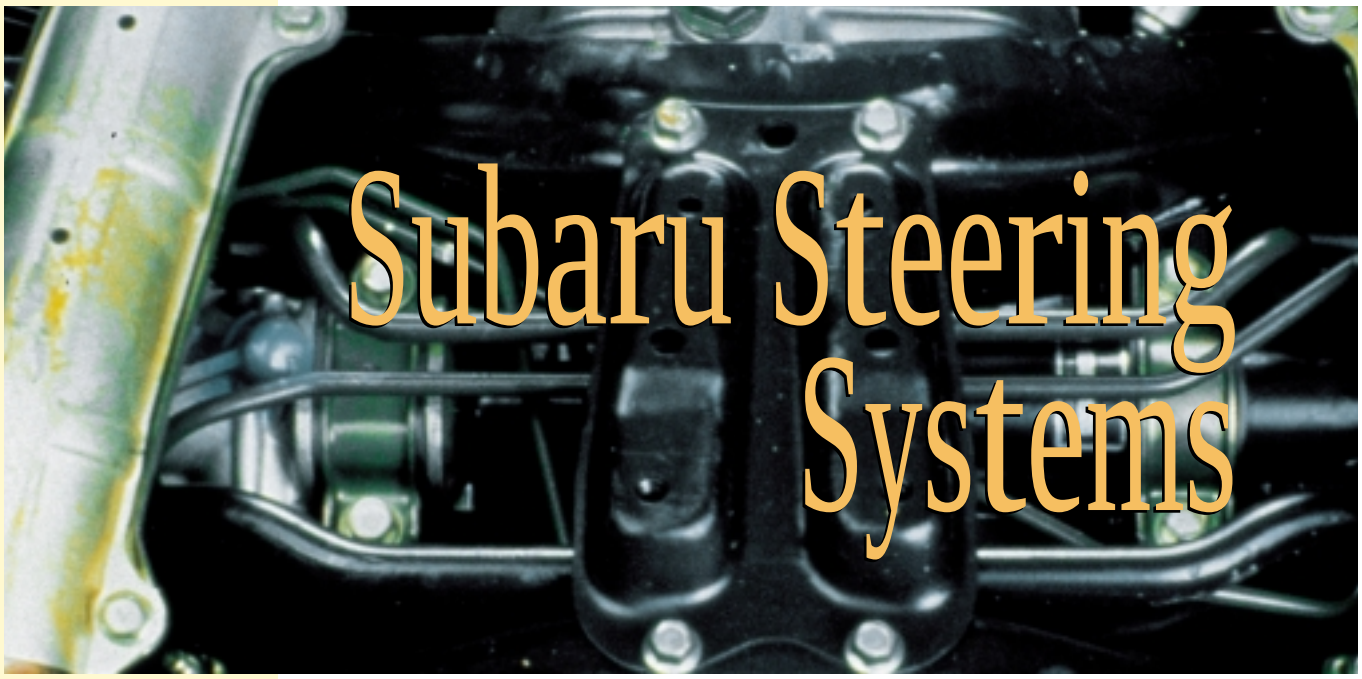


Subaru Steering Systems

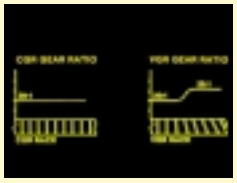
Rack And Pinion Steering Mechanism

Subaru steering systems utilize a rack and pinion steering mechanism. As the pinion gear rotates, the rack moves left or right. Rack and pinion steering gives the driver precise control over the wheels. The simple, compact design is easy to service.

Rack and Pinion Steering Mechanism

CGR – VGR Ratios

Two manual steering racks are used in Subaru vehicles: a constant gear ratio (CGR) rack and a variable gear ratio (VGR) rack. The teeth on the CGR rack are equally spaced so the turning effort is equal throughout the turning range. The teeth on the VGR rack are spaced closer together on the ends of the rack than in the middle. The turning effort decreases as the turning angle increases so sharp-radius turns are easier to make.



CGR–VGR Ratios

Legacy and SVX Steering Racks

Several different power steering racks have been installed in Subaru vehicles. The racks used in the L-series, XT, Legacy and SVX vehicles are similar. All have a one-piece gearbox and lack the external air vent distribution tube found on the rack in pre-'85 and carryover vehicles. However, the XT rack differs from the L-series rack in several ways. The XT rack is made of aluminum and has a different control valve. Different types of hydraulic seals are used in the two racks, and each has its own unique special service tool. The power steering rack in the pre-'85 model year vehicles and the Brat has a two-piece gearbox and an air vent distribution tube. It also has seals, service procedures and special service tools that differ from the other racks.

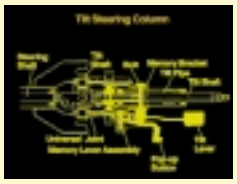
Legacy and SVX Steering Racks

Rigid Steering Column

Three types of steering columns are used in Subaru vehicles: a rigid steering column, a tilt steering column and the XT and SVX tilt and telescoping steering column. The rigid steering column is found on L-series DL models, the Legacy standard model, and Justy vehicles. The rigid steering shaft does not tilt or pop-up, but is collapsible (a safety feature). The shaft is connected to the gearbox by universal joints.

Tilt Steering Column

The tilt steering column is found on late-model L-series GL, Loyale, Legacy, and SVX vehicles. The tilt steering column features both tilt and pop-up operations. It is divided into two sections, upper and lower, connected by a universal joint. The L-series uses a friction type lock. By pushing down on the tilt lever, tension on a bolt is released, and the steering column may be tilted to an infinite number of positions. (Pre-'85 model year tilt steering columns could be tilted to only eight positions.) When the tilt lever is returned, the bolt tightens to lock the steering column in position. The Legacy and SVX use a gear type lock. The "Lift Up" lever tilts the steering column all the way up. The "Tilt Pull" lever tilts the steering column to the optimum driving position.



Tilt Steering Column

A pop-up/memory feature was added to the ‘85 and later model year L-series tilt steering column. On ‘85 and ‘86 model year vehicles, depressing a button on the left side of the steering column releases the tilt shaft. The tilt shaft on ‘87 model year vehicles is released by pulling forward a knob located on the left side of the column. Spring action lifts the column to its highest position. When the column is pulled down, a lock pin slips into a hole in the memory bracket, securing the column in its previous position.

The Legacy and SVX memory function is controlled by disengaging a movable gear from a stationary gear. This causes the coil springs to tilt the steering column up. A memory gear is engaged with the movable gear. A plate united with the memory gear is interposed between the movable and stationary gears. When the steering wheel is pushed down, the movable gear is disengaged from the plate which allows the stationary gear and the memory gear to return to the original position.

XT Steering Column

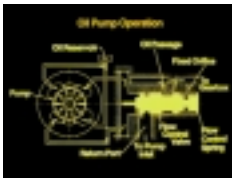
The XT steering column has tilt and pop-up features as well as a telescopic feature. A telescopic lever on the end of the steering column, when rotated counterclockwise, moves a lock key away from the steering shaft. This allows the control wing and the steering wheel to be moved in or out in an axial direction. The maximum telescoping stroke is 40 mm (1.57 in).

The operation of the tilt feature and pop-up feature on the XT steering column is similar to that of the L-series tilt steering column. Moving the tilt lever down releases the steering column. The rubber bushing in the toe board deflects to allow the column to pivot around the universal joint between the column and the gearbox. The dash also tilts up and down with the steering column.

Power Steering System

XT Pop-up Mechanism

The XT pop-up feature is operated by pulling a knob located on the instrument panel lower left side of the instrument panel. A cable connects the knob to the lockpin. Pulling the knob retracts the lockpin from the column bracket, allowing the spring to force the column upward. When the column is pulled down, it locks in its original position.



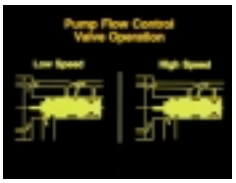
Oil Pump Operation

Power Steering Rack System

Subaru’s power steering system contains a pump, hydraulic line, and a gearbox (rack). The hydraulic pump is a vane-type pump driven by the engine. It provides pressurized fluid for the system.

Oil Pump Operation

The pump has two internal valves: a flow control valve and a relief valve. The flow control valve regulates the volume of power steering fluid delivered to the rack. During high engine rpm, the pressure in the pump overcomes the flow control valve spring. The control valve slides back to close off an oil passage to the rack and to open an oil return port to the pump inlet. This reduces the power assist to the rack during high speeds, improving the steering wheel feel and response.



Flow Control Valve Operation

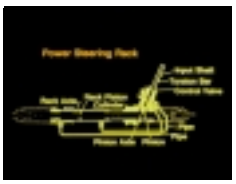
Relief Valve Operation

Pressure in the system is also controlled by the relief valve built into the flow control valve. The relief valve consists of a ball valve and a relief spring. When hydraulic pressure in the system reaches a specified value, the ball valve opens so that part of the working fluid flows into the return port via the fixed orifice.

Relief Valve Operation

Power Steering Rack

The gearbox consists of a control valve and a power cylinder. A power piston attached to the rack divides the cylinder into two chambers. As fluid is directed by the control valve to either side of the piston, the rack is pushed in the same direction in which the steering wheel is being turned.



Power Steering Rack

Control Valve Operation

Hydraulic fluid supplied to the rack is controlled by the rotary control valve. As part of the pinion gear shaft, the control valve directs fluid flow to one side or the other of the power piston. When steering effort is not applied to the pinion shaft, hydraulic pressure in the valve and to both pressure chambers is held equal. Oil is directed from the center of the valve back to the pump.

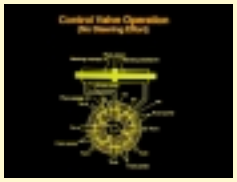
As steering effort is applied, a torsion bar in the valve deflects in proportion to the resistance encountered. Fluid is allowed to pass directly from the pump discharge side to

Subaru Steering Systems

the pressure chamber, creating a pressure differential between the two chambers. This hydraulic imbalance causes the piston and rack to move to one side. Piston movement causes fluid in the low pressure chamber to return to the pump through the control valve. The more the torsion bar deflects, the greater the pressure differential becomes. The increased pressure assists in the turning effort.

Steering System Troubleshooting

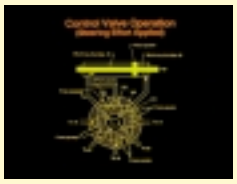
Steering performance symptoms may be the result of a number of problems. The cause of the problem could be inside or outside of the steering system. For example, heavy or hard steering could be a result of a malfunctioning pump, of low idle speed, of a defective control valve or of tires not properly inflated. When diagnosing the cause of a steering problem, carefully follow the troubleshooting charts given in the appropriate model year service manual.



Control Valve Operation (No Steering Effort)

Oil Leak Points

Leaks in the gearbox should be confirmed before removing the gearbox from the vehicle. If leakage is suspected, clean the suspected portion, and turn the steering wheel from lock to lock approximately 30 or 40 times with the engine running slowly to verify the leakage. Refer to the service manual for the correct repair procedures.

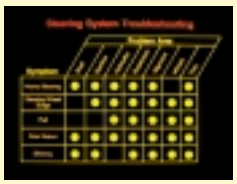


Control Valve Operation (Steering Effort Applied)

Power Steering System Pressure Testing

If the troubleshooting procedures lead you to suspect a fault in the power steering system, perform a pressure test. The vehicle must be equipped with the specified tires and rims and the tires must be properly inflated. Then, bring the engine up to operating temperature before performing the test. Keep the following precautions in mind as well:

- Do not leave the pressure gauge valve closed for more than five seconds; doing so may damage the pump.
- Do not hold the steering wheel in the full lock position for longer than five seconds; this may damage the pump.
- Keep the engine speed at idle.
- Handle power steering fluid carefully; catch spilled fluid with shop cloths to prevent damage to the vehicle's finish.



Steering System Troubleshooting

Power Steering Pressure Test

Attach pressure gauge 925711000, adapter A 926210000, and adapter B 926220000 to the discharge part of the pump, then perform the three pressure tests listed below.

Step 1: *Regular pressure*

Engine idling, valve open:
142 psi (10 kg/cm2) or less

If No:
- Crimped Fluid line – **Replace,**
- Leaking fluid line – **Tighten or replace,**
- Clogged fluid line – **Drain or replace.**

Oil Leak Points

Step 2: *Relief pressure*

Engine idling, valve closed:
L-series/Loyale SPFI: 40-55 kg/cm2 (569-782 psi)
XT/XT6: 60-75 kg/cm^2 (853-1067 psi)
Legacy: 75-80 kg/cm^2 (1067-1138 psi)
SVX: 78-85 kg/cm^2 (1109-1209 psi)

If No:
- Faulty relief valve
- Oil pump leak
- Worn pump

In all cases replace pump.

Step 3: *Working Pressure*

Engine idling, valve open,
steering wheel turned stop to stop:
L-series/Loyale SPFI: 40-55 kg/cm^2 (569-782 psi)
Loyale MPFI/XT/XT6: 60-75 kg/cm^2 (853-1067 psi)
Legacy: 75-80 kg/cm^2 (1067-1138 psi)
SVX:78-85 kg/cm^2 (1109-1209 psi)

If No:
- Faulty control valve – **Replace.**

If Yes:
- System Okay.

Power Steering System Check

Servicing The Steering System

Note: Always refer to the appropriate model year Subaru Service Manual and follow the procedure for removal of the SRS airbag module prior to any repair and servicing or removal of the steering wheel and steering column from all airbag-equipped Subaru vehicles.

Column Removal Precautions

- Reference service manual Section 4-3 for rigid column and tilt column servicing procedures.
- Always disconnect the U-bolt joint before loosening the column mounting bolts.
- Disconnect the wiring harness connectors before removing column.
- Install a 8 mm x 16 mm lock bolt to secure XT column.
- Remove the XT column carefully to avoid damaging meter and instrument panel.
- For proper steering wheel alignment, center the front wheels and scribe an alignment mark between the steering wheel hub and the shaft, prior to disassembly.

When removing the steering column, always observe the precautions listed above.

Gearbox Servicing Precautions

Do Not:

- Crimp the pipes.
- Scratch the rack or cylinder.
- Clog the air passages.

Do:

- Lubricate the seals/bushings.
- Install the seal lips toward the pressure area.
- Use the correct special tools.

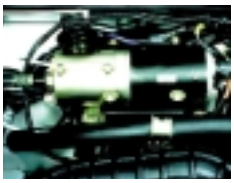
Follow the above precautions when servicing the steering gearbox. For detailed instructions on steering rack overhaul, refer to the appropriate model year service manual.

Airbag Steering Column Procedures

Airbag Steering Column Installation Precautions:

- Reference all airbag-equipped vehicles.
- Review the roll connector phasing procedures listed in the appropriate model year service manual, Section 4-3.
- The roll connector must be phased to the steering system only when the front wheels are centered.
- Align the inner center indicator on the rotating cover (next to window) with the arrow on the connector case.
- Complete the following alignment adjustments when the inner indicator in the window shows:
  - —1R - rotate cover one full rotation to the right
  - —2R - rotate cover two rotations to the right
  - —1L - rotate cover one full rotation to the left
  - —2L - rotate cover two rotations to the left
- Use the guide pins to align the roll connector with the steering wheel.

Cybrid Steering Components

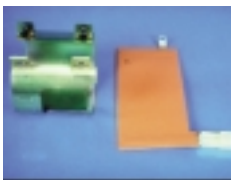


Motor and Pump Assembly

Cybrid Power Steering

The Cybrid Power Steering System was standard equipment on the XT6. It's a computer-controlled, electric motor-driven hydraulic steering system, using a power-assisted rack and pinion assembly similar to the XT.

This system provides improved steering feel and more precise power assist over a wider operating range. Fuel consumption is reduced because it requires less horsepower due to the electrically-driven hydraulic pump. The specific system used on the XT6 is quicker than other XT power steering systems, with just 3.2 turns lock-to-lock.



Heater

Cybrid Steering Components

The Cybrid Power Steering System consists of four major components:

- The Motor and Pump assembly mounted on the front bulkhead (firewall),
- A Steering Sensor located inside the vehicle at the base of the steering column,
- A Signal Controller located in the left rear quarter panel,
- The Power Controller mounted on the front bulkhead (firewall) to the left of the Motor/Pump assembly.

Steering Sensor Assembly

Motor/Pump Assembly

The Motor/Pump assembly is similar to a starter motor, since it has an armature, fields, and brushes which are serviceable. The electric motor drives a pump which is very similar in design to an engine driven pump. This combination replaces the familiar belt driven P/S pump assembly. The Cybrid System requires special hydraulic fluid to retain stable viscosity during cold temperatures.

Subaru Steering Systems

Heater

The Pump incorporates an electric heater to warm the hydraulic fluid in extremely cold operating conditions, improving the steering performance. A thermistor type switch located on a bracket above the Motor/Pump assembly, senses the underhood (ambient) temperature and sends an input to the Signal Controller.

The Heater operates for approximately five minutes after engine start-up. The Signal Controller grounds the heater relay, which passes battery voltage to the heater. The heater relay is located near the motor/ pump assembly.

Note: The Heater only works when the thermistor signals an extreme cold condition.

Signal Controller

Steering Sensor Assembly

The Steering Sensor sends a steering frequency signal to the Signal Controller. The Steering Sensor consists of two components:

- Photo coupler,
- Sensor Plate with 60 slits.

As the sensor plate passes through the photo coupler it generates a pulse signal which is interpreted as steering frequency. A 360 degree turn equals 60 pulses. Four 90 degree movements also equal 60 pulses.

Note: The Signal Controller determines the difference between one full (360 degree) rotation of the steering wheel and four quarter (90 degree) turns based upon vehicle speed.

Power Controller

Signal Controller

The Signal Controller receives inputs primarily from the vehicle speed sensor and the steering sensor. It continuously monitors the driving conditions over any given 20 second time period.

Based upon an average of the vehicle speed and the steering frequency, it then determines the amount of power assist (duty ratio) required. This signal is then sent to the Power Controller which in turn operates the motor.

Power Controller

The Power Controller is the last major Cybrid steering component. It functions like a duty solenoid in order to control the electric current to the Motor/Pump assembly. The power controller regulates the ground circuit of the motor based upon input from the Signal Controller. A 100 percent duty equals maximum assist.

Motor and Pump Alignment

Operation

The Signal Controller selects one of four driving modes, based on vehicle operation:

- High Speed Driving
- Suburban Driving
- Winding Road Driving
- City Driving

High speed driving requires the least amount of power assist. As the vehicle speed increases, the power assist decreases. During suburban driving the vehicle speed is slower but the steering input is usually more frequent. In this mode of operation the power assist generally increases.

For winding road driving the speed varies, but it is generally moderate. In this case, the steering input is frequent and the power assist is close to maximum. City driving is characterized by its low speed and frequent steering inputs. In this case, assist is at or near maximum. When the steering input stops the power assist gradually decreases.

Power Steering Pump

Operating Conditions Above 6 MPH

The driving mode is determined by the steering frequency and the vehicle speed. The signal controller then selects a driving mode and determines an appropriate duty ratio for that mode.

When the driving mode changes, the duty ratio is altered gradually (approximately 2.5 percent every 0.1 second). This provides a smooth transition from one steering mode to another, which prevents possible feedback to the steering wheel.

Steering Rack

Operating Conditions Below 6 MPH

When there is NO steering input, the duty ratio is zero percent (no assist). However, with any steering input, the duty ratio immediately increases to 100 percent (maximum assist). The sub-fan turns off (if it was on) but turns back on again when the steering input ceases. With continued steering input, the duty ratio remains at 100 percent unless the vehicle speed exceeds 6 MPH. When the steering input ceases, the duty ratio reduces approximately 2.5 percent every 0.5 second. This prevents possible feedback to the steering wheel.

Subaru Steering Systems

Service Procedures

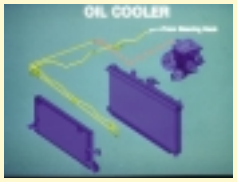
Motor and Pump Alignment

The pump assembly is serviced similar to the belt driven pump on the H-4 engine. The electric motor has serviceable brushes, similar to those in a starter motor.

Note: This system uses special hydraulic fluid. DEXRON II may be substituted in an emergency. Flush and replace with IDEMITSU fluid as soon as possible.

Note: The pump should be indexed as shown in order to facilitate proper reassembly.

Note: Detailed trouble-shooting and service procedures can be found in Section 4-3 of the service manual.



Oil Cooler

Self-Diagnostics and Failsafe

In the user mode, the driver is notified by the STEERING light whenever a system malfunction occurs in:

- The Signal Controller,
- The Signal System (Sensors),
- The Power Controller,
- The Power Source for the pump motor.

Note: This is a highly reliable steering system. However, should an electrical component malfunction, it will always fail safe for "limp home."


Rubber Coupler

Fail Safe Results

If the pump motor current exceeded 100 Amps for 10 or more seconds, power assist will cease. The STEERING light will come on and the duty ratio will be reduced to 0 percent. However, full manual control will allow the vehicle to be safely driven.

If the vehicle voltage drops below 9 volts, there will be partial power assist. The STEERING light will come on and the duty ratio will be gradually reduced. Should the voltage recover, the duty ratio will return to normal and the steering light will go off.

If the engine stalls, the STEERING light will come on and the duty ratio will be gradually reduced. This allows power assist for several seconds. Once the engine is restarted however, the STEERING light goes off and the power assist returns as needed.

Should there be a loss of the speed sensor signal (Above 15 MPH), the STEERING light will come on and the duty ratio will be maintained at the previously set level.


Power Steering Pressure Switch

Note: Prior to any servicing or fault diagnosis, confirm that the vehicle has had MPS controller set PIN 31186GA070 installed. For additional details refer to Campaign Bulletin #WZM-48. For vehicles which have had this replacement procedure performed, refer to MSA5T9212A XT6 Electronic Controlled Motor Drive Power Steering Service Manual Supplement and the appropriate model year Service Manual, Section 4-3 for D-Check and fault diagnosis procedures.


Steering Components

SVX Engine Speed and Vehicle Speed Sensitive Steering Systems

There are two model-specific systems available on SVX vehicles:

- The engine speed sensitive, or conventional belt driven hydraulic pump and pinion type steering system is standard equipment on the SVX.
- An SVX equipped with the Touring Package uses an optional vehicle speed-sensitive system. This system provides normal power assist at low vehicle speeds for reduced driver steering effort, and reduced steering assist at increased vehicle speeds for increased road feel and improved engine operating efficiency. Both systems have many similarities with the Legacy system.

Power Steering Pump

Both systems share many similarities to existing Subaru steering systems. Both use a belt-driven power steering pump, although the pump housings are different in appearance.

Rack

A conventional power assisted rack with the standard Subaru lines and hoses is used by the standard system.

Oil Cooler

An oil cooler pipe has been added to both SVX systems. It is located in front of the radiator on the return side of the system.

Rubber Coupler

A steering shaft rubber coupler is used by both SVX systems to reduce road noise and vibration.

Subaru Steering Systems

Power Steering Pressure Switch

A power steering pressure switch is located on the outlet side of the pump. The switch monitors increased engine load during idle speed steering. The switch provides an input to the MPFI ECU, which prevents stalling by raising the engine idle speed. There is not an additional trouble code for the MPFI ECU.

Vehicle Speed Sensitive Power Assisted Steering (Optional System)

Soleniod Pinion Assembly

Main components unique to this system are:

- Power steering control unit,
- Vehicle speed sensor (speedometer system),
- Reaction (duty) solenoid valve,
- Modified pinion assembly.

Steering System Diagram

The steering system ECU receives input from the engine speed sensor through the MPFI ECU and the transmission vehicle speed sensor. The ignition switch provides power for the system, while the battery provides power for the memory. The diagnostic test mode connectors are also an input to the control unit.

The control unit sends signals to the reaction control solenoid valve located on the pinion assembly housing and to the steering system warning lamp located on the dash to the left of the steering wheel.

Reaction Mechanism

Solenoid Pinion Assembly

The reaction solenoid valve controls the amount of hydraulic power assist to the rack. The valve is mounted to the pinion housing. The valve is controlled by the steering system ECU output signal based upon vehicle and engine speed input to the ECU. The solenoid valve functions on a duty ratio to control the power assist.

A high duty ratio means the solenoid activation period is longer and low fluid pressure is supplied to the pinion reaction chamber. More assist pressure is supplied to the system, to reduce driver steering effort.

Conversely, a low duty ratio means a shorter solenoid activation period and high fluid pressure is provided to the pinion reaction chamber. Less assist pressure is supplied to the system, increasing the driver steering effort.

When there is zero duty ratio, such as a disconnected solenoid harness, maximum pressure is supplied to the pinion reaction chamber. This results in minimum assist pressure to the system and maximum driver steering effort.

Vehicle Speed Sensitive Steering

Reaction Mechanism Components/Operation

The pinion assembly functions similar to previous Subaru systems with the addition of a reaction mechanism (located between the brackets).

The reaction mechanism components are:

- Reaction piston assembly,
- Steel balls,
- Pinion output shaft and torsion bar,
- Pinion input shaft with rotary valve.

During normal operation, such as straight ahead driving, the duty ratio is low and the pressure to the reaction piston is high. The piston holds the steel balls in the grooves of the input shaft reaction arm, allowing for less torsional twist of the torsion bar. This decreases the pressure flow to the system, which decreases the power assist to increase driver steering effort.

A high duty ratio during low vehicle speeds provides low pressure to the reaction piston. The piston allows the steel balls to move in the grooves of the input shaft reaction arm. This allows more torsional twist of the torsion bar, which increases the pressure flow to the system and increases power assist to decrease driver steering effort.

Failsafe operation is dependent upon the type of failure, i.e., the reaction solenoid, sensor signal failure, or steering system ECU. The control unit discontinues the duty signal to the reaction solenoid. This results in high reaction chamber pressure and the power assist is fixed at the minimum level.

Test Connectors

The system has three diagnostic modes:

- *D-Check*
- *Read Memory*
- *Clear Memory*

The trouble codes are displayed by the STEERING light.

To access the D-Check mode:

- Connect a ground wire to the test mode connector terminal #5, then start the engine.
- Move the vehicle at least 31 feet and then remove the ground wire from terminal #5.
- Read the codes emitted by the steering system warning lamp.

To access Read Memory:

- Connect the ground wire to test mode connector terminal #6.
- Start the engine and then remove the ground wire from terminal #6.
- Read the codes emitted by the steering system warning lamp.

To Clear Memory:

- Turn the ignition switch off.
- Connect a jumper wire to terminal #5 and #6
- Start the engine and remove the jumper wire from terminal #5 and #6. Confirm that the memory is clear.

Trouble Codes

The diagnostic trouble codes are:

1 = Reaction solenoid circuit: shorted,
2 = Reaction solenoid circuit: open,
3 = Vehicle speed sensor fault,
4 = Memory back-up circuit fault,
5 = Engine speed signal fault,
Constant Flashing = System okay.

Note: Always refer to the appropriate model year service manual Section 4-3 troubleshooting procedure section when performing self diagnosis.

Notes and Cautions

Steering Column Removal

Always refer to the appropriate model year Subaru Service Manual and follow the procedure for removal of the SRS "Airbag" Module prior to any repair and servicing or removal of the steering wheel and steering column from all airbag equipped Subaru vehicles.

Always disconnect the U-bolts before loosening the column mounting bolts.
Disconnect the wiring harness connectors before removing the column.
Remove the XT column carefully to avoid damaging the meter and instrument panel.

Steering Gearbox Overhaul

- Do not crimp the pipes.
- Do not scratch the rack or the cylinder.
- Do not clog the air passages with grease.
- Coat the seal and bushings with ATF fluid before installing them.
- Install the seals with their lips toward the pressure area.
- Use the correct special tools.

Airbag Steering Column Installation

Review the roll connector phasing procedures listed in the appropriate model year service manual, Section 4-3.

The roll connector must be phased to the steering system only when the front wheels are centered.

Align the inner "center" indicator on the rotating cover (next to window) with the arrow on the connector case.

Complete the following alignment adjustments when the inner indicator in the window shows:

- 1R - rotate cover one full rotation to the right
- 2R - rotate cover two rotations to the right
- 1L - rotate cover one full rotation to the left
- 2L - rotate cover two rotations to the left Use the guide pins to align the roll connector with the steering wheel.

The SVX tie-rod dust boots require special servicing procedures because the rack tie-rod dust boots are one time use only. Cut the small end of boot to remove the boot. Always replace the boot if removed. The boot uses a wire tie on the large end of the boot.

The left side (pinion side) tie rod has a groove next to the boot clamp groove. The right side does not have a groove.