SUBARU®

Confidence in Motion

Technician Reference Booklet

Steering Suspension, Axles and Wheels

AUTOMOTIVE YES Youth Educational Systems® PROUD PARTNER

ASE WE SUPPORT PROFESSIONAL CERTIFICATION THROUGH THE National Institute for AUTOMOTIVE SERVICE EXCELLENCE

SU SUBARU UNIVERSITY

May 2017

MSA5P0173C

05L301002I

This Technician Reference Booklet (TRB) is designed to be used in a classroom environment or as a guide for self study.
The TRB is not intended to be used as a supplement or substitute for the Subaru Service Manual. Always consult the appropriate Service Manual when performing any diagnostics, maintenance or repair to any Subaru vehicle.

Table of Contents

INTRODUCTION AND OPERATION **7**
Power Steering 7
Outline of the Steering System 7
Pinion Shaft........ 7
Rack Shaft 7
STEERING CONSTRUCTION **8**
Rack and Pinion........ 8
Steering Gear Ratio 8
Variable Gear Ratio (VGR) Power Steering 9
While driving straight ahead:........ 9
While turning: 9
Steering Column 9
Tilt Steering........ 9
Energy-Absorbing Mechanism........ 10
Ripping Plate System........ 10
Expand Plate System 10
Impreza........ 11
Airbag Steering Column Installation........ 12
POWER STEERING........ **13**
Power Steering System Overview........ 13
Oil Pump 13
Control Valve 13
Power Cylinder 13
Oil Pump 14
Oil Pump Operation........ 15
Flow Control Valve Operation........ 15
Pressure-Sensitive Valve........ 16
Relief Valve 18
Control Valve........ 19
Control Valve Operation 20
When the steering wheel is in the center position........21
When the steering wheel is turned to the right........22

POWER STEERING SYSTEM PRESSURE TESTING 23
Power Steering Pressure Test 24
STEERING RACK OVERHAUL 25
Notes and Cautions 35
Steering Column Removal 35
Steering Gearbox Overhaul 35
ELECTRONIC POWER STEERING 36
Introduction 36
Component parts include: 36
Resolver 39
Torque Sensor 46
EPS Motor Construction 51
Basic operation 53
3 phase explanation 53
Motor Operation 55
EPS Assist Limit Logic 58
Counter Electromotive Force 58
Repair 58
Diagnostics 59
2015 LEGACY AND OUTBACK ELECTRIC POWER STEERING (EPS).......... 62
Major Changes 62
Electric Power Steering Circuit 63
Drive Motor 64
Resolver Sensor 65
Torque Sensor 66
Magnetic Ring 66
Flux Rings 67
Flux Collecting Rings 67
Flux Collecting Yoke 68
Flux Collecting Yoke 69
Alignment Collar 70
Diagnostics 71

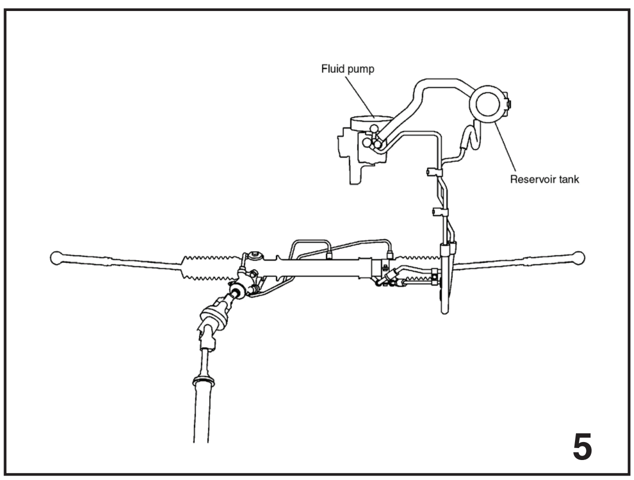
FORCES WORKING ON AN AUTOMOBILE 74
Suspension 74
Factors Affecting Handling and Stability 74
Camber 75
Function of Camber 75
Kingpin Angle 76
Purpose of Kingpin Angle 76
Caster Angle 77
Function of Caster Angle 77
Purpose of Toe-in 77
Thrust Line 78
Suspension 78
FRONT AND REAR SUSPENSION 80
Front Strut Type Suspension 80
Dual Link Strut Type Suspension 80
Multi-Link Suspension 81
COIL SPRING AND SHOCK ABSORBER 84
Shock Absorber Function and Characteristics 85
TIRES 86
Relationship of Tires and Suspension 86
Incorrect Camber 86
Incorrect Caster 87
Incorrect Toe-in 87
Loose or Damaged Suspension Parts 87
Abnormal Tire Wear 88
Tire Pressure Monitoring System 89
Transmitter Operation 90
Malfunction Judgment Conditions 90
Tire Pressure Monitoring Systems 95
SUSPENSION AND SUB FRAME 2010MY~2014MY 98
Transmission Removal 108
2015 LEGACY AND OUTBACK ENGINE SUPPORT BRIDGE 111

INTRODUCTION AND OPERATION

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

Power Steering

A large force is required to operate the steering when a vehicle is stopped. As the vehicle speed increases, a smaller force is required to operate the steering. In other words, a very large force is required to operate the steering wheel when the steering wheel is turned while the vehicle is stopped. Power steering provides an extra force making it possible to steer the vehicle with the same force regardless of the vehicle speed.



Pump and Rack

Outline of the Steering System

The three main elements of the vehicle are driving, turning and stopping. Steering controls the element of turning.

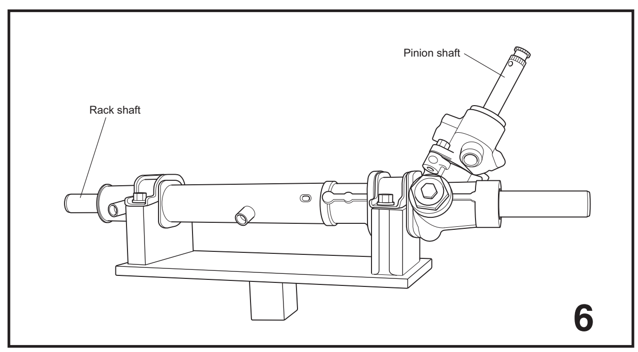
Normally, vehicles are designed to drive straight ahead when the steering is not operated. When turning a corner or changing lanes, the direction of the tires must change and the vehicle must turn. Using a rack and pinion, the steering converts the force exerted by the driver on the steering wheel to a laterally directed force, and at the same time it boosts the force so that the vehicle can turn.

Pinion Shaft

The function of the pinion shaft is to transmit the steering wheel turning force to the rack, causing it to operate.

Rack Shaft

The rack shaft converts the rotational force of the pinion shaft to the lateral force, changing the direction of the wheel. It also functions to boost the steering force according to the ratio between steering wheel diameter and pinion diameter.

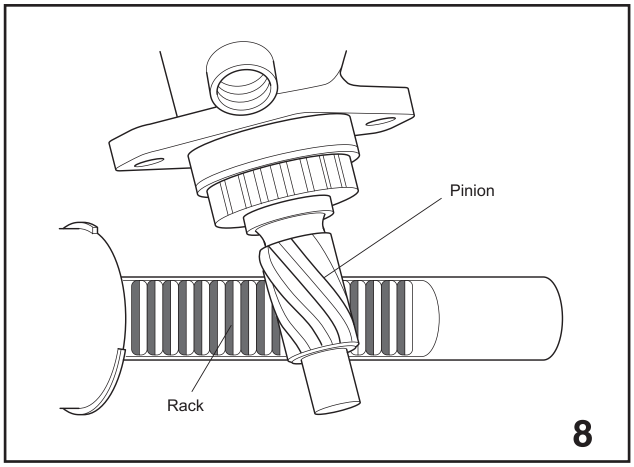


Rack Mounted on Holding Tool

STEERING CONSTRUCTION

Rack and Pinion

A rack-and-Pinion steering gear has a pinion installed on the end of the steering shaft. The pinion is meshed with a rack therefore the rotation of the pinion is converted to lateral movement of the rack, which moves the left and right wheels.



Pinion and Rack Gears

Steering Gear Ratio

NOTE: In the rack-and-pinion steering system, the gear ratio cannot be calculated with the rack treated as a straight line (because the gear ratio would be infinitely large). Accordingly, the steering angle ratio is from this point forward described as the gear ratio.

The steering gear ratio indicates the angle of the tires when the steering wheel is turned. For example, if one rotation of the steering wheel (360°) corresponds to a tire angle of 20°, then 360 ÷ 20 = 18.

THE NUMBER IN THIS EXAMPLE 18 represents the steering gear ratio.

As the steering gear ratio increases, the steering effort diminishes, as does the shock imparted to the steering wheel from the wheels, but the wheel response deteriorates. As the steering gear ratio decreases, conversely, the steering effort increases, but the wheel response improves, making a highly sensitive steering operation.

Variable Gear Ratio (VGR) Power Steering

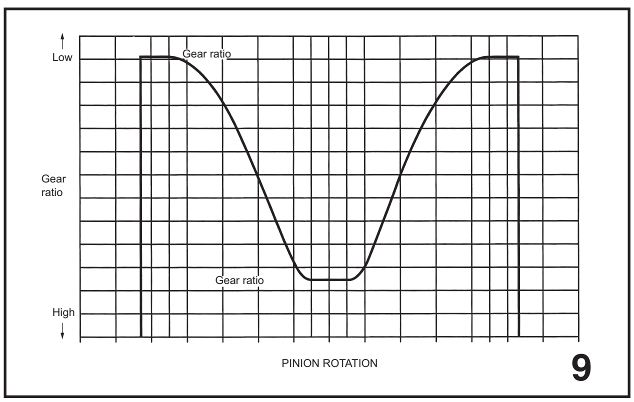
Certain vehicle models use a VGR type rack and pinion. With the VGR system, the gear ratio is varied dependent on steering wheel turning angle.

While driving straight ahead:

A larger gear ratio is used to alleviate kickback and other adverse effects that occur while the vehicle is in motion. Road handling characteristics are also improved because the driver's body movements are not readily imparted to the steering.

While turning:

Steering response is improved because the gear ratio becomes smaller as the turning angle increases.



Pinion Rotation Chart

In the VGR system the angle of the gear equipped on the rack is varied, causing the pinion and gear contact point to vary. The gear is set on the rack so that the gear thickness increases as the gear moves away from the center of the rack. As the steering wheel is turned to the left or right, therefore, the gear ratio becomes correspondingly lower.

This means that the rack moving speed at both ends is larger than that of the center part.

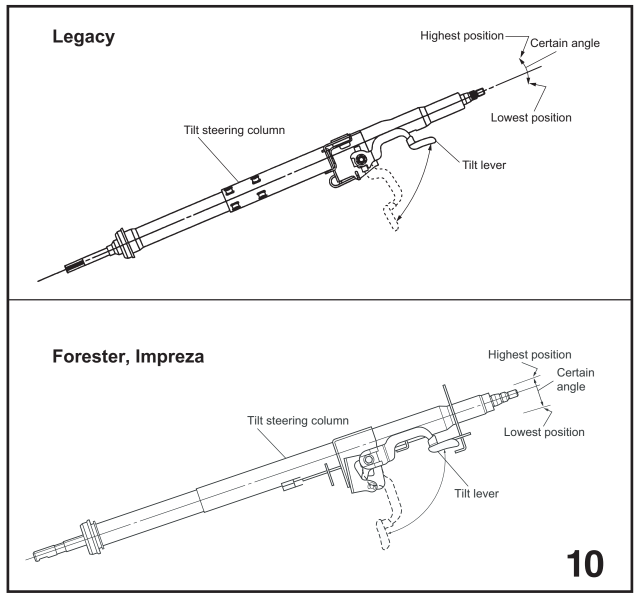
Accordingly, the gear ratio at both ends becomes smaller than that of the center part.

Steering Column

Tilt Steering

Tilt steering is an aid to safe driving, for it allows the driver to adjust the steering wheel position to suit his or her height and physique.

The steering wheel position is adjusted by moving the tilt lever downward, thereby releasing the steering wheel and allowing it to be raised or lowered within a certain range. The steering wheel can then be locked in position by operating the tilt lever again.



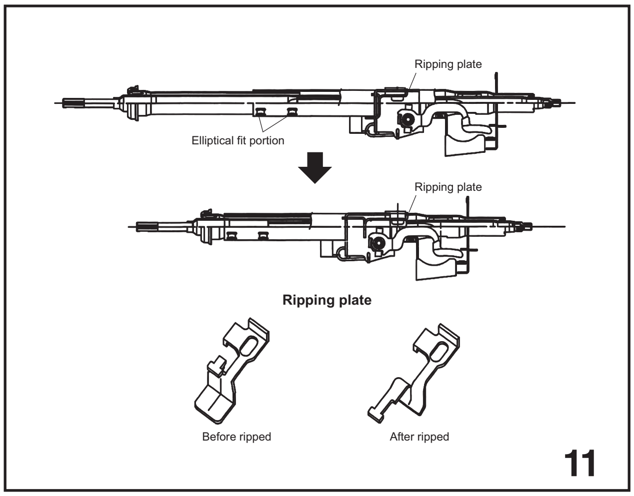
Steering Columns

Energy-Absorbing Mechanism

An energy-absorbing mechanism is provided to protect the driver during a collision when his or her body comes into contact with the steering wheel because of inertia.

Ripping Plate System

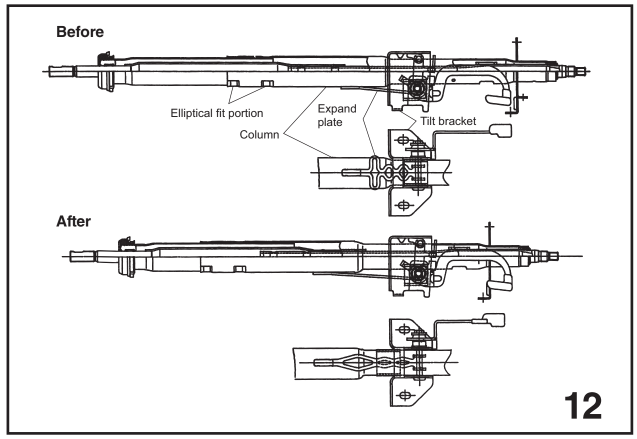
In the ripping plate system, the plate is set on a part of the tilt lever. When a collision occurs and the driver comes into contact with the steering wheel, the ripping plate breaks, causing the steering shaft to shorten, protecting the driver.



Ripping Plate System

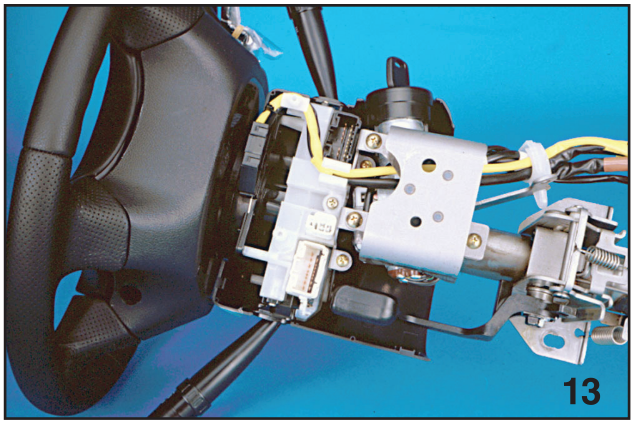
Expand Plate System

In the expand-plate system, the plate expands when the driver comes into contact with the steering wheel during a collision. This causes the steering shaft to shorten, protecting the driver.

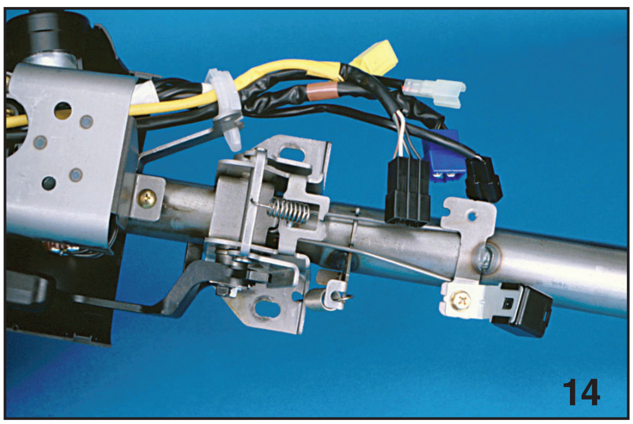


Expand Plate System

Impreza



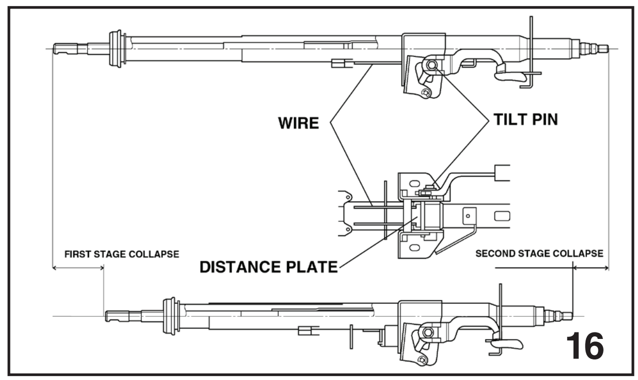
Impreza Steering Column



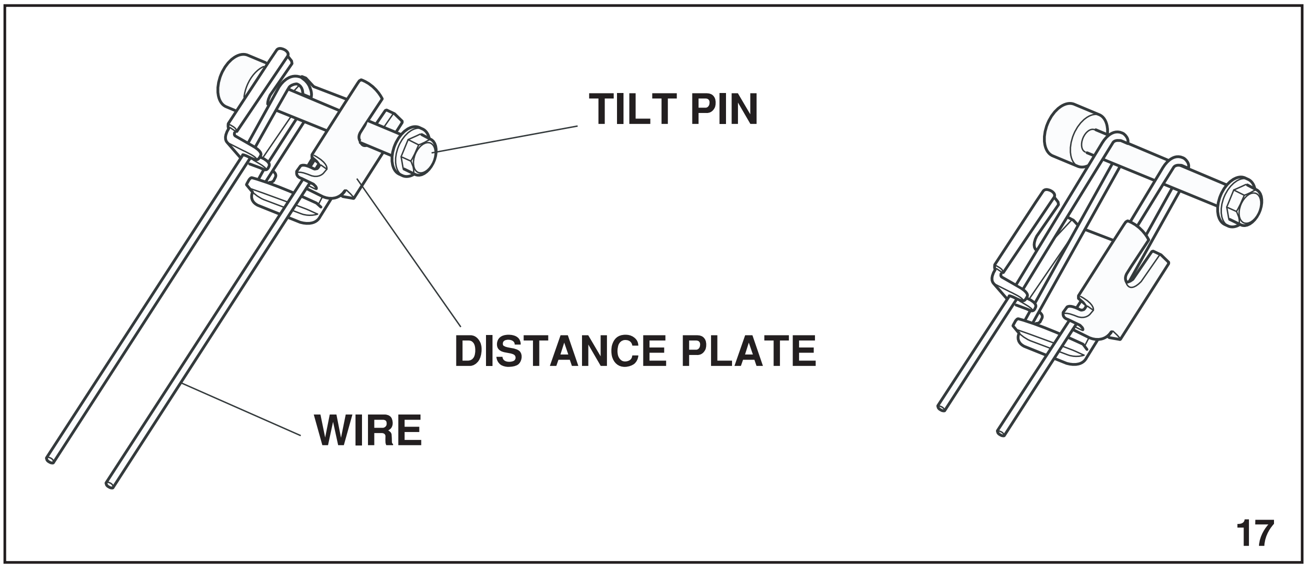
Energy Absorbing Wire

All 2002 and newer Impreza vehicles are equipped with a 2-stage energy absorbing steering column. The 2nd stage action is possible because of the use of an energy absorbing wire and mount. During the first stage collapse the lower section of the column slides into the outer section or jacket of the column. If a secondary force is applied to the upper part of the column, the energy absorbing wire will begin to stretch allowing the column and the steering wheel to move toward the dash.

Collapsible Steering Column



Before and after collapse



Energy Absorbing Wire Operation

While this secondary collapse is occurring the column moves away from the mount and is supported only by the energy absorbing wire. The amount of secondary collapse will be in proportion to the energy contained in the secondary force.

Airbag Steering Column Installation

Review the roll connector phasing procedures listed in the appropriate MY Service Manual.

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

POWER STEERING

Power Steering System Overview

The power steering is comprised of the oil pump, the control valve, and the power cylinder.

Oil Pump

Driven by the engine, the oil pump generates the oil pressure that operates the power cylinder, while the flow control valve built in the pump controls the oil flow rate.

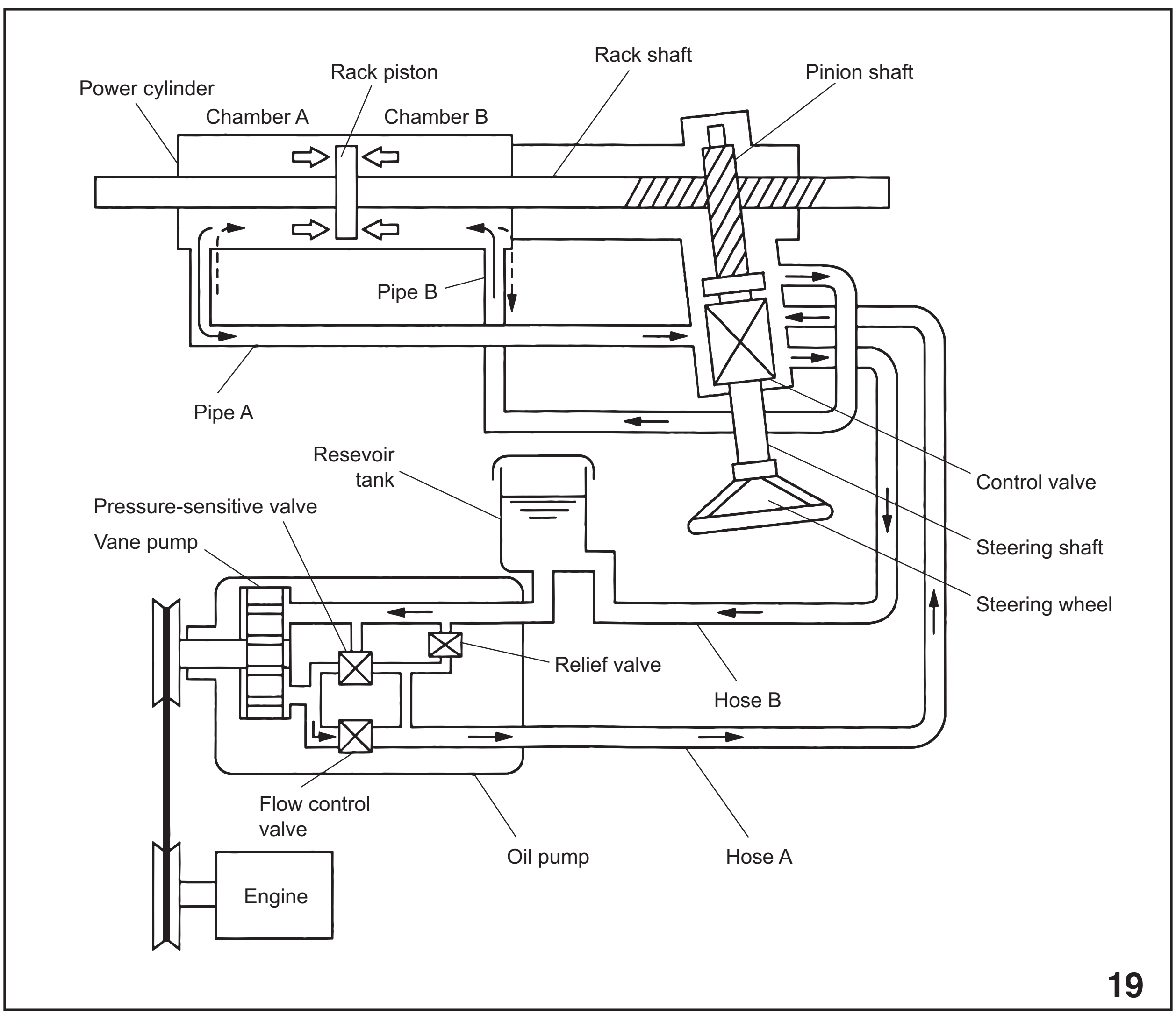
Control Valve

The control valve directs the oil to the left or right power cylinder.

Power Cylinder

The power cylinder is comprised of a piston installed on a rack shaft and cylinder, and it is operated by the oil pressurized by the oil pump.

The oil pressurized by the oil pump is fed through the flow control valve to the steering gearbox, and afterwards it is returned to the reservoir tank.

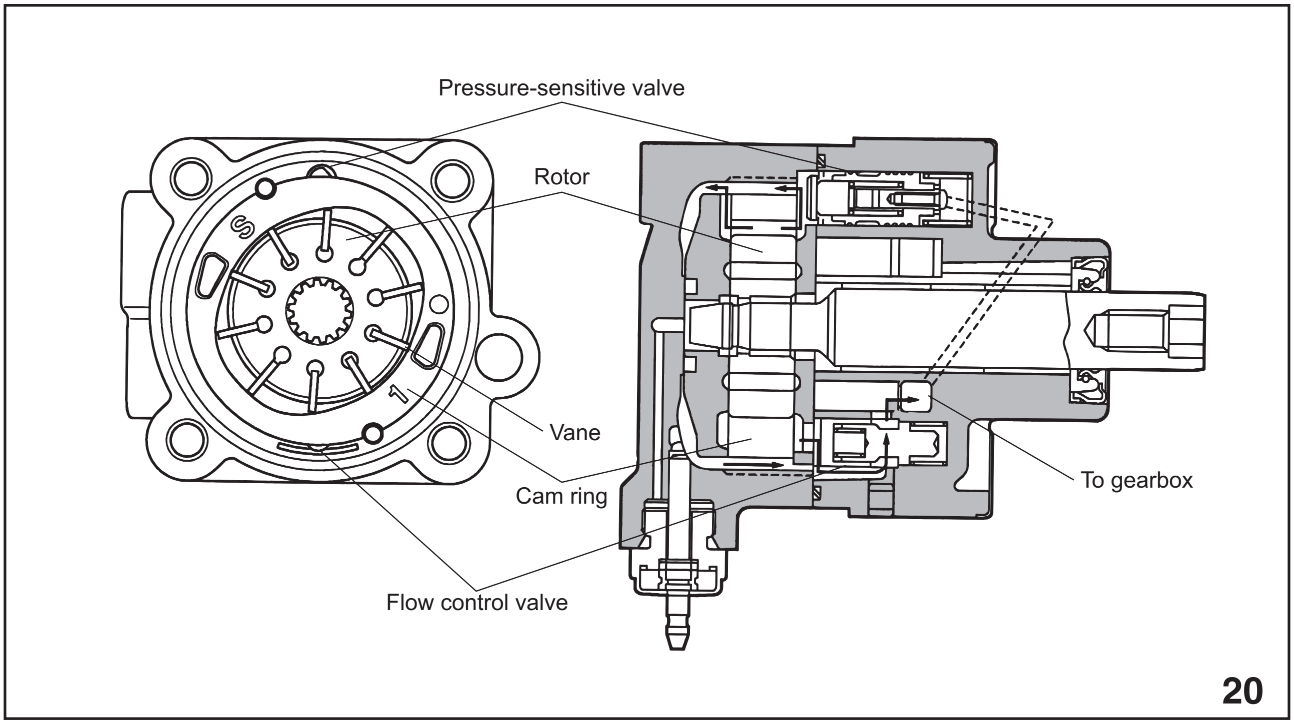


Hydraulic Layout

Oil Pump

The oil pump is driven by the engine by means of a belt. It is a vane-type pump comprised of a rotor, cam ring, and 10 vanes.

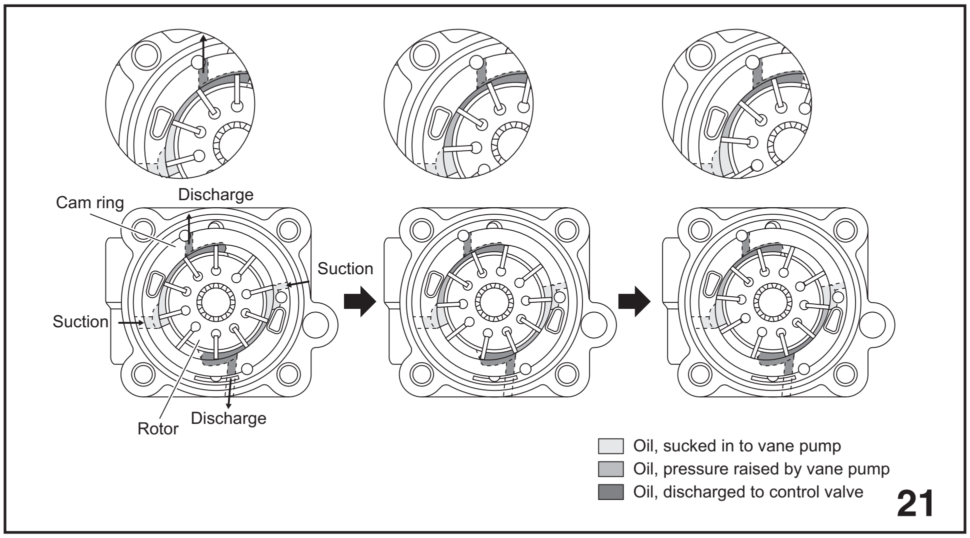
In addition, a flow control valve, pressure-sensitive valve, and relief valve are provided to control the oil pressure.



Power Steering Pump

Oil Pump Operation

When the oil pump rotor is turned by the engine, the vanes which fit into each groove of the rotor are pushed outward by the centrifugal force of the rotor and press against the cam ring. Because the cam ring is shaped oval to the rotor, a negative pressure is created in the pump suction port that draws in oil, and a pressurized oil is created on the discharge side that is forced out of the discharge port.

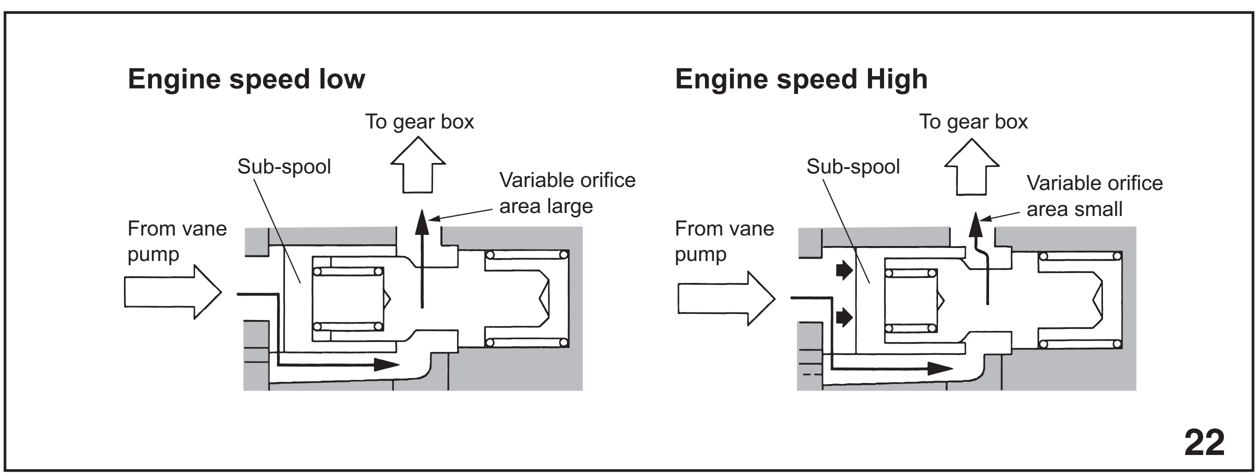


Power Steering Pump Operation

Flow Control Valve Operation

In order to obtain a small steering effort at low speeds and obtain a large steering effort at high speeds, this valve suitably controls the flow rate of working fluid to the gear box out of the pump discharge port which increases in proportion to the pump speed.

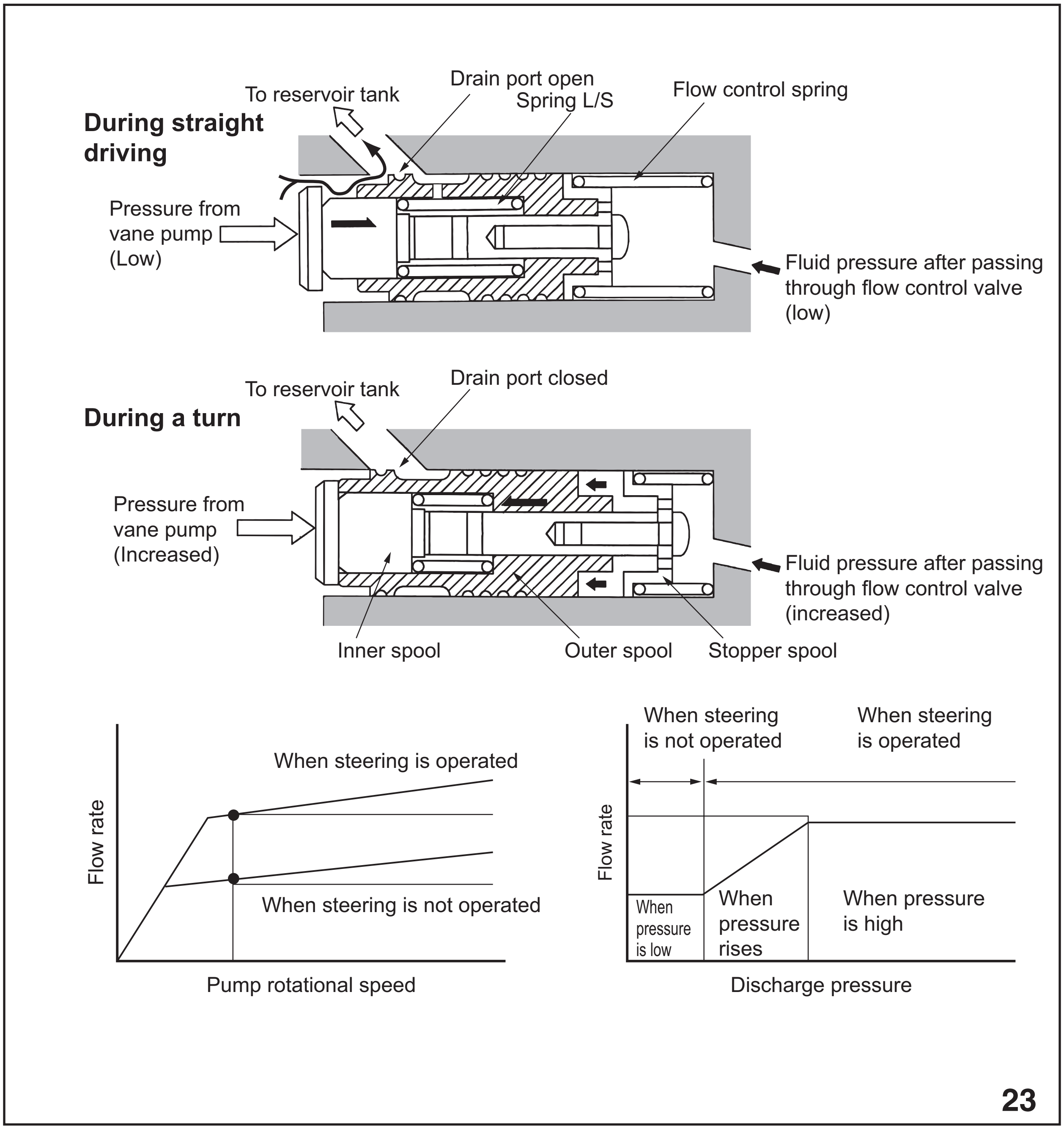
A sub spool is installed inside the flow control valve. When the oil pump discharge rate, overcomes the force of a spring in the sub spool, the sub spool moves to the right, reducing the width of the oil channel to the gearbox, controlling the oil flow rate.



Flow Control Valve Operation

Pressure-Sensitive Valve

This valve prevents energy loss by reducing the oil flow rate to the control valve and lowering the pressure losses in the system (piping, gearbox, and pump) when the steering is not operated (during low-pressure conditions).



Pressure-Sensitive Valve Operation

<table>
<tr><th></th><th colspan="2">Steering</th><th>Drain port</th><th>Oil flow rate</th><th>Pump power consumption</th></tr>
<tr><td>When pressure is low</td><td colspan="2">When steering is not operated</td><td>Large</td><td>Low</td><td>Small</td></tr>
<tr><td>When pressure increases</td><td rowspan="2">When steering is not operated</td><td>Valve opearation starts</td><td>Medium</td><td>Medium</td><td>Medium</td></tr>
<tr><td>When pressure is high</td><td>Valve opearation ends</td><td>Small</td><td>High</td><td>Large</td></tr>
</table>

1. **When pressure is low (steering is not operated)**

   When the steering is not operated, the oil pressurized by the oil pump simply passes through the control valve, so the oil pressure does not rise. At the same time, the drain port is widely opened because the pressure sensitive valve outer spool is pushed against the stopper spool by the spring L/S.

   Since the flow control spring set load is low, this causes the oil pressure produced by the vane pump to drain away, reducing the pressure difference at the front and rear of the spool assembly and the discharge flow rate to the control valve.

2. **When pressure increases**

   When the steering wheel is turned to the left or right, the control valve is also turned and passage to the reservoir tank is closed. Therefore, oil pump discharge pressure increases.

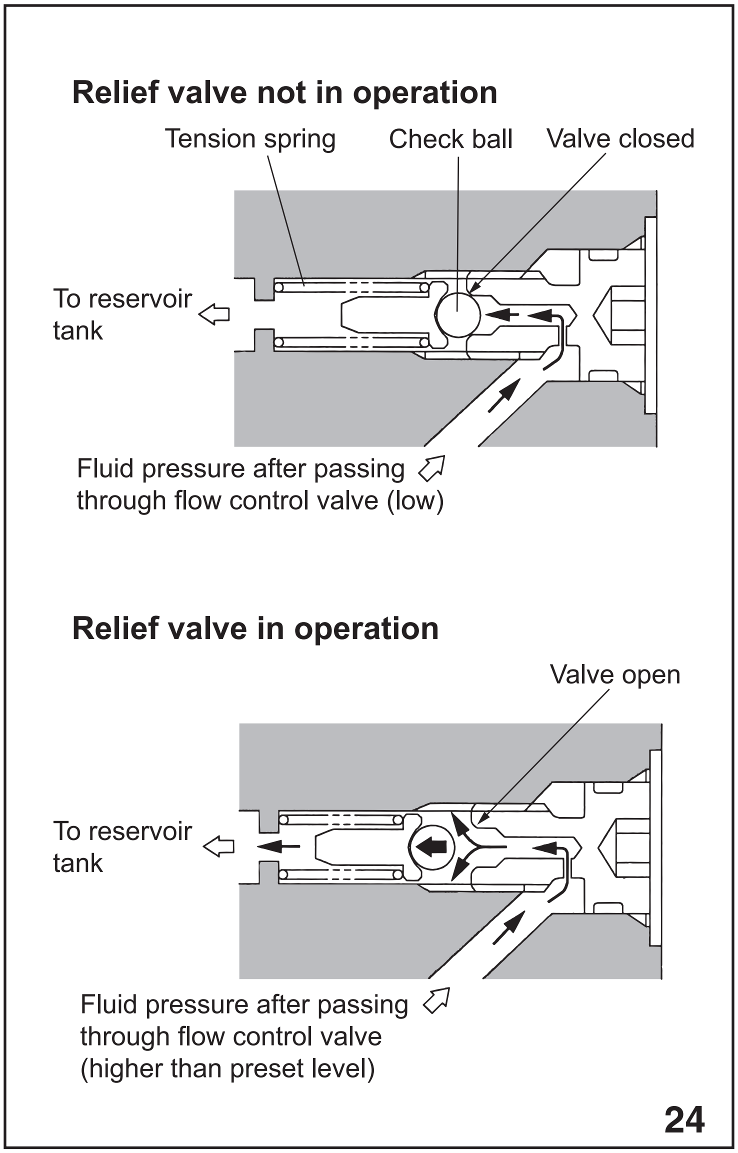
3. **When pressure is high**

   At high pressure conditions the outer spool contacts the inner spool front end and the two parts work in unison, keeping the oil flow rate at maximum.

Relief Valve

The relief valve is comprised of a tension spring and check ball. Oil pressure from the flow control valve is applied to the right side of the relief valve, and the left side is connected to the oil reservoir tank.

During normal operation, the check ball inside the valve is pushed to the right side by the spring force, and the valve is closed. When the oil pressure from the flow control valve rises abnormally (when the steering wheel stays locked, for example), the oil pressure overcomes the spring force and moves the check ball to the left, opening the valve and allowing the oil pressure to escape into the reservoir tank preventing the pressure from being excessive. When the oil pressure from the flow control valve drops afterwards, the spring force closes the valve again.

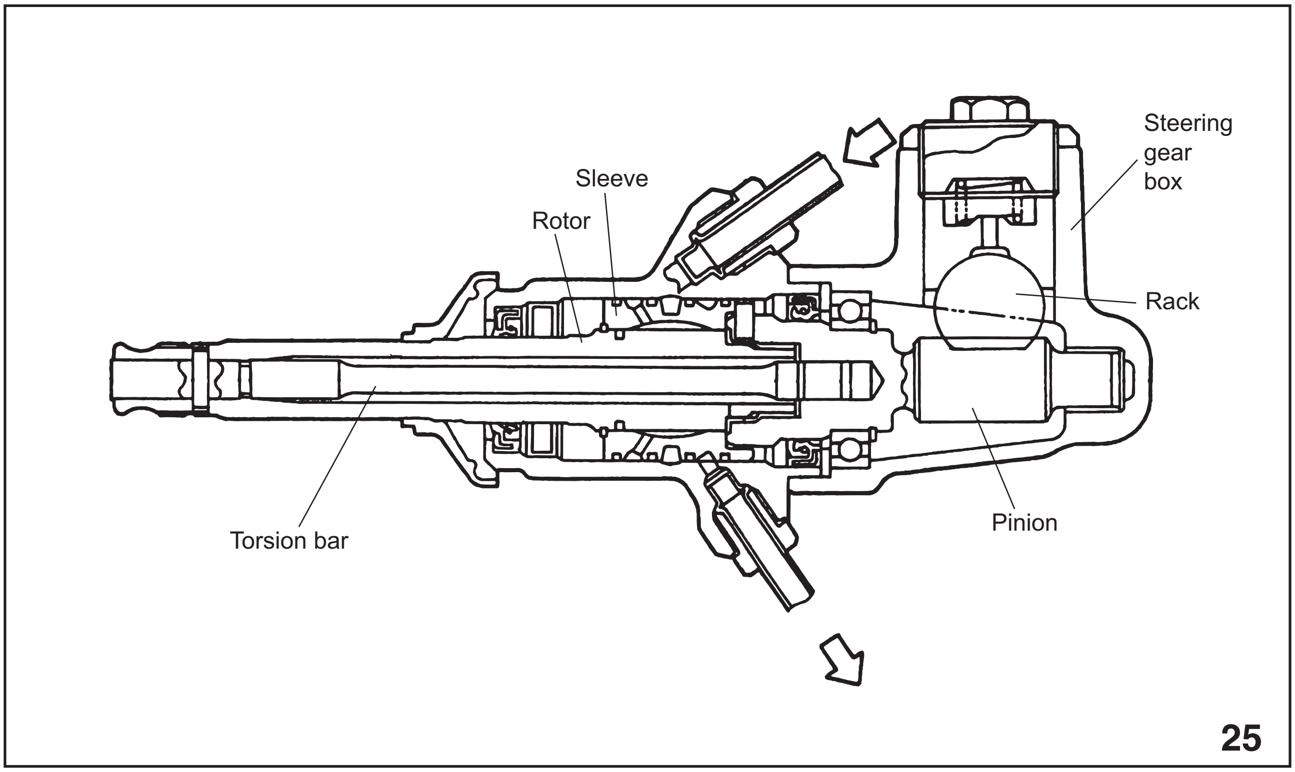


Relief Valve Operations

Control Valve

The control valve consists of a rotor, which rotates together with the steering shaft, and a pinion that rotates together with the sleeve and the torsion bar. The pinion and rotor are loosely engaged with a spline, and the torsion bar which is twisted by the turning force applied to the steering wheel connects them. This generates a relative displacement of the rotor and sleeve and thereby increases or decreases the oil channel cross-sectional area and controls both the change over of the working fluid channel and the working pressure.

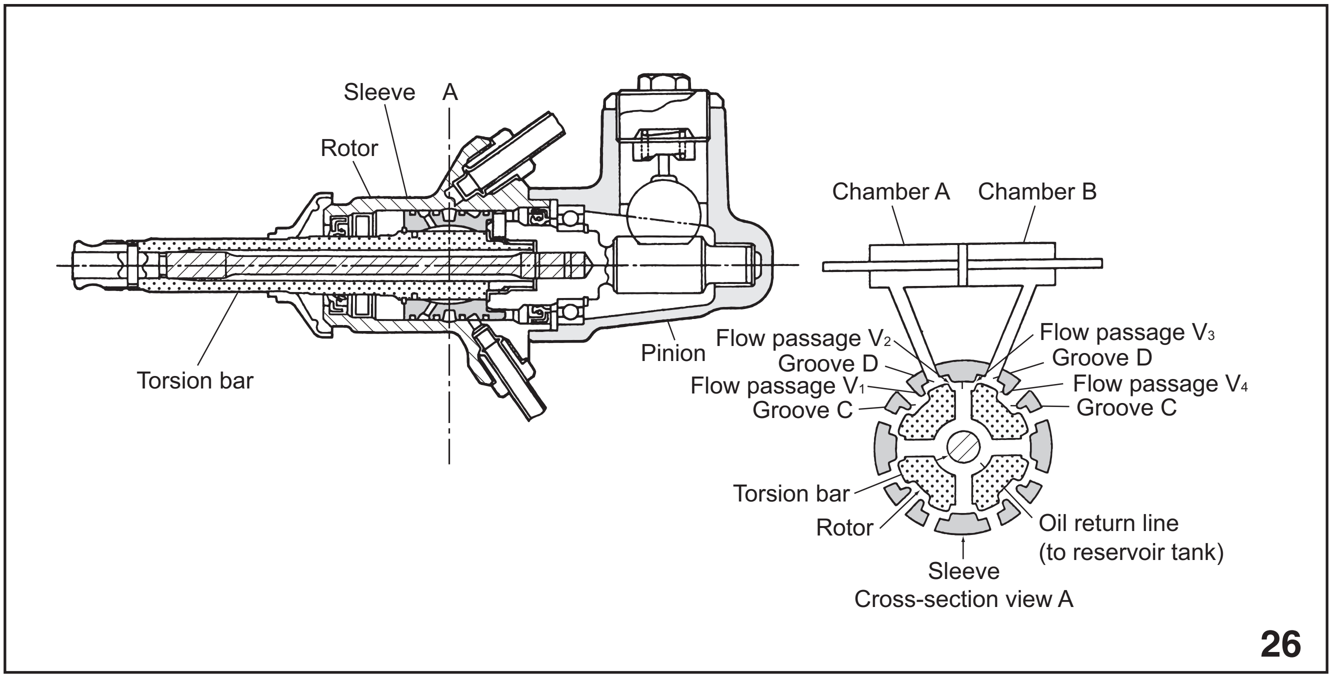
When oil pressure is not produced due to oil pump breakdown, drive belt damage, or other cause, torque is directly transmitted from the valve rotor through the spline to the pinion.



Control Valve

Control Valve Operation

When the steering wheel is turned to the left or right and the torsion bar twists due to resistance with the road surface, the rotor connected to the steering shaft turns, simultaneously switching between the oil channels to chambers A and B and those from chambers A and B to the reservoir tank.

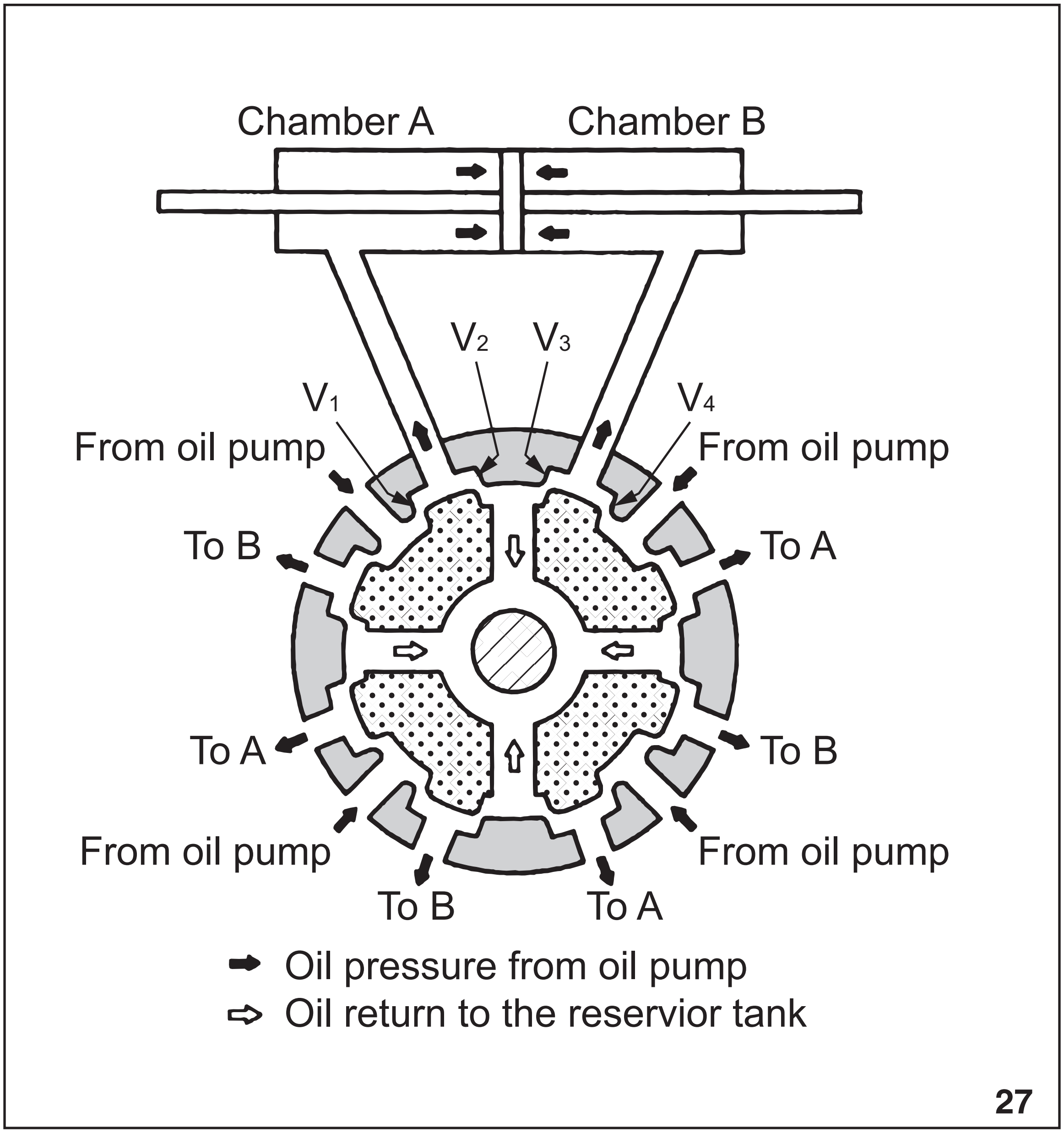


Control Valve Operation

When the steering wheel is in the center position

The torsion bar is not twisted since the steering wheel is in the center position. The rotor and sleeve are in their center positions and oil channels V1, V2, V3, and V4 have a uniform width. The oil pressure applied to chambers A and B is equal and the steering maintains straight-ahead travel; afterwards, the oil is returned to the reservoir tank.

In this situation, the channel V_1, V_2, V_3, and V_4 are opened widely and oil from the oil pump is drained to the reservoir, keeping oil pressure at a low level.

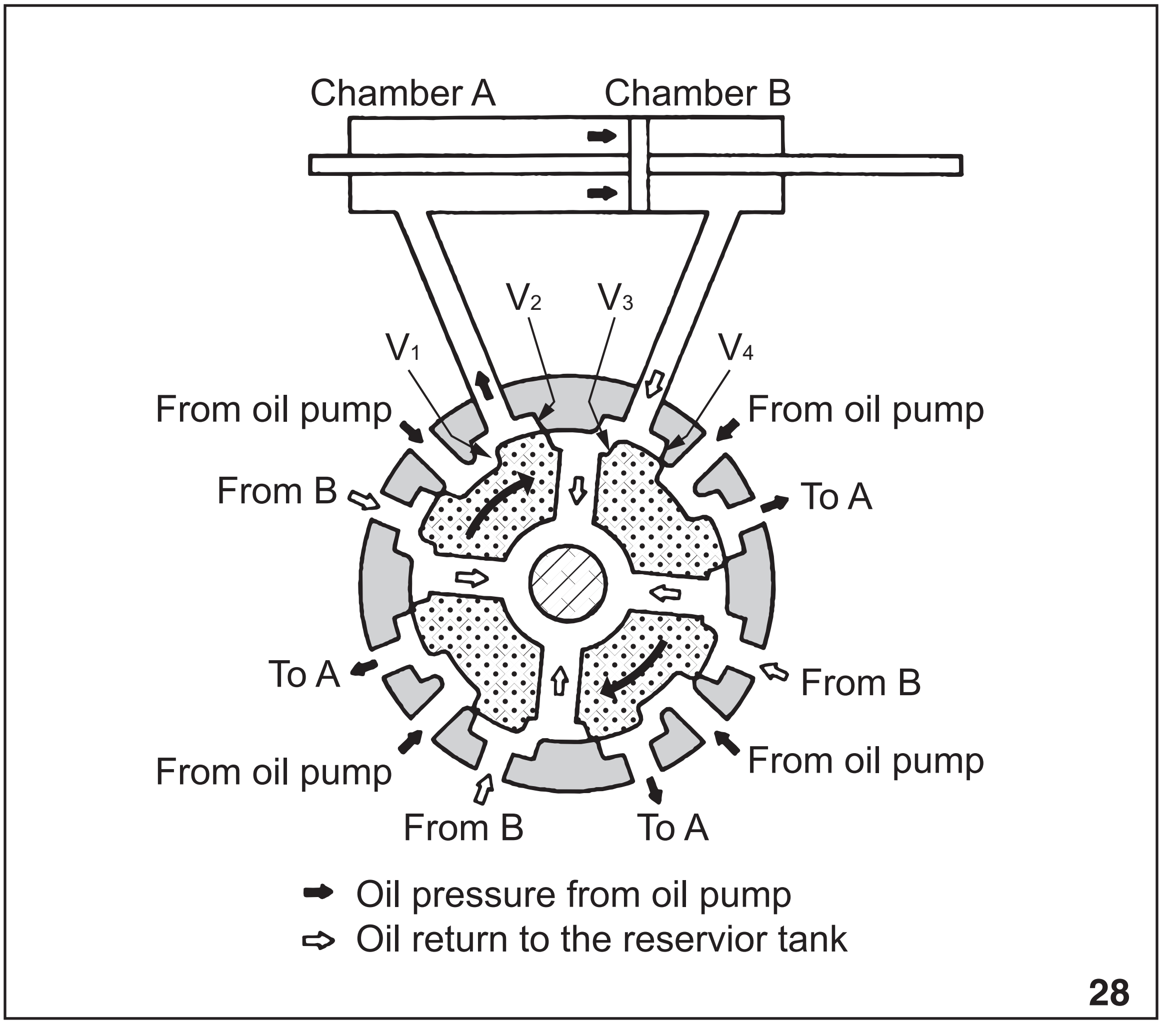


Center Position

When the steering wheel is turned to the right

As the steering wheel is turned to the right, the twisting of the torsion bar causes the rotor to move, connecting oil channels V1 to V2, and V3 to V4 and increasing the width of channels V1, and V3.

The oil pressurized by the oil pump then enters chamber A, passing through oil channel V1, while the oil in chamber B is pushed by the piston and returned to the reservoir tank via oil channel V3. This reduces the steering effort and makes it easier to turn the steering wheel to the right. As is evident from the figure, the channels V2 and V4 are closed and there is no way that oil from the oil pump return to the reservoir tank, therefore oil pressure from the oil pump increases to the necessary level to move the rack piston.



Turning to the right

NOTES:

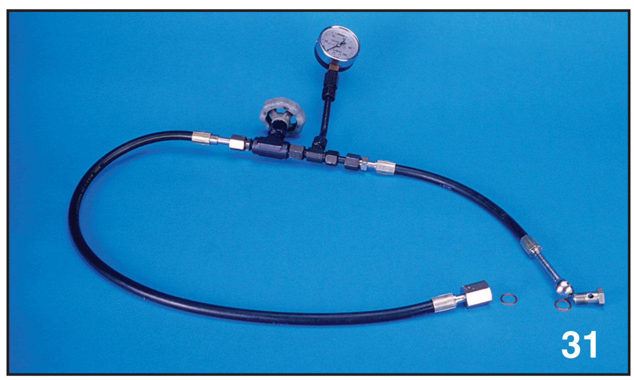
POWER STEERING SYSTEM PRESSURE TESTING

Pressure Gauge

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

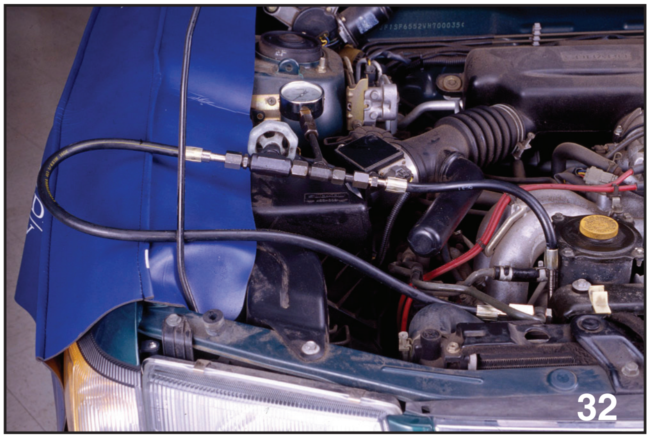
ALWAYS WEAR EYE PROTECTION

1. Do not leave the pressure gauge valve closed for more than 5 seconds; doing so may damage the pump.
2. Do not hold the steering wheel in the full lock position for longer than 5 seconds; this may damage the pump.
3. Keep the engine speed at idle.
4. Handle ATF fluid carefully; catch spilled fluid with shop cloths to prevent damage to the vehicle's finish.



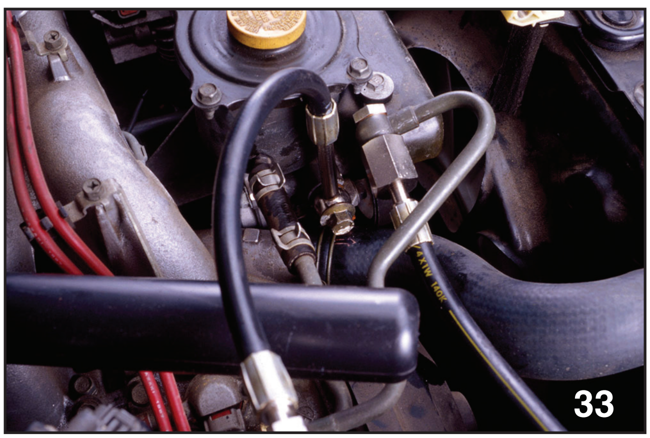
Pressure Gauge with Adapters

Power Steering Pressure Test

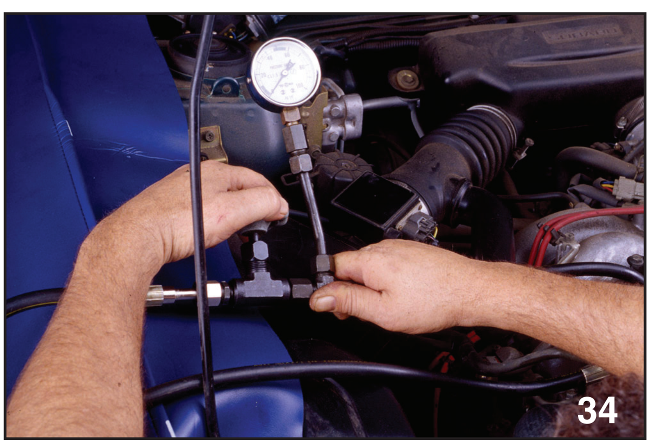


Gauge in place

Attach pressure gauge using the correct hoses to the discharge port of the pump.



Connections at Pump



Opening/Closing Valve

Then perform the three pressure tests listed.

Step 1: Regular pressure
Engine idling,
valve open:

↓

OK Not OK → Crimped Fluid line → Replace
→ Leaking fluid line → Tighten or replace
→ Clogged fluid line → Drain or replace

↓

Go to step 2

↓

Step 2: Relief pressure

Engine idling,
valve closed

↓

OK Not OK → Faulty relief valve
→ Oil pump leak → Replace
→ Worn pump

Go to step 3

Step 3: Working Pressure

Engine idling,
valve open,

steering wheel
turned stop to stop:

↓

OK Not OK → Faulty control valve → Replace

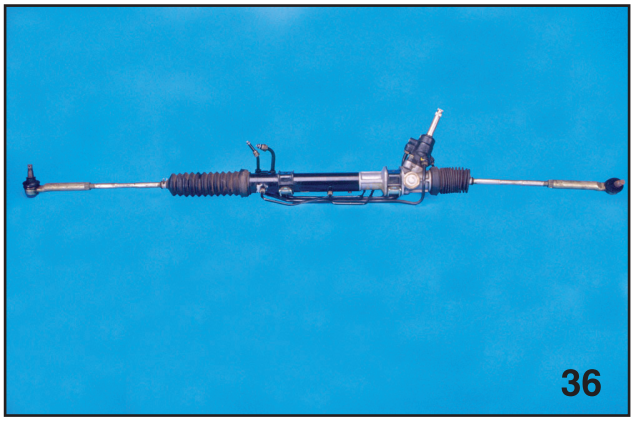
↓

Yes

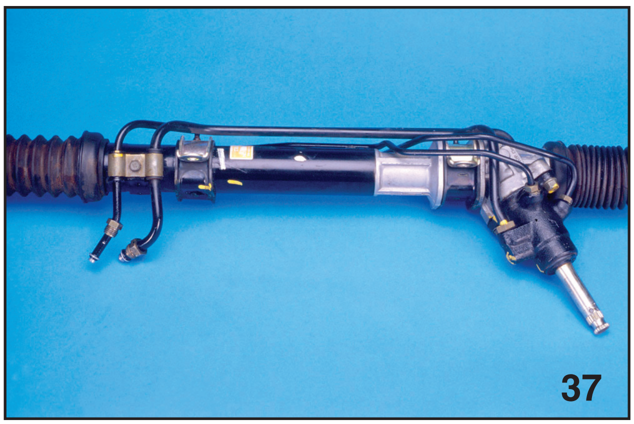
↓

System OK

STEERING RACK OVERHAUL



Rack

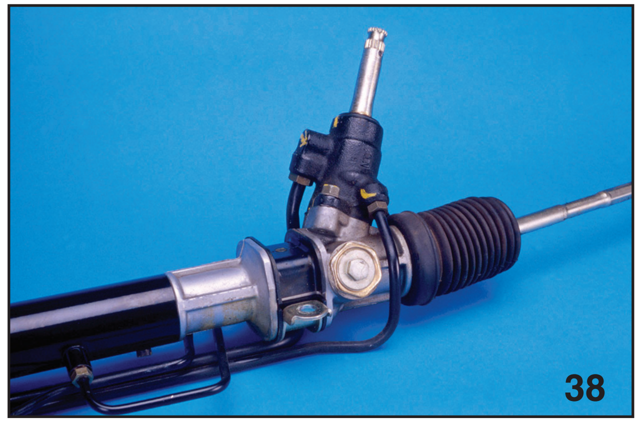


Pipe Routing

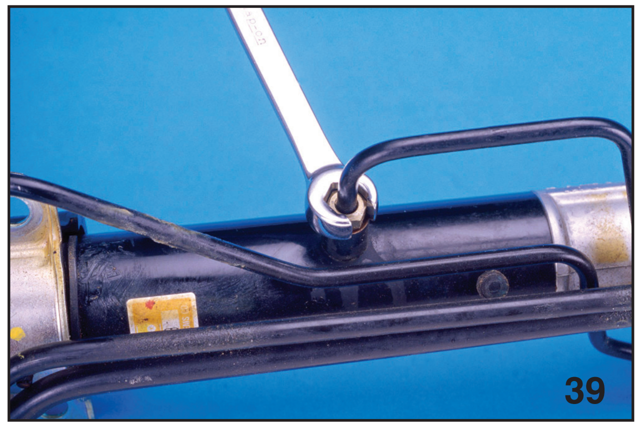
1. 2002 Legacy rack and pinion

Note: **Refer to the Subaru Claims Policy and Procedure Manual for details on steering racks that are eligible for repair.**

Note: **The following procedure is to serve as an example of steering rack overhaul. Follow the procedure in the appropriate Subaru Service Manual (on STIS) for the model year being repaired.**

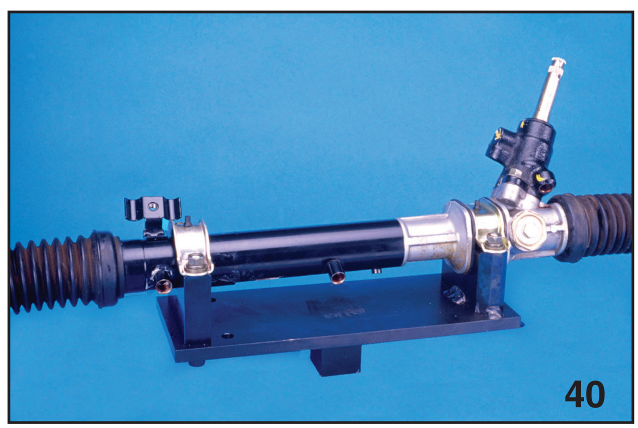


Control Valve Connections



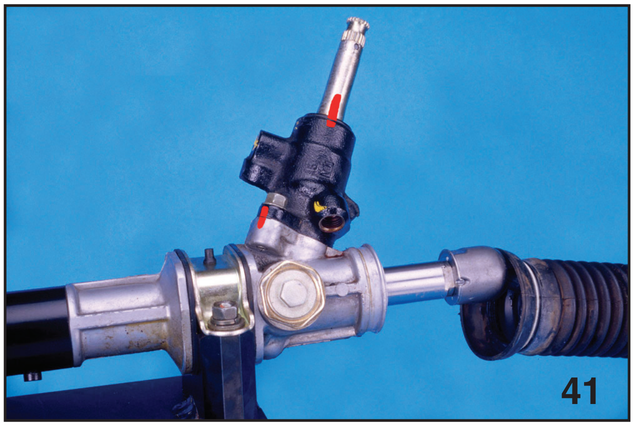
Rack Connections

2. Remove hydraulic lines from rack and pinion



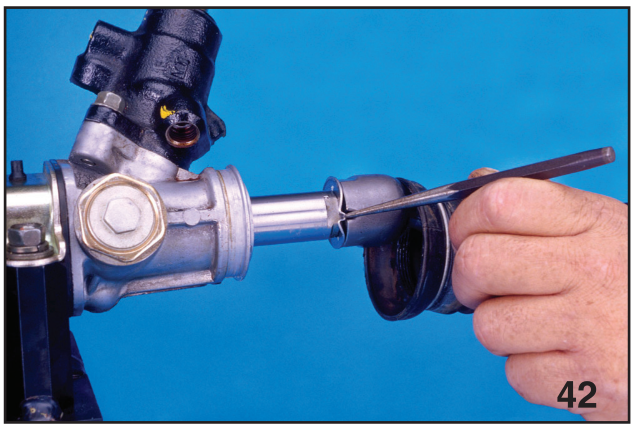
Rack in Holding Tool

3. Mount rack onto rack and pinion fixture. ST 926200000



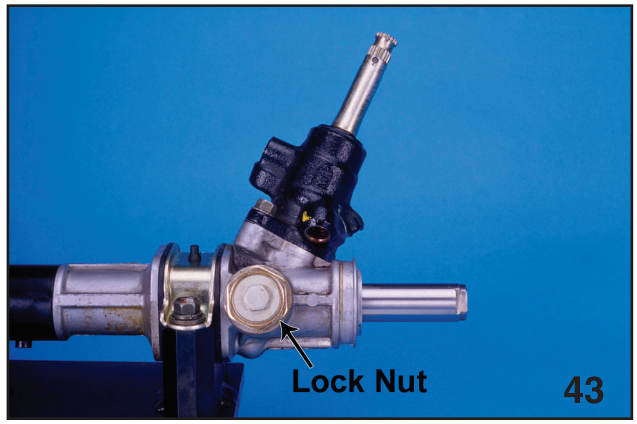
Removing Bellows

4. Remove tie-rod bellows from both sides of rack



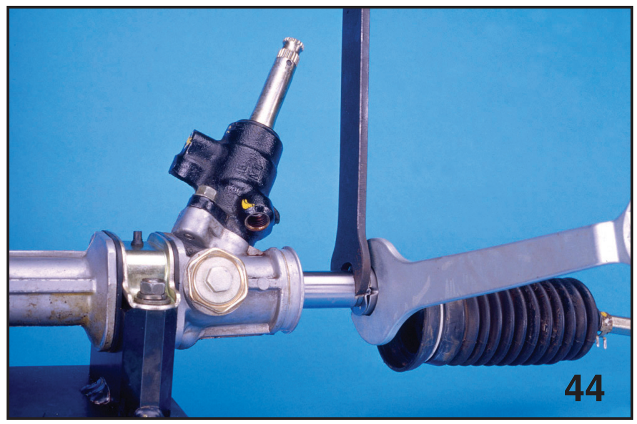
Unstaking Locking Washer

5. Using a hammer and cold chisel, remove stakes from locking washers.



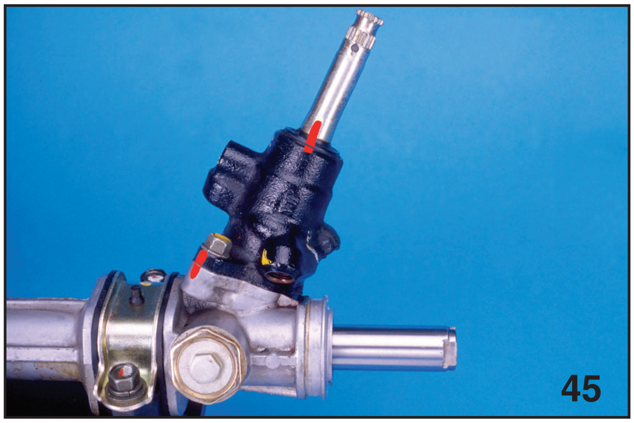
Lock Nut

6. Tighten adjusting nut to assist with holding the rack stationary.



Removing Inner Tie Rods

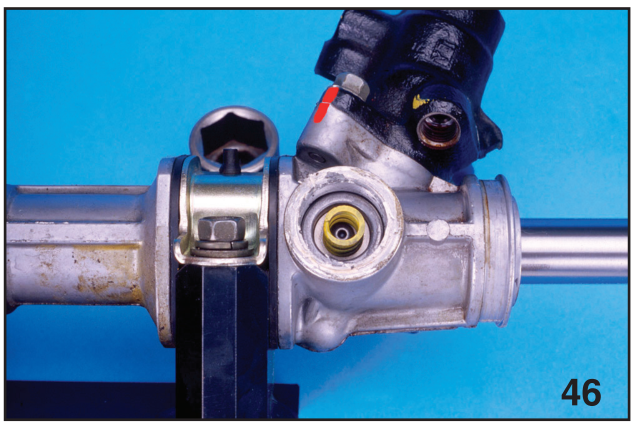
7. Remove inner tie-rods with a 32mm wrench.



Protruding Rack

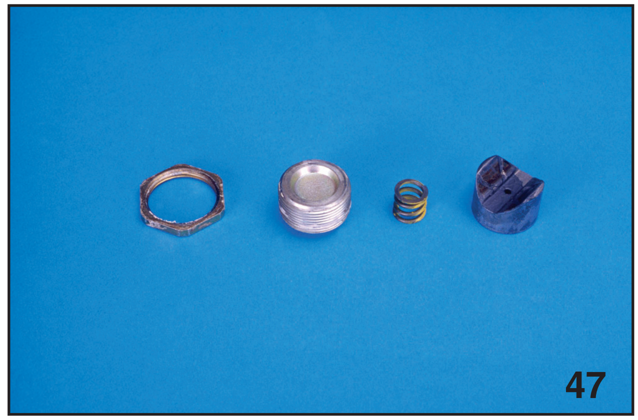
8. Loosen adjusting screw and position drivers side of rack so it protrudes 2.6 inches from rack housing.

   Using paint, mark the relationship of the stubshaft to valve housing and valve housing and rack housing.



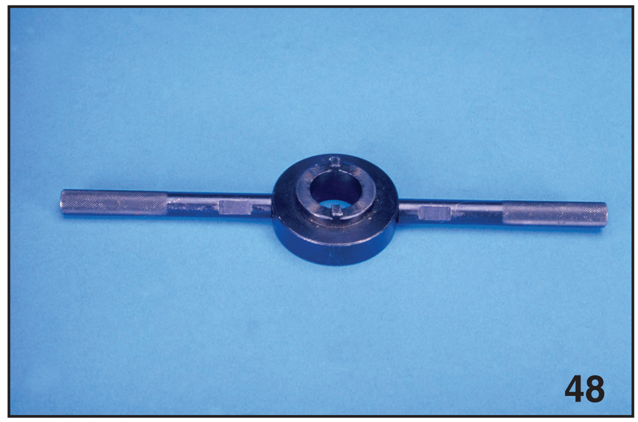
Lock Nut and Adjusting Screw Removed

9. Loosen lock nut using ST 926230000



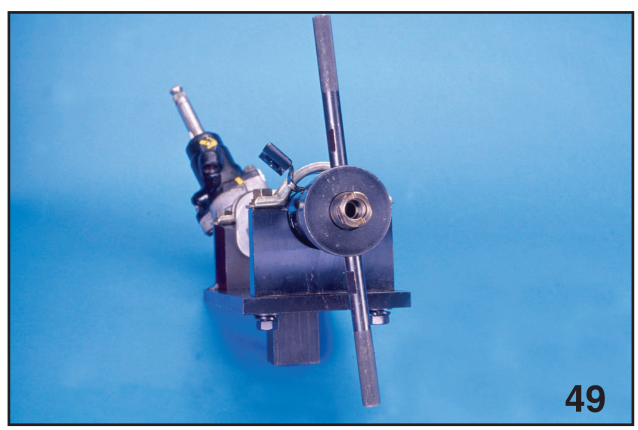
Lock Nut, Adjusting Nut, Spring And Sleeve

10. Remove adjusting nut and sleeve.



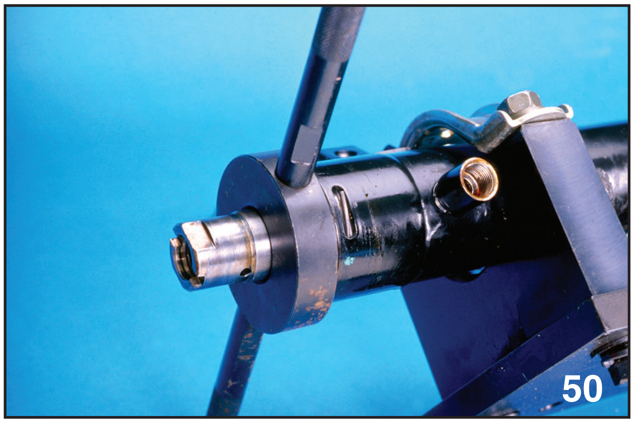
Special Tool

NOTE: Tool number varies by model year

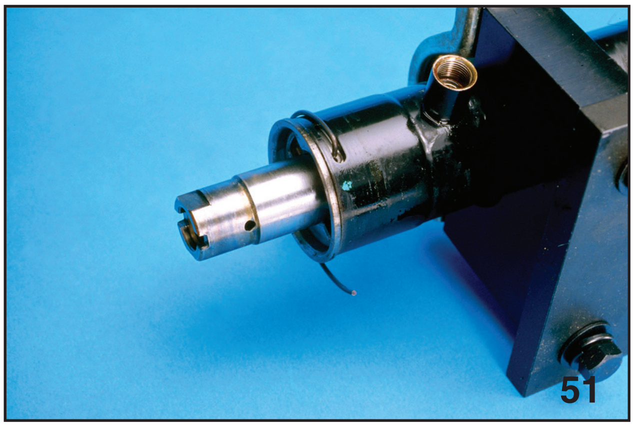


Special Tool Usage

11. Using snap ring pliers or special tool, rotate stopper until circlip comes out of stopper.

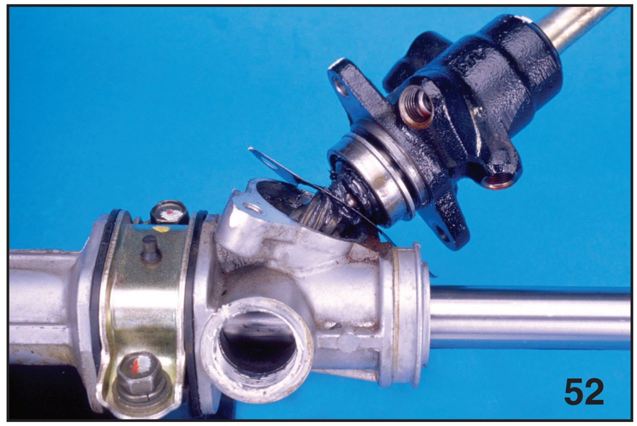


Locate End Of Circlip

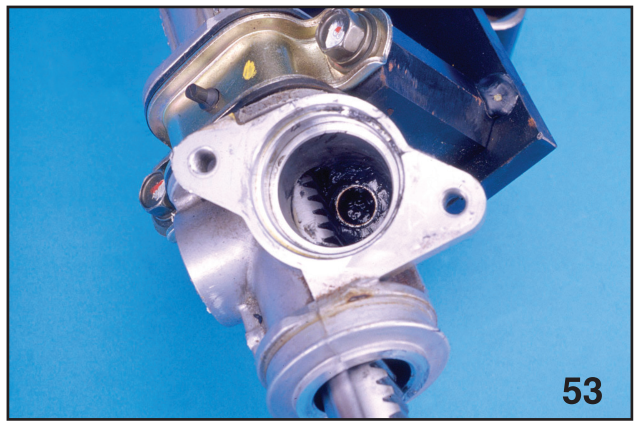


Removing Circlip

12. Rotate circlip in opposite direction and remove it from stopper.

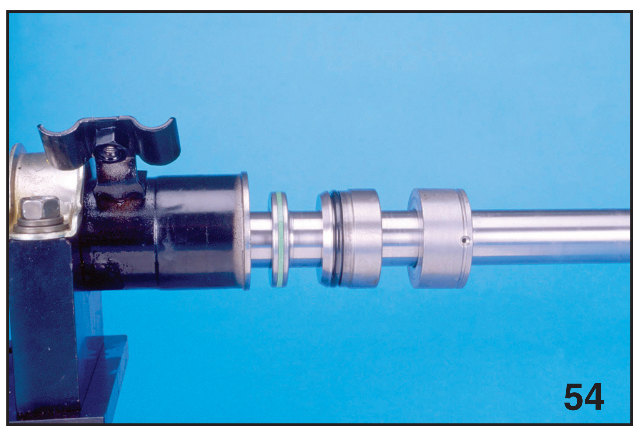


Removing Control Valve



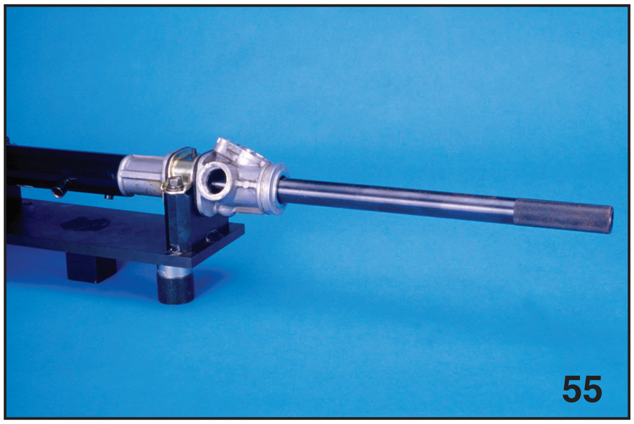
Control Valve Removed

13. Remove two bolts holding valve assembly to rack housing.
14. Remove valve housing from rack.

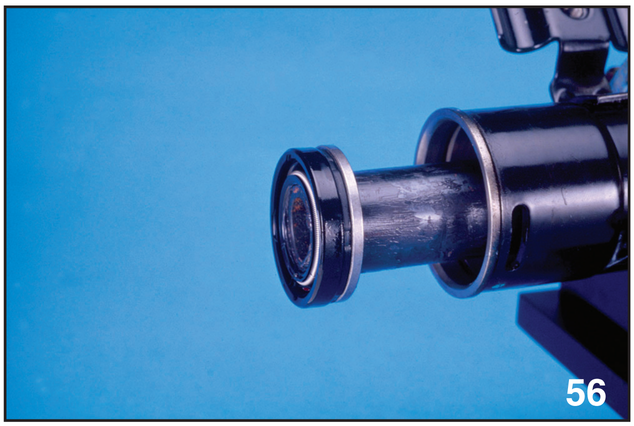


Removing Outer Rack Seal

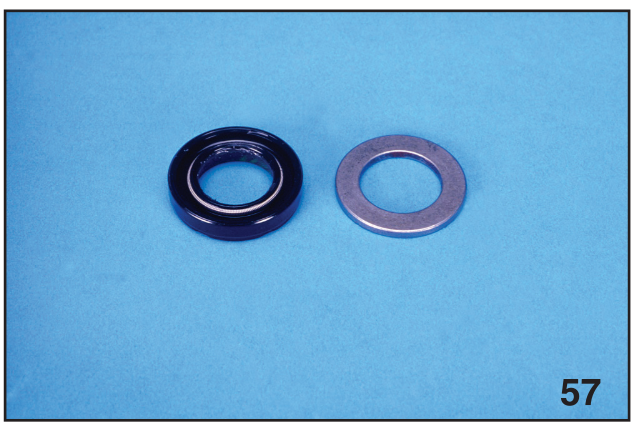
15. Carefully remove rack piston, rack stopper, and rack bushing from rack housing.


55

Removing Inner Rack Seal

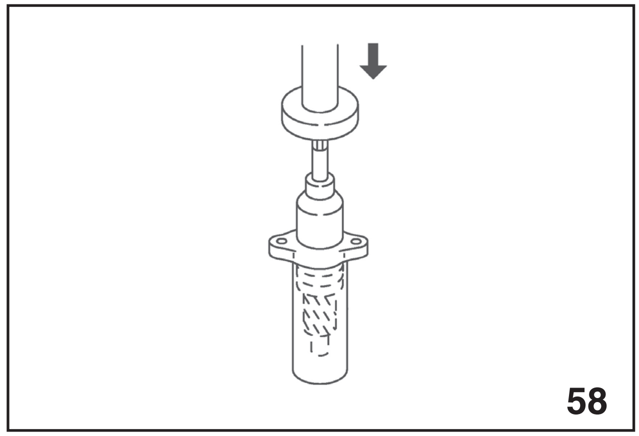

56

Inner Seal and Backing Washer On Tool


57

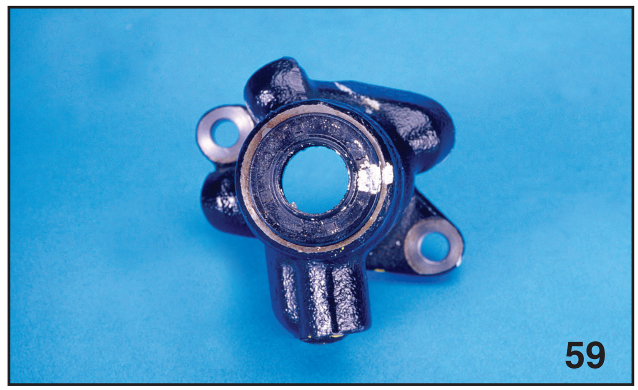
Inner Seal and Backing Washer

16. Using ST 34199AE050 remove inner rack seal from rack housing.


58

Removing Rotary Control Valve

17. Using a press, remove rotary control valve from control valve housing.


59

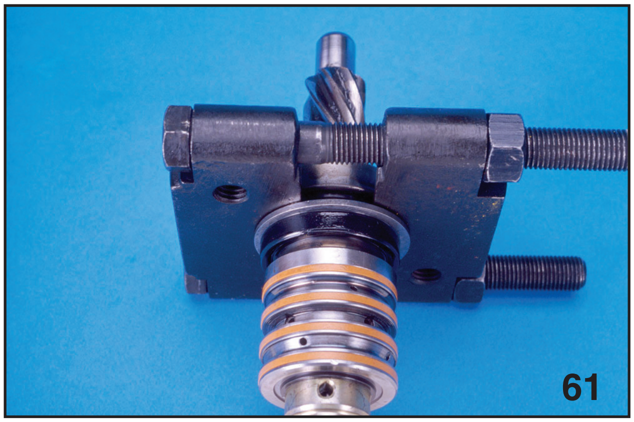
Dust Seal

18. Pry dust seal from valve housing.

60

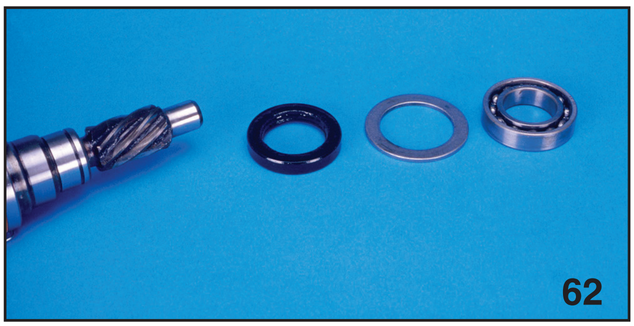
Snap Ring And Upper Seal

19. Remove snap ring from top of valve housing and pry out upper seal with a screwdriver.



Removing Lower Bearing

20. Using a press, remove lower bearing and backing washer from rotary control valve. This is necessary to replace the lower seal on the rotary control.

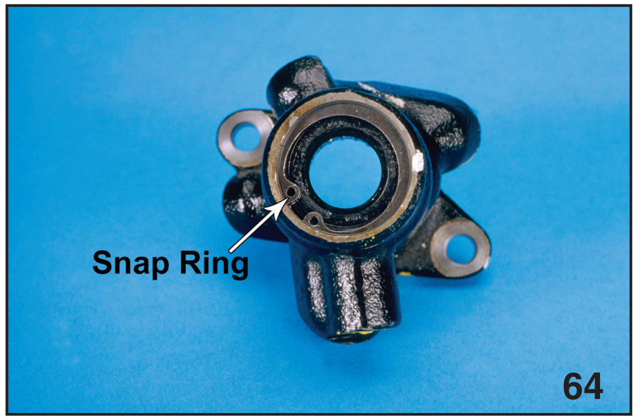


Lower Seal And Bearing

21. Remove lower seal from rotary control valve.

Upper Seal

22. Using ST 927610000, install new upper seal in rotary control valve housing. Coat seal with Dexron III before installation.

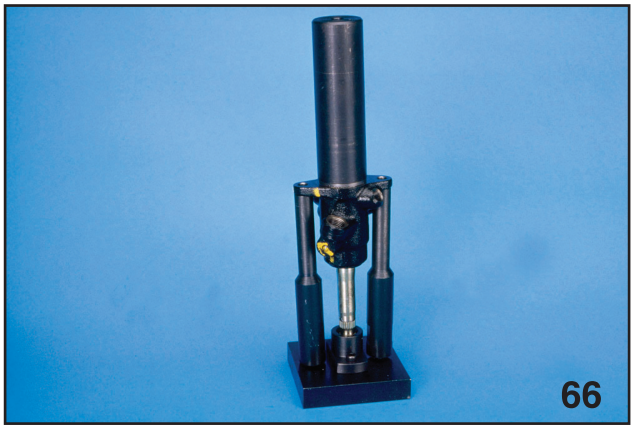


Snap Ring

23. Install snap ring to retain new seal.
24. Wrap splines of stub with electrical tape.

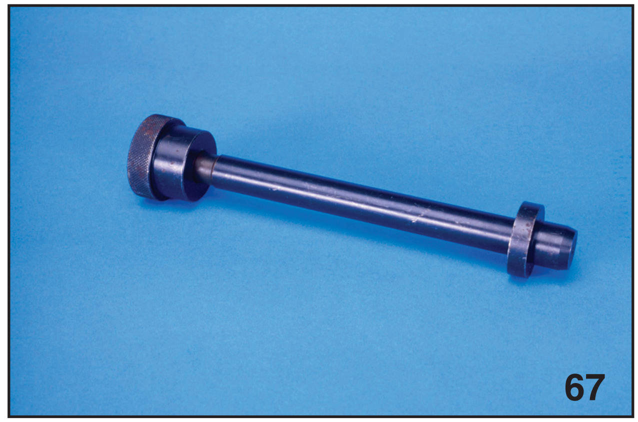
Installing Rotary Control Valve

25. Install rotary control valve into housing.

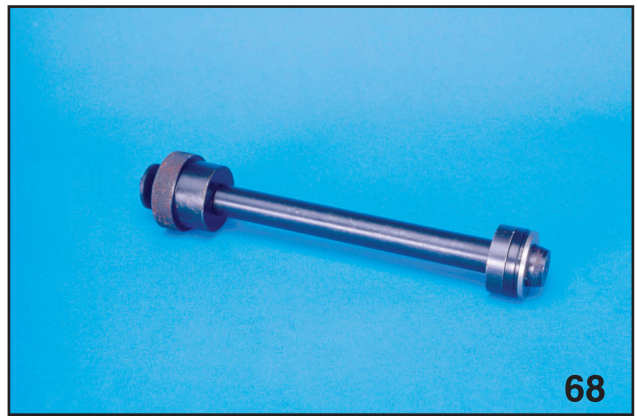


Installing Lower Seal

26. Using ST 926370000, 927630000, 927620000 to install new lower seal in rotary control valve housing.
27. While housing is still installed in fixture, install new backing washer and new ball bearing onto rotary control valve using ST 927640000.
28. Lubricate pinion and bearing with Moly grease included in kit.

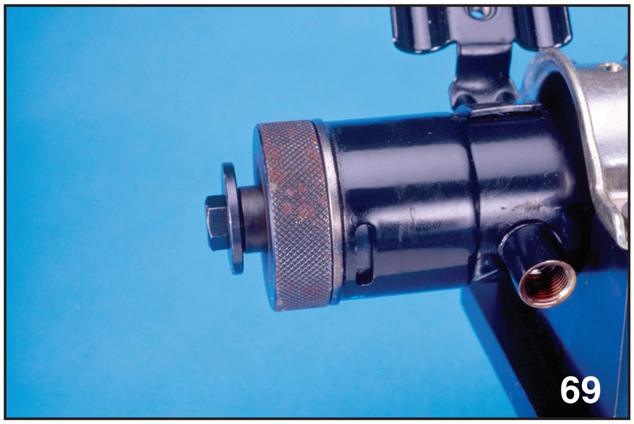


Inner Seal Tool



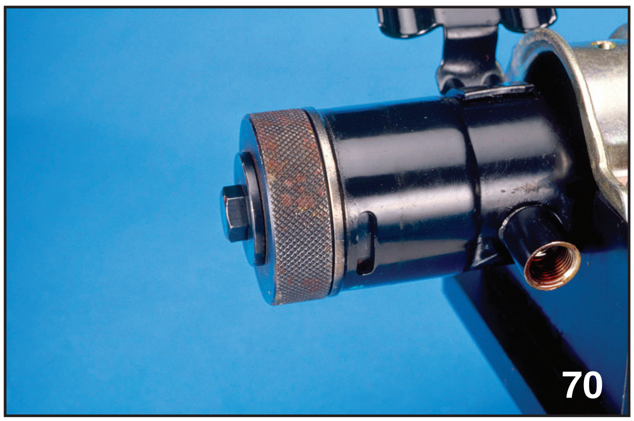
Inner Seal And Backing Washer On Tool

29. Install new rack housing inner seal onto ST 34199AE050. Lubricate with Dexron III before installation.



69

Inner Seal Tool In Rack Housing



70

Inner Seal Installed

30. Install inner seal into rack housing.

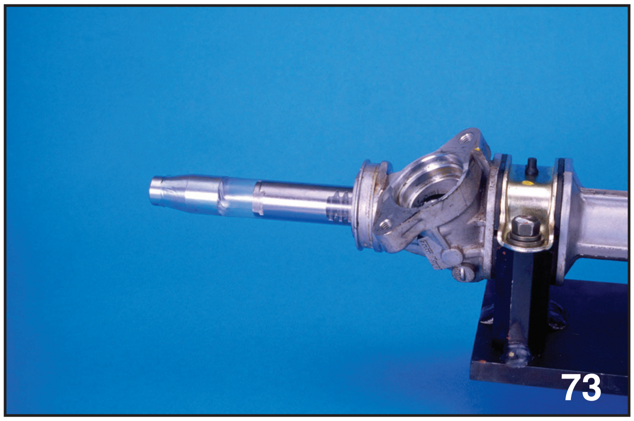
71

Rack Cover

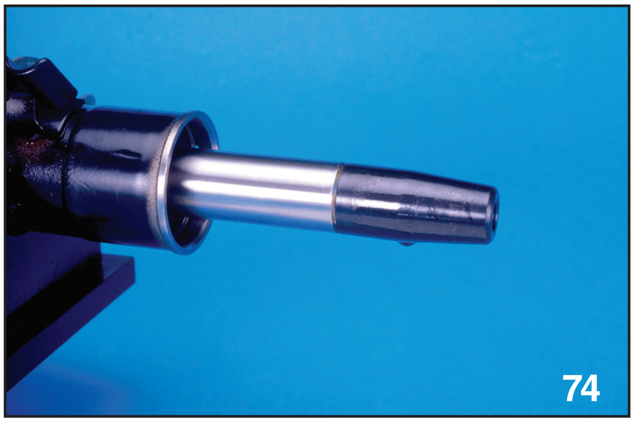
72

Rack Cover Installed

31. Cover rack teeth with ST 926390001.

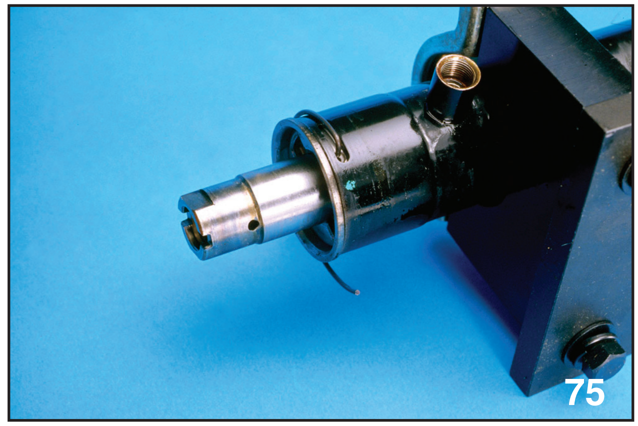


Installing Rack Into Rack Housing



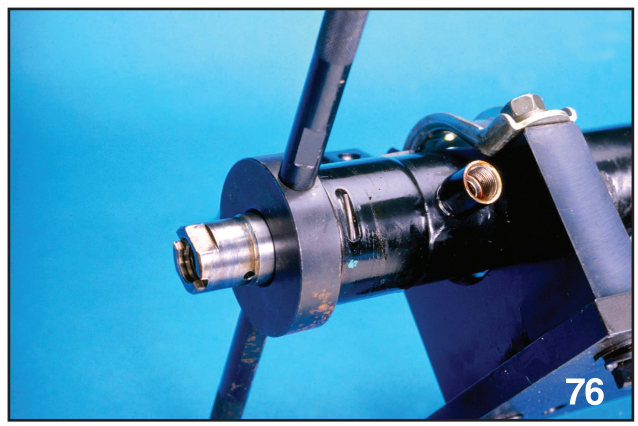
Remove Rack Cover

32. Carefully install rack piston into rack housing sliding it through inner seal.
33. Pack rack teeth with moly grease included in kit.
34. Adjust rack piston so it protrudes from drivers side of rack housing 2.6 inches. Install rotary control valve and housing. Before installation line up marks on valve with those on housing. After installation, insure all marks line up.



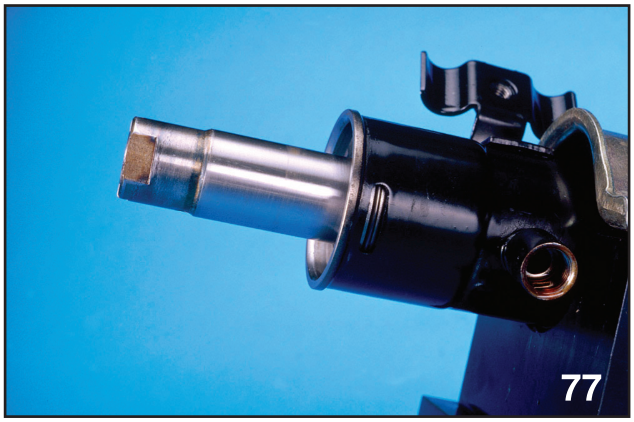
Circlip Installation

35. Using ST 926400000, and 927660000 install new rack bushing and stopper into rack housing. Install stopper in to housing until inner groove on housing lines up with outer groove on stopper. Lubricate rack bushing with Dexron III before installation.



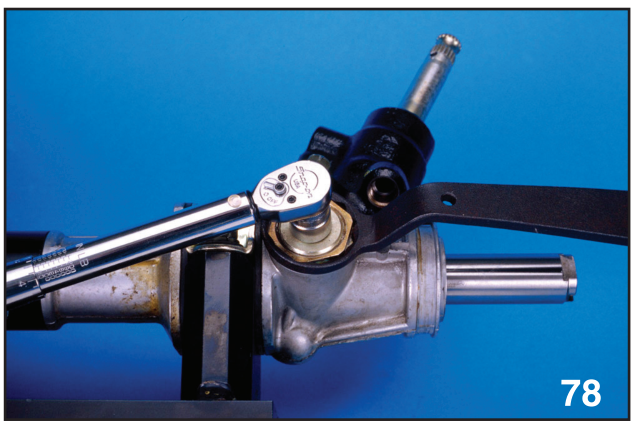
Circlip Tool

36. Install new circlip wire into rack stopper.



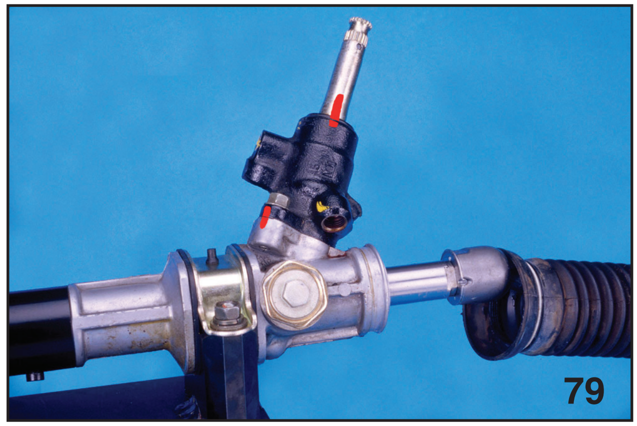
Circlip installation Complete

37. Using snap ring pliers rotate stopper to draw in circlip wire. Rotate stopper 90 degrees after circlip wire has drawn in.
38. Lubricate adjusting sleeve with moly grease and install sleeve, spring and adjusting screw into rack housing.
39. Coat threads of adjusting screw with Three bond 1141.



Torquing Adjusting Nut

40. Torque adjusting nut to 65 in. lbs. Repeat this process several times to insure proper contact.
41. After torquing adjusting nut, back off 25° degrees.
42. Install locknut and torque to 29 ft. lbs.



Installing Inner Tie Rods

43. Using new stake washers, reinstall tie rod ends and stake washers down with chisel.
44. Remove rack from holding fixture and reinstall hydraulic lines. Use new O-rings on lines before installation.

Notes and Cautions

Steering Column Removal

Note: Always refer to the appropriate Model Year Subaru Service Manual and follow the procedures for removal of the SRS "Airbag" Module prior to any repair and servicing or removal of the steering wheel and steering column from all "Airbag" equipped Subaru vehicles.

Always disconnect the U-bolts before loosening the column mounting bolts.

Disconnect the wiring harness connectors before removing the column.

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.

ELECTRONIC POWER STEERING

Introduction

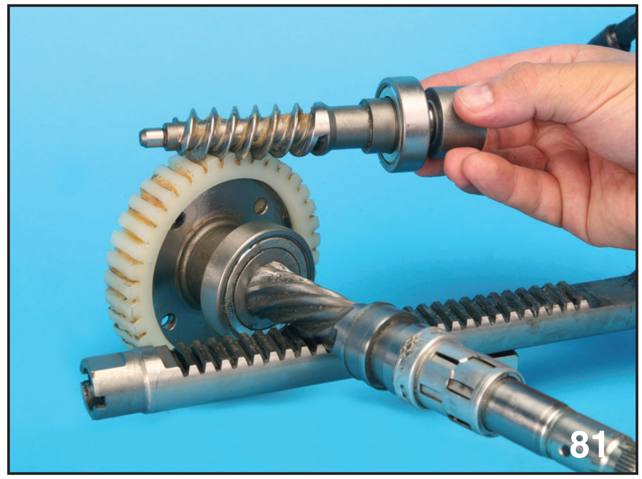
The Electronic Power Steering system (EPS) is a pinion gear assist type that provides the power assist through the rotation of the pinion gear. This type of system provides a 2 percent improvement in fuel efficiency over the present hydraulic system.

The EPS becomes active after the engine is started and will stay active if the engine stalls. The EPS will also stay active if the engine is turned off and the key is turned back on within 10 seconds.

Always wait at least 10 seconds after the engine is turned off to turn the ignition on or high battery drain will occur. Always consult the appropriate service manual before performing any service work to the EPS.

Power assist levels will decrease with increasing vehicle speed. Currently there is no PID on the SMIII to monitor assist level during normal operation.

A PID for EPS condition is located on the Power Steering menu which will show Normal, Assist Limitation or Assist Off. Assist Limitation will occur if there is a problem with the Controller Area Network (CAN) or if there a problem with any of the inputs to the CAN shared by the EPS. An overheating EPS control module or low battery will also result with Assist Limited. Assist OFF will result if there is a problem with any of the EPS major components. A review of these fail-safe and normal conditions will be reviewed in the lab.

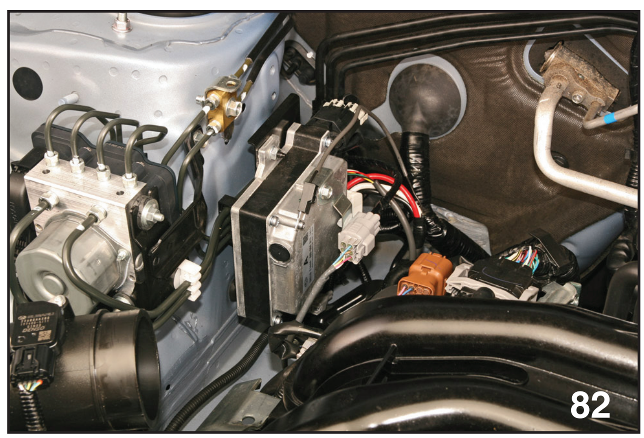


Theory of operation

A Permanent Magnet Alternating Current motor drives a Worm Gear that is in mesh with a Nylon Reduction Gear. The Reduction Gear is press fitted onto a set of splines on the Pinion Shaft and delivers the assist to the Rack Gear instead of pushing on the Rack Gear as in a Hydraulic System.

Component parts include:

1. Electric Power Steering Control Module



EPS Control Module

The EPS Control Module monitors and controls EPS operation through the use of the Motor Resolver Sensor, Torque Sensor and CAN input. Normal, limited and fail-safe operations are provided. The EPS Control Module is also a DC to AC inverter, supplying 12 volts of alternating current at a maximum of 100 Amps.

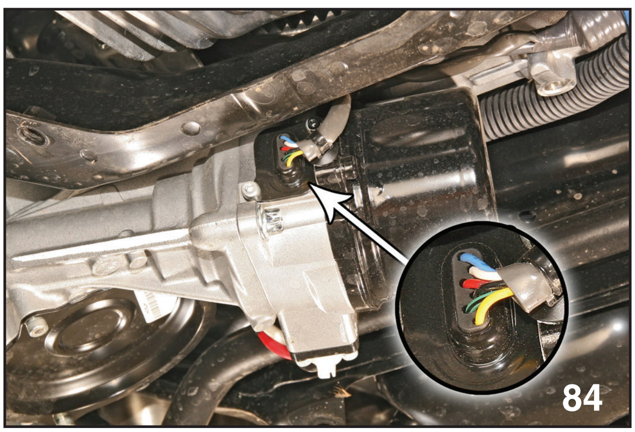
The EPS Control Module is equipped with K line diagnostics and cannot be reflashed.

2. Motor

EPS Motor

The EPS Motor is an 8 pole Permanent Magnet Synchronous AC motor. The motors speed, strength and direction are controlled by the EPS Control Unit.

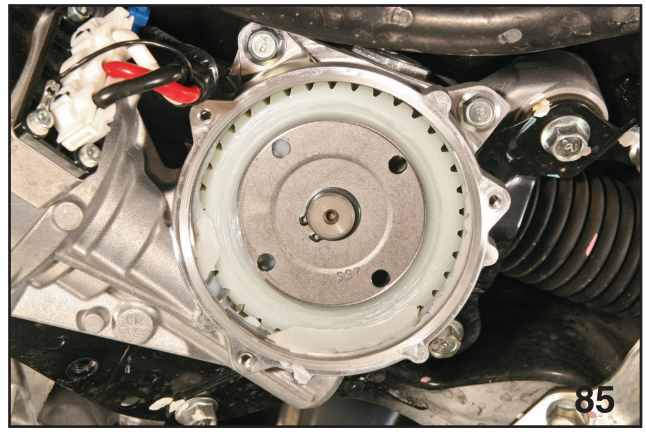
3. Motor Resolver Sensor



EPS Motor Resolver Sensor

The Motor Resolver Sensor is a device that measures the rotation of the motor and communicates operating data to the EPS Control Module.

4. Reduction Gear



EPS Reduction Gear

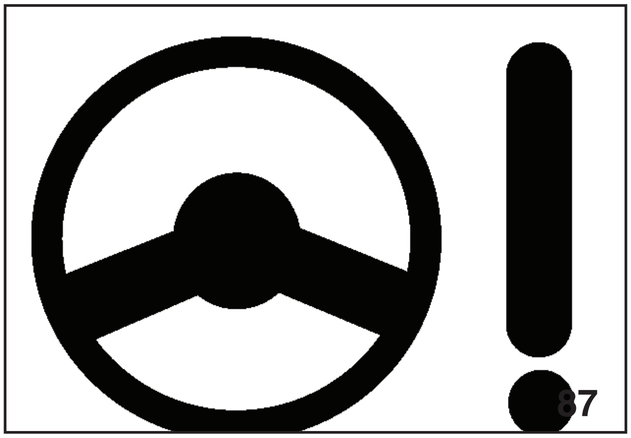
The Reduction Gear inputs the power assist into the steering rack assembly. During fail-safe operation the reduction gear drives the EPS Motor resulting in extra effort to manually steer the vehicle.

5. Steering Torque Sensor

Steering Torque Sensor

The Steering Torque Sensor monitors the driver's input and the EPS system's mechanical output.

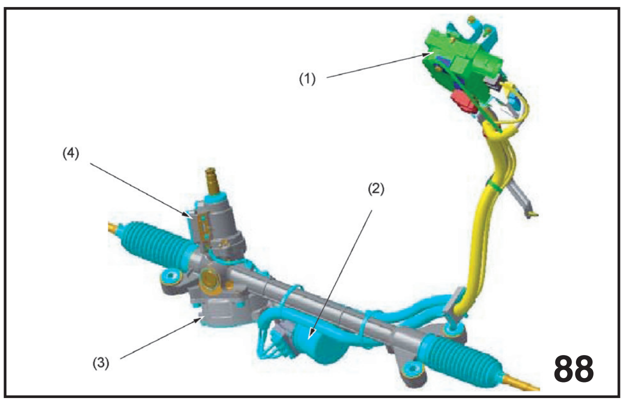
6. Steering Warning Light



Steering Warning Light

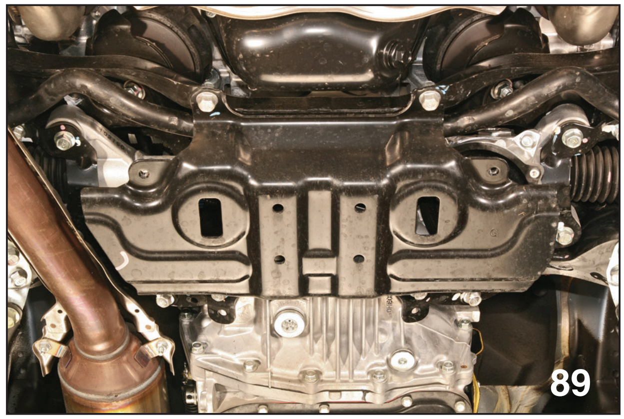
The Steering Warning Light illuminates during the light check cycle and when the EPS is in fail-safe. The Steering Warning Light will not illuminate during Limited assist operation.

7. Steering Rack and Pinion Assembly



EPS Assembly

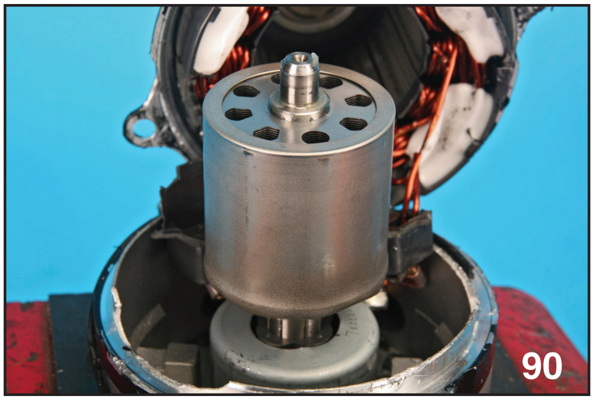
1. EPS Control Unit
2. EPS Motor and Resolver
3. Reduction Gear
4. Torque Sensor



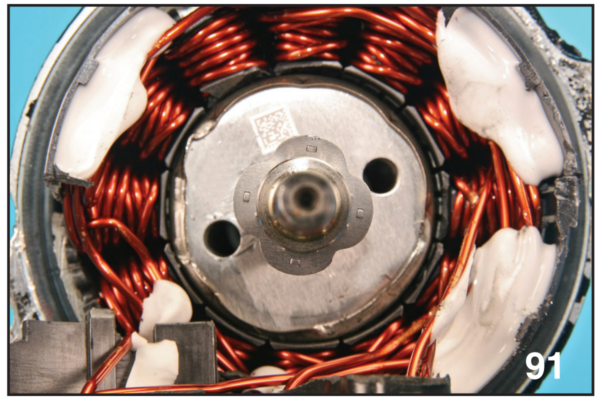
Steering Rack Guard

The new steering rack is shielded by a metal rock guard. This protects the steering rack and the EPS electrical component parts.

Resolver

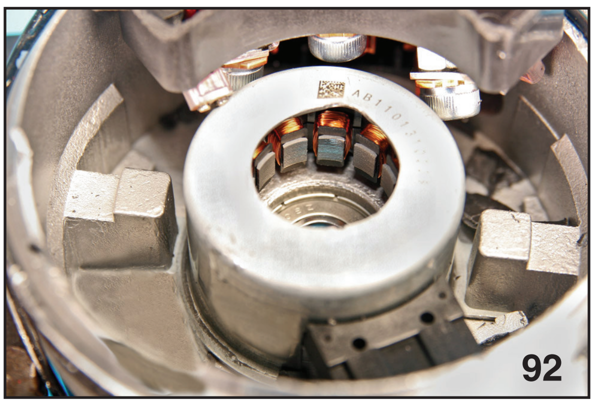


Resolver In Motor

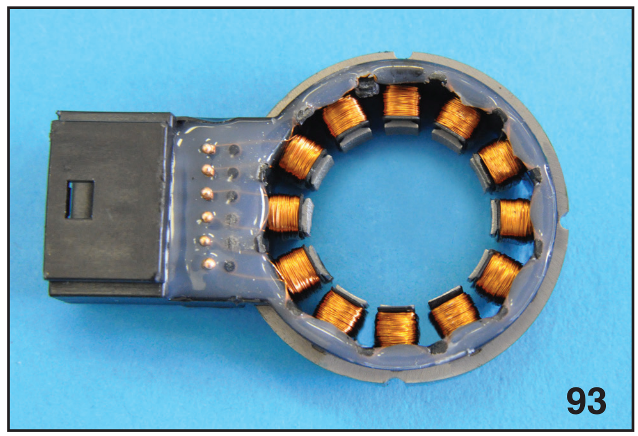


Rotor

The Resolver is mounted in the motor housing and works with a Rotor that is press fitted to the motor shaft.

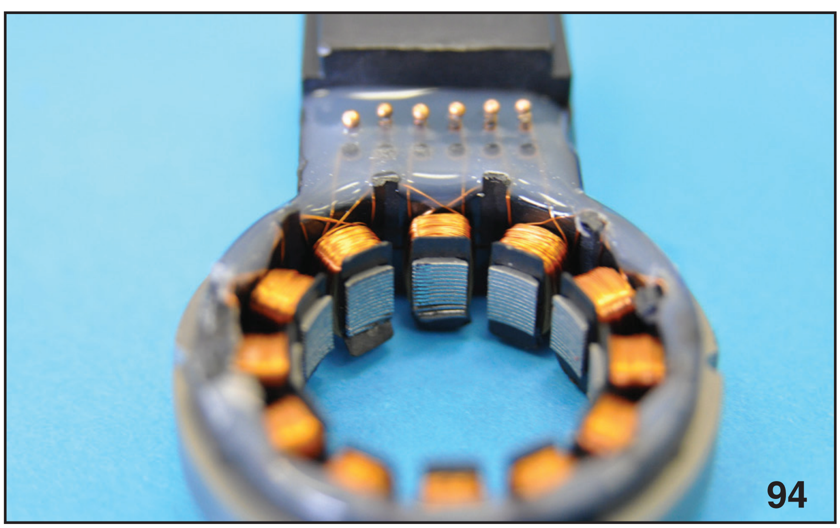


Resolver Stator Windings



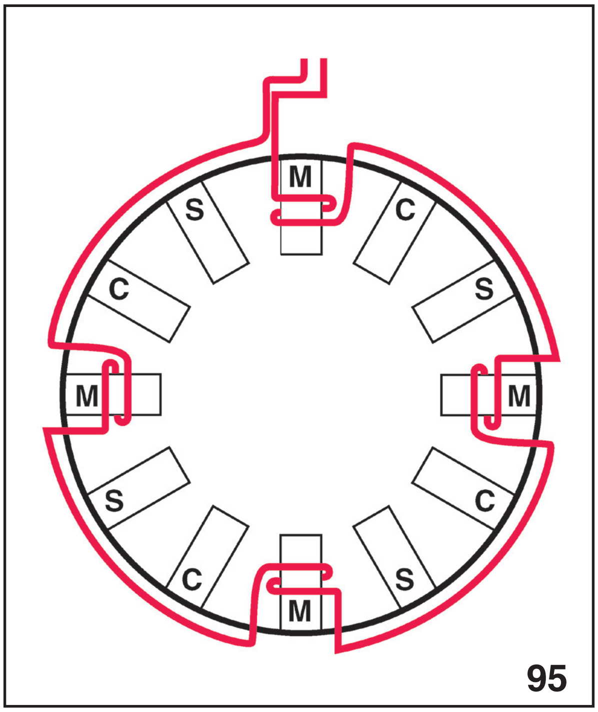
Resolver Top View

The resolver is constructed with 3 circuits.



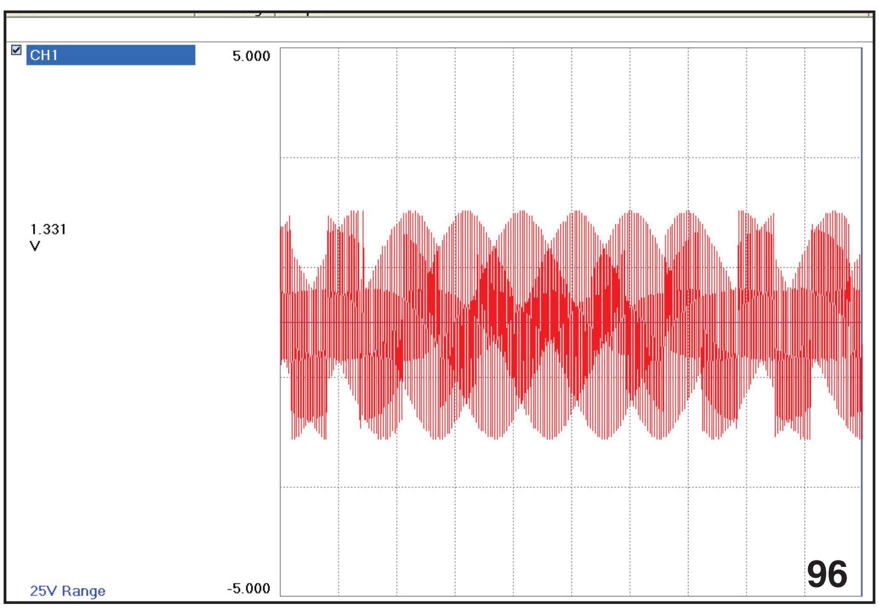
Resolver Side View

Each of the three circuits is wound around Stator segments which are designed to either create or receive a magnet field.



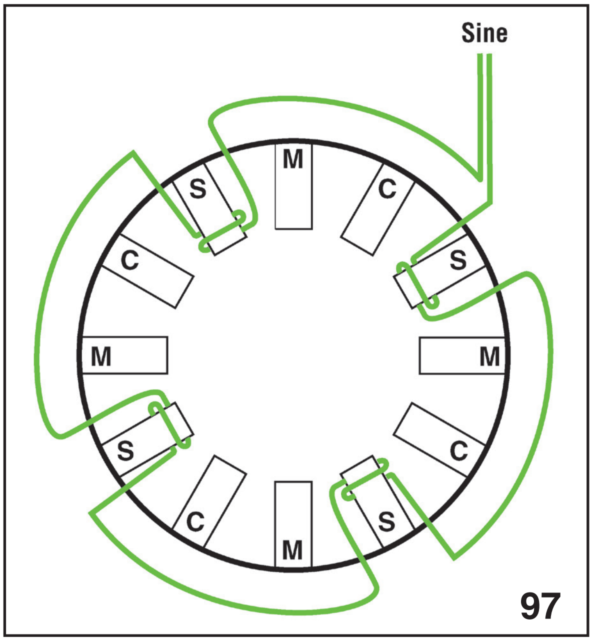
Magnetic Windings

The first circuit is the Resolver power supply. This is an AC voltage supply from the Control Module and remains at a set value.

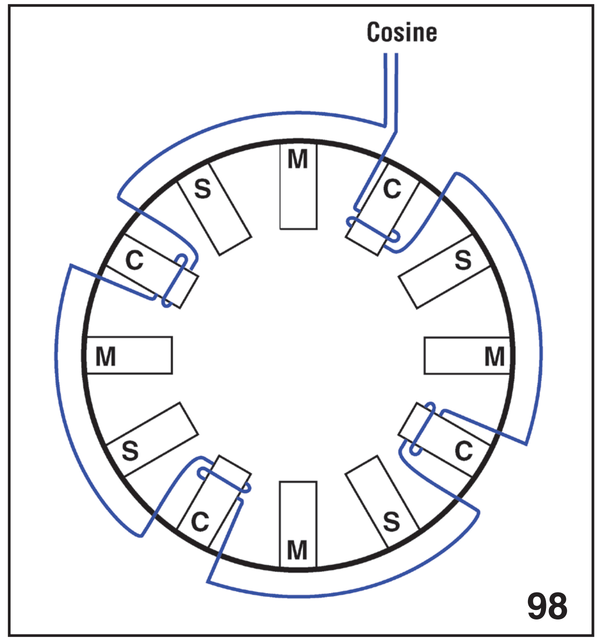


Resolver Power Supply

The Magnetic Stator Windings are all wired so that the orientation of the magnetic poles are all the same. The poles will all reverse at the same time as the AC Sine Wave changes.



Sine Artwork



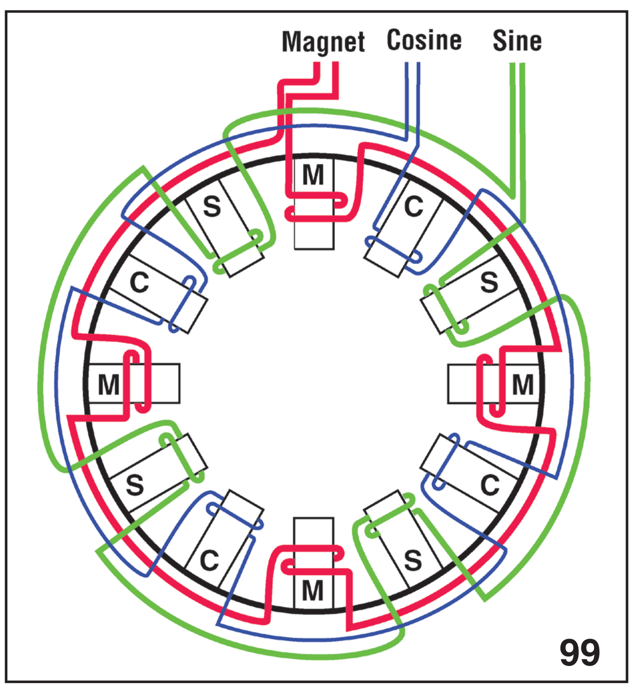
Cosine Artwork

The second and third circuits are the Sine and Cosine Stator windings.

Sine and Cosine are two of the main functions in Trigonometry that can be used to determine degrees of a circle.

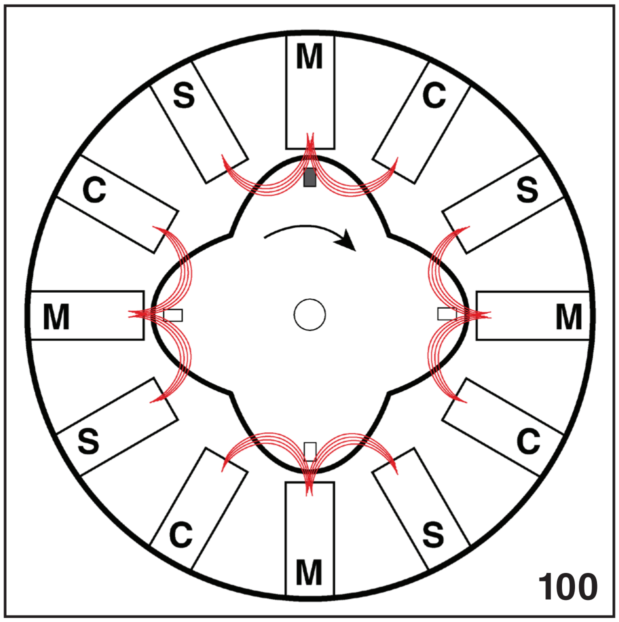
The EPS Control Unit uses the input values from the Sine and Cosine windings in the Resolver to determine the EPS motor's position.

These circuits act as transformers when magnetically coupled with the AC voltage supply magnetic Stator windings. The alternating magnetic field created by the magnetic Stator windings is directed into the Sine and Cosine windings by the movement of the Rotor.

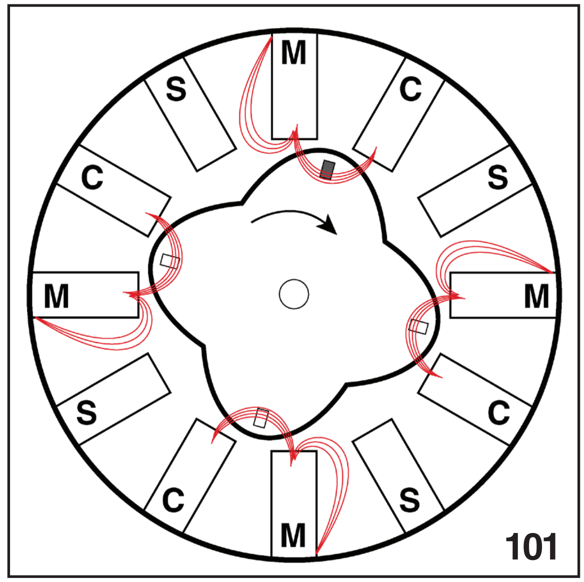


All Of The Windings Together

Resolvers are utilized in many applications and have proven to be more reliable and robust that any other sensor for measuring motor rotation. Resolvers have a wide operating temperature range and withstand mechanical shock without changing performance.

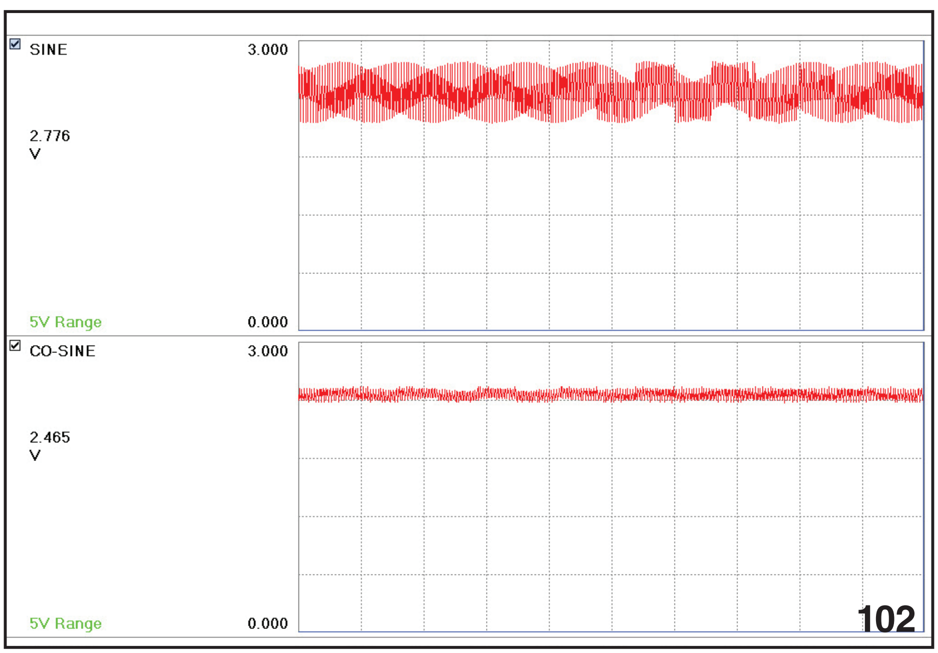


12:00



12:30

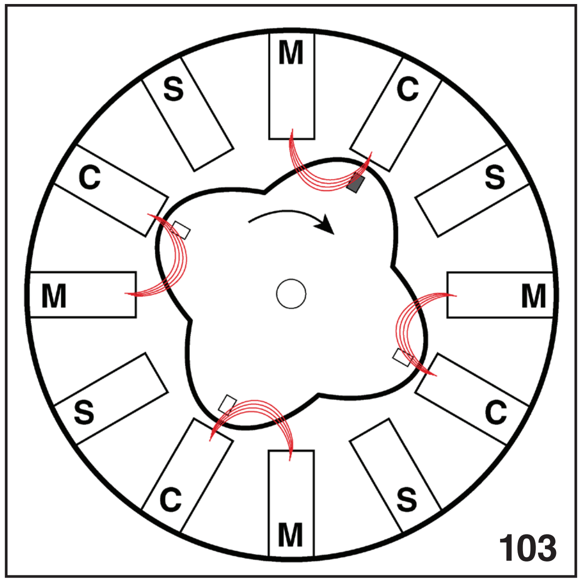
At zero steering angle the Rotor tips are lined up over the magnetic Stator windings. The magnetic fields flow into the Rotor tips but because all of the magnets are the same polarity, the magnetic field is directed away from the center of the Rotor and cuts across the Sine and Cosine windings.



SM3 File Zero Steering Angle

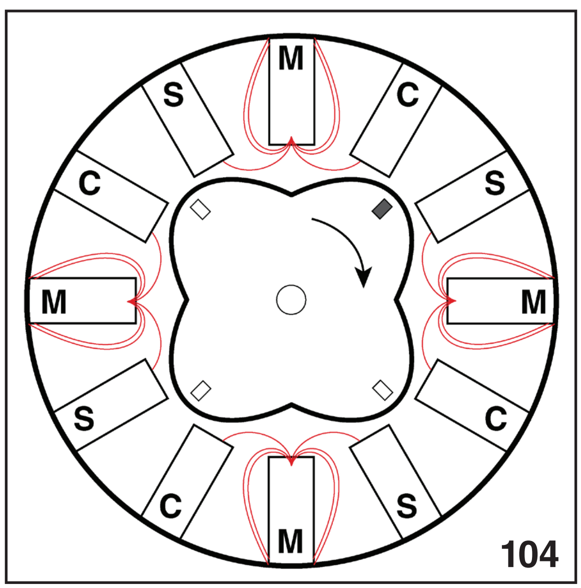
The Sine Stator windings have several more coils of wire wound around them than the Cosine Stator windings so a higher Sine voltage is created.

As the Rotor begins to move, in this case clockwise, the air gap becomes too great for the magnetic field to cut across the Sine Stator Windings so the Sine voltage drops to zero volts. At the same time more of the magnetic field is directed into the Cosine windings so the cosine winding voltage begins to increase.



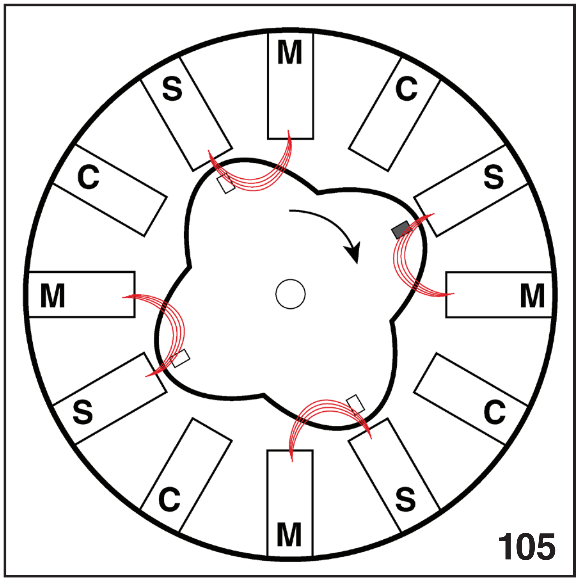
1:00

When the Rotor Tips align over the Cosine Windings the full strength of the magnetic field is induced and the maximum cosine voltage is generated.

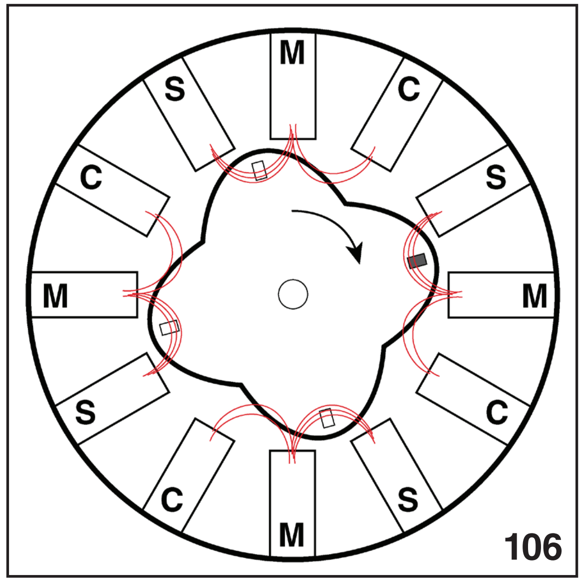


1:30

At about 45 degrees of rotation the voltage in the Sine and Cosine Windings will both drop to near zero.

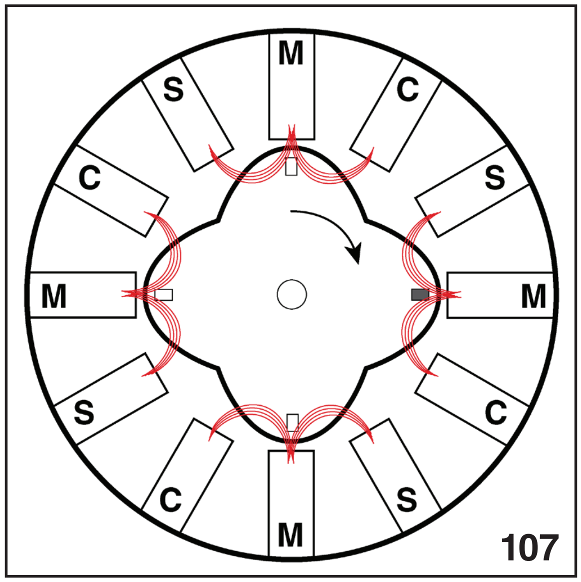


2:00

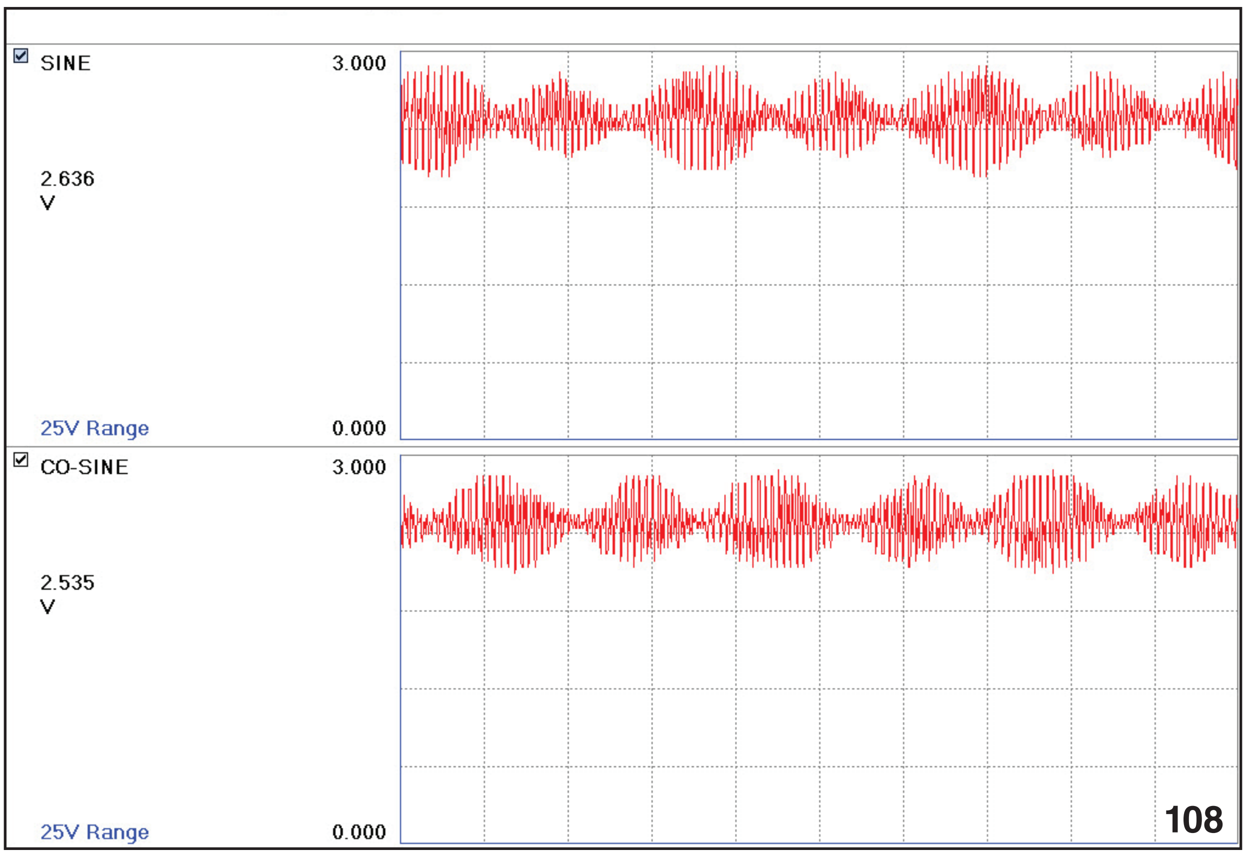


2:30

The Sine voltage will become maximum as the Rotor tips align over the Sine Stator windings.



3:00

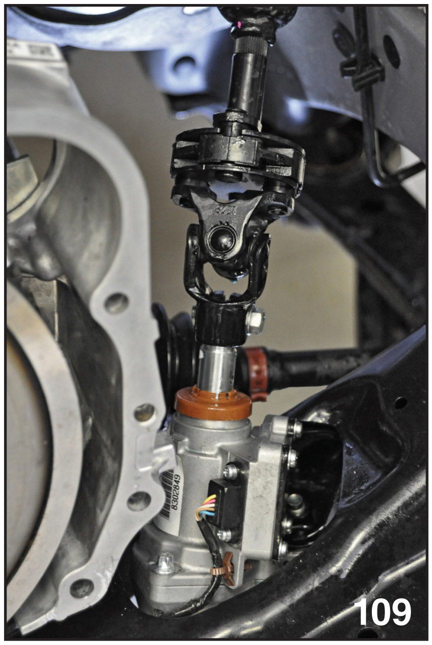


Sine And Cosine

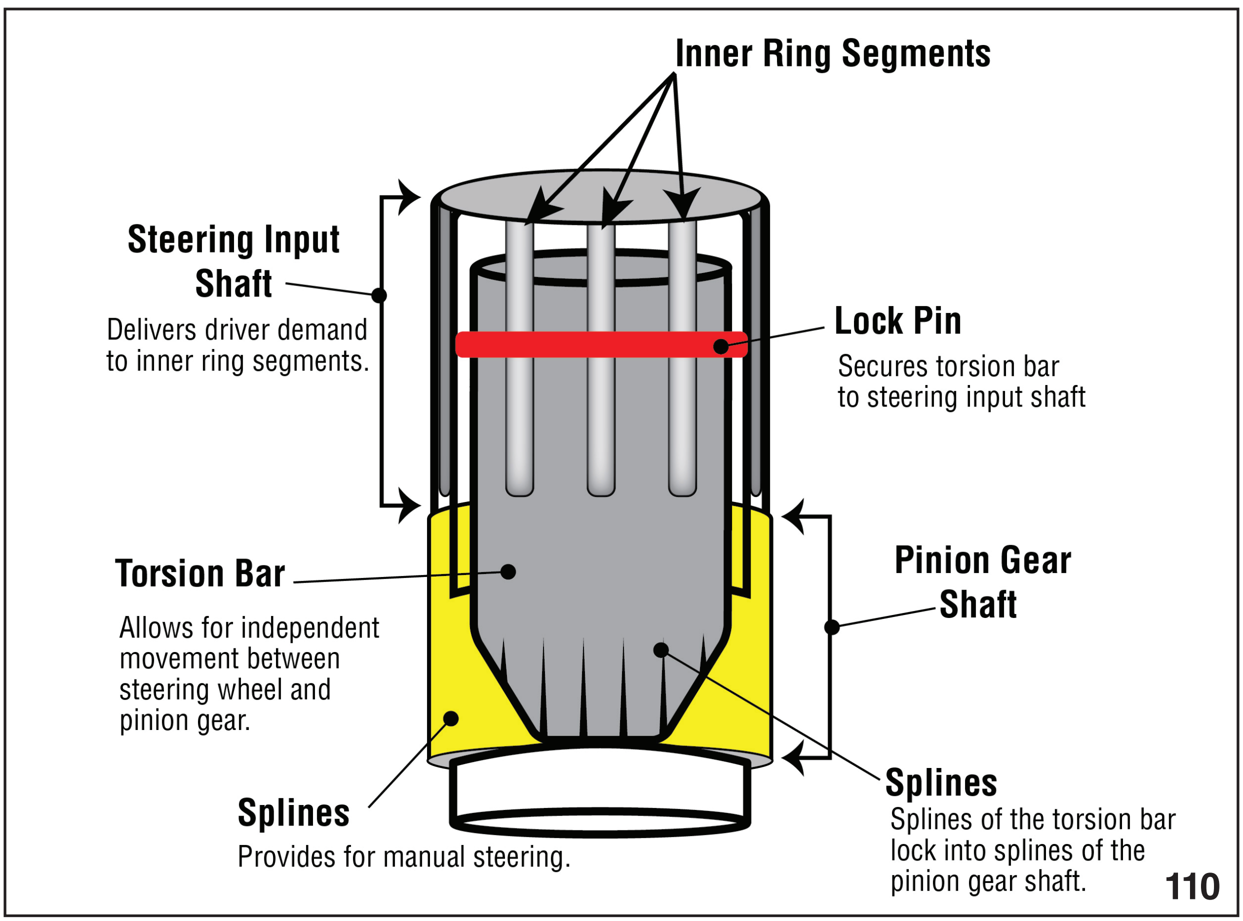
Continued rotation clockwise will align the Rotor Tips directly over the magnetic Stator windings resulting in low voltage to the Sine and Cosine windings.

These signals are processed by the EPS Control Unit to determine motor position to a single degree.

Torque Sensor



Torque Sensor



Torque Sensor Artwork

The Torque Sensor delivers the driver's demand and the force acting on the tires to the EPS Control Module.

For example; if the tires are in heavy sand, the force applied to the tires will be great. The difference between the driver demand and the steering movement of the tires has the potential to very large. In this condition the amount of power assist needs to very large so that the driver demand can be met.

If the tires are on smooth asphalt, the force applied to the tires will be small. The resulting difference between the driver demand and the steering movement of the tires will be small. This results in a low amount of power assist.

Many other factors must also be considered such as tire condition, tire pressure, vehicle speed and turning angle.

To accomplish this input to the EPS Control Module many parts are required.

1. A part that moves as the steering wheel moves.

Inner Ring

Outer Ring

2. A part that moves as the pinion gear of the rack moves (this represents the force applied to the tires).

Left Turn

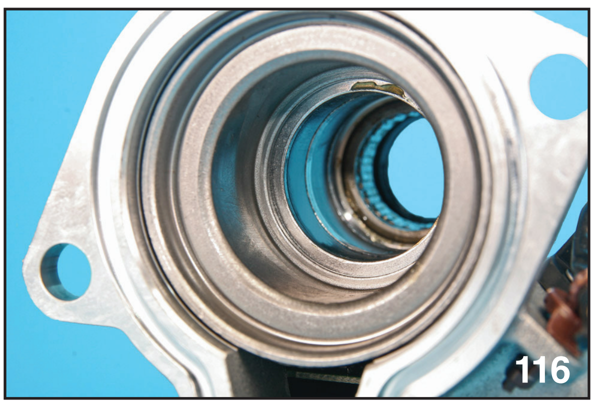
Center

Right Turn

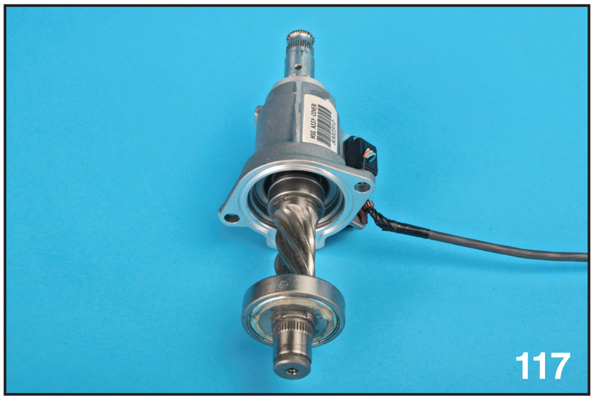
The upper windows operate to open during a left hand turn. The lower windows operate to open during a right hand turn.

Low force turns have small openings and heavier force turns have larger openings.

3. A device that determine the difference between the two.

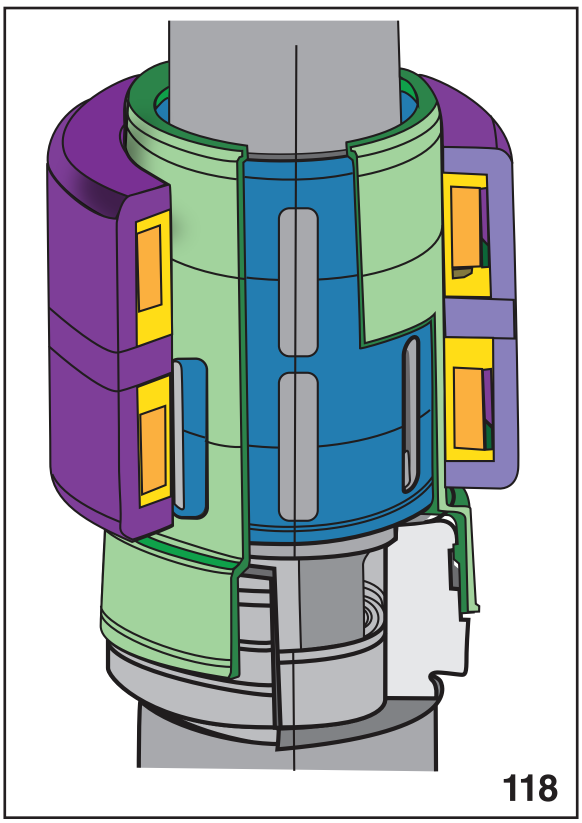


Torque Sensor Inside View

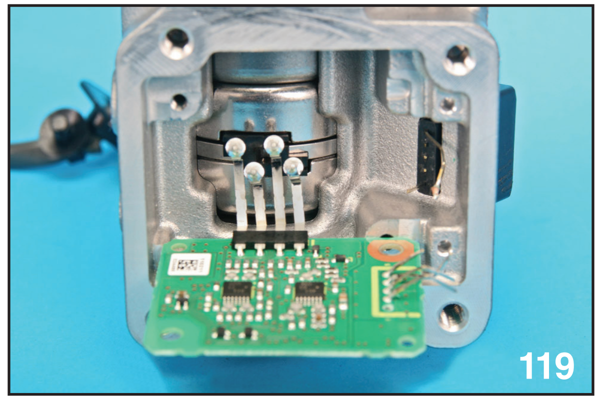


Torque Sensor

All of the parts are contained in the same type of housing that the Control Valve assembly would normally occupy on a conventional hydraulic power steering system.



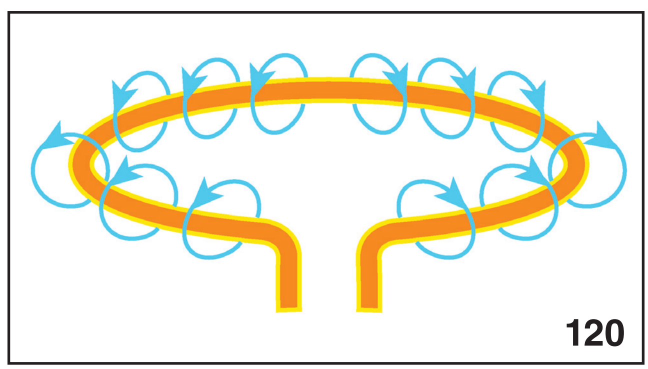
Torque Sensor Artwork



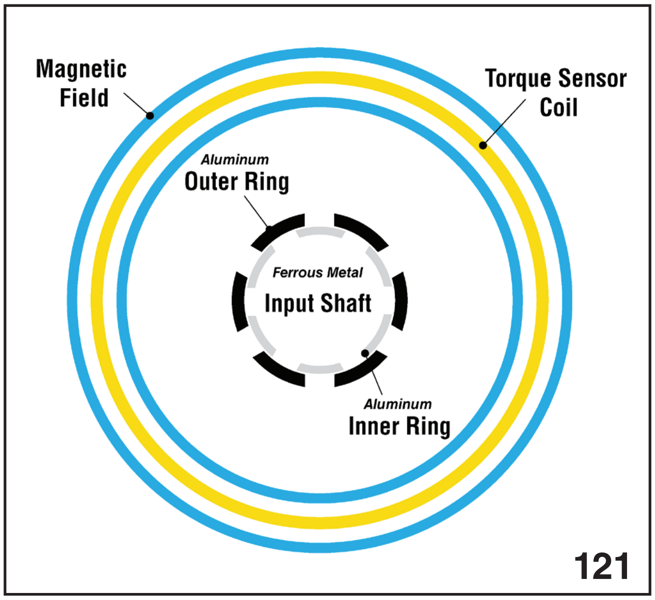
Torque Sensor Construction

The electrical section of the Torque Sensor consists of two independent coils of wire. One of the coils determines if a right hand turn is in progress. The other coil determines if a left hand turn is progress. An Integrated Circuit (IC) board in the assembly receives power and ground from the EPS Control Module. The IC board inverts DC to AC and sends this voltage to each coil in a separate circuit.

The AC voltage energizes the coils and a pulsing magnetic field is established. The magnetic field collapses into its respective coil every time the voltage crosses zero. This has an effect on the total voltage in the coil circuit. The IC monitors this voltage and the applied voltage to determine a value.

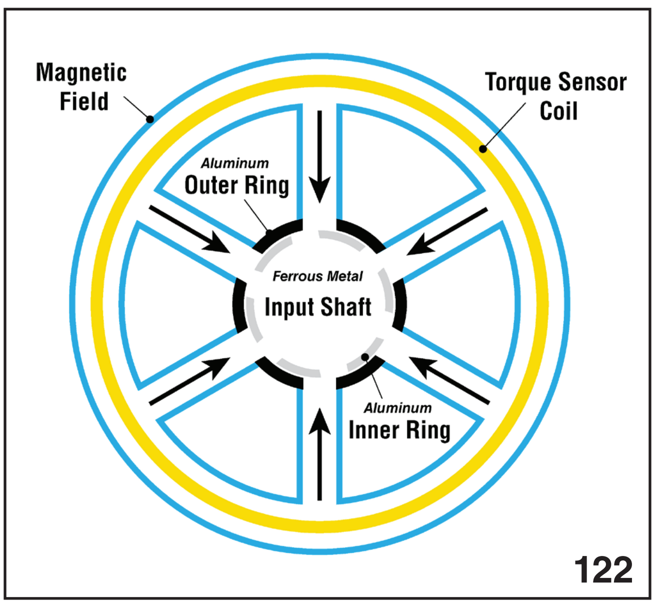


Torque Sensor Magnetic Field



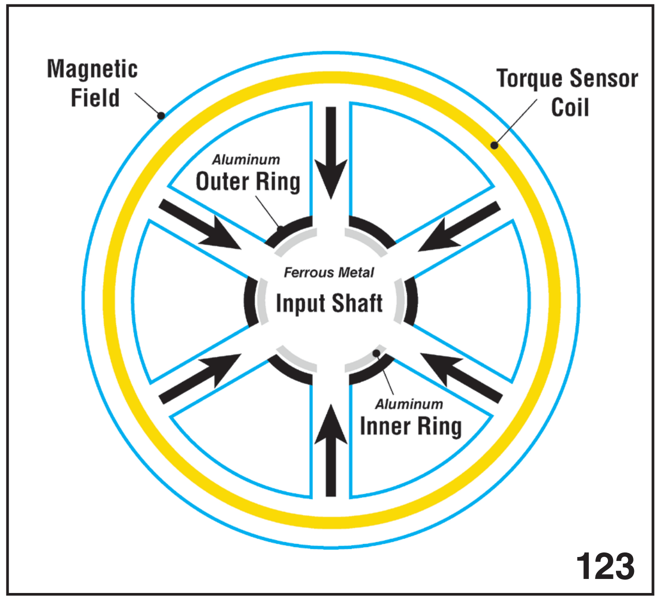
Closed

At a zero steering angle all of the magnetic field surrounding each coil collapses back into the coils.



Partial Opening

A partial opening of the windows exposes a small portion of the input shaft. The aluminium shielding formed by the inner and outer rings can no longer keep the magnetic field from reaching the ferrous metal of the input shaft. This begins to focus or concentrate the magnetic field. The result is a higher induced voltage into the coils.

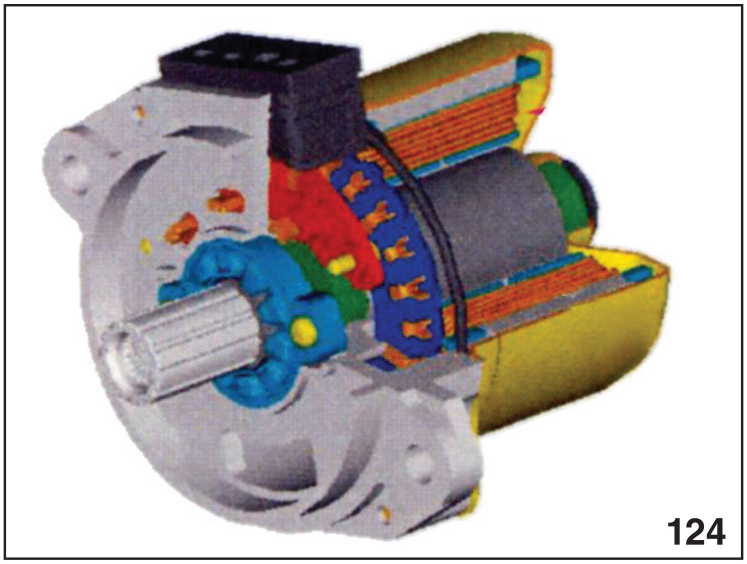


Wide Open

A larger opening of the windows results in larger induced voltage.

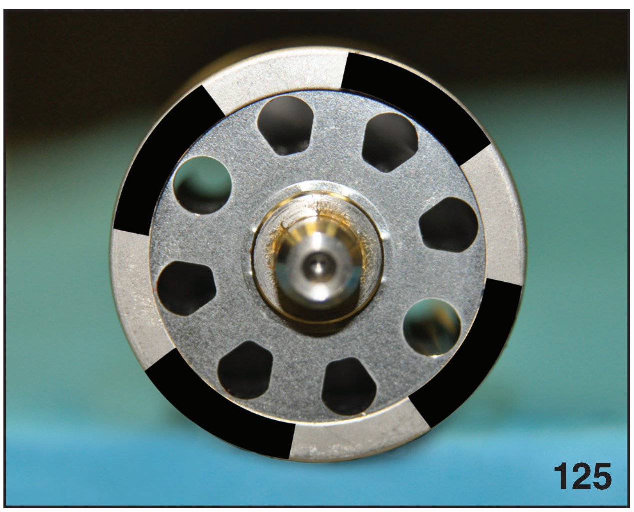
The IC then sends a DC voltage signal to the EPS Control Module to determine direction and force of the turn.

EPS Motor Construction

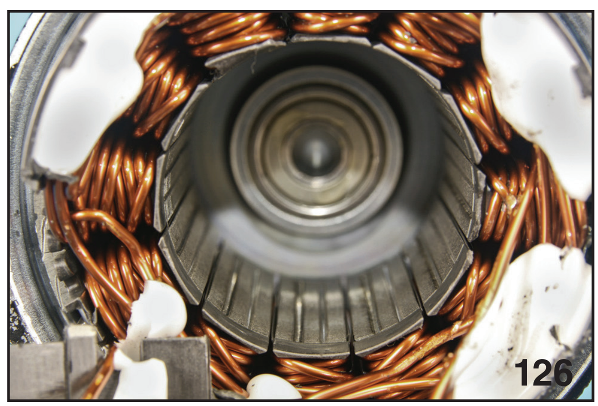


EPS Motor Artwork

The EPS Motor is an 8 pole Permanent Magnetic Synchronous AC Motor. It is constructed with a Brushless Permanent Magnet Rotor with 8 Rare Earth Magnets and 12 Stator windings. The motor operates by pulling and pushing on the Rotor with the electromagnets formed by the Stator windings. Timing of the pulling and pushing is very critical for controlling speed, direction, and power of the motor.

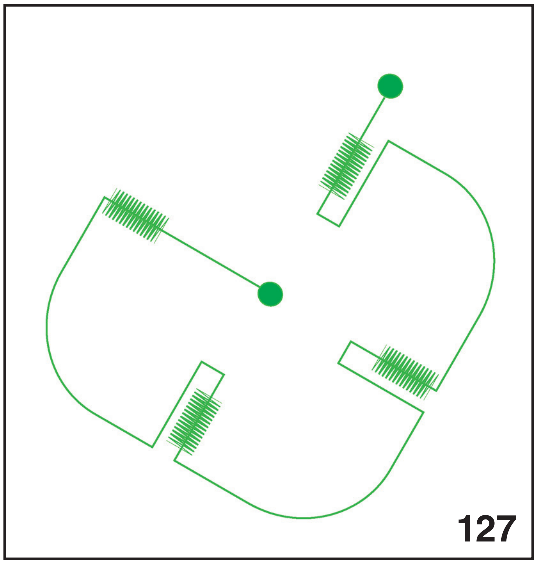


Rotor Magnet Pole Arrangement

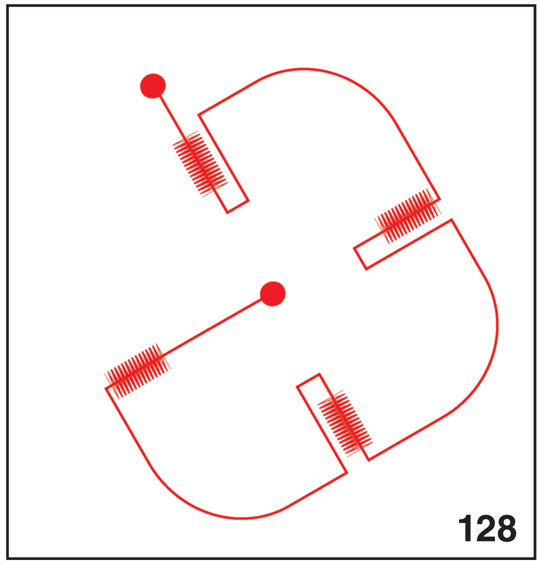


Stator Windings

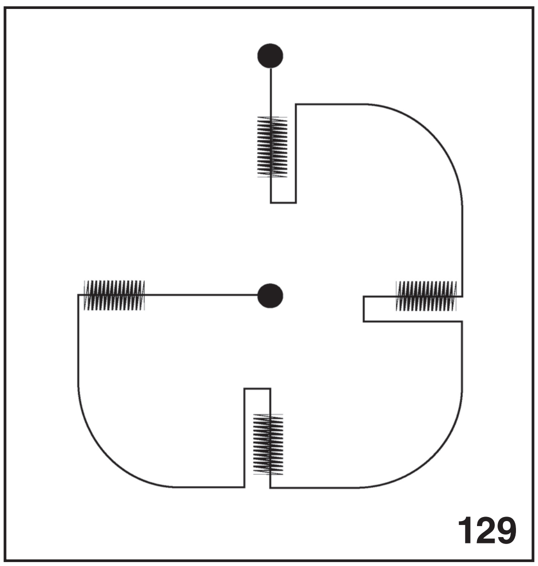
Timing is controlled by the working power delivered to the motor from information generated by the Resolver. The synchronous timing of the motor is a method of controlling the Rotor to move with the rise and fall of the AC sine-wave. Maximum torque from the motor is created when the AC sine-wave is at the highest point and produces the strongest magnetic field in the Stator winding. The Rotor must be in the correct position or synchronized to take advantage of this magnet field. A Rotor arriving too early or too late falls out of synchronization and power output from the motor is reduced.



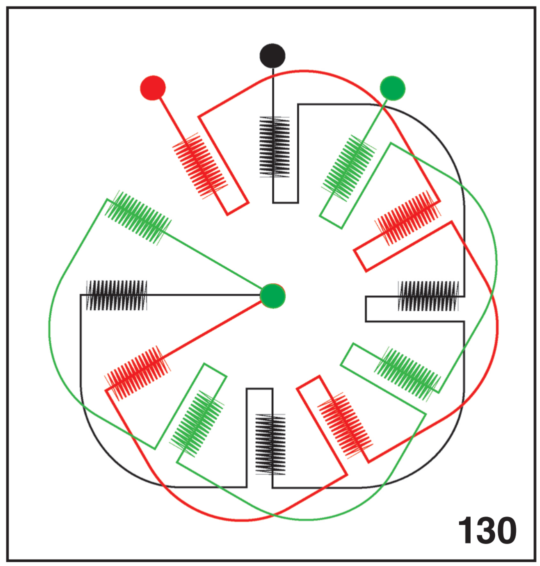
U Winding



V Winding



W Winding



U V W Windings

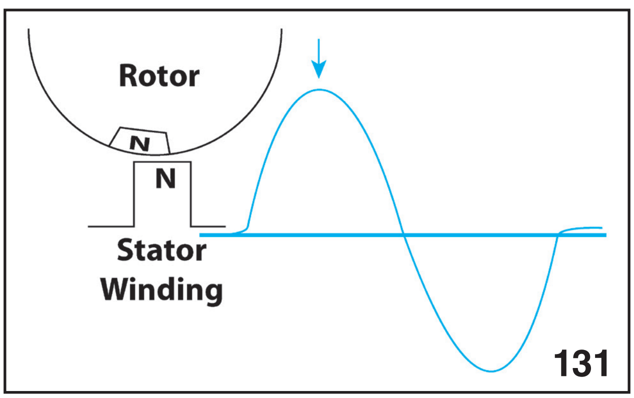
The motor is wired with 3 sets of Stator windings named U, V, and W. This type of identification is an industrial standard for describing 3 phase electrical.

Advantages of 3 phase electricity include: smaller conductors, lower voltage drops, and precision magnetic field control.

Basic operation

The wiring of the Stator in the EPS Motor is in a “Y” configuration. Each of the three branches are connected together at the motor end of the circuit and individually wired into the EPS control module. Each branch has a set of Stator coils which are wired wrapped in a specific pattern to establish an electromagnet when energized. The polarity of the magnetic field will be determined by the direction of the current flow through the coil.

The branches of the Stator “Y” configuration are supplied with 3 phase alternating current. Each branch will be positive or negative, based on the Rotor location but a branch will never be both positive and negative at the same time. Two of the branches may be positive and one may be negative or two may be negative and one may be positive. There must be a potential difference between positive and negative for the circuit to operate.

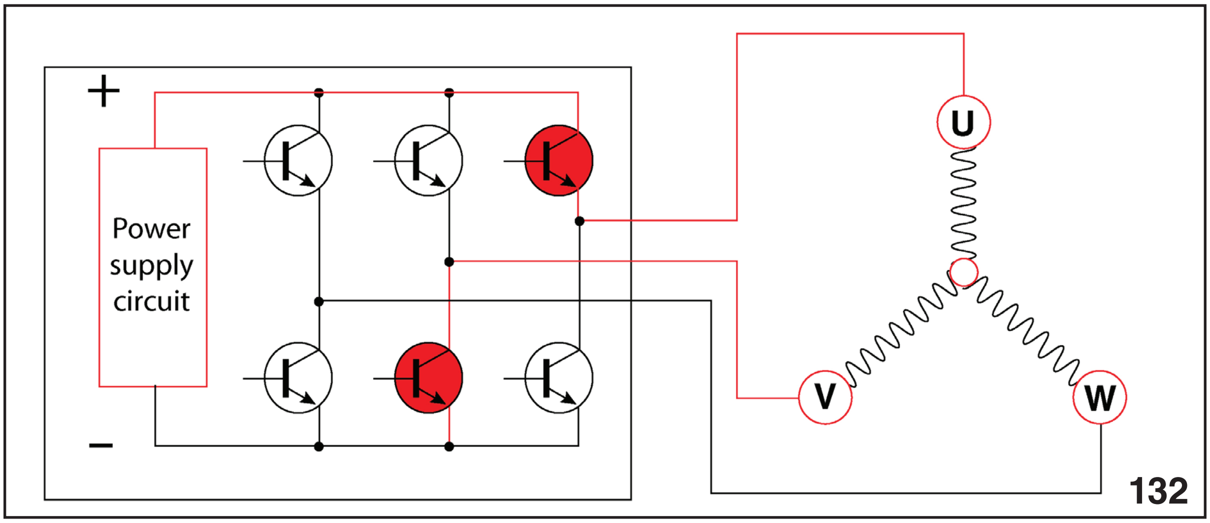


Max Torque

3 phase explanation

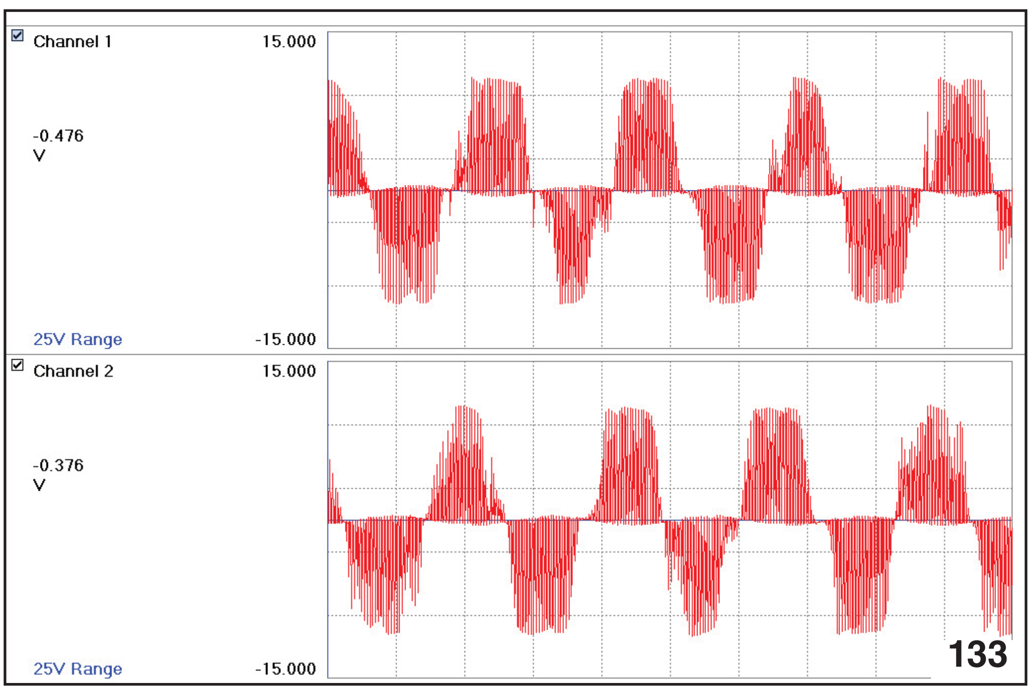
A sine-wave of a branch is described in electrical degrees which can be compared to the degrees of a circle. The sine-wave theoretically begins at 0 degrees and increases in positive voltage to 90 degrees before the voltage begins to decrease. From 90 degrees to 180 degrees the voltage is still positive. Negative voltage begins at 180 degrees and reaches its highest negative potential at 270 degrees. The negative potential begins to decrease as the sign wave approaches 360 degrees. The actual voltage will depend on the position of the sine-waves of the other two branches. Mechanical degrees of the motor do not coincide with the electrical degrees of sine-waves. A positive phase of the sine-wave (0 to 180 degrees), will rotate the motor approximately 45 degrees.

Maximum torque from the motor is created when the AC sine-wave is at the highest point and produces the strongest magnetic field in the Stator winding. The Rotor must be in the correct position or synchronized to take advantage of this magnet field. A Rotor arriving too early or too late falls out of synchronization and power output from the motor is reduced.



H Bridge

The EPS control module inverter function utilizes 2 sets of 3 power transistors in an "H" bridge configuration. The "H" bridge allows the voltage to be reversed through each branch while the logic of the EPS control module controls the amplitude and frequency of the simulated sine-wave. The EPS control module operates the inverter function at 2500 Hz and adjusts the power (voltage and amperage) through the amplitude control and controls motor speed with the frequency control. Voltage will range from 0 to 12 volts AC (actual potential difference will be Higher) and up to 100 Amps.



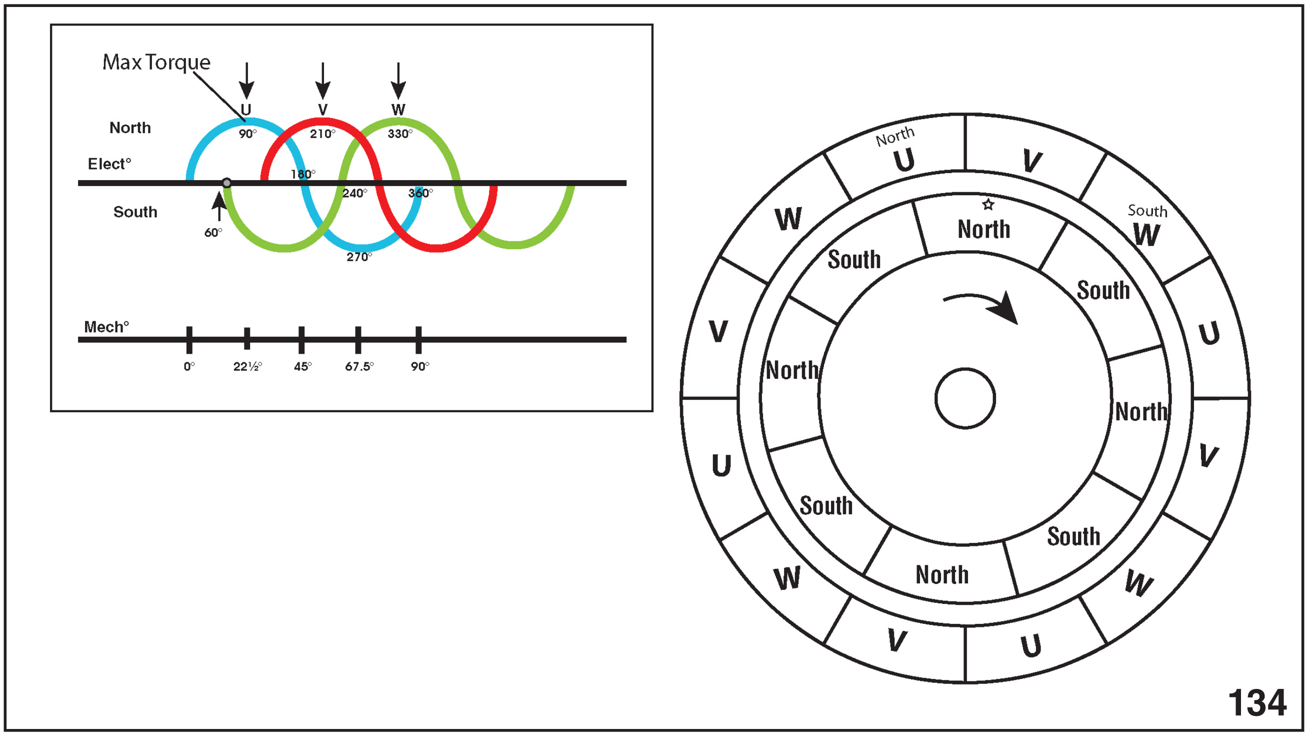
SMIII UVW

Motor direction is changed by controlling the "H" bridge to reverse 2 of the 3 branches of the Stator windings. Branch selection is determined by Rotor position.

The polarity of the electromagnets determines if a pulling force or pushing force is created inside the motor.

Motor Operation

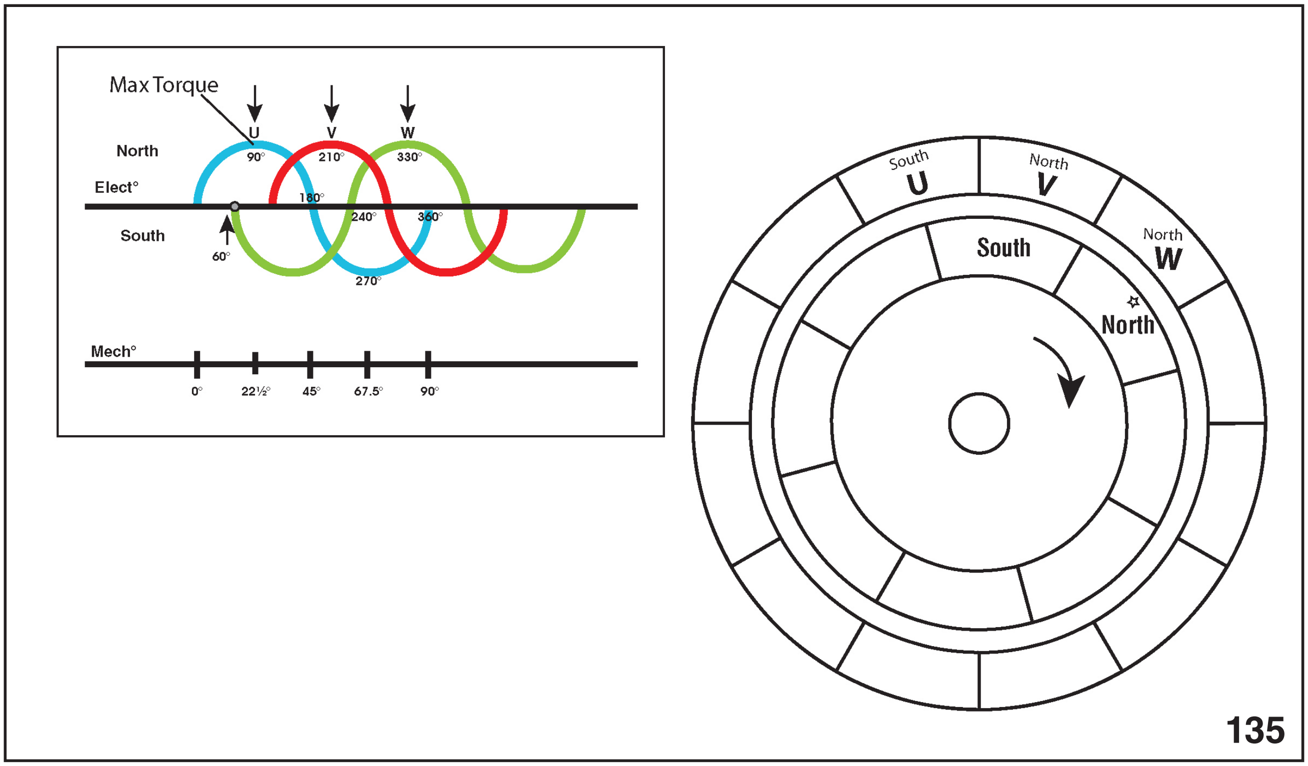
The Rotor is built with 8 alternating poles, north and south, of permanent magnets. Each pole makes up 45 degrees of the circumference of the Rotor. Compared to the width of the Stator winding field shoe, the width of a magnetic pole of the Rotor is 1 and ½ times wider. This enables the Rotor magnets to be affected by more than one Stator field shoe, or the magnetic fields created by the Stator. This prevents cogging or a notch type operation of the motor, and assists without of phase prevention. The 12 Stator winding field shoes are separated by 30 degrees inside the motor housing.



Motor Operation -1

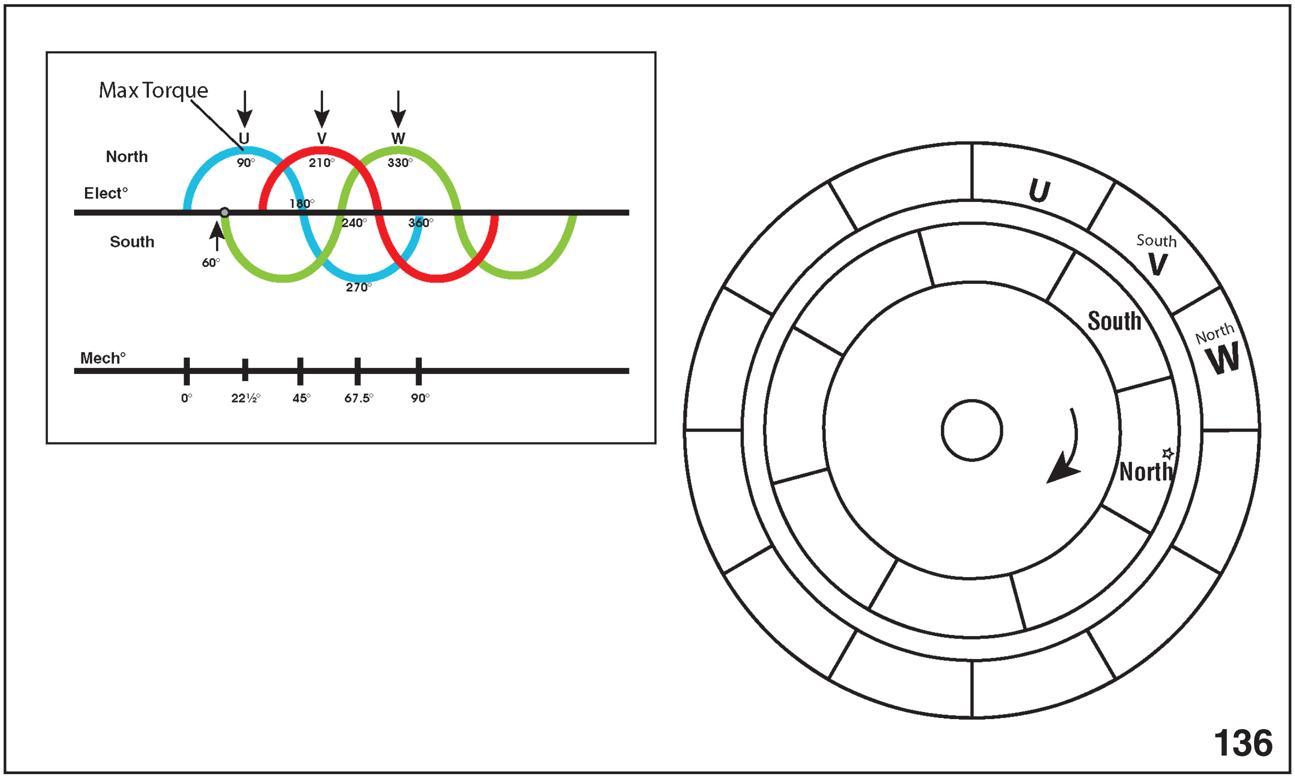
At the beginning of operation the U winding is delivered a positive Sine Wave and the W winding receives a negative Sine Wave. The U windings become North poles and repel the North poles of the Rotor. The W windings become South poles and repel the South poles of the Rotor. The trailing magnets on the Rotor for both the North and the South poles are their polar opposites. The resulting action is North repelling North and attracting South at the same time. Simultaneously, South poles repel South poles and attract North poles at the same time.

Approximately 30 degrees of rotor rotation later the V winding turns on and is delivered a positive Sine Wave, creating additional North poles. At this point in motor operation all three windings are on. The U winding is still providing for North poles on the Stator and the W is still providing for South poles. The strength of the U and the W windings is decreasing while the strength of the V windings is increasing.



Motor Operation -2

At approximately 45 degrees of Rotor rotation the U winding is receiving a negative Sine Wave, creating South poles while the V winding is delivered a positive Sine Wave creating North poles. The W winding is still negative producing South poles that repel South poles on the Rotor and attract North poles but is near zero and delivers very little potential difference. The U windings are repelling South poles and attracting North poles of the Rotor. The V windings are repelling North poles and attracting South poles.

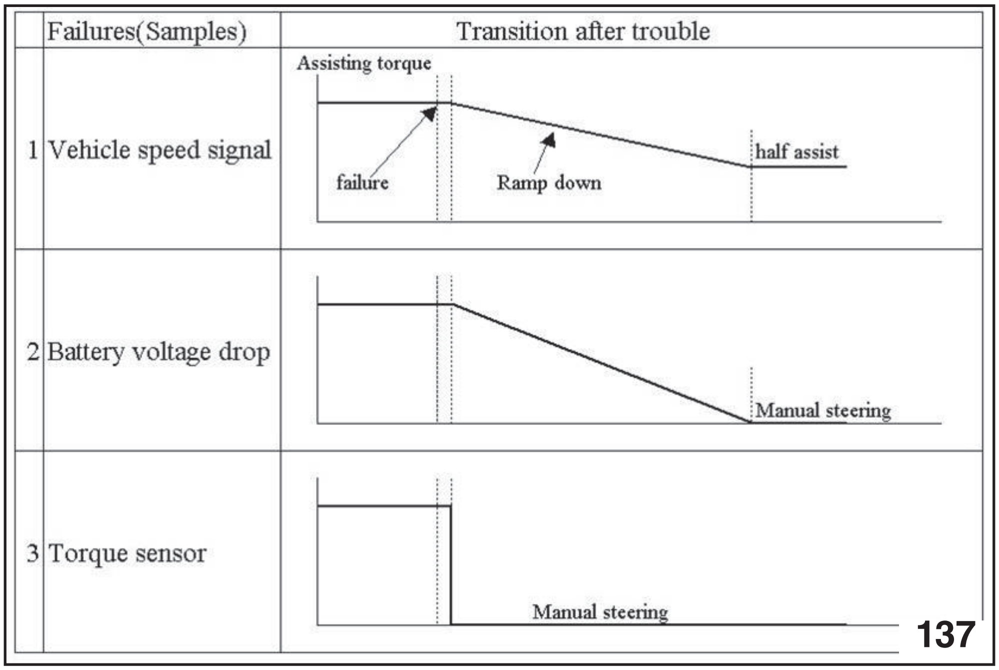


Motor Operation -3

At approximately 60 degrees of Rotor rotation the W winding is receiving a positive Sine Wave, creating North poles while the V winding is delivered a negative Sine Wave creating South poles. The U winding is still negative producing South poles that repel South poles on the Rotor and attracting North poles but is near zero and delivers very little potential difference. The W windings are attracting South poles and repelling North poles of the Rotor. The V windings are repelling South poles and attracting North poles.

This process repeats as long as the EPS Control Unit maintains the power to the Stator windings.

EPS Assist Limit Logic

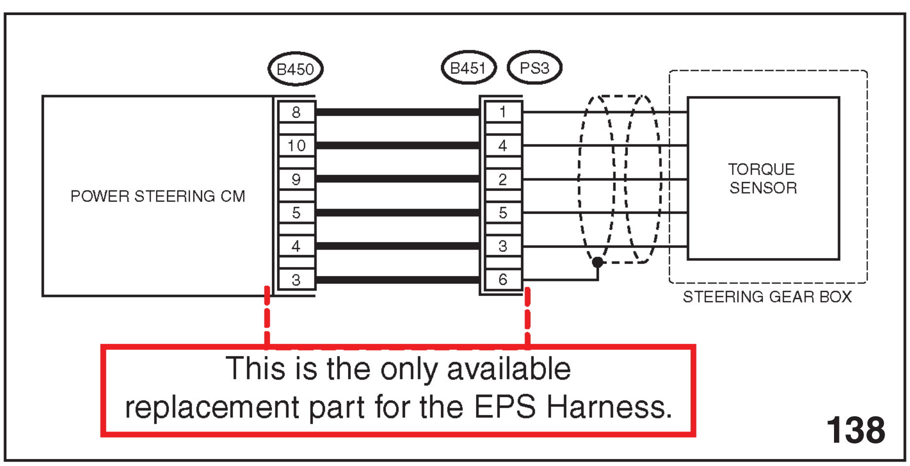


EPS Assist Logic

Counter Electromotive Force

Counter Electromotive Force (Counter EMF) is a voltage generated inside a motor as a result of a conductor moving through a magnetic field. This voltage opposes or flows in the opposite direction of the power supplied voltage and functions as a natural resistor that slows down normal motor operation. Counter EMF levels increase with increased motor speed and increased power (current multiplied by voltage) and must be considered to provide the correct motor operation for all assist levels. The EPS system overcomes Counter EMF through EPS Control Unit programming and torque sensor input.

Repair



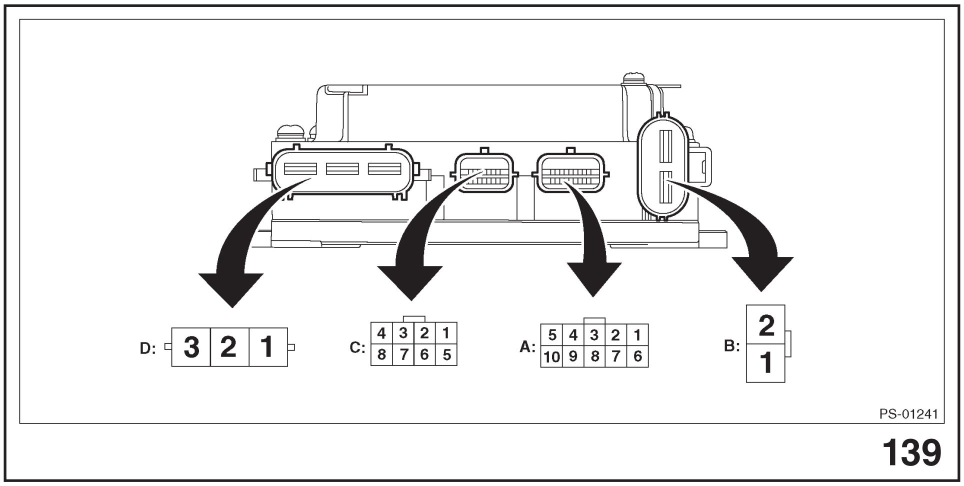
EPS Harness Wiring

Repairs to individual wires of the EPS system are not allowed.

Diagnostics

Control Module I/O Signal

Electrical Specification



Terminal Numbers

NOTE:
The terminal numbers of the power steering control module connectors are as indicated in the figure.

Description	Terminal No.	Input/output signal Measured value and measuring conditions
Power supply (IG SW)	A1	Battery voltage is detected with the ignition switch ON when measuring between A1 — B1.
Subaru Select Monitor communication line	A2	Digital signal; can not be measured
Shield GND	A3	0 V is constantly detected.
Main torque sensor	A4	The voltage changes when the steering is operated to the right or left with the ignition switch ON.
Sub torque sensor	A5	The voltage changes when the steering is operated to the right or left with the ignition switch ON.
CAN communication	A6	Digital signal; can not be measured
CAN communication	A7	Digital signal; can not be measured
Torque sensor operating power supply	A8	Approximately 8 V is detected with ignition switch ON.
Torque sensor ground	A9	0 V is constantly detected.
Torque sensor standard power supply	A10	Approximately 3 V is detected with ignition switch ON.
Ground	B1	Battery voltage is constantly detected when measuring between B1 — B2.
Power supply	B2	
Resolver S1	C1	Varies depending on the operational status of the motor.
Resolver S3	C2	
Resolver S2	C3	
Resolver S4	C4	
Excitation power supply for resolver	C5	
Common output	C6	
Motor U phase	D1	Varies depending on the motor output.
Motor V phase	D2	
Motor W phase	D3	

READ CURRENT DATA

1) On «Main Menu» display, select {Each System Check}.
2) On «System Selection Menu» display, select {Power Steering System}.
3) On «Power Steering Diagnosis» display, select {Current Data Display & Save}.
4) Using the scroll key, scroll the display screen up or down until the desired data is shown.
The list is indicated in the following table.

Display	Contents to be displayed	Range	Unit
Torque sensor main output	Main torque sensor output voltage is displayed.	0 — 5	V
Torque sensor sub output	Sub torque sensor output voltage is displayed.	0 — 5	V
Torque sensor reference voltage	Torque sensor standard voltage is displayed.	0 — 5	V
Power current	The current flowing to CM is displayed.	–128 — 127	A
Vehicle speed	Vehicle speed is displayed. (CAN communication data)	0 — 255	km/h
Engine speed	Engine speed is displayed. (CAN communication data)	0 — 12750	rpm
Detection current at ECM	The current flowing to the motor relay is displayed.	–128 — 127	A
3-phase motor current (U-phase)	The U phase actual current value as calculated by the microcomputer from the torque sensor input is displayed.	–128 — 127	A
3-phase motor current (V-phase)	The V phase actual current value as calculated by the microcomputer from the torque sensor input is displayed.	–128 — 127	A
Motor angular speed	Data from the resolver sensor is displayed.	–4096 — 4064	rpm
ECM Temperature	The thermistor temperature of the steering control module is displayed.	–50 — 205	°C
Power supply voltage	Battery voltage is displayed.	0 — 25.5	V
Torque sensor power supply voltage	The power supply voltage output to the torque sensor is displayed.	0 — 10.2	V
IG voltage	The power supply voltage supplied to the ECM is displayed.	0 — 25.5	V
CAN bus status	Either Active/Passive/Bus Off is displayed.	Active	—
EPS operating condition	Either Normal/Assist Stop/Assist Limitation is displayed.	Normal	—
Target Current at ECM	The motor target current value required for assist is displayed.	–128 — 127	A
Steering angle	Steering angle of steering wheel is displayed.	–640 — 635	deg
Reading assist MAP	Either MAP1/MAP2/MAP3 is displayed.	MAP1	—
Overheating protection intervention history	Number of interventions to the overheat protection control (assist limitation for protecting the power steering from overheating) *1	0 — 250	times
IGN count from overheating protection (most recent)	Number of times the ignition switch is ON from the intervention to overheat protection control (most recent) until now *2	0 — 65000	times
IGN count from overheating protection (previous)	Number of times the ignition switch is ON from the intervention to overheat protection control (previous) until now *2	0 — 65000	times
IGN count from overheating protection (before previous)	Number of times the ignition switch is ON from the intervention to overheat protection control (before previous) until now *2	0 — 65000	times
Assist limit history (low voltage, high voltage)	Number of intervention to assist limit when the power supply voltage is low or high *1	0 — 250	times

NOTE:
- *1 When the value exceeds the maximum of 250 times, 250 is displayed.
- *2 When there is no intervention of the overheating protection control, “65535” is displayed. If an error such as control unit memory error, etc. occurs, “65534” is displayed.

FREEZE FRAME DATA

NOTE:
- Freeze frame data stored at the time of trouble occurrence is shown on the display.
- Each time a trouble occurs, the latest information is stored in the freeze frame data in memory.
- One freeze frame data will be stored.

8. General Diagnostic Table

A: INSPECTION

Trouble	Possible cause	Corrective action
• Steering effort is heavy in all ranges. • Steering effort is heavy at stand still. • Steering wheel vibrates when turning.	1. Tire and wheel • Improper tire out of specifications • Improper wheel out of specification • Tires not properly inflated	Replace or reinflate.
	2. Measure the steering wheel effort. <Ref. to PS-38, TURNING RESISTANCE OF GEARBOX, INSPECTION, Electric Power Steering Gearbox.>	Adjust or replace.
• Vehicle leads to one side or the other. • Returning force of steering wheel to center is poor. • Steering wheel vibrates when turning.	1. Tire and wheel • Flat tire • Mixed use of different tires • Mixed use of different wheels • Abnormal wear of tire • Unequal tread remaining • Unequal pressure of tire	Adjust, fix or replace.
	2. Front wheel alignment • Improper or unequal caster • Improper or unequal toe-in • Loose suspension connections	Adjust or retighten.
	3. Measure the steering wheel effort. <Ref. to PS-38, TURNING RESISTANCE OF GEARBOX, INSPECTION, Electric Power Steering Gearbox.>	Adjust or replace.

NOTE:
When performing repeated steering operation with the vehicle at standstill, the steering effort may be temporarily heavy because the heat generated in the system activates the power steering protection control. This is not a malfunction caused by the steering system. After a while, it will return to normal steering effort. (In this case, the steering warning light will not come on and there will be no DTC.)

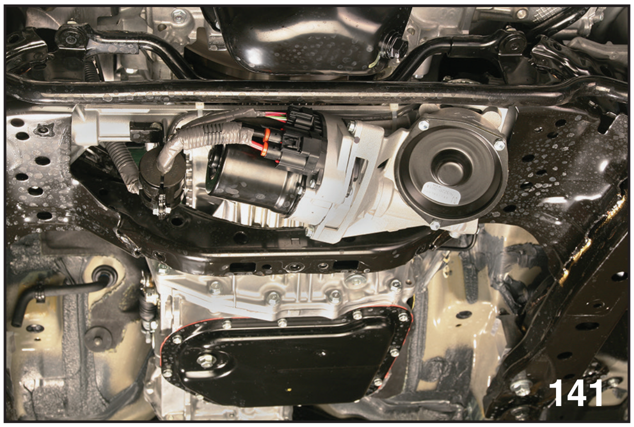
1. NOISE AND VIBRATION

NOTE:
- When turning the steering wheel with the brake applied when the vehicle is parked, a screeching noise may be generated by the brake disc and pads. This is not a fault in the steering system.
- There may be a small vibration around the steering devices when turning the steering wheel at standstill, even though the component parts are operating properly.

Trouble	Possible cause	Corrective action
Rattling noise (intermittent) While engine is running.	Interference with adjacent parts	Check the clearance. Correct if necessary.
	Looseness of linkage, play of steering, improper tightening (looseness) of suspension joint or steering column	Retighten or replace.
	Noise emitted from inside of the gearbox	Replace the gearbox assembly.
Knocking When turning steering wheel in both directions with small angle repeatedly at engine ON or OFF.	Excessive backlash Loosened lock nut for adjusting backlash	Adjust the backlash. When the noise remains after adjustment, replace the gearbox assembly.
	Insufficient tightening or play in the tie-rod or tie-rod end	Retighten or replace.
Grinding noise (continuous) While engine is running. (While operating the steering.)	Fault inside of gearbox	Replace the gearbox assembly.
	Faulty bearing of the column assembly - steering	Apply grease or replace.
	Occurs when turning the steering wheel with brakes (service or parking) applied.	If the noise goes off when brake is released, it is normal.
Vibration While engine is running. (with/without steering turned)	Excessive play in steering, looseness of suspension parts	Retighten.

2015 LEGACY AND OUTBACK ELECTRIC POWER STEERING (EPS)

An enhanced Electric Power Steering (EPS) system has been adopted for the 2015 Legacy and Outback. This design is similar to 2012 Impreza and 2014 Forester models. In addition to a more accurate and natural steering feel, the adoption of EPS provides a 2 percent improvement in fuel efficiency over the current hydraulic system.

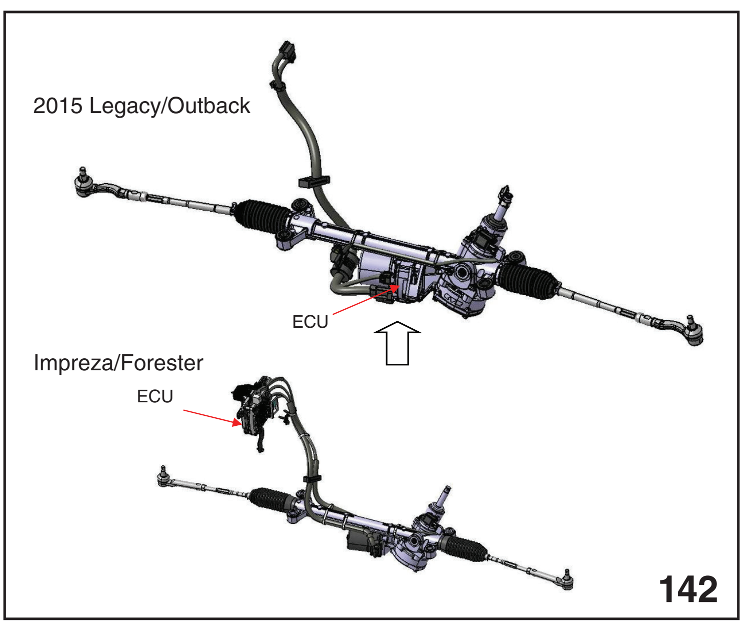


2015 Legacy And Outback Steering Rack

Major Changes

The EPS system on the 2015 Legacy and Outback features the following differences:

- The EPS Control Unit and Gear Box are now combined into a single assembly.
- The U, V, and W Motor Windings and the Resolver Sensor connections are provided directly within the Control Unit.
- The Torque Sensor has been changed to a Flux Ring style sensor.

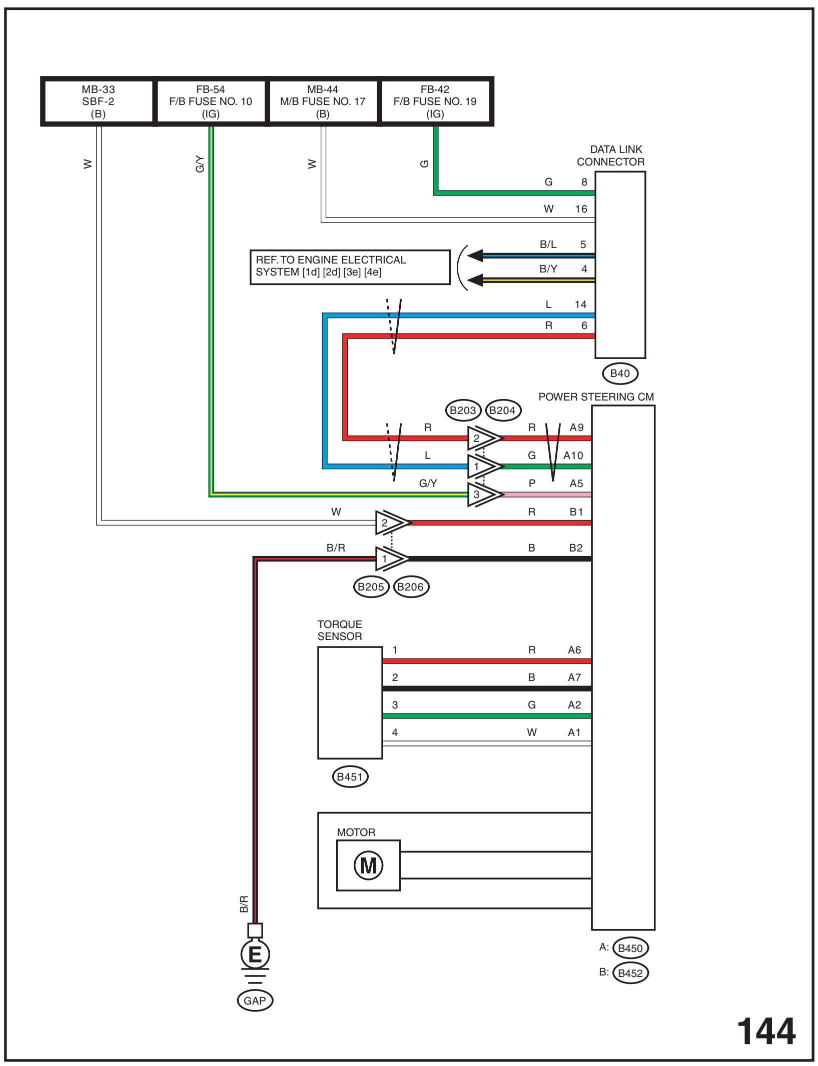


EPS Comparison

Electric Power Steering Circuit

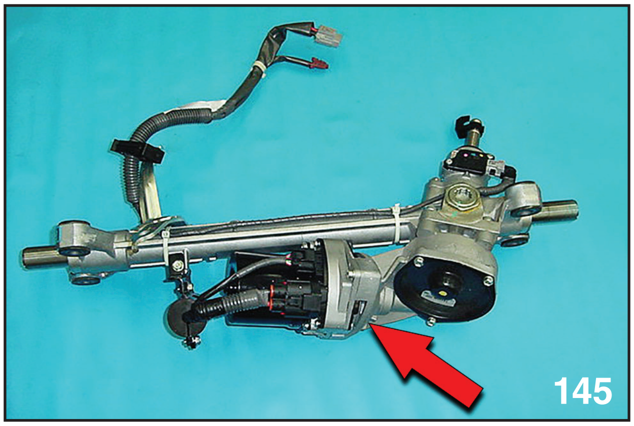
Connections from the EPS Rack assembly to the vehicle have been reduced to two. Connector B205 provides supply voltage and ground to the EPS while connector B203 contains CAN communication and an Ignition Switch signal.

EPS Wiring Harness

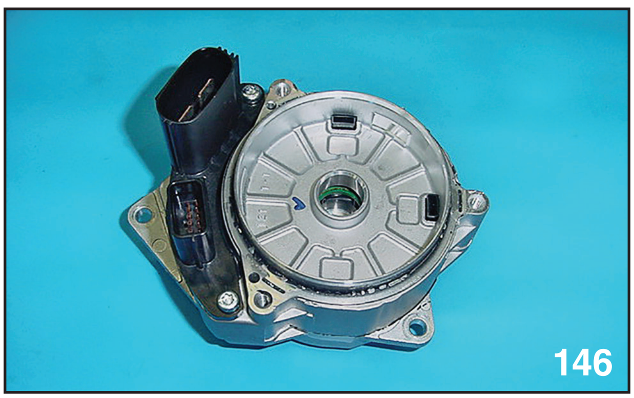


EPS Wiring Diagram

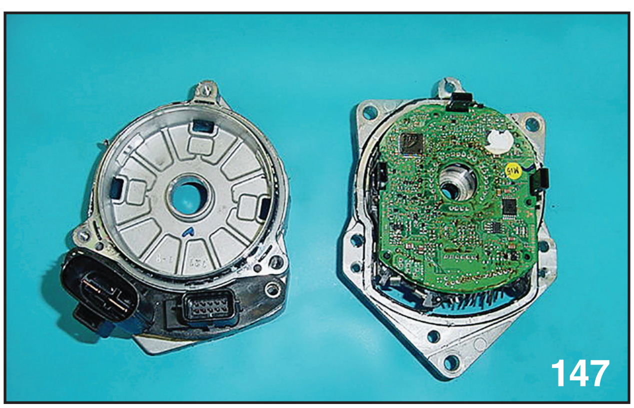
The EPS Control Unit and Gear Box are now combined into a single assembly. These components cannot be serviced individually.



Control Unit Location



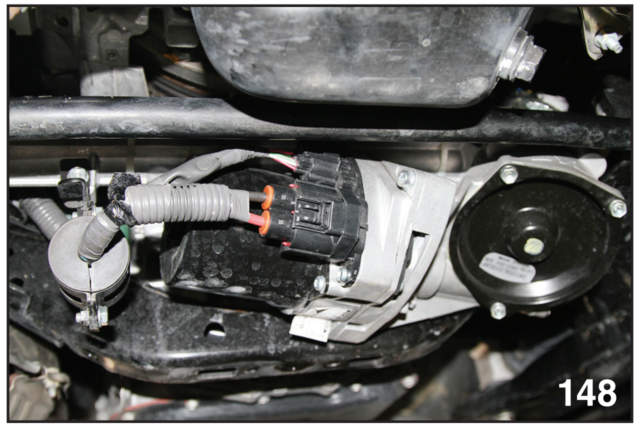
Control Unit Connections



Control Unit

Drive Motor

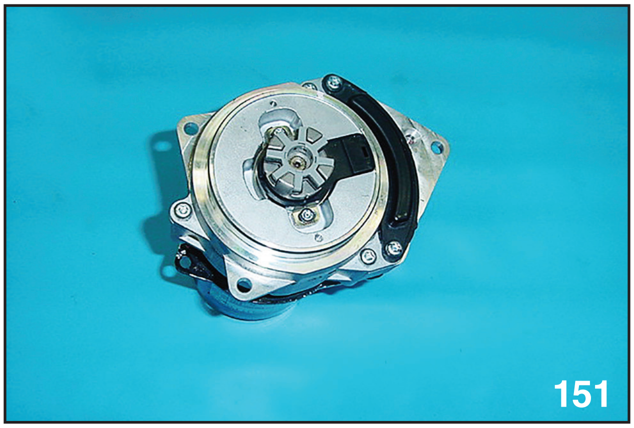
The EPS Motor is an eight pole Permanent Magnet Synchronous AC motor. DC power and ground are supplied through connector B205 where it is controlled via "H" bridge transistors inside the EPS Control Unit.



EPS Drive Motor (In Vehicle)

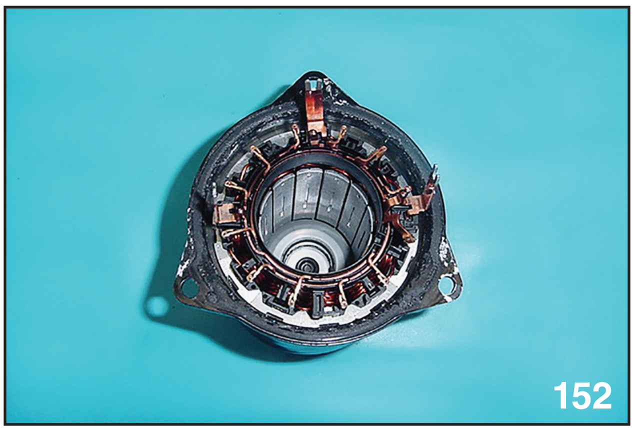
EPS Drive Motor

Exposed Rotor Magnets

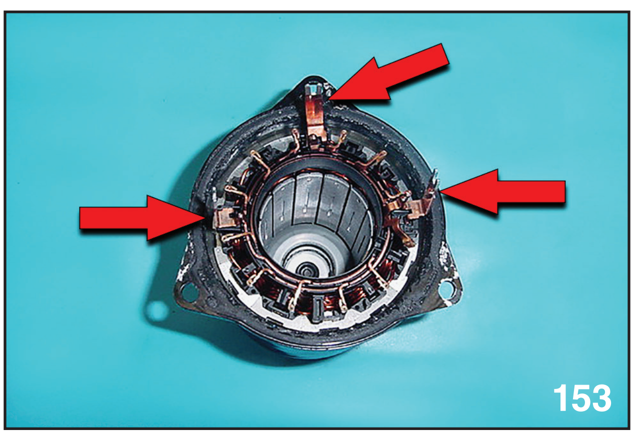


Drive Motor Coupling

Connections for the U, V, and W windings are supplied through a bus bar inside the control unit.



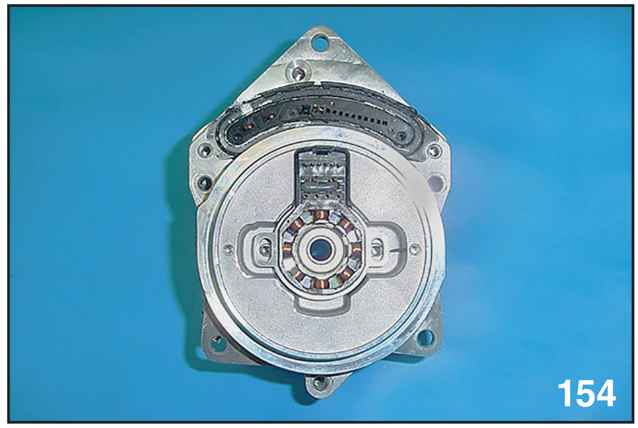
Drive Motor Windings



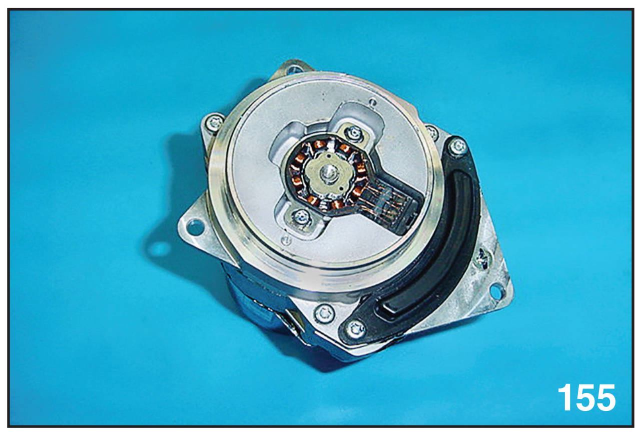
U, V, and W Connections

Resolver Sensor

The Resolver Sensor is mounted in the Motor Coupling housing and is press fitted to the motor shaft. This Resolver uses a 5 tip Rotor where as Impreza and Forester models used a 4 tip Rotor. Timing for the EPS motor is based on information provided by the Resolver Sensor.



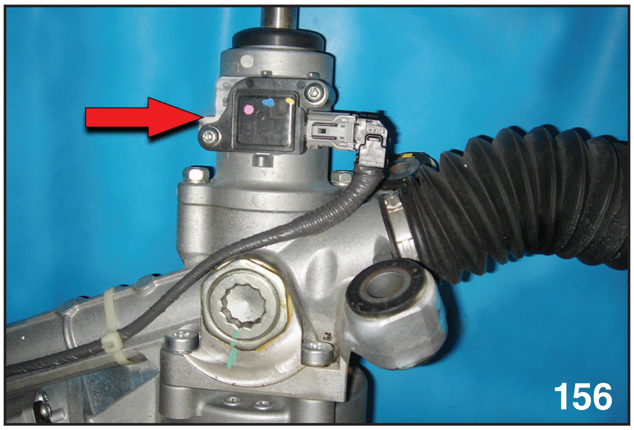
Resolver Windings



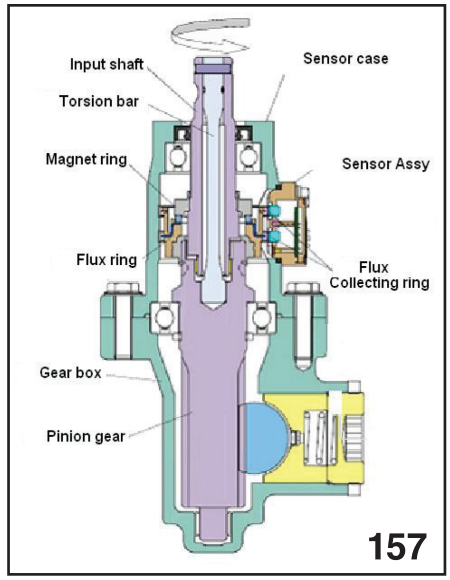
Resolver 5 Tip Rotor

Torque Sensor

The Torque Sensor delivers the driver's demand and force acting on the tires to the EPS Control Module. This EPS uses a Flux Ring style sensor that detects torque acting on the torsion bar of the Steering Rack input shaft. The sensor consists of a Magnet Ring, Flux Ring, Flux Collecting Ring, and Flux Yoke.



Torque Sensor



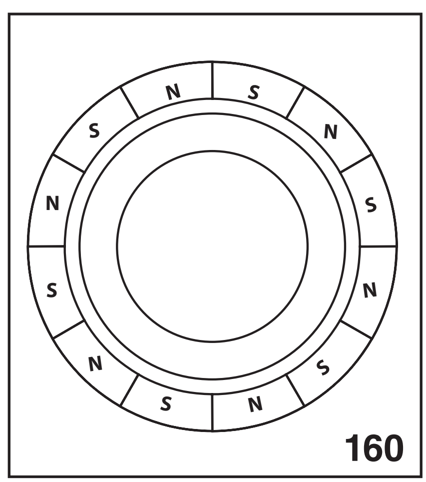
Input Shaft Cross Section

Magnetic Ring

The Magnet Ring, containing alternating North and South poles, is fixed to the Torsion Bar. As the Input Shaft rotates, resistance from the driver's demand creates torsion deforming the shaft. This deformation rotates the Magnet Ring and varies the North and South magnetic flux lines that are detected in the Flux Ring.

Input Shaft

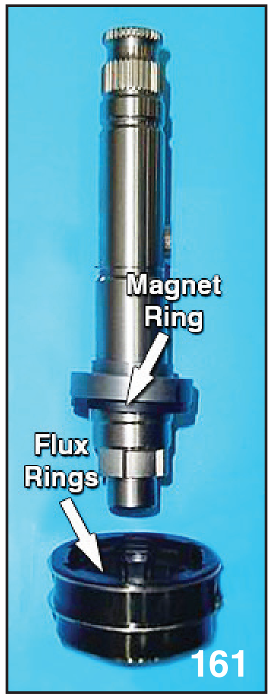
Magnet Ring



Magnet Ring Poles

Flux Rings

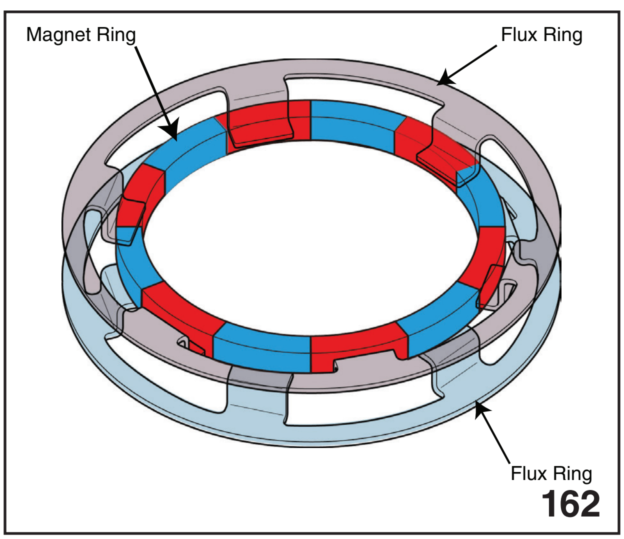
The Flux Rings detect the North and South magnetic fluctuations from the Magnet Rings movement. The 2 rings are identified as the Main and Sub.



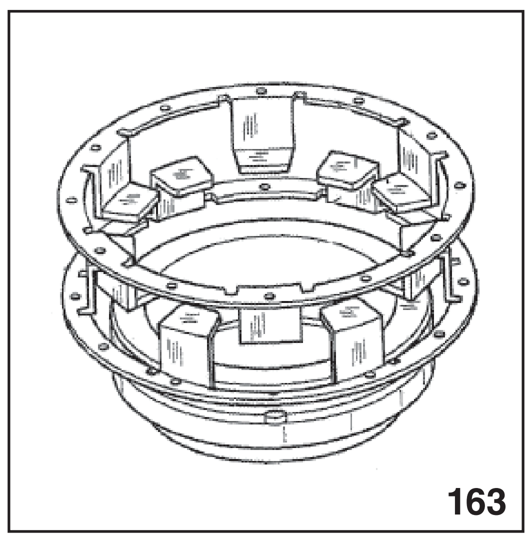
Magnet Ring And Flux Rings

Flux Collecting Rings

The Flux Collecting Rings transfer the North and South magnetic fluctuations from the Flux Rings to the Flux Collecting Yoke.



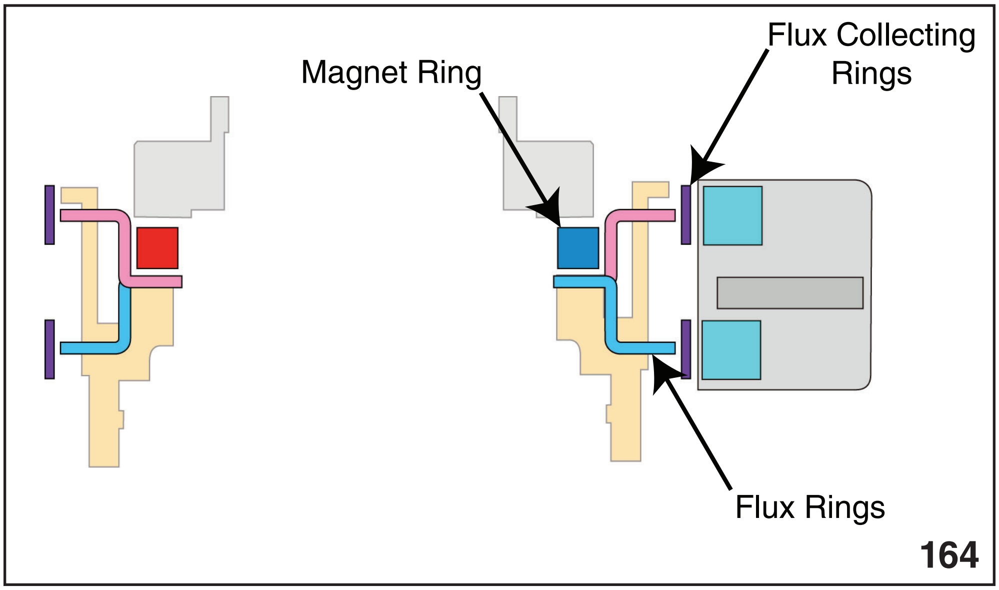
Magnet Ring and Flux Rings Artwork



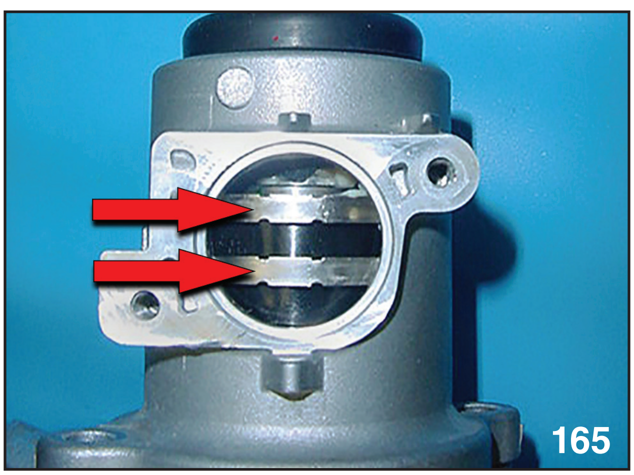
Flux Rings Artwork

Flux Collecting Yoke

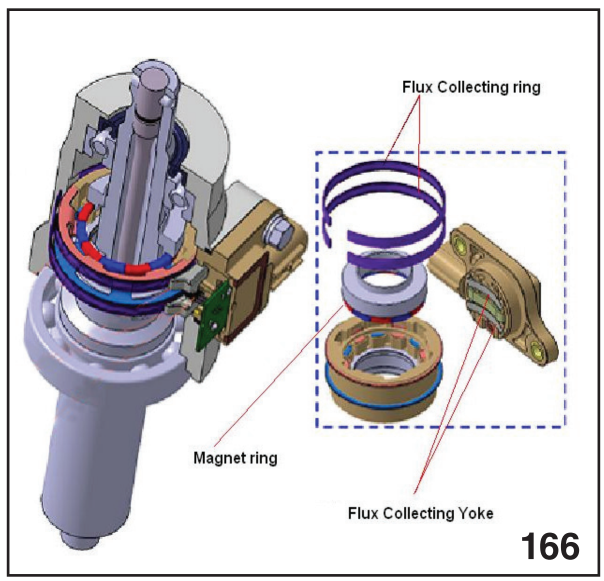
The Flux Collecting Yokes transfer the North and South magnetic fluctuations from the Flux Collecting Rings to the Hall IC of the Torque Sensor. Based on the Torque Sensors interpretations, motor direction and torque will be varied.



Flux Rings And Flux Collecting Rings



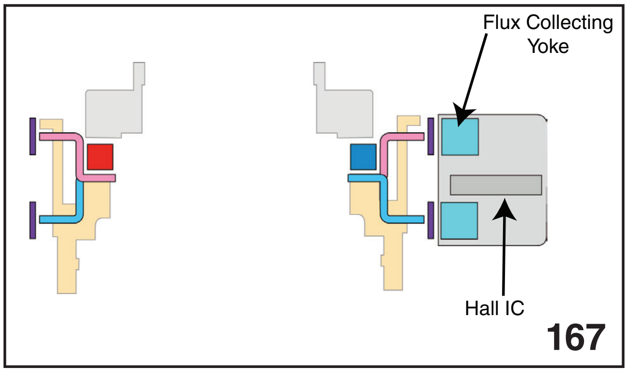
Flux Collecting Rings



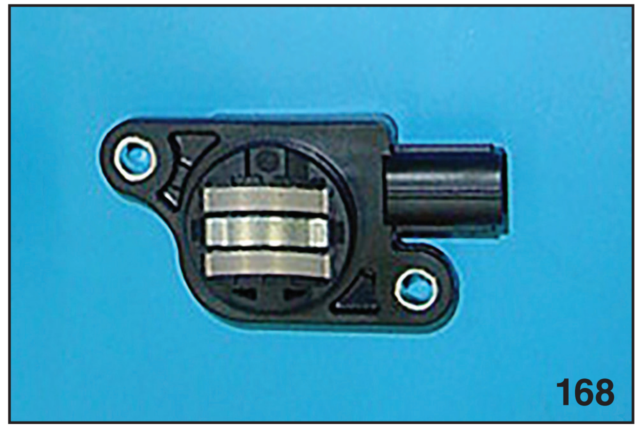
Flux Collecting Rings

Flux Collecting Yoke

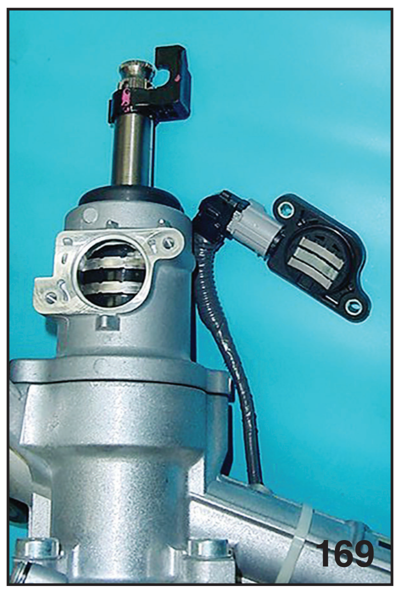
The Flux Collecting Yokes transfer the North and South magnetic fluctuations from the Flux Collecting Rings to the Hall IC of the Torque Sensor. Based on the Torque Sensors interpretations, motor direction and torque will be varied.



Flux Collecting Yoke And Hall IC



Flux Collecting Yoke And Hall IC



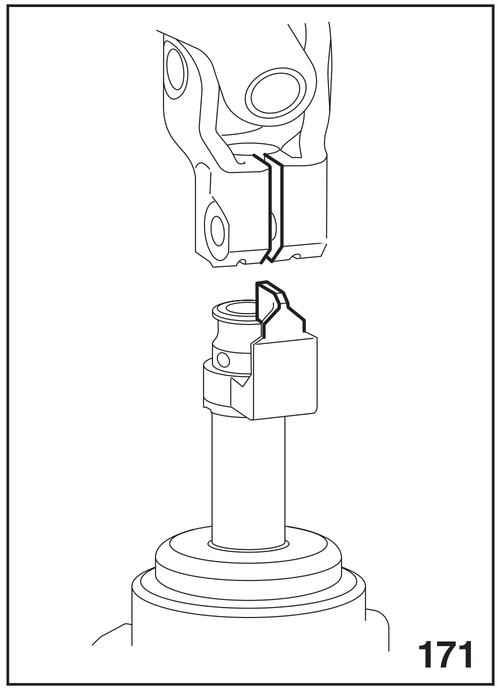
Sensor Removed

Alignment Collar

The Steering Gearbox shaft is now fitted with a plastic collar for alignment of the universal joint during assembly.


170

Alignment Collar


171

Universal Joint Installation

NOTES:

Diagnostics

Since the Control Unit has been incorporated into the Gear Box assembly, diagnostics have been simplified. Resolver and U, V, W Motor Winding related diagnostics are no longer necessary as any faults relating to these components will require a Gear Box assembly replacement.

DTC	Item	Content of diagnosis
None	Without DTC	Normal
	“Assist limitation” is displayed in the current data «EPS operating condition».	Assist limitation is performed due to overheat protection control.
	“Overheating protection intervention history” in current data display shows 1 or more.	There are previous records of intervention to overheat protection control.
C2511	Torque Sensor Failure 1 (Main)	• Poor connector contact • Forgot to connect connector • Faulty torque sensor section circuit • Faulty torque sensor coil
C2512	Torque Sensor Failure 2 (Sub)	
C2513	Torque Sensor Failure 3 (Much Tolerance)	
C2514	Torque Sensor Power Supply Failure	
C2521	Motor Failure 1 (Motor)	• Poor connector contact • Forgot to connect connector • Harness open/short circuit • Motor open circuit • Power transistor shorted/open • Terminal power supply or ground short
C2522	Motor Malfunction 2 (Resolver)	
C2531	ECU Failure 1 (CPU Failure)	Faulty main unit of power steering control module
C2532	ECU Failure 2 (Peripheral Circuit Failure)	Faulty main unit of power steering control module
C2533	ECM Failure 3 (Board Temperature Sensor Failure)	Faulty main unit of power steering control module

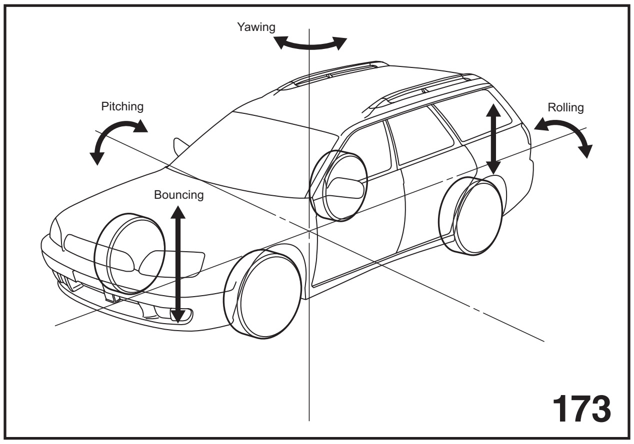
Inspect harness for possible damage. Replace if necessary. If harness is OK, Torque Sensor or control Unit has failed. Replace the Gear Box assembly.

Replacement of Gear Box Assembly is necessary.

Conventional CAN Diagnostics

DTC	Item	Content of diagnosis
C2541	Vehicle Speed Failure(Sensor Failure)	• Poor connector contact • Forgot to connect connector • Harness open/short circuit • VDC system failure
C2543	Error Passive Status	Defective CAN communication
C2545	EyeSight System Abnormal	EyeSight system failure
C2546	EyeSight Value Abnormal	EyeSight system failure
C2547	EyeSight Check Sum Abnormal	• EyeSight system failure • Defective CAN communication
C2548	Vehicle Dynamics Control Module Abnormal	VDC system failure
C2551	Power Supply Relay Failure	• Power supply voltage malfunction • Faulty relay contact
U0073	Control Module Communication Bus Off	Defective CAN communication
U0100	Lost Communication With ECM/PCM “A”	Defective CAN communication
U0122	Lost Communication With Vehicle Dynamics Control Module	Defective CAN communication
U0126	Lost Communication With Steering Angle Sensor Module	Defective CAN communication
U0155	Lost Communication With Instrument Panel Cluster (IPC) Control Module	Defective CAN communication
U0401	Invalid Data Received From ECM/PCM “A”	Defective CAN communication
U0416	Invalid Data Received From Vehicle Dynamics Control Module	Defective CAN communication
U1235	Lost Communication With EyeSight	Defective CAN communication
U1433	Invalid Data Received From EyeSight	Defective CAN communication

FORCES WORKING ON AN AUTOMOBILE



Various Forces Artwork

Various forces work on the wheels of an automobile while it is being driven. These include forces that work in the up-down direction, left-right direction, and front-rear direction.

A vehicle is supported by its suspension, which is subjected to the above-mentioned loads while the vehicle is being driven.

The suspension supports the vehicle weight and cushions the impact of road irregularities, and keeps the tires in contact with the road surface at all times. This insures proper vehicle operation during acceleration, braking and turning.

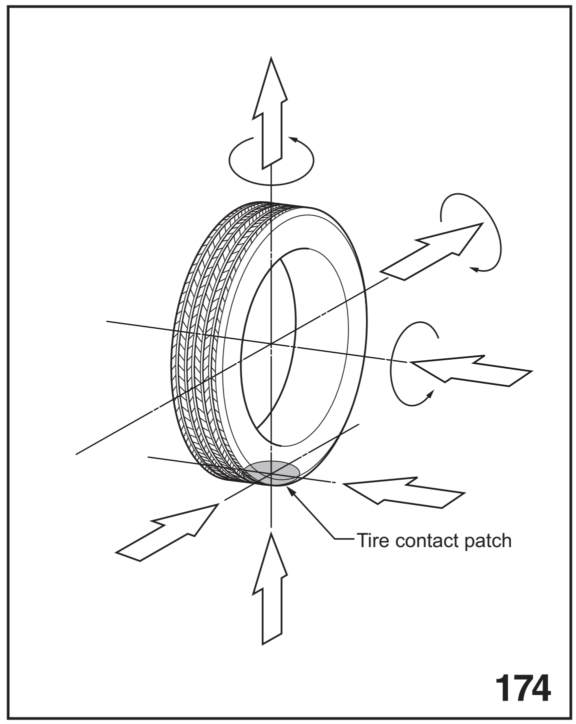
Suspension

In automobiles, the front suspension and rear suspension are independently attached to the body.

When the front and rear parts of a vehicle are moving at the same phase, the vehicle is said to be bouncing, and when they are moving in opposite phases, it is said to be pitching. These phenomena will vary depending on the location of the vehicle center of gravity, the spring constant of the front and rear springs, damping and forces.

Factors Affecting Handling and Stability

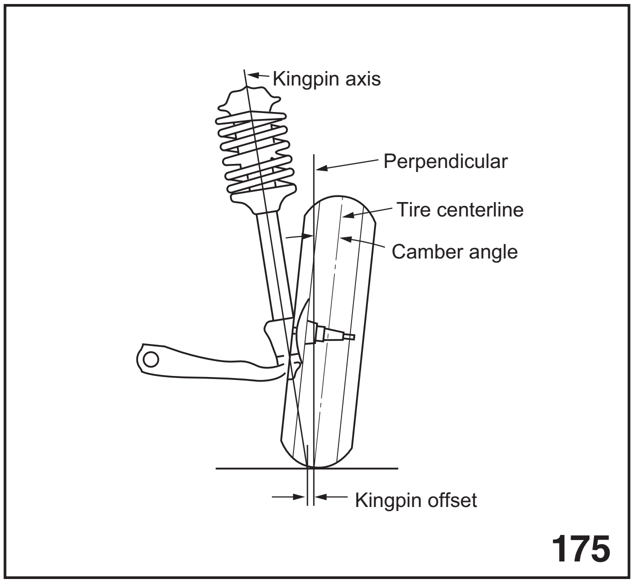
The forces applied to each of the four wheels of an automobile while it is being driven change minutely because of the workings of the suspension and the accompanying wheel alignment changes, relation between the steering system, differences in drive system, etc. and road handling characteristics and stability will be changed.



Tire Contact Patch Artwork

1. Camber or toe angle varies due to rolling (roll)
2. Camber or toe angle varies due to elastic deformation of the suspension (compliance)
3. Variation in tire characteristics (variation in side force due to tire cornering power varies that accompanies on load change)
4. Effects of drive system (torque steering, power drift, and other drive system effects)

Camber



Camber Artwork

Viewed from the vehicle front, the front wheels and tires are set at a certain angle (tilt) from straight ahead, as is shown in the diagram. This angle is called the camber angle. If the wheel leans out at the top, it is said to have a positive camber; if it protrudes out at the bottom, it is said to have a negative camber.

Function of Camber

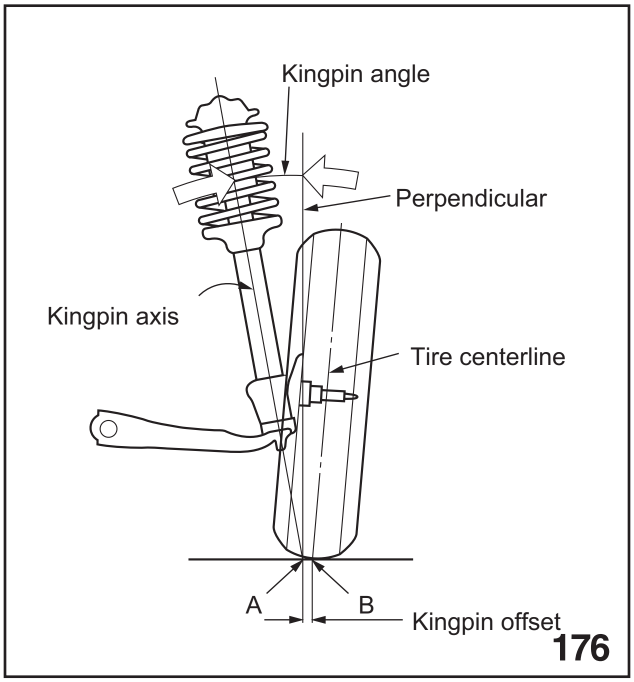
The initial camber angle is set so that the camber to the ground stays close to 90° even though the camber to the vehicle body changes due to the up – down movements of the wheel caused by loads, roll tendency, and other factors. The reason that the wheels should be upright is because the tire contact area is the largest and the tire grip is the best when the tires are upright, and because it produces the largest cornering force when the steering wheel is turned. It is also most advantageous from the standpoint of tire wear.

When the camber angle is too large (even when turning, for example), tire wear becomes a problem. The vehicle body leans outward when the vehicle is cornering or turning, so the tire and wheel camber to the ground changes in the positive direction at the outside wheels and in the negative direction at the inside wheels. As a result, an initial negative camber is being used in more and more models in order to secure an adequate cornering force on the outside wheels where more weight is applied for stable cornering.

Kingpin Angle

Viewed from the vehicle front, normally the kingpin axis is set so that it tilts inward (toward the automobile) at the top. This tilt is referred to as the kingpin angle.

In addition, the distance between point A (where the extended kingpin axis line meets the road) and point B (the contact patch center) is called the kingpin offset.



Kingpin Artwork
(viewed from the vehicle front)

If point A is inboard from point B, the kingpin offset is said to be positive, and if it is outboard from point B, the offset is said to be negative.

Purpose of Kingpin Angle

The purpose of the kingpin angle is to assist the self aligning torque (improve straight-ahead travel characteristics), alleviate steering effort, and cushion kickback.

When the steering wheel is turned, the tires turn around the kingpin axis. There is, however, a rolling resistance in the tires, and this resistance generates a moment around the kingpin axis. This moment is practically in proportion to the kingpin offset, so the smaller the offset, the less the steering effort that is required. Due to the effects of the camber angle, the kingpin offset can be set smaller than the actual offset produced by the kingpin angle.

However, since the tire contact patch has a certain area, the steering effort can never be zero, even if the kingpin offset is zero.

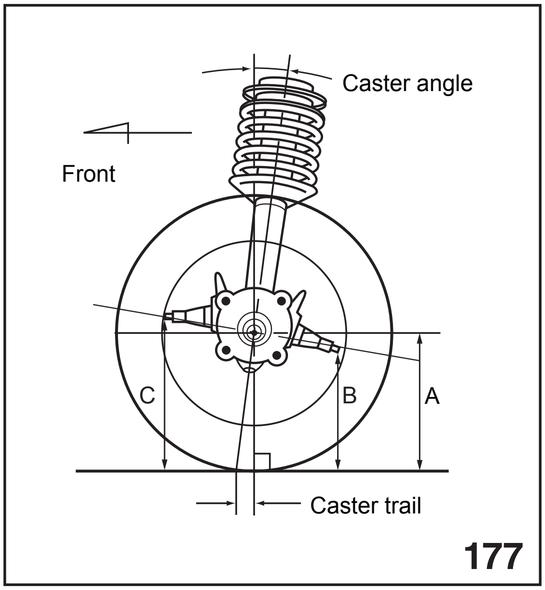
During brake action or when shock is imparted to the tires and wheels due to road irregularities, a moment is similarly working around the kingpin axis, but this moment can be alleviated by reducing the kingpin offset.

With the kingpin set at an angle, turning the steering wheel causes the spindle end to drop below the straight-ahead position (A > B), as is shown in the diagram. Accordingly, the wheels lift the vehicle body only by that amount, and this positional energy becomes the self aligning torque. The larger the kingpin angle, therefore, the larger the steering self aligning torque (straight-ahead travel restoring force), and the larger the required steering effort.

Caster Angle

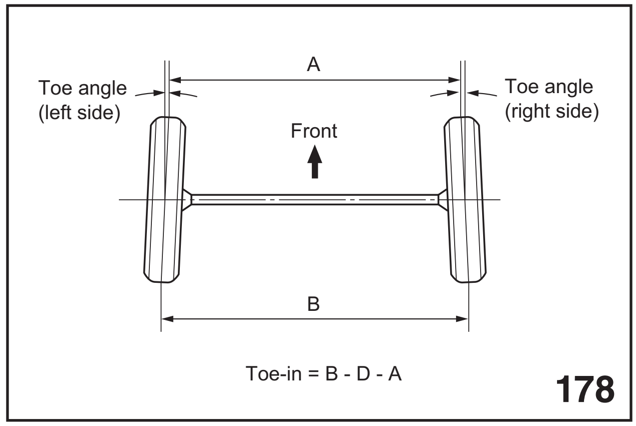
Viewed from the side, the kingpin axis is generally set so that the kingpin top tilts rearward, as is shown in the diagram. This angle is called the caster angle.

Function of Caster Angle



Caster Angle Artwork

The caster angle also secures straight-ahead driving characteristics as a self aligning moment around the kingpin axis. The distance between the spindle end and the road surface is considered in the diagram, with A, B, and C representing the steering wheel center, left stop, and right stop positions, respectively. Because of the caster angle, C > A > B. When the steering wheel is turned to the left, therefore, the vehicle body is lifted on the inner wheels side (B) (only by an amount roughly equivalent to A – B), and positional energy, which then becomes the self aligning torque, is obtained.



Toe In Artwork

When the front wheels are viewed from above as shown in the diagram, and the distance between the right and left tire center-lines is indicated as A at the leading edge of the tires and B at the trailing edge of the tires, then generally A < B. This difference (B – A) is referred to as toe-in. Conversely, if the distance at the leading edge is larger, the condition is called toe-out. Also, the angle formed by the tire center-line in the fore-and-aft direction and the line through the tire center at a right angle to the vehicle axis is called the toe angle.

Purpose of Toe-in

The purpose of toe-in is to prevent toe-out due to the camber angle and the tire rolling resistance. It also prevents tire wear by executing this function.

Since tire side slip is avoided, tire wear can be prevented. If the kingpin offset is positive, moreover, the tire rolling resistance will create a moment around the kingpin axis in the outer direction, which in turn creates a toe-out effect. By setting the front wheels at toe-in beforehand, therefore, toe-out while driving is prevented.

Thrust Line

The thrust line is the vehicle straight-ahead travel line. With the front wheels set in the straight-ahead position, as is shown in the diagram, the rear wheel travel direction will deviate from the vehicle's geometrical center if the rear wheel toe angle or other setting is incorrect. The line of this deviation is referred to as the thrust line.

Suspension

The angle that the rear wheel travel direction deviates from the geometrical center is called the thrust angle.

The thrust angle is mainly determined by the rear wheel toe angle.

It is obtained as follows.

The thrust angle should be as close to possible to zero. If it is too large the following problems will result.

1. The vehicle will "dog track".
2. The vehicle will oversteer at one side and understeer at the other side while cornering.
3. Tires will wear unevenly.

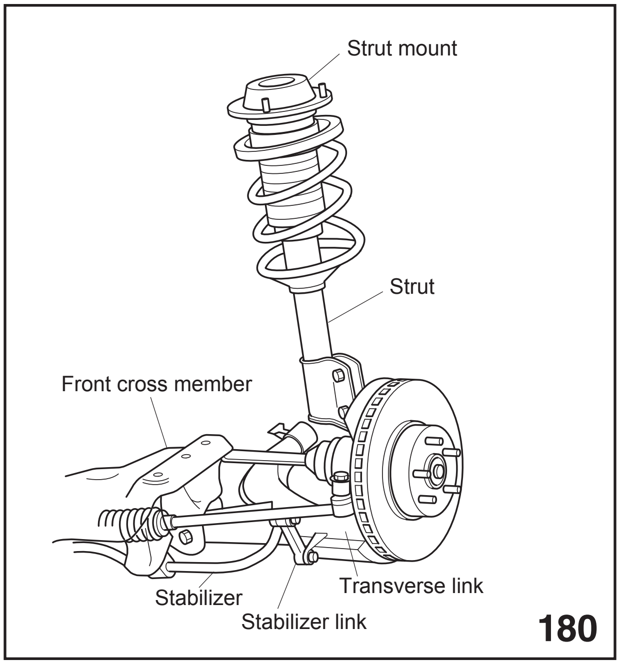
The thrust angle is mainly produced by a deviation between the left and right rear wheel toe angles, but it is also produced by the following causes.

1. Lateral deviation of the front member, lower link, transverse link, or other front-end part due to an accident involving the front wheels;
2. Shifting of rear axle rearward due to bent rear axle, broken off leaf spring center bolt, or loose U-bolt.

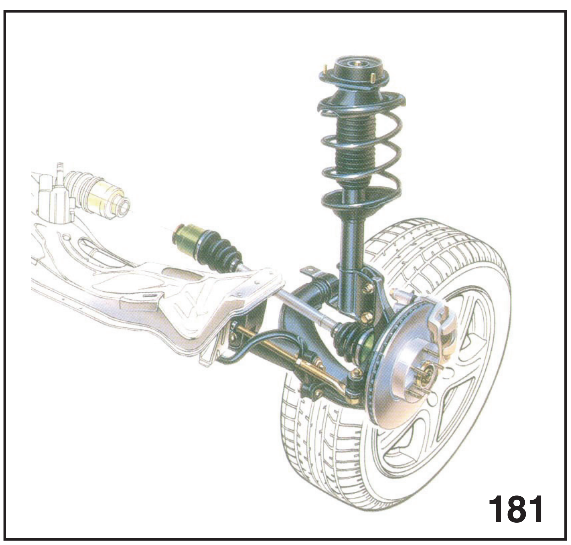
FRONT AND REAR SUSPENSION

Front Strut Type Suspension

The two types of strut suspensions used by Subaru are described in the following. In the front end a strut type suspension with a relatively simple structure is used, consisting of a strut mount, strut, transverse link, stabilizer link, stabilizer, and front crossmember.



Front Strut Artwork



Front Strut Type Suspension (MacPherson Strut)

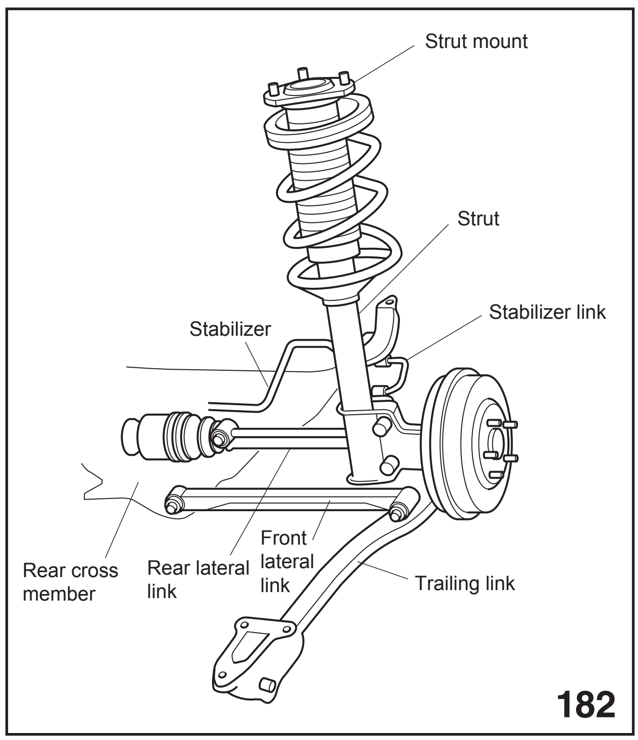
Dual Link Strut Type Suspension

In the rear end a dual link type strut suspension.

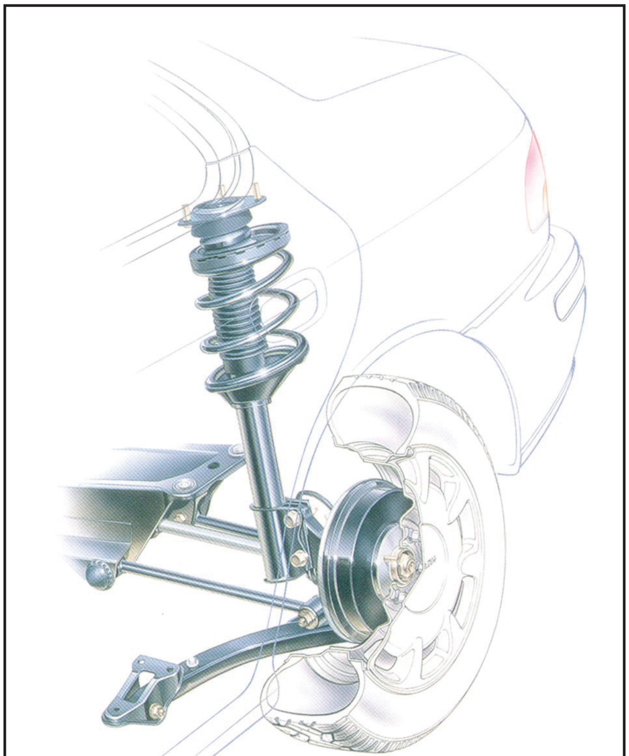
The dual link type strut is comprised of two lateral links, a trailing link, and a strut Assy. The strut Assy consists of a dual-cylinder shock absorber.

The crossmember is mounted to the frame through bushings. The stabilizer, which extends rearward from the crossmember, is mounted to the frame through a bracket and to the rear lateral link through a stabilizer link.

Part name	Function
Trailing link	Support longitudinal forces
Coil spring, strut, and rubber mount	Support up-down directional forces
Dual links	Support lateral forces



Rear End Dual Link Strut Type Artwork



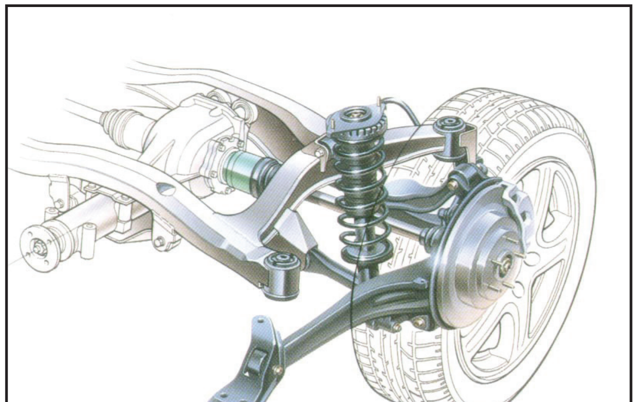
183

Rear Strut Type (Chapman Strut), Dual Link

Multi-Link Suspension

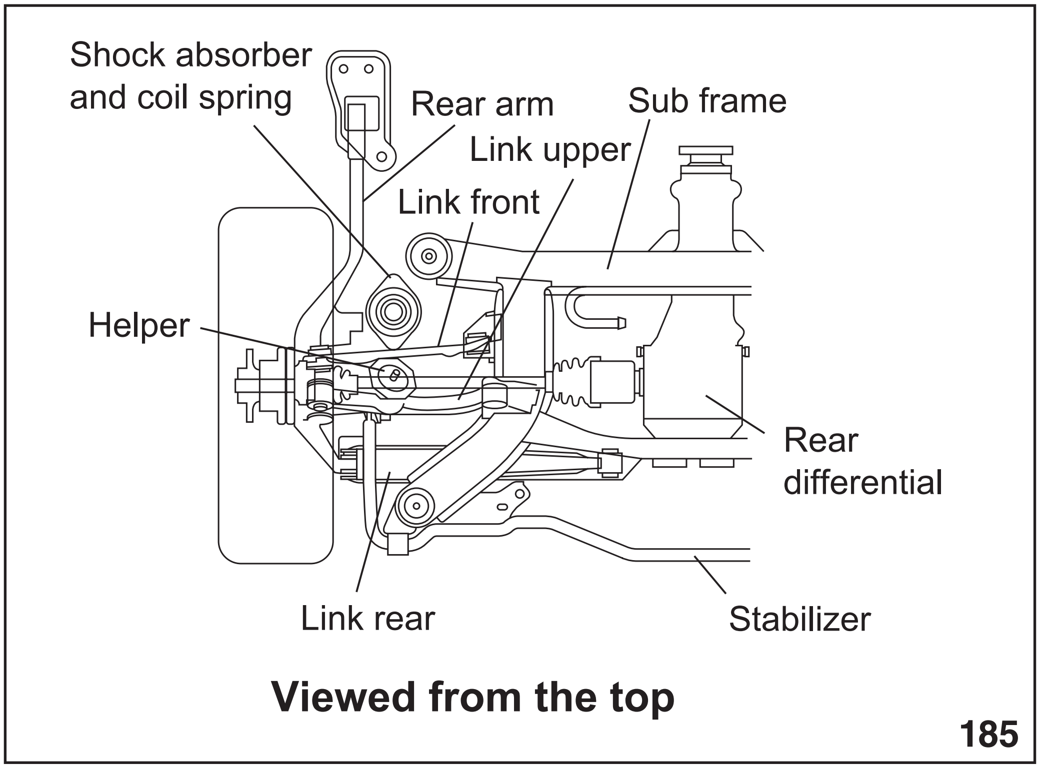
The multi-link suspension is comprised of three links, front, rear and upper, a rear arm, stabilizer, sub frame, and other parts. The multi-link suspension evolved from the double wishbone suspension and uses several links, as opposed to the double wishbone arrangement. The multi-link suspension allows greater freedom in alignment design; maximizes tire grip by optimizing alignment changes due to forces generated by braking, driving, cornering, and so on; and improves road handling characteristics.

In addition, since the three links and rear differential are mounted to the sub frame, the suspension gives a quiet ride.

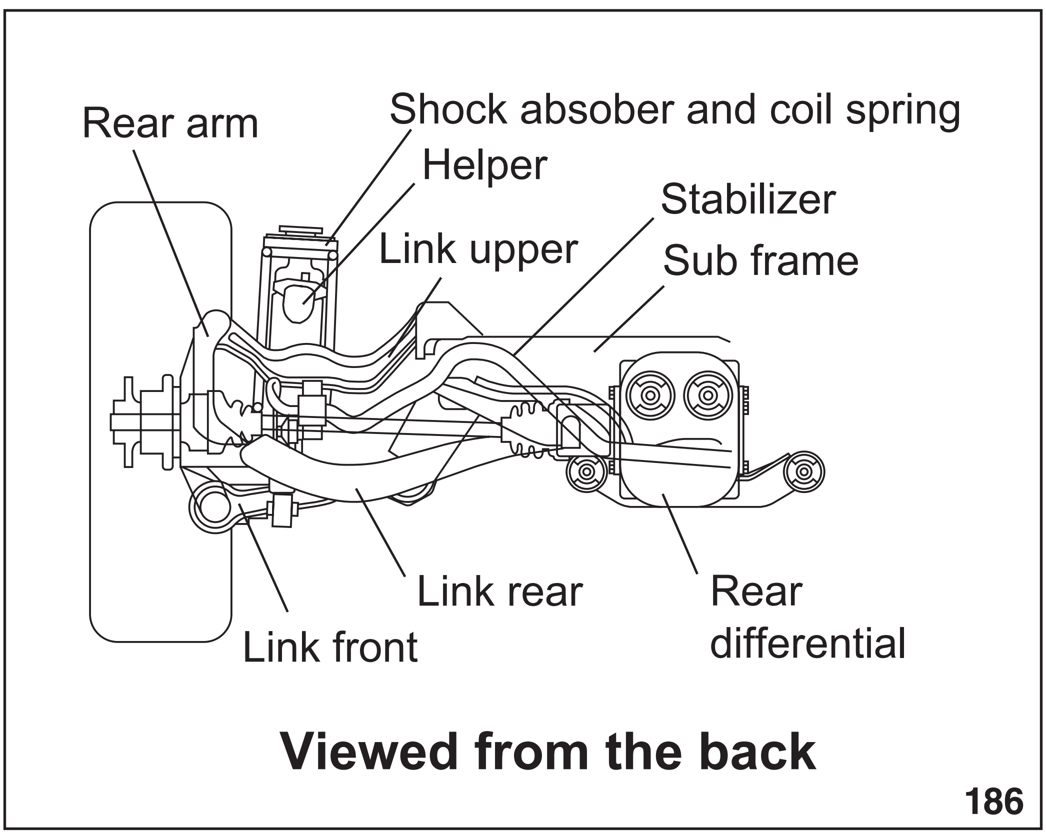


184

Rear Strut Type, Multi-link (Legacy)



Viewed From The Top Artwork



Viewed From The Back Artwork

COIL SPRING AND SHOCK ABSORBER

A coil spring is spring steel wound in a coil shape.

Springs like the leaf spring and torsion bar spring are used only in suitable applications like commercial vehicles.

This is because of the following coil spring advantages.

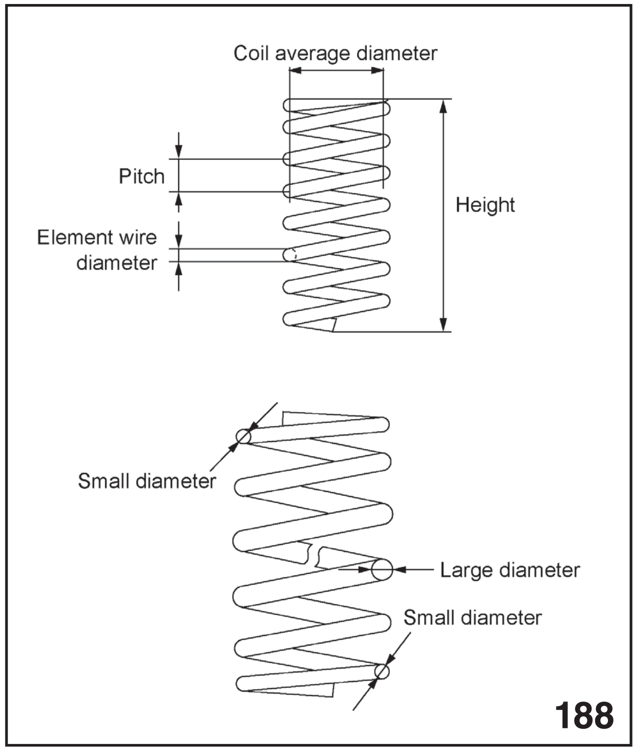
1. It allows the use of a softer spring (smaller spring constant).
2. The suspension can be made more compact and the unsprung weight can be reduced.

Accordingly, the coil spring gives a more comfortable ride and better road handling characteristics—which is why it is widely used in passenger vehicles.

All coil springs are compression type springs made from a round spring steel bar wound in a coil shape. The compression force is received by a twisting of the element wires in the coil.

The spring constant is in direct proportion to the element wire diameter raised to the 4th power, and in inverse proportion to the coil diameter raised to the 3rd power and the number of coil turns. In order to improve riding comfort, moreover, some coil springs use nonlinear springs so that the spring constant varies according to the spring's compressed length (spring constant is small and spring is soft under light-load conditions).

These nonlinear characteristics are obtained by varying the element wire diameter, as well as the pitch and coil diameter, as is shown in the diagram below.



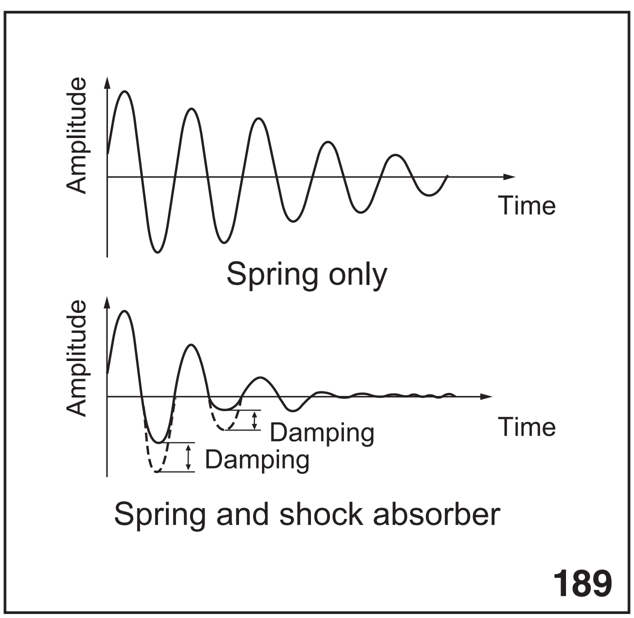
Wire Diameter (Pitch & Coil Diameter)

Shock Absorber Function and Characteristics

The shock absorber reduces and controls vehicle vibration by absorbing the energy of the body up-and-down movements. It improves riding comfort, protects cargo, and prolongs the vehicle life by reducing the stress of the different parts of the vehicle. It also controls wheel vibration and other unsprung weight vibration, and improves the vehicle driving performance.

The braking action of a shock absorber is called a damping force. The mechanism that is solely used in vehicles to generate this damping force is one that utilizes resistance to the viscous flow of a fluid (oil), because, for one reason, the damping characteristics can be freely set to correspond to the mechanism operating speed.

The shock absorber is cylindrical in shape and the damping force, although it has different characteristics, is effective in both the compressing direction and the expanding direction. In fact, for riding comfort and other reasons, the damping force in the expanding direction is stronger than in the compressing direction.



Damping Force

TIRES

Relationship of Tires and Suspension

The suspension supports the body weight and cushions vibration, and by various means it removes impediments to the transmission of the forces between the tires and the road surface, caused by changes in the vehicle position that occur while the vehicle is being driven. Increased shock to tires caused by a faulty suspension part not only accelerates tire damage but also makes the vehicle driving characteristics unstable and adversely affects tire life.

In addition, uneven and premature tire wear is caused and wear is promoted when the smooth rolling of tires is hindered by a worn bushing or bearing, a damaged arm or rod, or a malfunctioning air spring or shock absorber.

The driving characteristics will become dangerously unstable if the tire type, shape, and construction (bias ply tire, radial tire, etc.) are mixed or if the degree of wear of tires is Significant different.

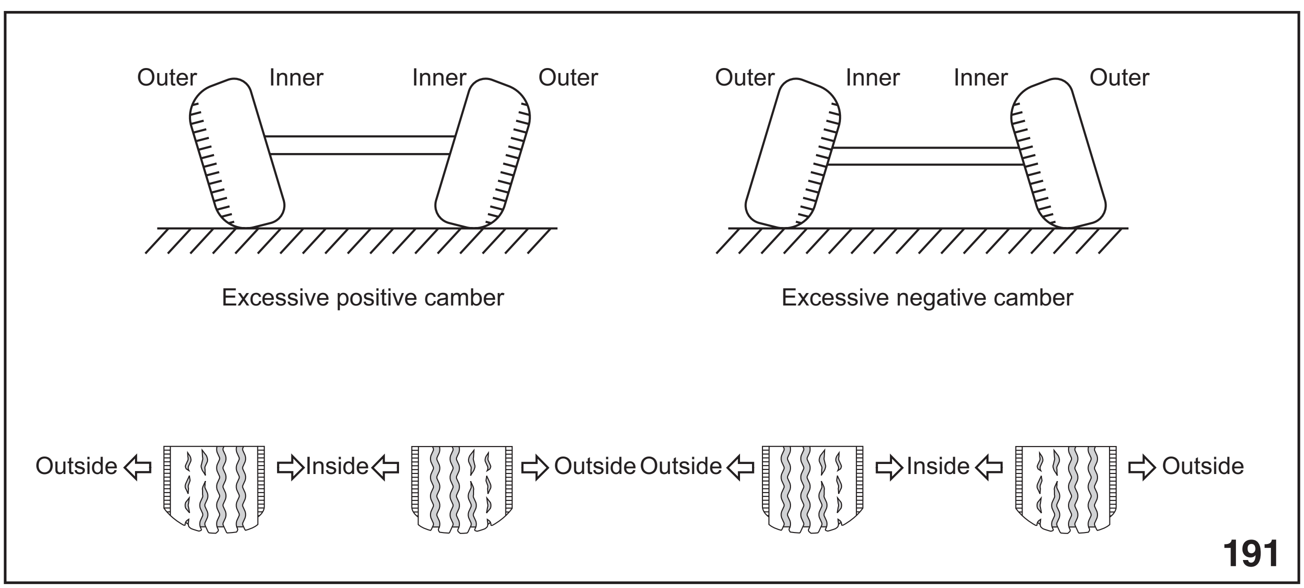
Factors such as wheel alignment and axle parallelism strongly influence a vehicle's performance. Faulty wheel alignment is the cause of increased steering effort, unstable handling, tire side slip, and uneven tire wear. At high speeds, moreover, these faults are particularly dangerous, so the need for proper wheel alignment becomes critical.

The degree of alignment is predetermined for each alignment (camber, caster, kingpin angle, toe-in, etc) independently and for how each alignment works together in relation to the other. Therefore, wheel alignment inspection must comply with predetermined standards.

Incorrect Camber

If the camber is too large, the tire will wear on one side only, and the wear may assume a wave-shaped pattern.

If the camber is too far positive, the tire will wear on the outside edge; if it is too far negative, the tire will wear on the inside edge.



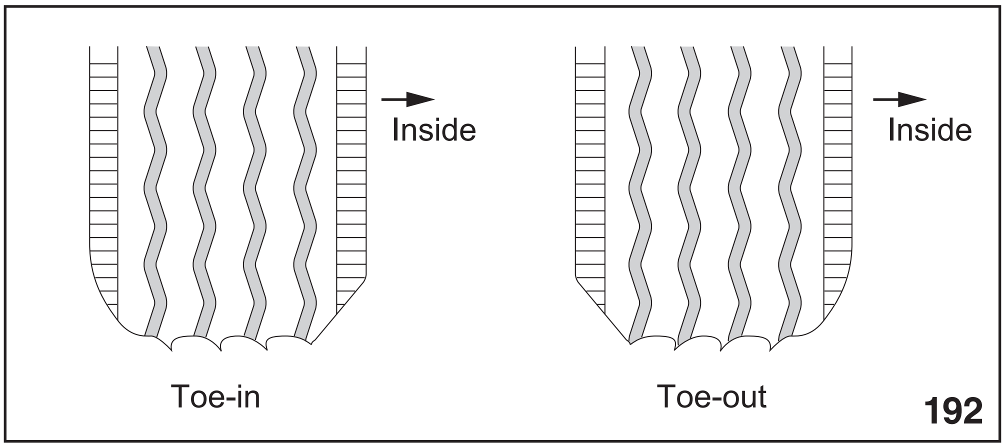
Incorrect Camber Artwork

Incorrect Caster

If the caster is incorrect, the vehicle may wander and the tires may wear prematurely.

Incorrect Toe-in

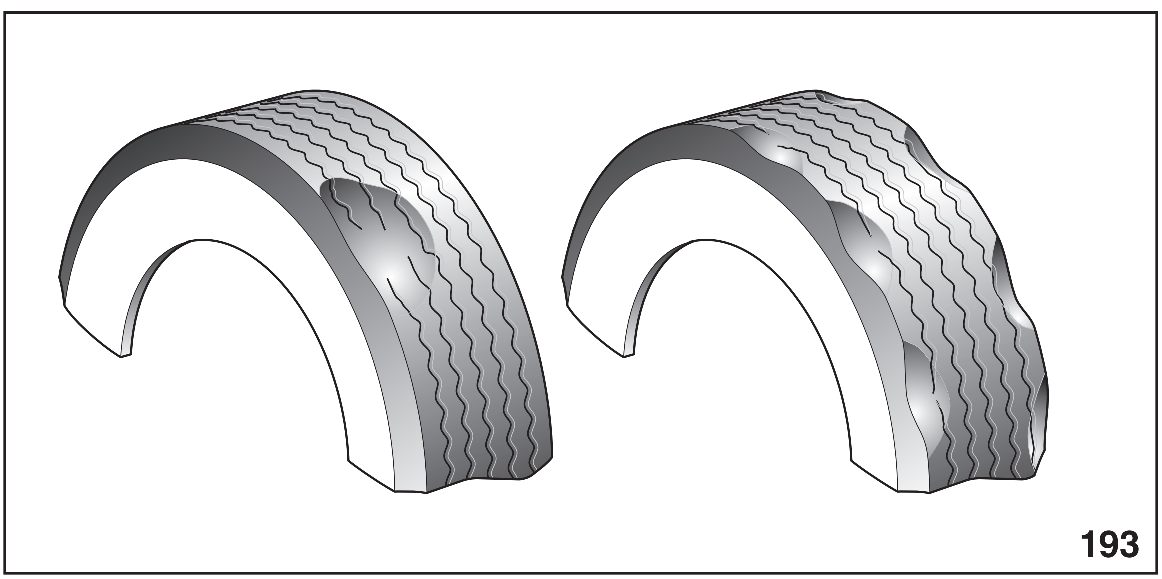
If there is too much toe-in, the tire tread will wear in a featheredge pattern, with the sharp edges pointing toward the vehicle, or the tread on the outside shoulder will wear excessively. If there is too much toe-out, conversely, the tire tread will wear in a featheredged pattern, with the sharp edges pointing away from the vehicle, or the tread on the inside shoulder will wear excessively. In addition, these phenomena may also be accompanied by premature tire wear.



Premature Tire Wear Artwork

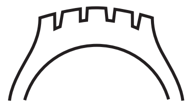
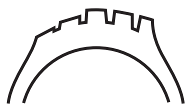
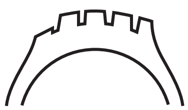
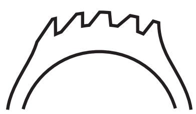
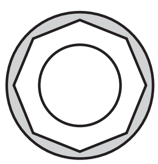
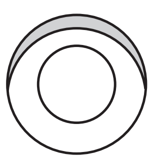
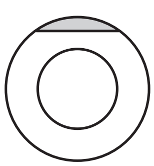
Loose or Damaged Suspension Parts

A loose tie-rod, bent axle, eccentric or bent disc wheel, and other problems that produce an unbalance in the suspension rotating parts will result in spot wear on the tires.



Spot Wear On Tires Artwork

Abnormal Tire Wear

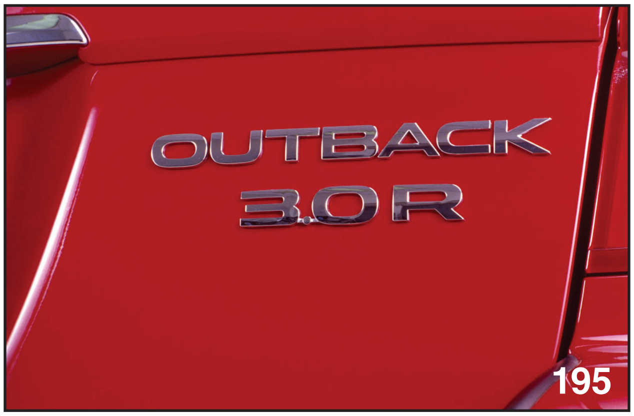
Name	Wear pattern		Main Cause
Normal wear	 Tire cross section	All parts of tire are uniformly worn.	
Uneven wear	 Tire cross section	Tire is worn on one side only (usually the outside edge).	Incorrect toe-in camber
Shoulder wear	 Tire cross section	Tire shoulder is worn on one side only (usually the outside shoulder).	Incorrect camber
Featheredge wear	 Tire cross section	Tire shoulder is worn on one side only in a distinctive featheredge Pattern.	Incorrect toe-in
Wavy wear	 Tire cross section	Wave-shaped wear pattern (especially on shoulders)	1. Eccentric or bent tire and wheel 2. Eccentric or bent hub and spindle 3. Loose bearing or kingpin 4. Unbalance in rotating parts
Eccentric wear	 Tire cross section	One half of tire is worn	1. Eccentric or bent tire and wheel 2. Eccentric or bent hub and spindle 3. Loose bearing or kingpin 4. Unbalance in rotating parts
Spot wear	 Tire cross section	Tire is worn in one spot or several separate spots	1. Excessive brake action on specific part due to worn brake drum 2. Loose bearing or kingpin 3. Loose ball joint 4. Bent axle or eccentric tire or wheel

NOTE: Various occasions of wear may occur.

194

Abnormal Tire wear Chart

Tire Pressure Monitoring System



Outback

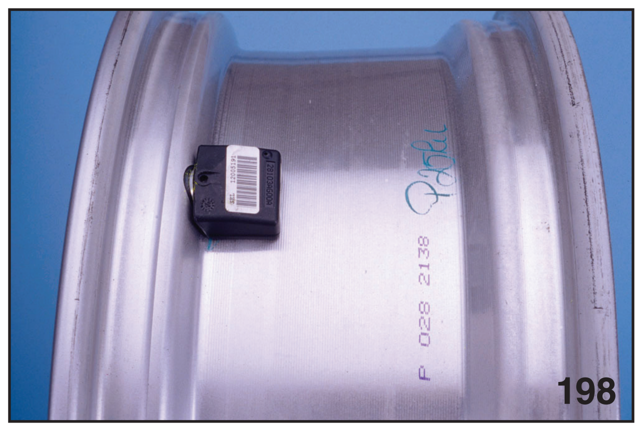
During the 2005 model year the Tire Pressure monitoring System (TPMS) was equipped on all Outback 3.0R sedan and wagon models.

Warning Light

TPMS is designed to alert the driver that pressure in a tire is below Specifications.

Tire

The specification for setting the alert for front tires is 210 Kpa (30 P.S.I.) and below. The specification for setting the alert for the rear tires is 200 Kpa (29 P.S.I.) and below. The TPMS does not identify which tire pressure is low to the driver. When the alert is set the pressure in all tires should be checked.



Transmitter

System components include a transmitter for each wheel, control unit and warning light for displaying the alert.

The transmitter consists of the tire valve stem, (Non Serviceable) radio transmitter and a non serviceable lithium battery. The lithium battery has a life span of about 10 years. The valve stem core can be serviced however if the valve stem is damaged the entire transmitter assembly must be changed.

NOTE: Newer style transmitter can be replaced separately.

Transmitter Operation

The transmitter has a built-in centrifugal switch that is activated when the tire speed reaches 9.3 to 21 mph (15 to 35 km/h). While the switch is on the transmitter sends a radio signal to the receiver once per minute. This radio signal includes three separate pieces of information;

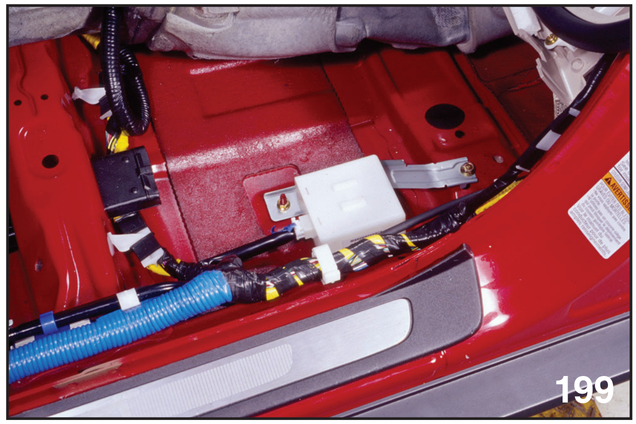
Function code- A code indicating the transmitter mode at that time.

ID code- An identifying code allotted to the respective transmitter.

Pressure data-Detected pressure data.

There are 6 function modes of operation for the transmitter:

1. Learn mode- Activated by the Technician using a special tool which creates a magnetic field that tells the transmitter to send a signal to the receiver although the wheels are not moving. This tells the receiver where each tire is located.
2. Low Battery Mode
3. Off Mode
4. Re-measure mode-When the pressure measuring result has changed by 1.2 p.s.i. (+- 8.4kpa). This mode will result in the pressure being checked again in less than one minute.
5. Wake mode-When the car is stopped, pressure measuring and transmission of the signal are stopped. Just beginning of operation.
6. Normal mode-When the tires are turning and the car reaches a given speed the centrifugal switch in the transmitter becomes on, the pressure is measured once a minute and the data is transmitted.



TPMS Control Unit

The control unit is located under the carpet below the driver's seat and is used to compare the signals received from each wheel against the established minimum pressure and activate the warning light on the combination meter. The control unit also performs system set up and diagnosis.

Make sure mounting area is free from moisture.

Malfunction Judgment Conditions

The receiver judges a system fault when the following conditions exist;

1. EEPROM fault-At the time of ID registration, the memory write data and the read data do not coincide.
2. Data reception impossible: No reception of data from the transmitter possible for at least 10 minutes with a car speed of 25 m.p.h. (40 km/h) or more.
3. Abnormal function code: At a car speed of 25 m.p.h. (40 km/h) or more, the re-measure function code has been received five times in a row.
4. Abnormal air pressure data: At a car speed of 25 m.p.h. (40 km/h) or more, the pressure data (Maximum value zero or max) has been received five times in a row.
5. Low battery: The low battery mode function code has been received at least 20 times in a row.

6. Abnormal vehicle speed sensor signal: The wake function code has been received at a car speed of 4 m.p.h. (6km/h) or lower. (Activates too soon.)

The warning light functions in three modes:

- Normal operation
- System Malfunction
- Low tire pressure

The receiver for the TPMS must be told where each tire is located on the vehicle as the front and rear tires have different minimum pressures.

```
Main Menu
1.All System Diagnosis
2.Each System Check
3.Digital Multi-meter
4.Oscilloscope
5.Saved Data Display
6.Function Setup
7.Self-Diagnosis
```

200

Each system check

```
System Selection Menu
Engine Control System
Transmission Control System
Cruise Control System
Brake Control System
Image Processing
Preview Control
Tire pressure monitor
Integ. unit mode
Radar sensor
Occupant Detection System
```

201

Tire Pressure Monitor

Using the Select Monitor and cartridge 24082AA260 select "Tire pressure monitor" from the "Main Menu". The Select Monitor will ask you to confirm "tire inflation pressure monitor".

```
Tire inflation pressure monitor

Press "YES"
```

202

Press "Yes" to continue

```
Tire pressure monitor diagnosis
1.Current Data Display & Save
2.Diagnostic Code(s) Display
3.Clear Memory
4.Transmitter ID regist confirm
5.Digital Multi-meter
6.Oscilloscope
```

203

Select "Transmitter ID registration confirmation"

```
Transmitter ID regist confirm
ID registration
Transmitter ID data monitor
```

204

Now select "ID registration" and Press "YES"

The Select Monitor will now display a statement indicating that once you proceed the existing Transmitter ID registration will be erased. Press "Yes" to continue.

FL	incomplete
FR	incomplete
RR	incomplete
RL	incomplete

205

Incomplete

Newer models use numbers instead of letters to identify a tire

The display will now indicate that all wheels are "incomplete". This communicates the registration status of each wheel or transmitter.

Tire And Tool

To begin registering each wheel, place the J-45295 TPMS Tool on the tire near the edge of the wheel while aligning the J-45295 TPMS Tool with the valve stem.

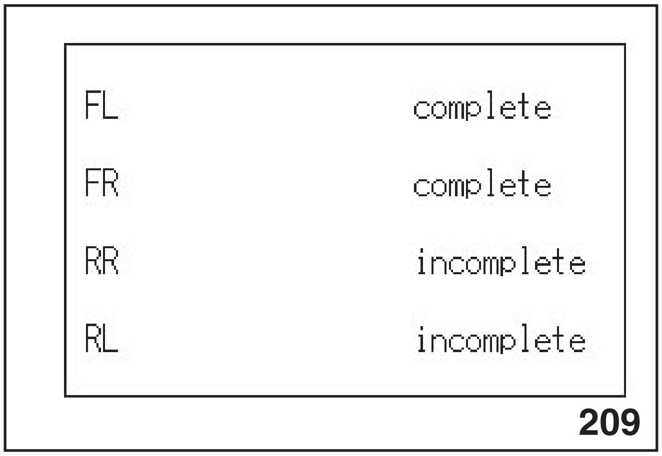
FL	complete
FR	incomplete
RR	incomplete
RL	incomplete

207

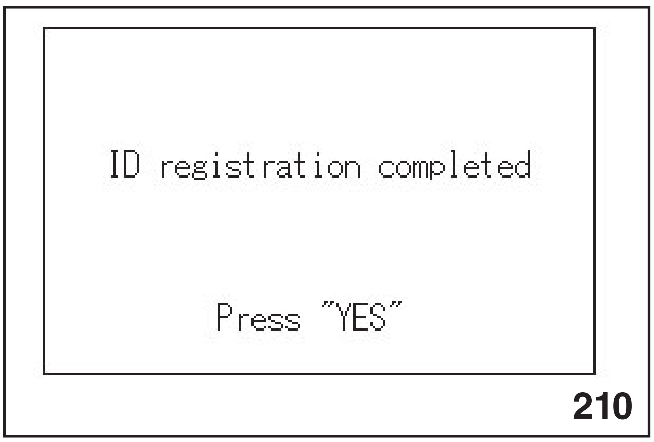
FL Complete

Left Front Turn Signal

Push and release the on button of the J-45295 TPMS Tool and observe the turn signal light. All turn signal lights will flash two times after the TPMS control unit has received the registration signal from the transmitter. This procedure must be completed for each wheel in the order displayed on the Select Monitor. As each wheel is registered the "incomplete" will change to "complete".



FL Complete - FR Complete



ID Registration Completed

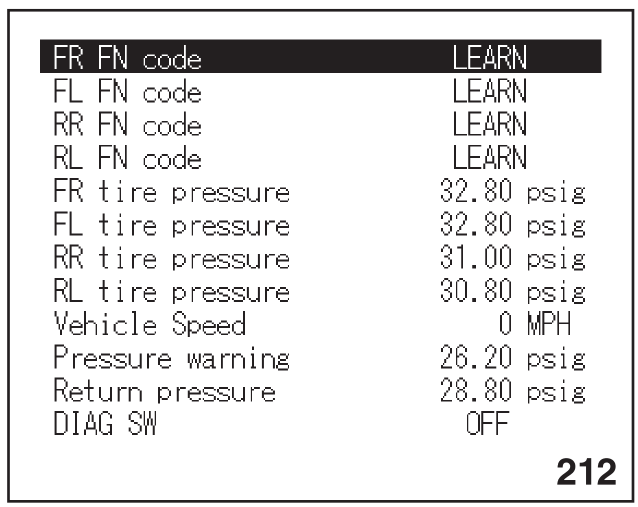
Label On Driver's B Pillar

Failure to follow the order will result in the TPMS control unit improperly identifying the actual location of each wheel. This can result in improper warning light activation and trouble code identification by the Technician.

Note: **Vehicle operation on a lift where some of the wheels may be below detection speed results in a 10 minute delay from the receiver before activating the warning light, indicating a problem.**

CAUTION:DO NOT USE INSTANT FLAT TIRE REPAIR TYPE PRODUCTS ON TIRES EQUIPPED WITH TPMS AS DAMAGE TO THE TRANSMITTER ASSEMBLE WILL OCCUR.

Note: **The warning light is turned off by driving at a speed that activates the transmitter after air pressure to a low tire has been replenished. (When key is off during the time the air pressure is added)**



FR FN Code

FR FN code	-
FL FN code	-
RR FN code	-
RL FN code	-
FR tire pressure	0.00 psig
FL tire pressure	0.00 psig
RR tire pressure	0.00 psig
RL tire pressure	0.00 psig
Vehicle Speed	0 MPH
Pressure warning	26.20 psig
Return pressure	28.80 psig
DIAG SW	OFF

213

FR FN Code

FL ID registered	B72F16
FR ID registered	B72E75
RR ID registered	B72F47
RL ID registered	B72EB2
Latest reception ID	B72EB2
Reception ID one ahead	B72F47
Before reception ID2	B72F47
Before reception ID3	B72F47

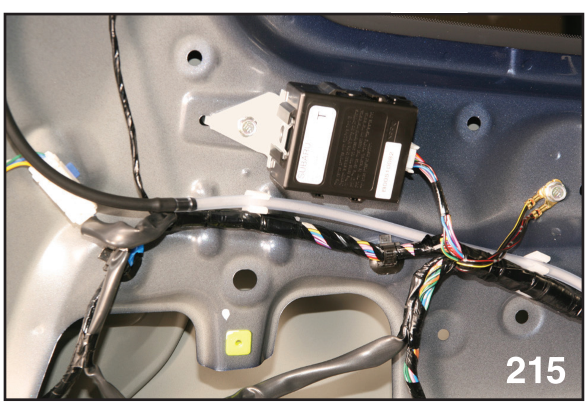
214

FL ID

Note: **If tires are rotated the ID codes must be changed. Clear old codes before setting new ones.**

TROUBLE CODES

11-Low pressure (FL)
12-Low Pressure (FR)
13-Low Pressure (RR)
14-Low Pressure (RL)
21-No Transmitter data (FL)
22-No Transmitter data (FR)
23-No Transmitter data (RR)
24-No Transmitter data (RL)
31-Wrong Pressure Data (FL)
32-Wrong Pressure Data (FR)
33-Wrong Pressure Data (RR)
34-Wrong Pressure Data (RL)
41-Wrong Function Code (FL)
42-Wrong Function Code (FR)
43-Wrong Function Code (RR)
44-Wrong Function Code (RL)
51-Low Battery Voltage (FL)
52-Low Battery Voltage (FR)
53-Low Battery Voltage (RR)
54-Low Battery Voltage (RL)
61-No vehicle speed signal (From ABS)



NOTE: ALL 2011 AND UP MODELS

DO NOT FLASH THE PARKING LIGHTS WHEN TPMS TRANSMITTERS ARE REGISTERED.

Keyless Entry / (TPMS) Tire Pressure Monitoring System

Beginning with 2010 Legacy and Outback Models, the Keyless Entry Unit and the Tire Pressure Monitoring System control units have been combined into a single unit. The new unit is located behind the left rear cargo area trim panel.

Tire Pressure Monitoring Systems

The new ATEQ VT 30 TPMS tool (J-51443) has been introduced for all Subaru vehicles, beginning with the 2015 Legacy and Outback. This serves as a replacement for SST J-51443.

216

ATEQ VT 30 TPMS Tool (J-51443)

Using the SSMIII, navigate to the TPMS Registration menu. Turn on the ATEQ VT 30 and select the appropriate vehicle for which you are servicing. Beginning with the L/F Tire, position the VT 30 on the sidewall of the tire just above the valve stem and initialize the trigger cycle by pressing the button with the red wireless symbol in the lower right of the touchpad. Work in a clockwise rotation and ensure that all four transmitters have been registered with the SSMIII. After successful registration of each transmitter, the VT 30 will display transmitter ID, measured pressure, and frequency data.

Item	Value
☑ Registered ID 1	11774806
☑ Registered ID 2	11784975
☑ Registered ID 3	11768899
☑ Registered ID 4	11801871

217

ATEQ VT 30 Display

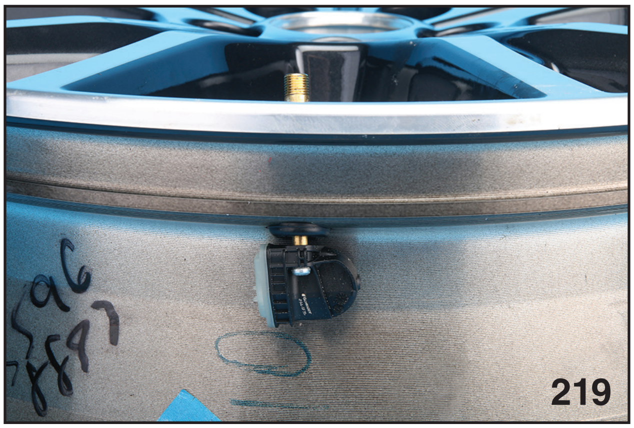
218

TPMS Transmitter ID's

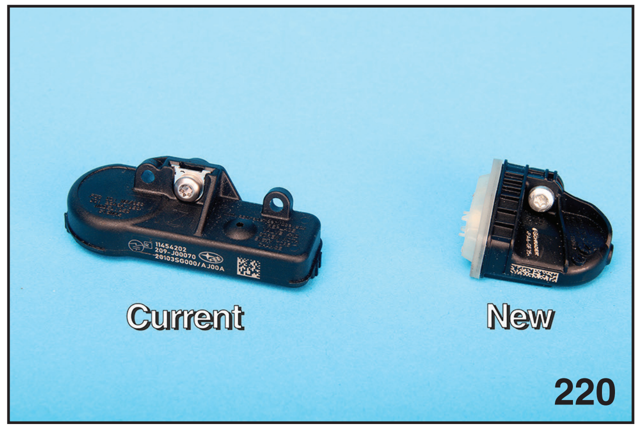
The 2017 Impreza features new generation TPMS transmitters that are more compact in construction.

The current VT-30 TPMS Registration Tool (J51443) requires a software update to function with the 2017 Impreza TPMS system. Information and update software can be found at https://www.ateq-tpms.com/en-us/home/support/

Note: Following a tire rotaion, the TPMS system will relearn transmitter locations. A relearn procedure is not necessary.



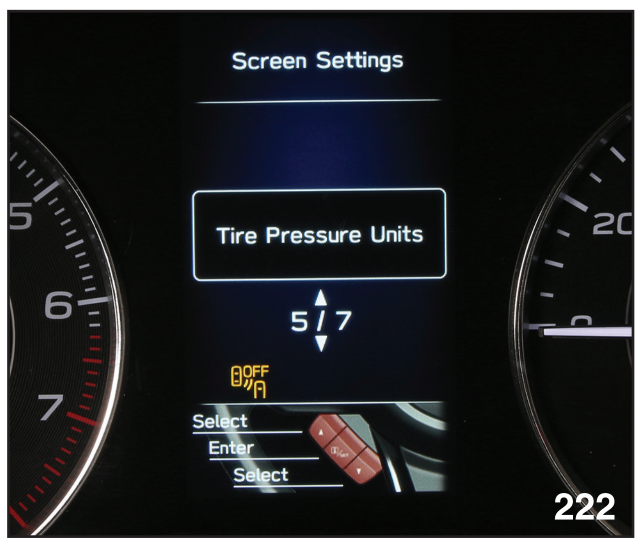
TPMS Transmitter



TPMS Transmitter — Comparison

Information related to the pressure in each tire is displayed in the Multi Information Display (MID). The units of measure can be customized by navigating though the MID Screen Settings menus.

MID — TPMS Display



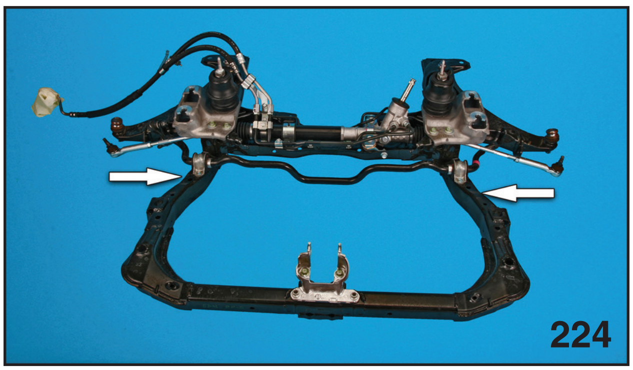
MID — Unit Customizing

Notes:

SUSPENSION AND SUB FRAME 2010MY~2014MY

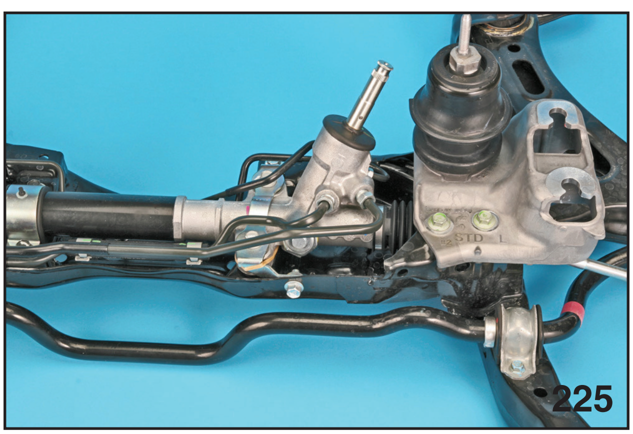
The 2010~2014 Legacy and Outback are built with a new sub frame that improves crash protection for vehicle occupants and engine compartment components. Additionally, serviceability is increased as the number of mounting points for the engine and transmission have decreased.

The sub frame serves as a mount for the steering rack, stabilizer bar, lower control arms, front engine mount and the forward transmission mounts.



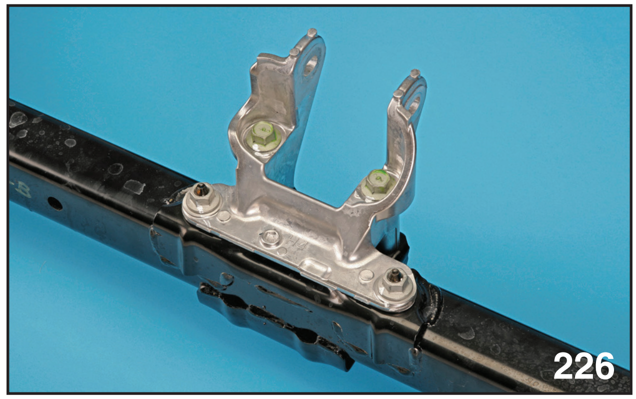
Sub Frame On Bench

Dependant on the severity of the frontal impact, the sub frame will deform at the indicated points and the transmission mounts will break away to absorb energy.



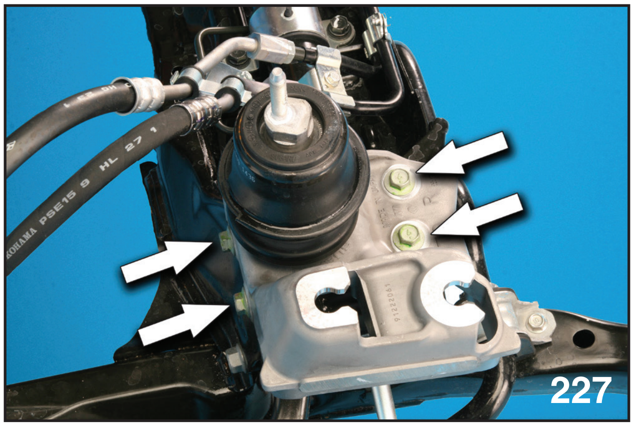
Sub Frame Mounted Components

NOTE: **New Steering Rack Control Valve Housing and Rack Housing are one piece.**



Front Engine Mount Support

Servicing the steering rack, transmission mount or lower control arm requires the removal of the sub frame from the vehicle.



Four (4) bolts secure the transmission mount to the sub frame

The engine and or transmission must be supported from above when the sub frame or transmission is removed.

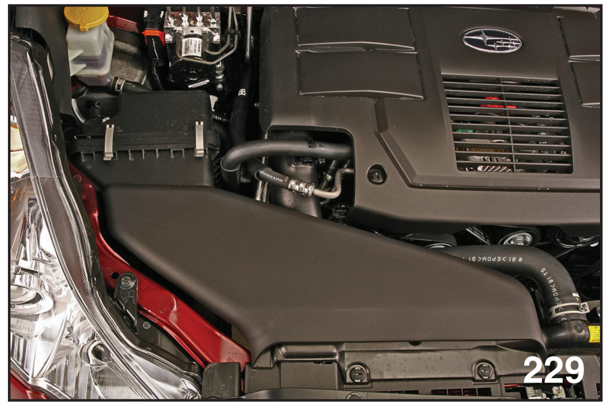
Special tool **J-50135** has been developed and must be used in accordance with the following instructions.

Center and lock the steering wheel with a seat belt.

****Disconnect the battery****

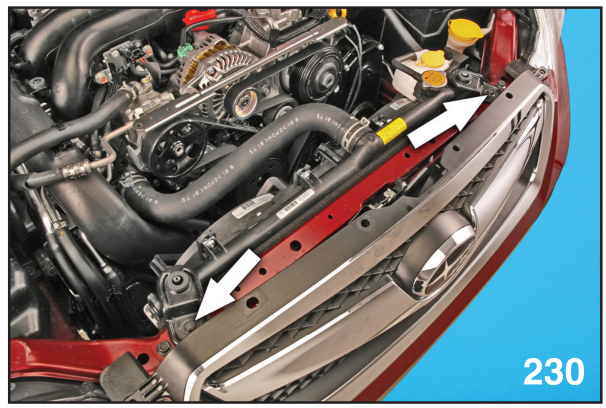
Engine Compartment

Caution: **Do not use tool J-50135 with the weight of the vehicle on the tires.**



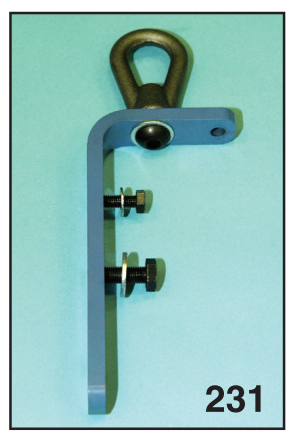
Fresh Air iIntake Duct

Remove the top engine cover, fresh air intake duct, resonator chamber and intercooler if equipped.



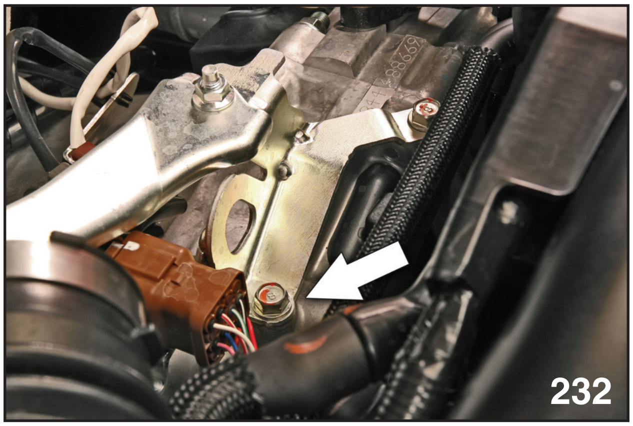
Upper Radiator Support (Trim Removed)

Remove the upper radiator trim panel



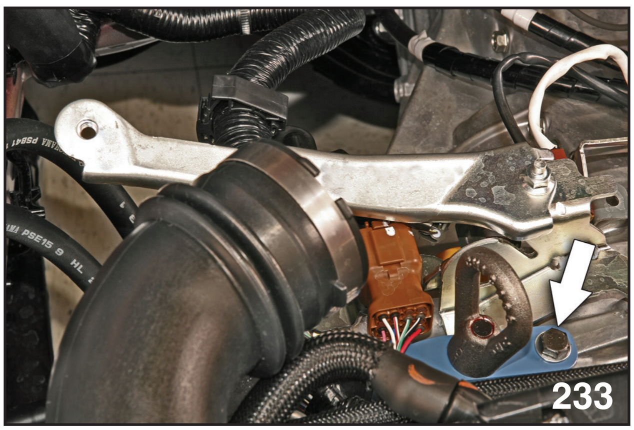
4 Cylinder Special Tool rear engine support (Turbo and NA) J-50136

Note: **This tool is no longer required for 2013 and 2014MY Legacy and Outback.**



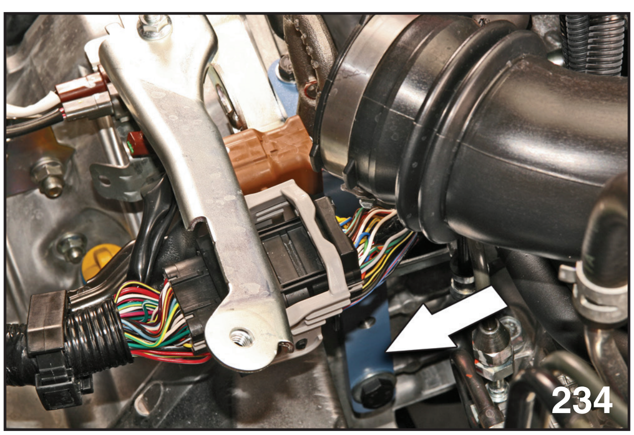
Upper Connection For Rear Engine Support

Remove the indicated bolt.



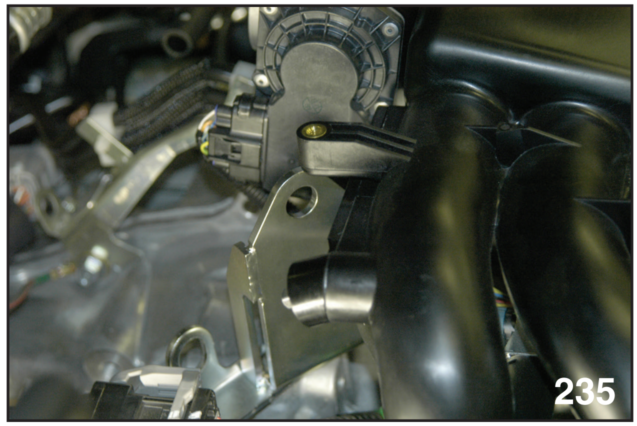
Rear Engine Support Upper Bolt

Install the hook upper bolt over the bracket and use the included bolt.

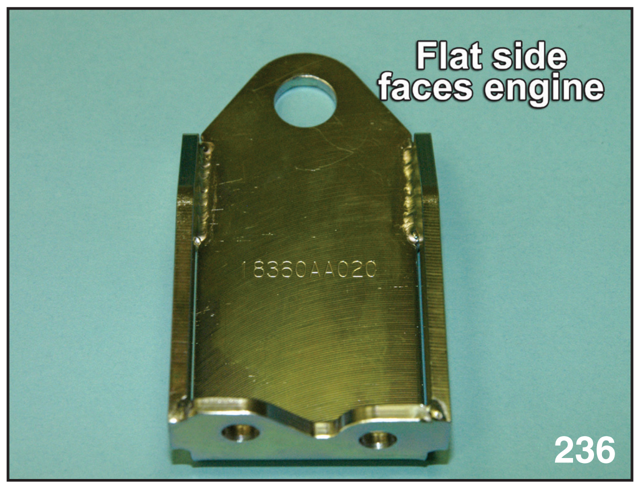


Rear Engine Support Lower Bolt

Install the rear engine support lower bolt into the threaded hole along the right side of the engine.

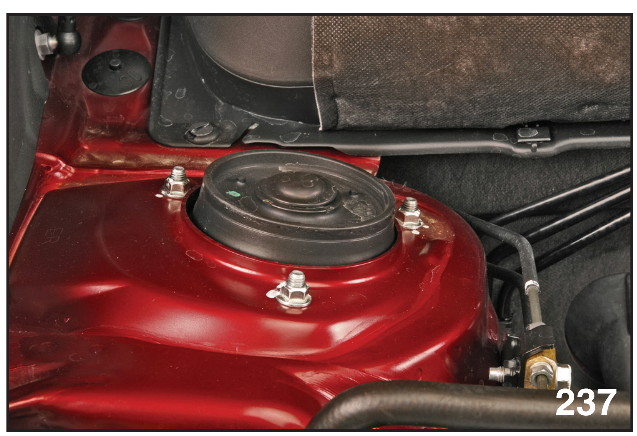


6 Cylinder Outback Lift Point



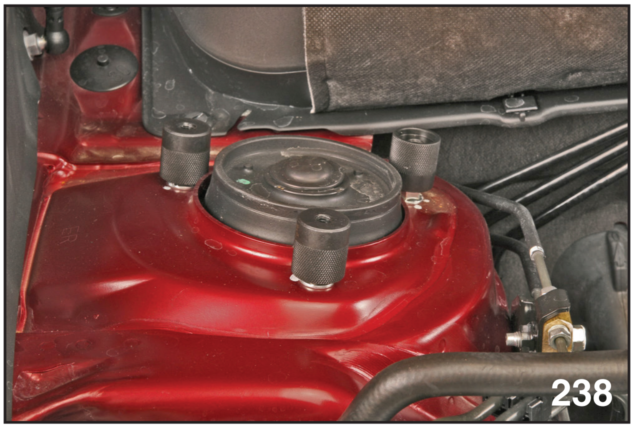
6 Cylinder Rear Engine Support Tool
18630AA020

6 Cylinder-Remove the factory rear lift hook and secure **18630AA020** as pictured above.



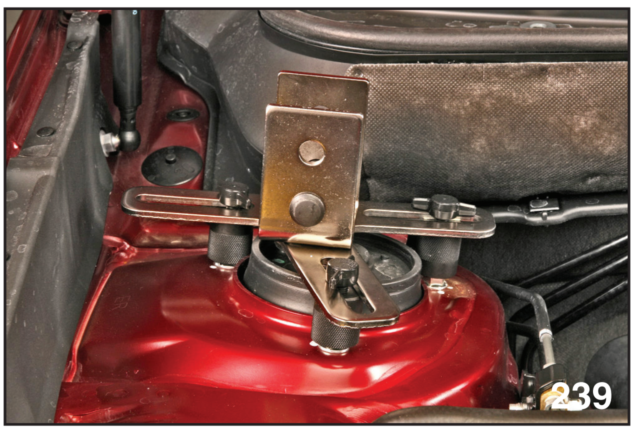
Upper Strut Mount

Clean the exposed threads of the upper strut mount.



Mount Adapters Installed

Install the mount adapters and shims to the left and right side strut mounts.

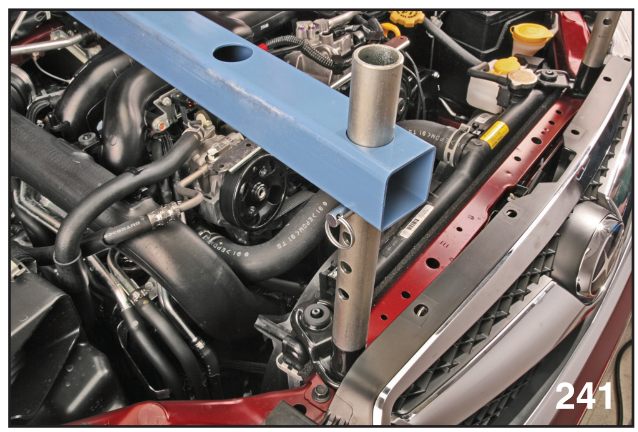


Lateral Bar Support Right Side

Install the lateral bar support right side as shown and attach it to the mount adapters with included wing bolts.

Left Side Lateral Bar Support And Lateral Bar

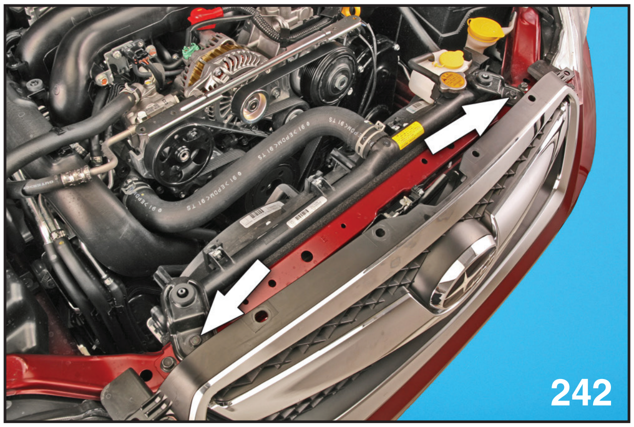
Install the left side lateral bar support and with a helper set the lateral bar into the lateral bar supports. Insert a locking pin through the lateral bar support and the lateral bar (on each side). Make sure the back side of the locking pin passes through the lateral bar and into the back side of the lateral bar support.



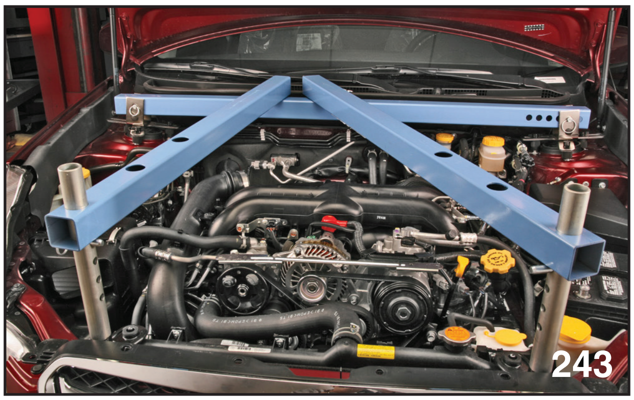
Longitudinal Bars And Posts

Place a post with the rubber coated end down into the bottom side of both longitudinal bars. Insert a locking pin through each post.

Note: **Each post must rest over the radiator support bracket bolts.**

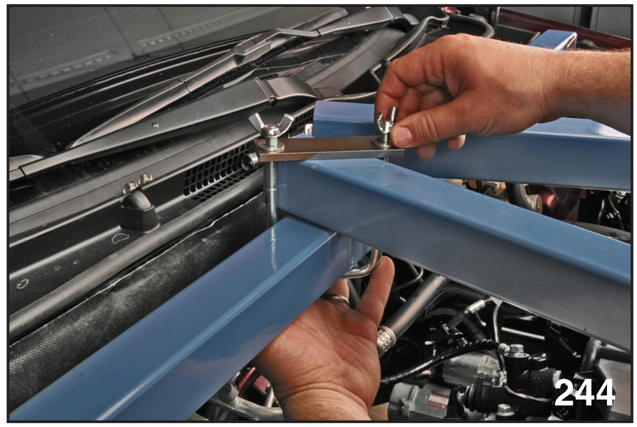


Radiator Support Bracket Bolts



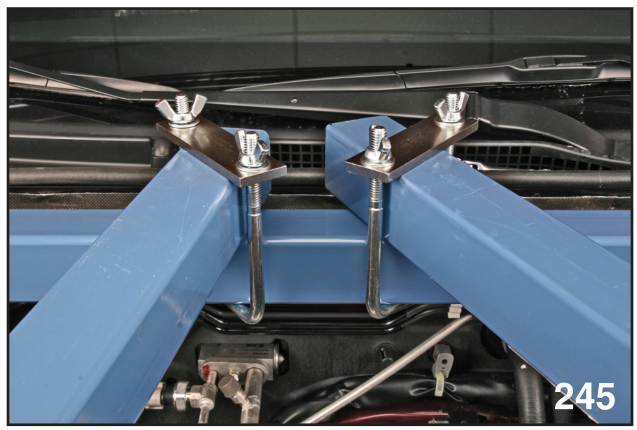
Longitudinal Bars In Place

The driver side longitudinal bar is 4 inches longer than the passenger side longitudinal bar. Ensure the driver side bar is properly placed.



Right Side Longitudinal Bar Clamp

Note: Lateral and Longitudinal bars must mate square. Shims at the strut mount adapters control this angle



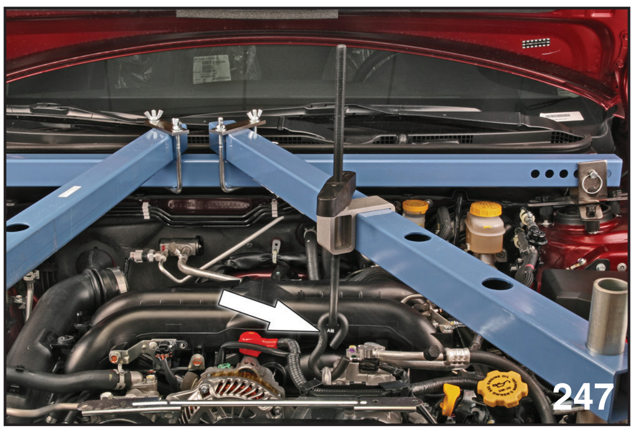
Both Clamps Installed

Install the bar clamps as shown and finger tighten only.

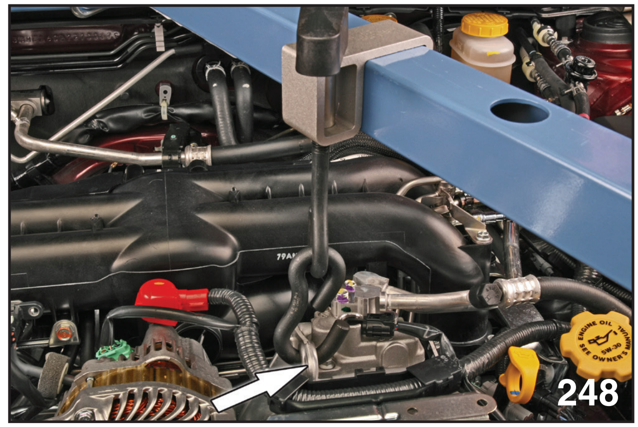
Position the driver side bar over the AC compressor and left side bar over the previously installed rear engine support.

Bars And Posts

The installed assembly should now appear as pictured below.

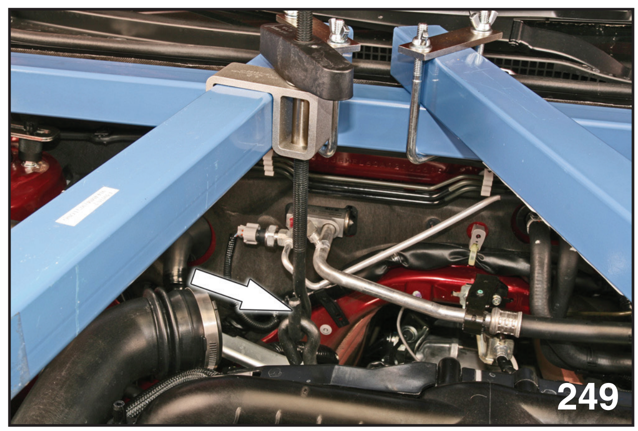


Front Support Hook

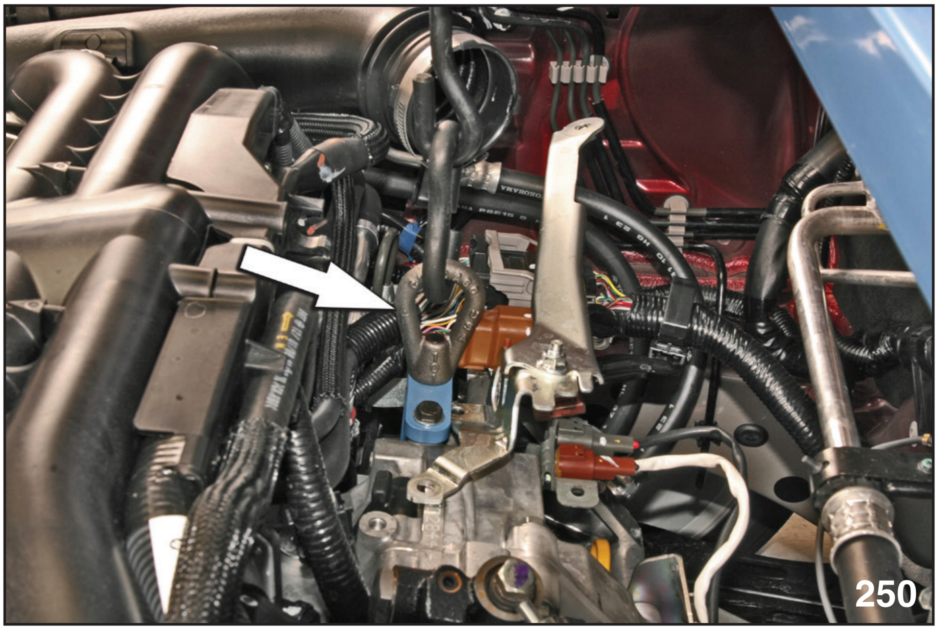


AC Compressor Eyelet

Place the front support hook over the driver side longitudinal bar and into the eyelet of the AC compressor. Tighten until the wing nut makes contact with the bar.



Rear Support Hook



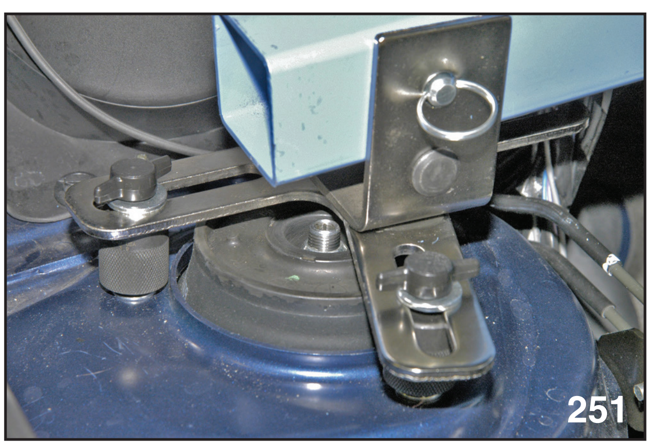
Rear Engine Support

Place the rear support hook over the passenger side longitudinal bar and into the previously installed rear engine support. Tighten until the wing nut makes contact with the bar.

Important note:

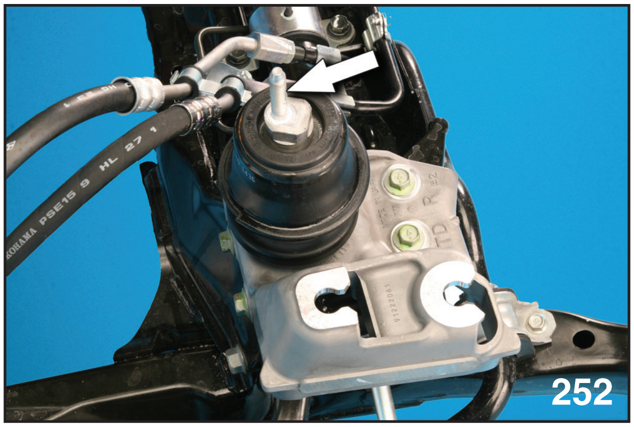
1. **SLIDE EACH BAR LEFT AND RIGHT TO CENTER EACH OF THE SUPPORT HOOKS DIRECTLY OVER THE AC COMPRESSOR AND REAR ENGINE SUPPORT.**
2 **TIGHTEN THE BAR CLAMPS FURTHER USING PLIERS OR SIMILAR TOOL.**
3. **TIGHTEN THE WING NUTS OF THE SUPPORT HOOKS TO PLACE A SMALL AMOUNT OF PRELOAD ON EACH SUPPORT HOOK.**
4. **ALWAYS USE BOTH SUPPORT HOOKS.**

Disconnect the power steering supply and return hoses from the power steering pump. Disconnect any support brackets for both hoses. Place the hoses so that they will not get tangled with any engine compartment components or wiring when the sub frame is lowered.



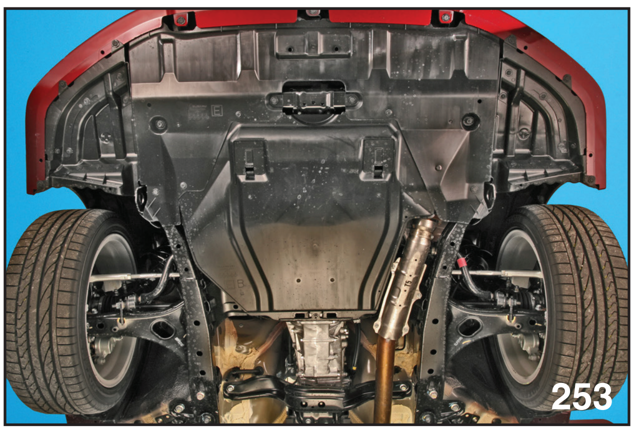
If it is necessary to lower the vehicle with the weight of the vehicle on the tires, you must position lateral bar support as shown here.

Remove the top side nut from the left and right transmission mount.



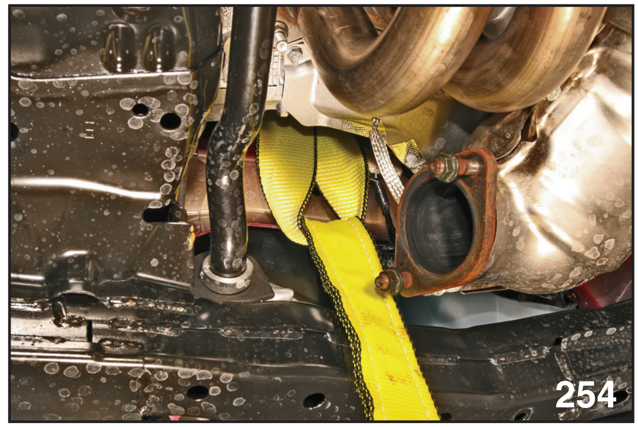
Mount Nut Location

Raise the vehicle on a lift.



Engine Undercover

Remove the engine under cover and exhaust pipe that crosses over the sub frame.

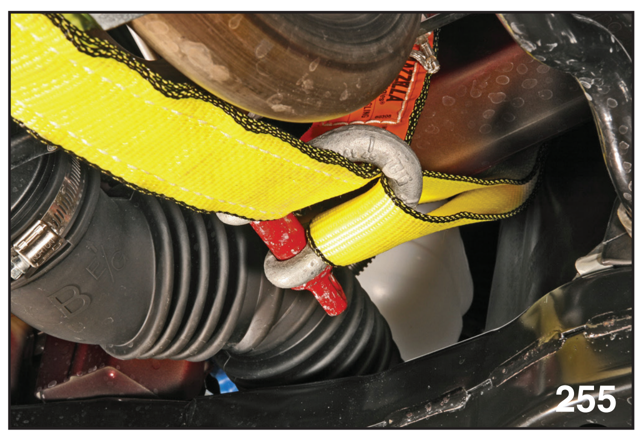


Safety Harness Installed Left Side

A safety harness will now be installed to protect Technicians in the event of engine hanger slippage.

Install the safety harness on the left side chassis ahead of the stabilizer bar on the inside of the sub frame. The safety harness must stay in place as the sub frame is removed.

Note: **Both ends of the safety harness have a stitched loop. The left side is connected to the vehicle by placing the harness over the chassis and then placing the opposite end through the loop over the chassis. Pull to tighten.**



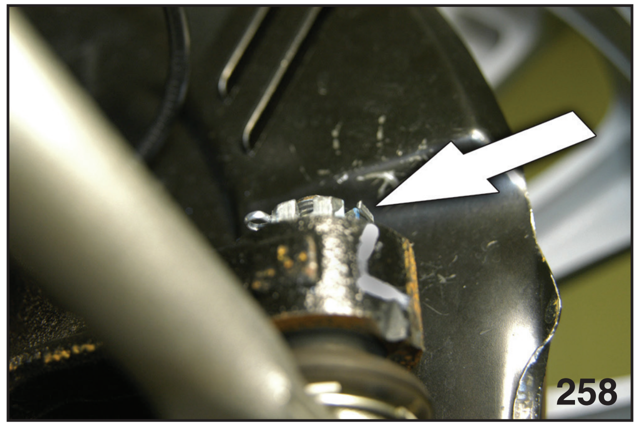
Safety Harness Installed Right Side

Safety Harness Complete

Place the other end of the safety harness over the right side chassis just ahead of the stabilizer bar and on the inside of the sub frame. Secure the harness by placing the included shackle through the loop and over the harness. Install and tighten the pin.

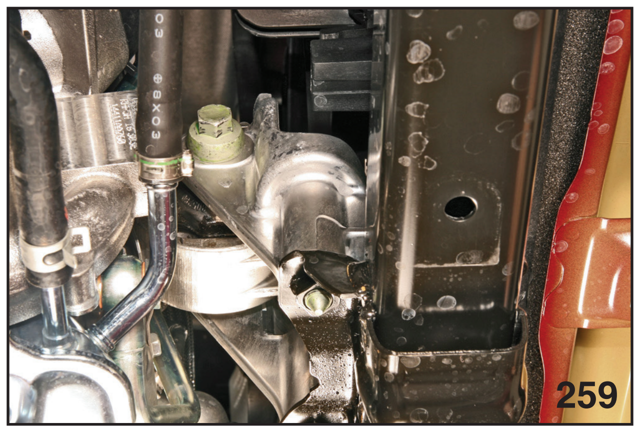
Left Side Suspension

Remove the lower ball joint clamping bolt and separate the ball joint from the wheel bearing housing. (Left and right side)



Cotter Pin

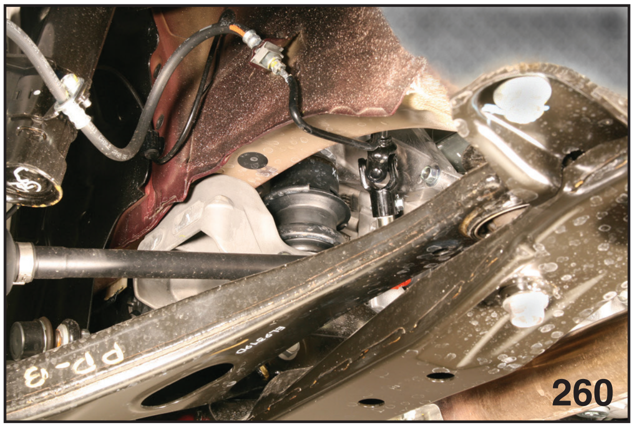
Remove the outer tie rod cotter pin and separate the outer tie rod from the wheel bearing housing. (Left and right side)



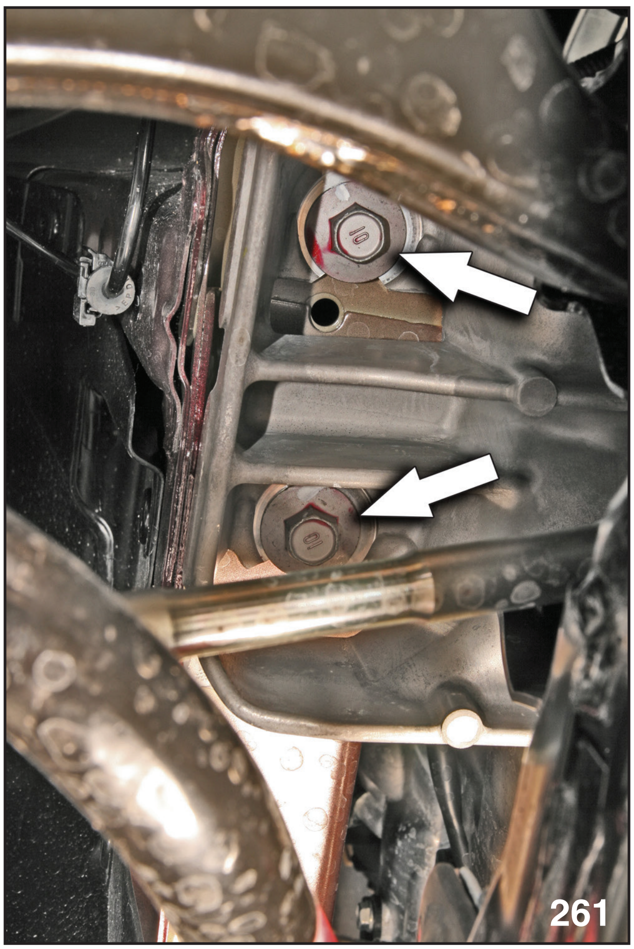
Front Engine Mount

Loosen the front engine mount lateral bolt and attempt to remove. The bolt ideally will slide out by hand. If there is too much tension on the bolt lower the vehicle and adjust the front and rear support hooks. (The front support hook will move the engine and transmission up and down. The rear support hook while supporting weight vertically will move the engine and transmission more to the left or right when adjusted). Remove the bolt when it can be pulled from the mount by hand.

Note: **Following this process will also ease installation of the sub frame.**

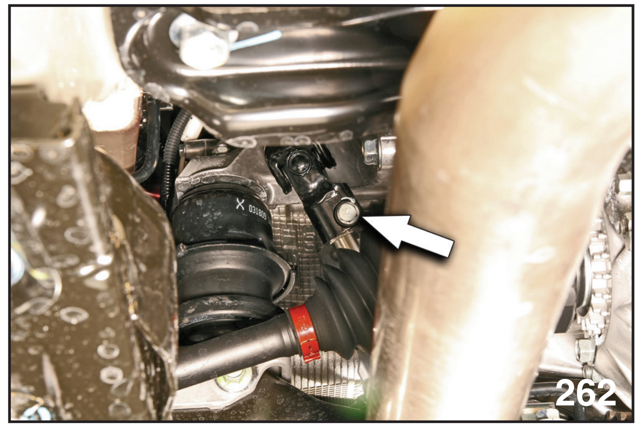


Left Side Transmission Mount



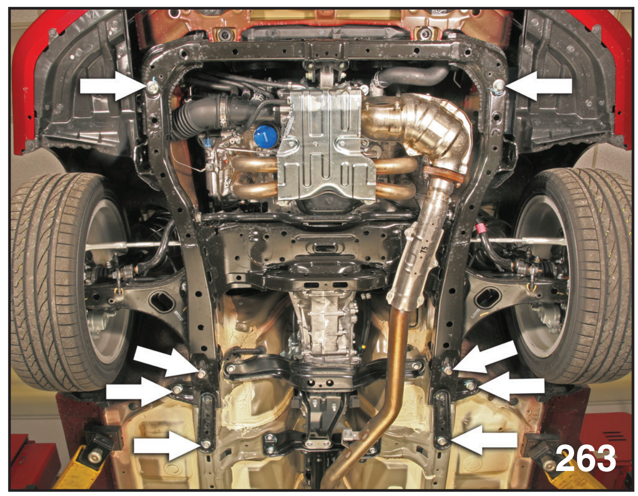
Transmission Mount Bolts

Locate the left and right transmission mount bolts. Remove two bolts from each side.



Steering Rack To Steering Shaft Cinch Bolt

Remove the steering rack cinch bolt.



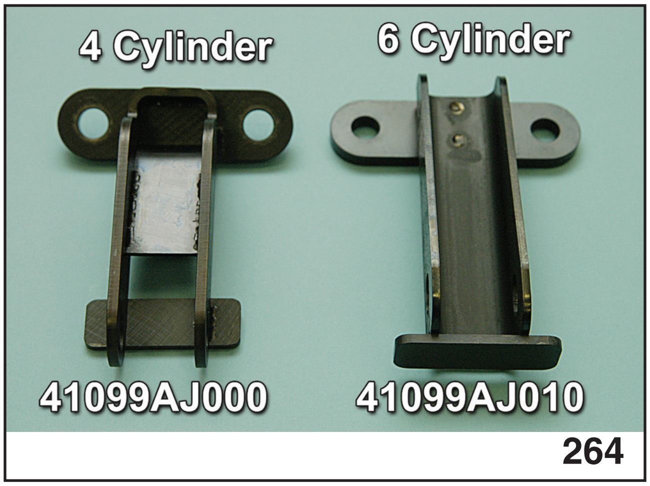
Sub Frame Complete

Note **This picture of the sub frame is shown without the safety harness in place to show bolt locations. Always use the safety harness when performing sub frame servicing.**

With the aid of a helper loosen and remove the indicated bolts. The sub frame can now be removed. Do not remove all of the bolts until the sub frame is supported at the front and rear. The sub frame weighs approx. 145 pounds. A transmission jack will assist with removal. If a transmission jack is used be sure to lash the sub frame to the transmission jack.

Transmission Removal

Transmission removal requires changing the angle of the engine and transmission to ease removal and ensure the sub frame is cleared. Two special tools exist for changing the angle.



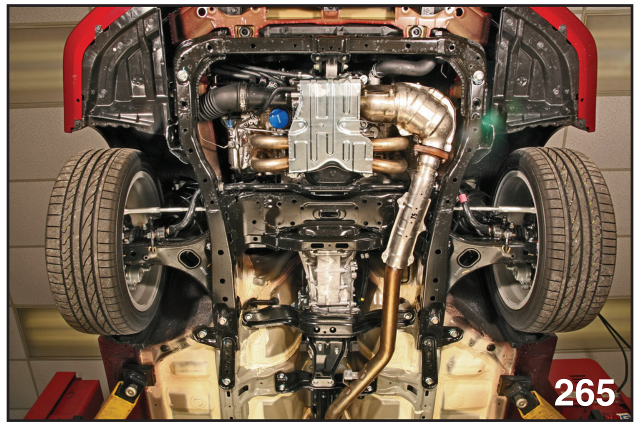
Tools

4 cylinder vehicles special tool **41099AJ000**

6 cylinder vehicles special tool **41099AJ010**

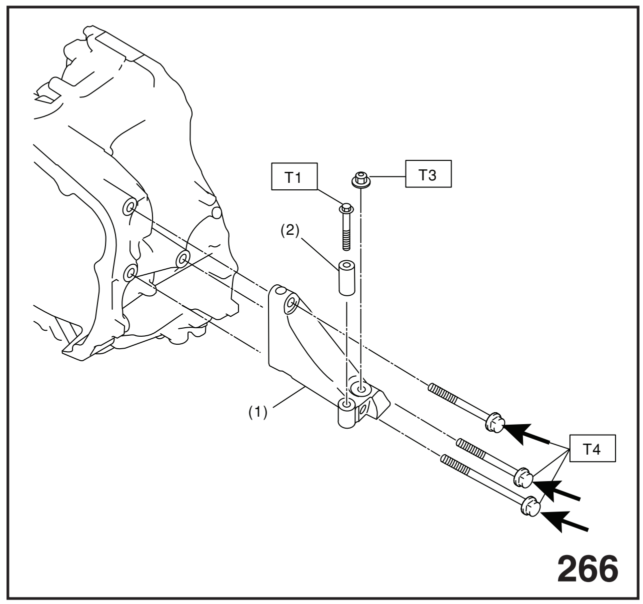
Note: **The main work idea during changing of the angle of the engine and transmission is to do so without placing stress on any mounting component that will fight against you. Following these steps as they are written will keep stress at a minimum and ease transmission removal. Follow the steps in reverse order for installation.**

Install the engine hanger as previously directed.



Under Car

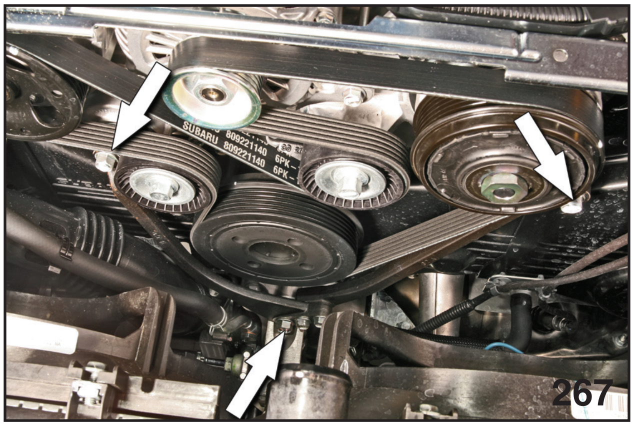
Remove the exhaust and rear cross member.



Transmission Mount Artwork

Lower the vehicle and remove the upper nut from the mount on each side.

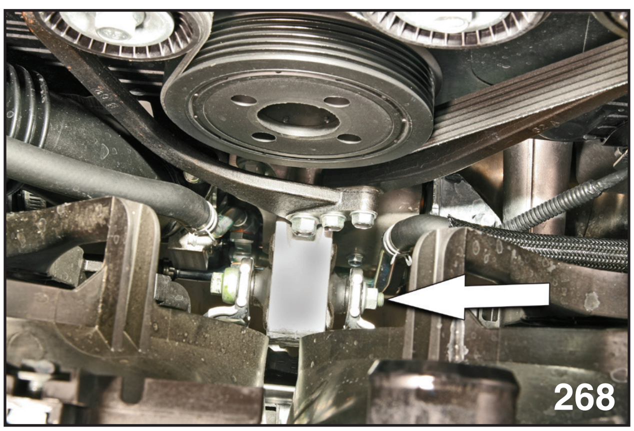
Remove the 3 bolts from the transmission mounts on each side of the vehicle. The bolt closest to the chassis frame must remain with the mount due to proximity to the frame. Remove the transmission mounting brackets from the engine compartment.



Reinforcement Rods
(4 Cylinder Engine Only)

Move to the front of the engine. Locate the two near vertical reinforcement rods and remove the bolt from each side that secures them to the engine.

Remove the lower bolt where the two rods intersect and remove the two rods from the engine compartment.



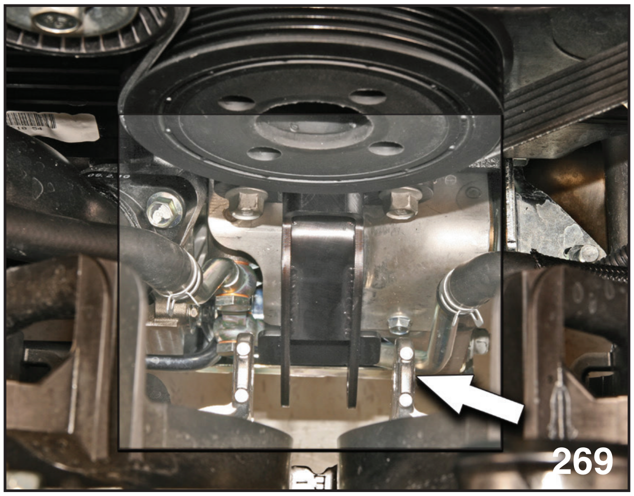
Front Engine Mount

Remove the front engine mount lateral bolt. Follow previous instructions on ensuring the bolt can be removed by hand. (6 cylinder use **41099AJ010**)

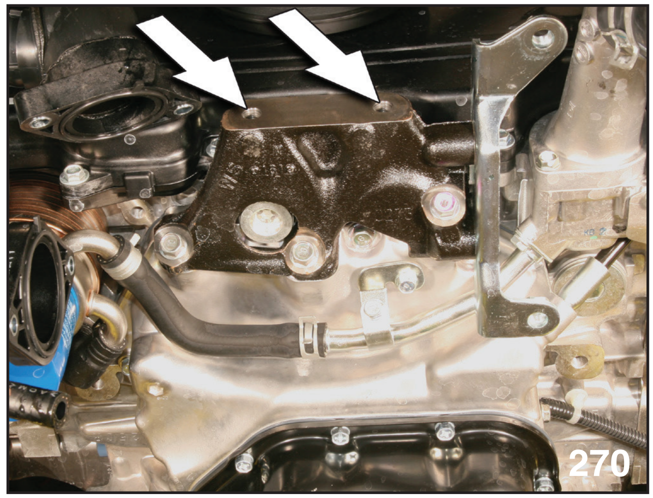
Remove the engine mount from the engine and replace it with special tool **41099AJ000**.

Tighten the bolts attaching the tool to the engine. Tighten the forward and rear lifting hooks to center the tool into the bolt passage of the sub frame. When centered install the bolt.

NOTES:

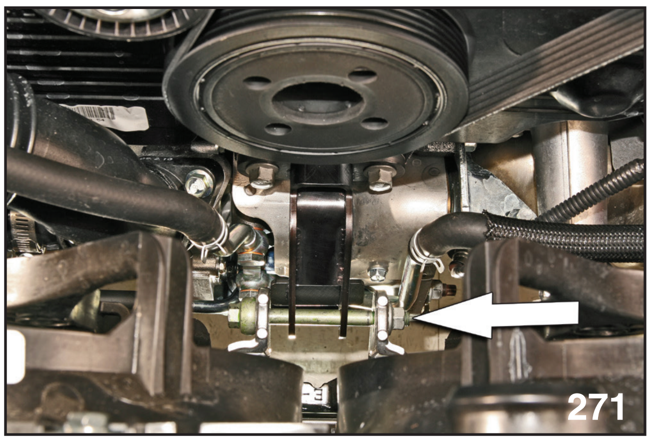


Tilt tool in Place Too Low



Special Tool Installation Points
(4 Cylinder engines)

NOTE: 6 CYLINDER ENGINE MOUNTING BOLTS GO THROUGH THE TIMING CHAIN COVER.



Tilt Tool Centered And Bolt Installed

Remove the transmission following the procedure in the appropriate Subaru Service Manual on STIS.

NOTE: **The Engine Hanger should also be used when servicing the front of the engine where the front engine mount must be removed.**

NOTE: **The Engine Hanger and Tilt tool should also be used when servicing the top shifter cable of the new 6 speed split case transmission.**

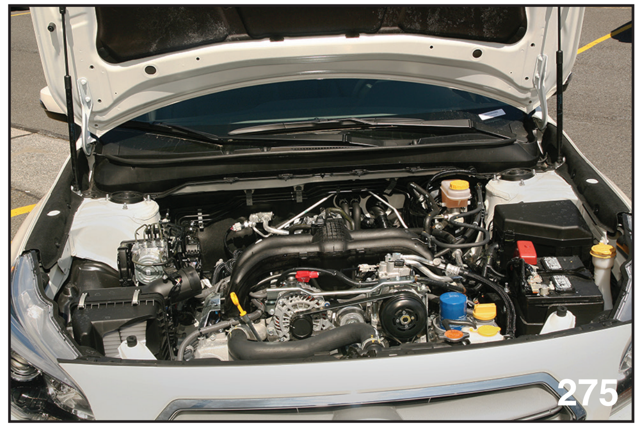
2015 LEGACY AND OUTBACK ENGINE SUPPORT BRIDGE

A new configuration of the existing SST J-50135 (Engine Support Bridge) has been adapted for the 2015 Legacy and Outback.

Engine Support Bridge

Remove the air inlet, ducting, and alternator cover.

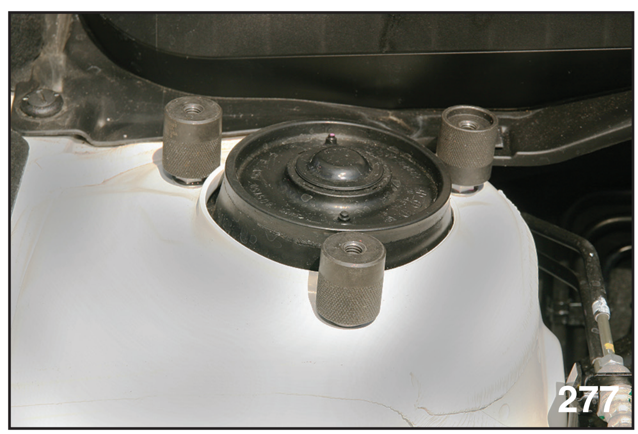
Engine Covers Installed



Engine Covers Removed

Prepare the mount adapters on the exposed threads of the upper strut mount.

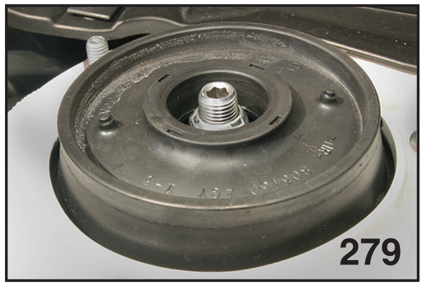
Upper Strut Mount Exposed Threads



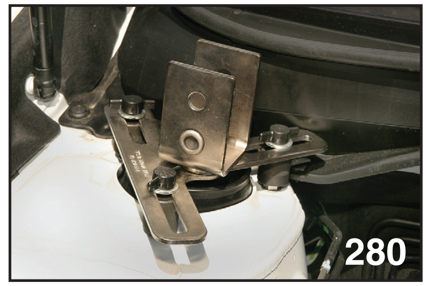
Mount Adapters Installed

Remove the center rubber strut caps and prepare the lateral bar supports as shown.

Rubber Strut Cap Installed



Rubber Strut Cap Removed

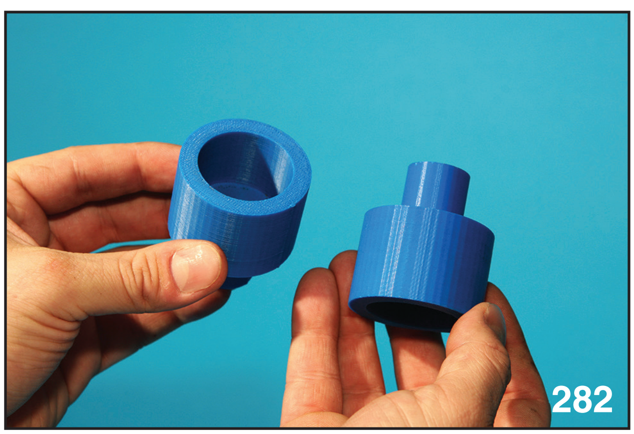


Lateral Bar Supports Installed

Install the Lateral Bar

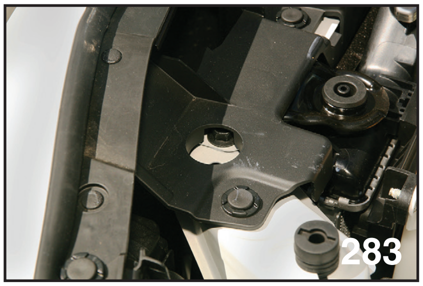
Lateral Bar Installed

Prepare new SSTs J-51658 (Engine Bridge Adapter Kit) and place through the provided openings in the upper radiator garnish. Install the Stanchions with the rubber side facing up.



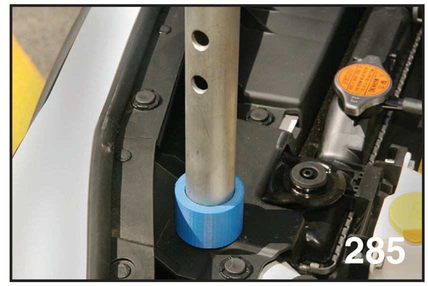
Prototype SSTs J-51658

NOTE: Prototypes shown. Actual Tools may vary.



Radiator Garnish Opening

Adaptor Installed

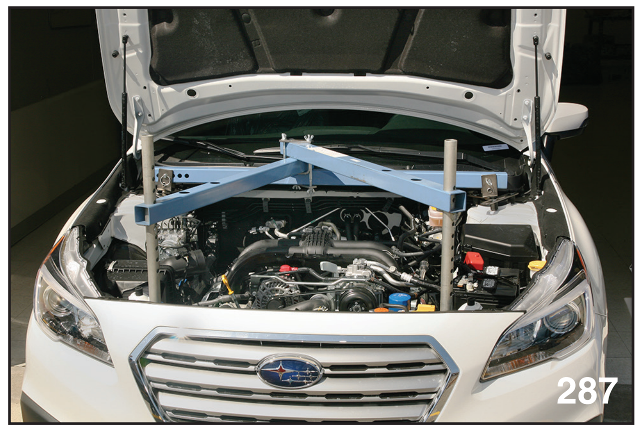


Stanchion Installed

Note: SSTs J-50135-5 (Long Stanchions) are used for this procedure. These SSTs are currently used as part of the BRZ Engine Support Bridge.

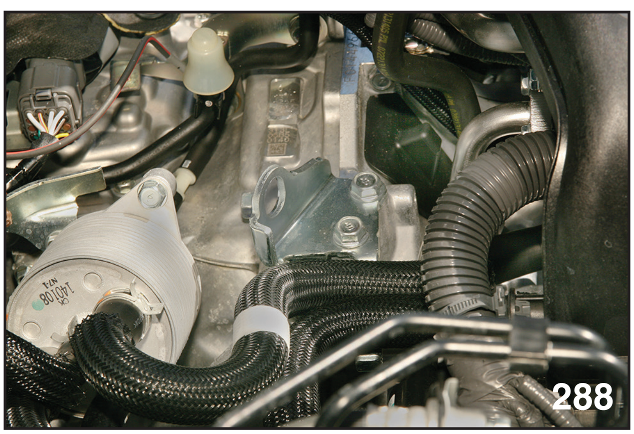
Install the longitudinal bars and posts.

RH Longitudinal Bar Installed

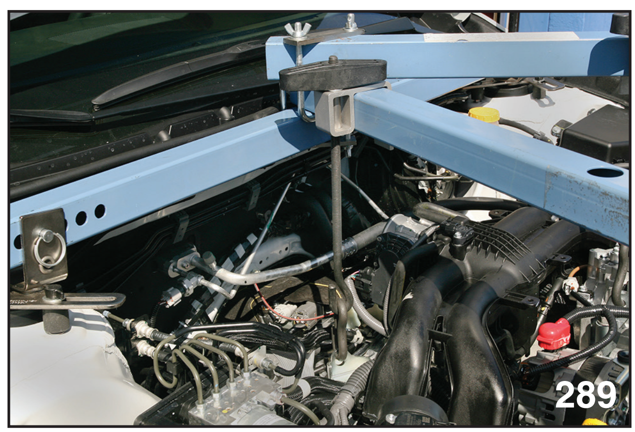


LH Longitudinal Bar Installed

Install the lifting hooks over the longitudinal bars

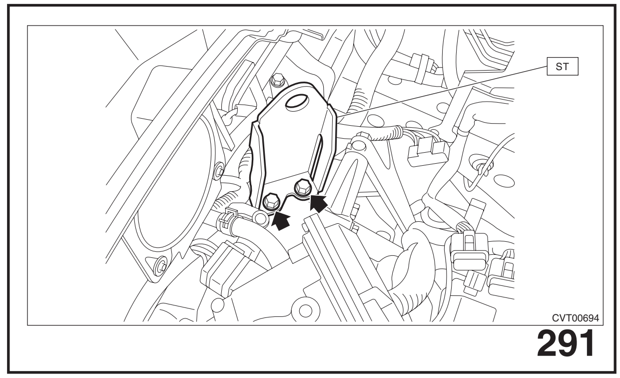


Rear Lifting Hook Location



Rear Lifting Hook Installed

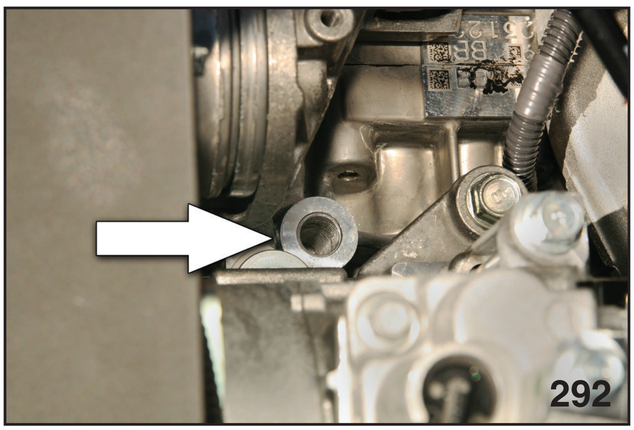
SST 18360AA020 (Hanger) must be used for EZ 3.6 Models as a hook point.

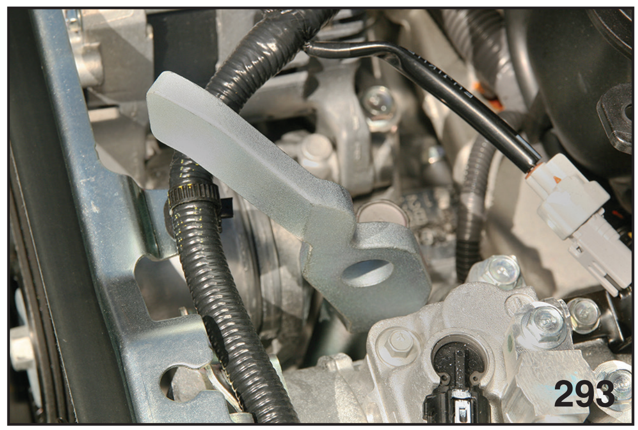


SST 18360AA020

H6 Model (ST): HANGER (18360AA020)

Install new SST 18360AA040 (hanger) to provide a front hook location during support or removal of H4 engines.





Front Hanger Location

Front Hanger Installed

Note: **SST 18360AA040 (hanger) tool is not necessary for H6 Removal.**

1. Using SST 18363AA050, bolt the hanger to the vacant threaded hole between the A/C Compressor and Alternator. A handle is also provided to assist in engine removal.

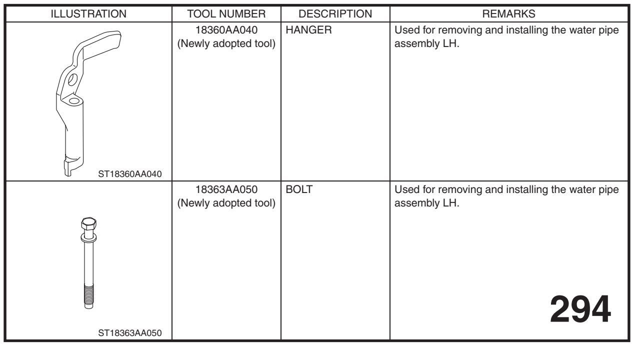


ILLUSTRATION	TOOL NUMBER	DESCRIPTION	REMARKS
ST18360AA040	18360AA040 (Newly adopted tool)	HANGER	Used for removing and installing the water pipe assembly LH.
ST18363AA050	18363AA050 (Newly adopted tool)	BOLT	Used for removing and installing the water pipe assembly LH.

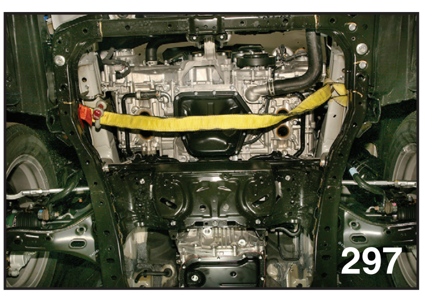
294

Special Tool Description

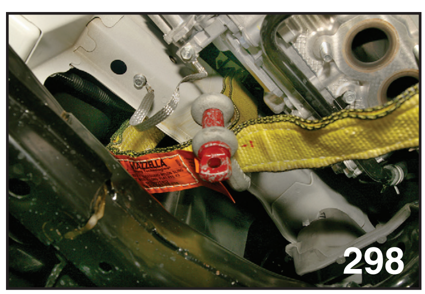
SST 18363AA050 & SST 18363AA040

Front Lifting Hook Installed

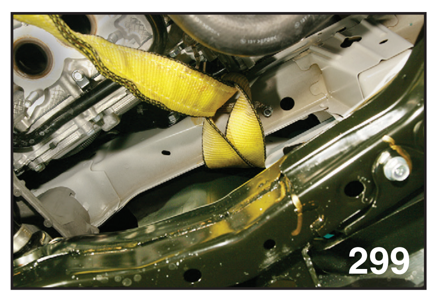
Install the SST J-50137 (Engine Safety Sling and Shackle) under the engine.



Safety Strap Installed



LH Frame Rail



RH Frame Rail