconds before proceeding).

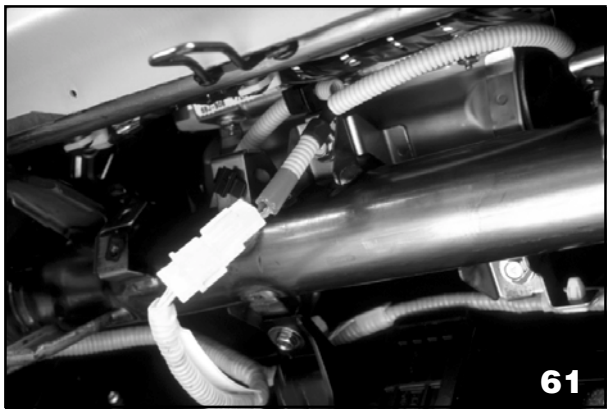




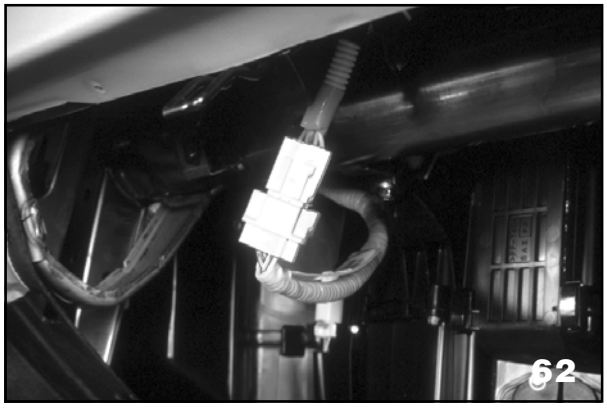
2001 MODEL LEGACY



All Legacy vehicles will share an enhancement to the passenger side SRS Air Bag System.



The air bag module now contains 2 inflation units. (Figure 57) Each one independently controlled by the SRS ECM. During an impact of lower speeds (above the deployment minimum specification) 1 side of the module will be activated followed by the other side. The time between the 2 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 2 sides activating for deployment. The 2 sides will be activated together above a higher impact speed.



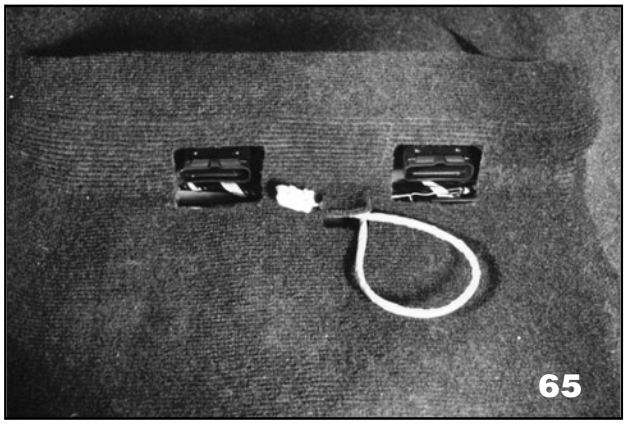
A new style of connector is used for the passenger side airbag module. The connector is disengaged by pulling down on the wider portion of the body harness while supporting the lower portion.



There is no change to the driver side SRS Airbag.

2002 MODEL IMPREZA WRX

WRX models will have side air bags as standard equipment.



Caution must be observed while removing the front seats to ensure the SRS wiring harness is not damaged.



The side impact switch is mounted on the left and right B pillars behind the seat belt trim panels.



The SRS Air Bag for Impreza 2002 will include the addition of seat belt pretensioners for all models (Passenger side air bag module is the single deployment type).



The control unit is located in front of the gate type shifter.

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Subaru of America, Inc. 2001

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