SUBARU®

Confidence in Motion

Technician Reference Booklet

Transmission Theory and Diagnosis Part 2

AUTOMOTIVE YES Youth Educational Systems® PROUD PARTNER

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April 2016
MSA5P2205C
02L201003I

This Technical 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.

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Transmission Theory and Diagnosis Part 2

Transmission Theory and Diagnosis Part 2

Introduction

This course is an introduction to Subaru manual and automatic transmissions. The concepts learned here will help you service and repair these transmissions. Service information and special tools are emphasized to help increase productivity when you return to your store. This course includes component identification, disassembly and assembly procedures, and adjustments.

Course Objectives

The Student will be able to:

- Apply proper use of Personal Protective Equipment (PPE) and other related safety practices related to Transmissions.
- Identify engine power coupling methods used in Subaru automatic and manual transmissions and perform basic torque convertor performance testing.
- Describe common driveline gearing components and perform basic gear ratio calculations.
- Identify common methods for changing gear rations in automatic and manual transmissions and examine synchronizer assemblies for basic operation.
- Identify and Manipulate precision measuring tools to accurately measure mechanical components, interpret the results, and determine selective adjustment components.
- Describe common final drive components and perform ring and pinion adjustment procedures.

Safety

Personal Protective Equipment

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Personal Protective Equipment

There are many safety precautions that you must observe when working on vehicle systems. Refer to the appropriate service information and observe all safety cautions and warnings.

As a general warning, before attempting to diagnose or service any vehicle system component, always wear appropriate work clothing such as:

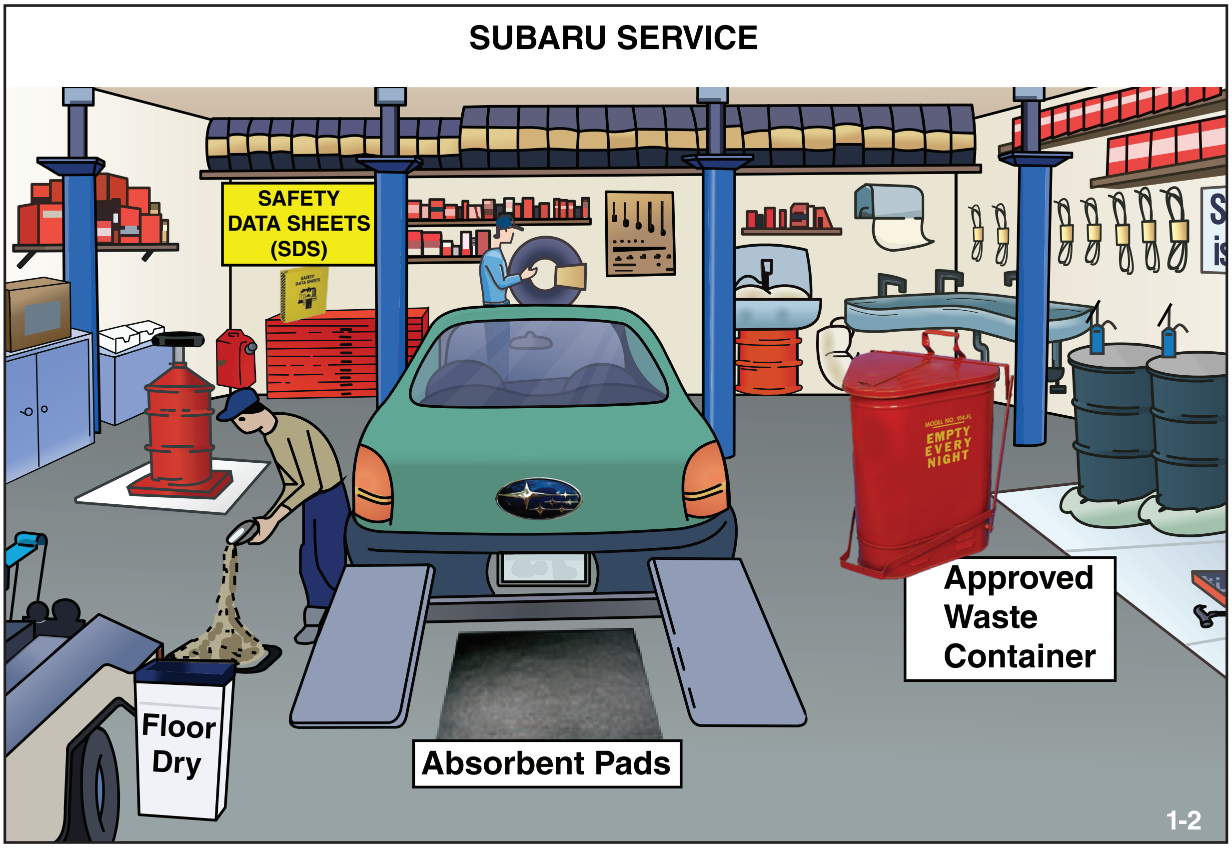
- Safety glasses with side shields
- Gloves (Chemical resistant)
- Approved Subaru uniform
- Protective shoes (steel toe, oil and slip resistant)

To avoid inhaling spray chemicals and dust, a properly ventilated work area is essential.

Refer to the Safety Data Sheets (SDS) located in the appropriate location in the service department.

WARNING: KEEP HANDS AWAY FROM HOT EXHAUST SYSTEM COMPONENTS. KEEP HANDS AND LOOSE CLOTHING AWAY FROM ROTATING COMPONENTS. ALWAYS WEAR APPROPRIATE CLOTHING AND PERSONAL PROTECTIVE EQUIPMENT. FAILURE TO OBSERVE THESE PRECAUTIONS CAN RESULT IN SERIOUS INJURY TO YOU AND/OR OTHERS.

Environmental Impact



Environmental Impact

Do not dispose of automotive fluid in drains, waterways, or landfills. These chemicals contain contaminants such as solvents that can leach into soil and waterways, causing environmental damage and health hazards.

Contain and collect spillage with non-combustible, absorbent material such as sand, floor dry, or absorbent pads, and place the contaminated material in a certified waste container for disposal according to local regulations.

When handling shop chemicals, always refer to the SDS for information about the particular chemicals to which you are exposed in your shop.

Warnings and Cautions

Gasoline

Keep gasoline, flammable solvents, and used rags in approved containers.

Battery Acid

If battery acid contacts your skin, rinse the area well with water. If battery acid is on your clothing, immediately remove the clothing.

If battery acid is ingested, DO NOT INDUCE VOMITING. Drink large quantities of water or milk. Follow with milk of magnesia, beaten eggs, or vegetable oil. CALL A PHYSICIAN OR POISON CONTROL CENTER IMMEDIATELY.

If battery acid comes in contact with your eyes, rinse your eyes with water for 20 minutes and get prompt medical attention.

If battery acid fumes are inhaled, move to a fresh air location and contact a physician for medical treatment.

Do not mix battery acid with other products that react with acid, such as toilet bowl or drain cleaners, bleach, or ammonia. Dangerous fumes form when mixed with chemicals like these.

Lubricants

Always dispose of oil in proper receptacles.

Coolant

Vehicle components are extremely hot immediately after driving. Take care not contact hot parts. Do not open the cooling system while it is hot. The cooling system is under pressure and if opened, can spray hot coolant and cause burns.

Follow all government and local regulations concerning disposal of used engine coolant.

ROAD TEST

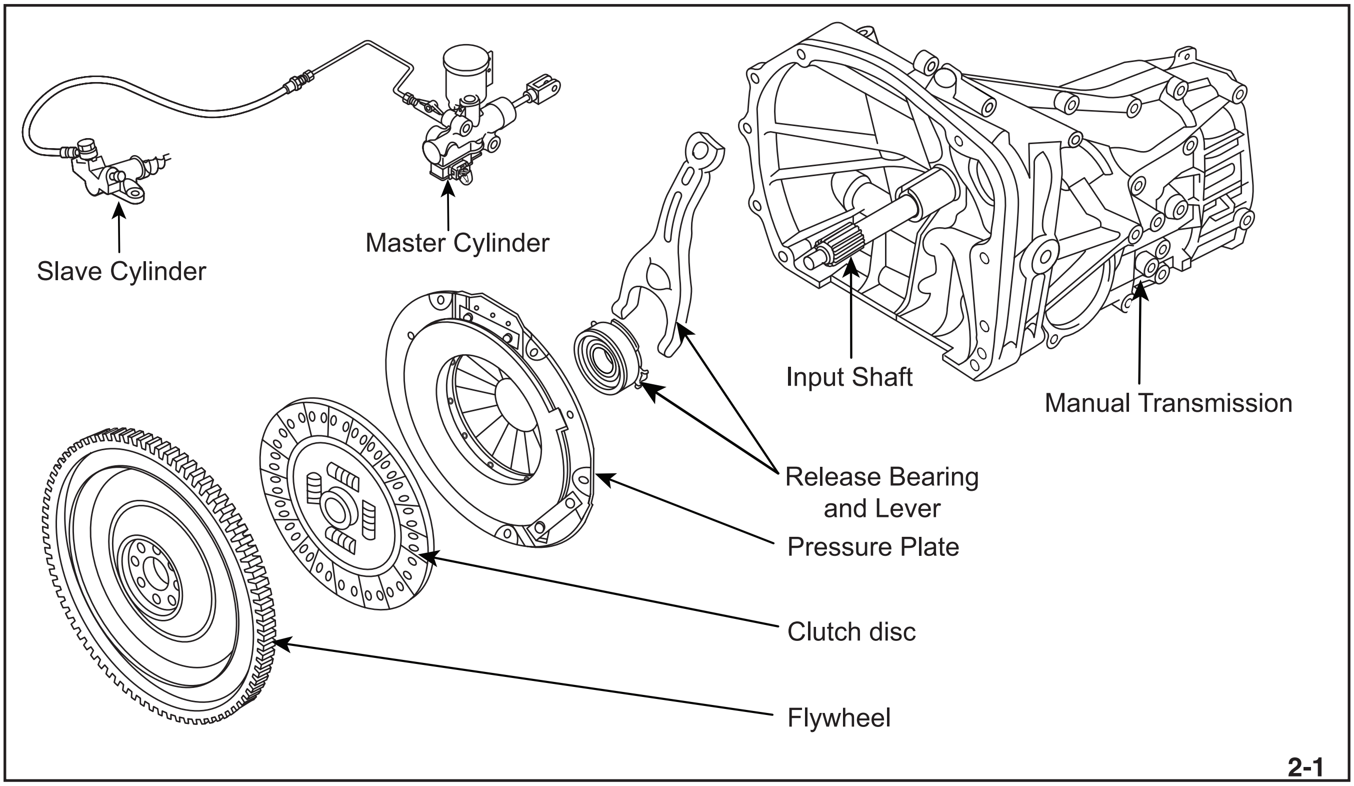
Always conduct road tests in accordance with traffic rules and regulations to avoid bodily injury and interrupting traffic.

SERVICING

- Remove contamination including dirt and corrosion before removal, installation, or disassembly.
- Keep the disassembled parts in order and protect them from dust and dirt.
- Before removal, installation, or disassembly, be sure to clarify the failure. Avoid unnecessary removal, installation, disassembly, and replacement.
- When disassembling the case and other light alloy parts, use a plastic hammer to force it apart. Do not pry the case apart with screwdrivers or other tools.
- Vehicle components are extremely hot after driving. Be wary of receiving burns from heated parts.
- Use Subaru genuine gear oil, grease, or equivalent. Do not mix gear oil, grease, etc. of different grades or manufacturers.
- Be sure to tighten fasteners including bolts and nuts to the specified torque.
- Place shop jacks or rigid racks at the specified points.
- Apply oil onto sliding or revolving surfaces before installation.
- Replace deformed or damaged snap rings with new parts.
- Before installing O-rings or oil seals, apply sufficient gear oil to avoid damage and deformation.
- Be careful not to incorrectly install or fail to install O-rings, snap rings, and other similar parts.
- Before securing a part on a vise, place cushioning material such as wood blocks, aluminum plates, or cloth between the part and the vise.
- Avoid damaging the mating surface of the case.
- Before applying liquid gasket, completely remove the old liquid gasket.

Engine Power Coupling

Manual Transmissions

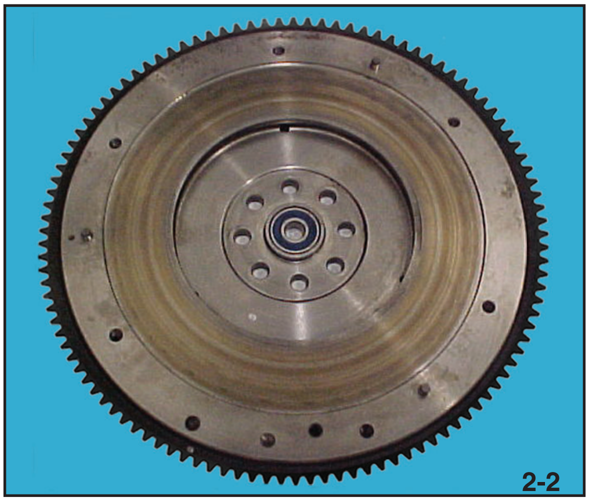


Manual Transmission Coupling Components

The vehicle engine develops power that is transmitted as torque from the engine crankshaft to the drive wheels. A smooth and gradual transfer of power and torque is accomplished using a clutch friction unit to engage and disengage the power flow.

The Subaru manual transmission power coupling system contains the following components: flywheel, clutch disc, clutch plate cover, release bearing, release lever, clutch hydraulic system, and transmission input shaft.

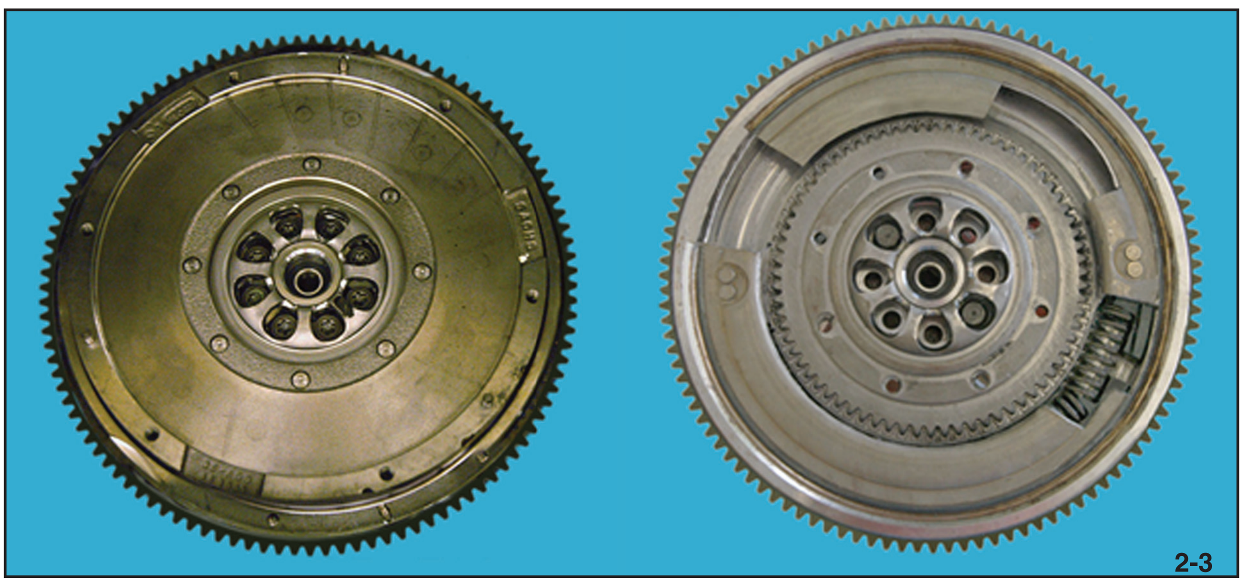
Flywheel



Solid Mass Flywheel

The flywheel is a large, heavy disc attached to the rear end of the engine crankshaft. The mass of the flywheel acts as a vibration damper for the engine. The rear face of the flywheel is machined flat and smooth to serve as the driving member of the clutch assembly.

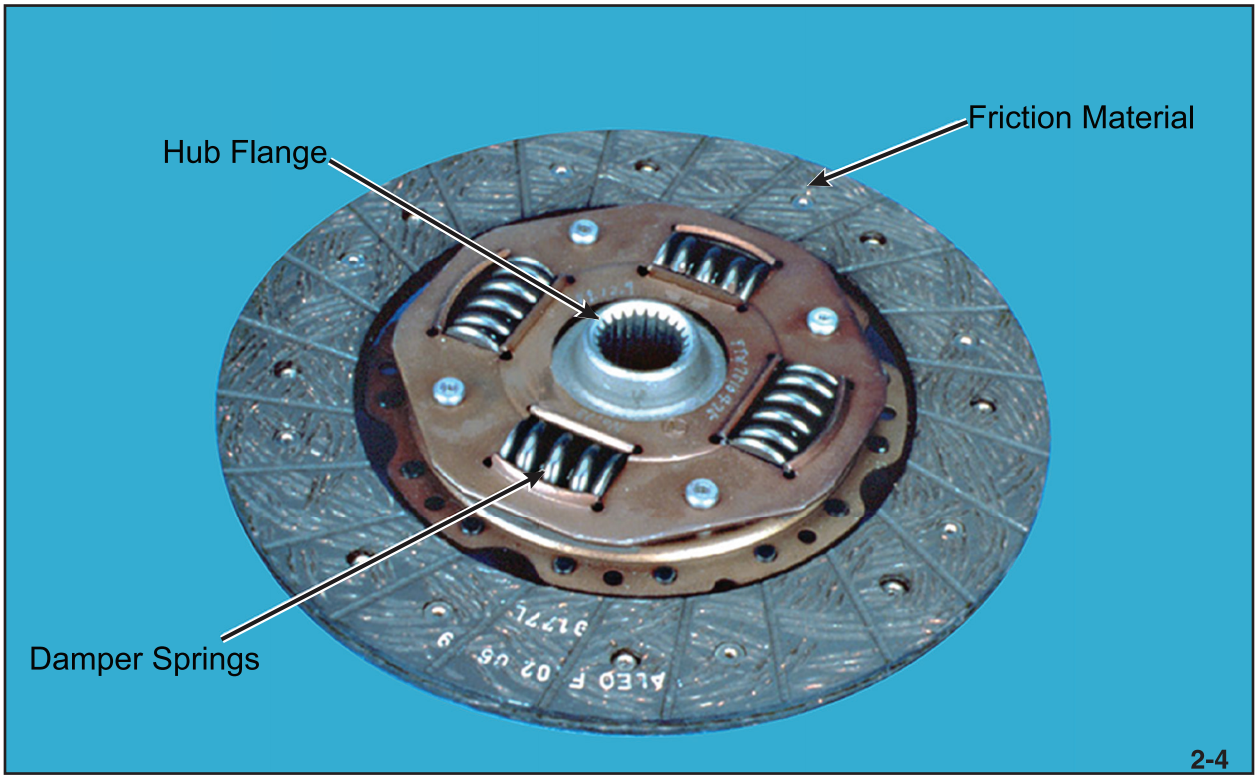
When the clutch is engaged, the rotary motion of the engine crankshaft is transferred from the flywheel, through the clutch, to the transmission input shaft. Subaru uses two types of flywheels, solid mass and dual mass. Both types serve the same purpose.



Dual Mass Flywheel

The dual mass flywheel used on turbo models consists of a primary flywheel, damper spring, ring gear, planetary gears, and a secondary flywheel. Torque fluctuation is dampened by lowering the rigidity of the powertrain. The damper springs within the flywheel absorb energy to reduce vibration and noise from the power unit.

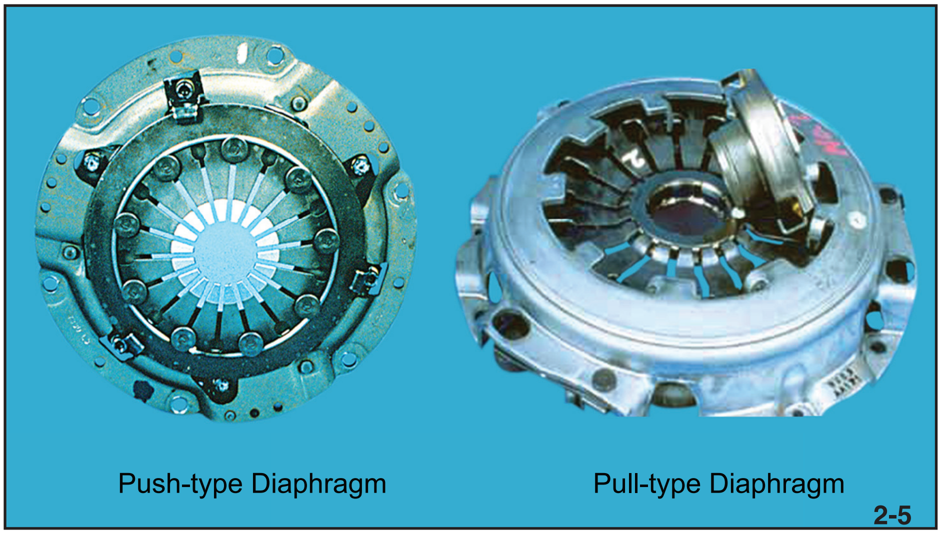
Clutch Plate (Disc)



Clutch Disc

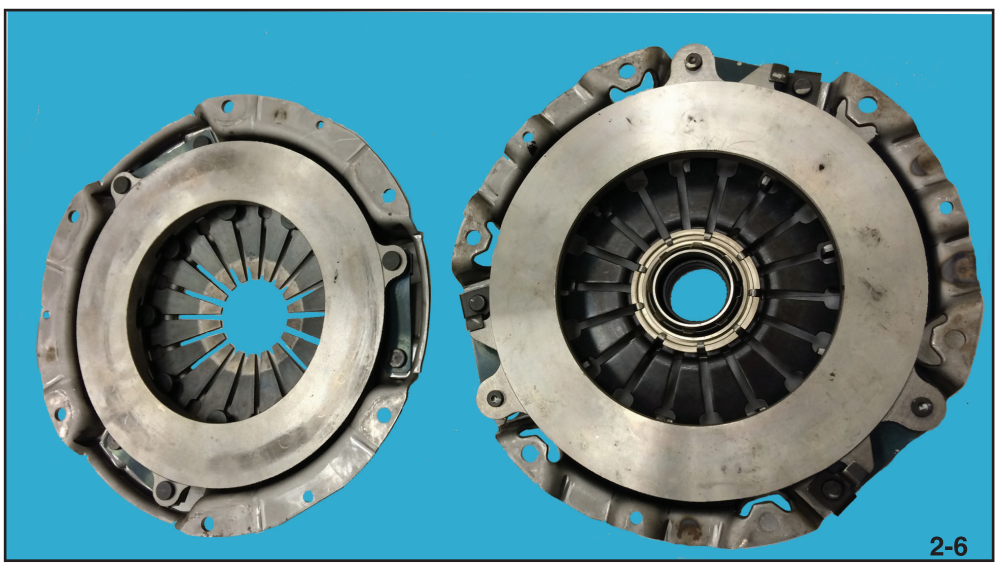
The clutch disc provides a solid connection between the flywheel and clutch cover. The transfer of power from the engine flywheel to the transmission input shaft occurs when the clutch disc is squeezed by the clutch cover springs and held tightly against the flywheel in a full lock condition. The clutch disc is constructed of a steel center disc and hub splined to match the transmission input shaft, along with coil-type damper springs to cushion rotational shock upon engagement.

Clutch Cover (Pressure Plate)



Clutch Cover

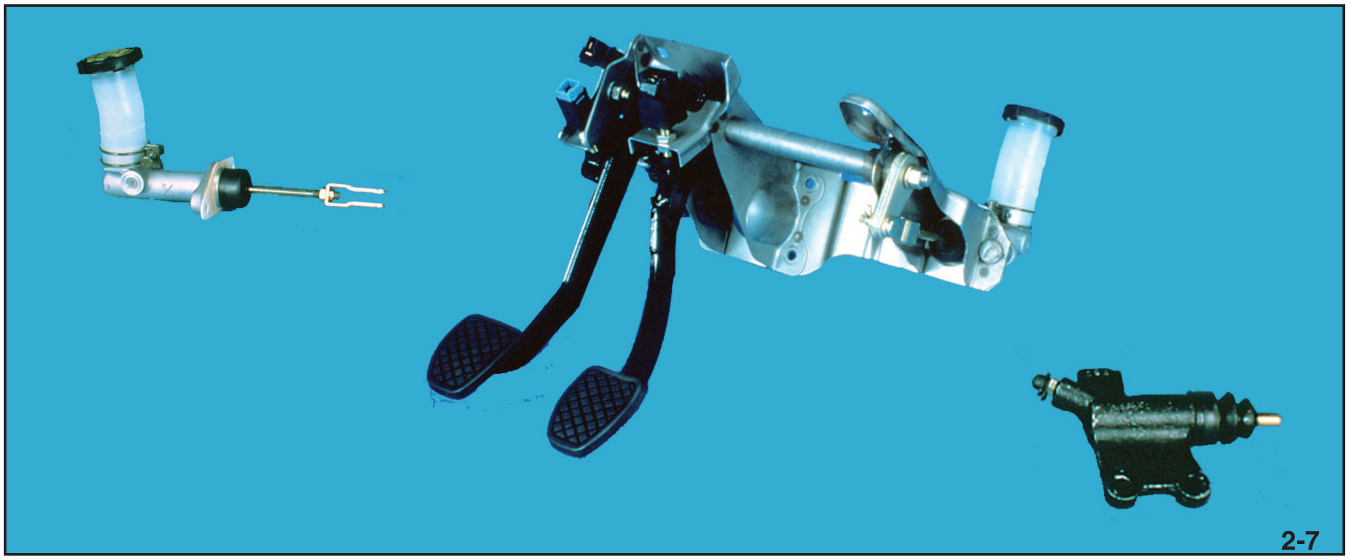
The purpose of the clutch cover (also called a pressure plate) is to connect and disconnect the flywheel and transmission input shaft, using the clutch disc. The clutch cover consists of a clutch plate, springs, clutch cover, and diaphragm-type release fingers. The clutch cover is bolted directly to the flywheel with the clutch disc between the flywheel and clutch plate. Strong spring pressure supplies the clamping force required to engage the clutch disc to the flywheel through the clutch cover assembly.



Pressure Plate Disc

Subaru uses two types of clutch covers for clutch operation. The push-type diaphragm releases pressure on the clutch disc by compressing the diaphragm with the release bearing, while a pull-type diaphragm releases pressure on the clutch disc by applying a pulling motion on the integral release bearing. The release bearing is actuated by the clutch pedal hydraulic system and release lever.

Hydraulic Clutch Operation



Hydraulic Components

The hydraulic clutch system contains the following components: foot pedal assembly, master cylinder with reservoir, fluid piping, slave cylinder, release lever, and release bearing. The hydraulic clutch system is filled with Subaru approved brake fluid.

When the clutch pedal is depressed, it pushes a rod connected to the clutch master cylinder that applies the mechanical pressure and is transformed into hydraulic pressure.

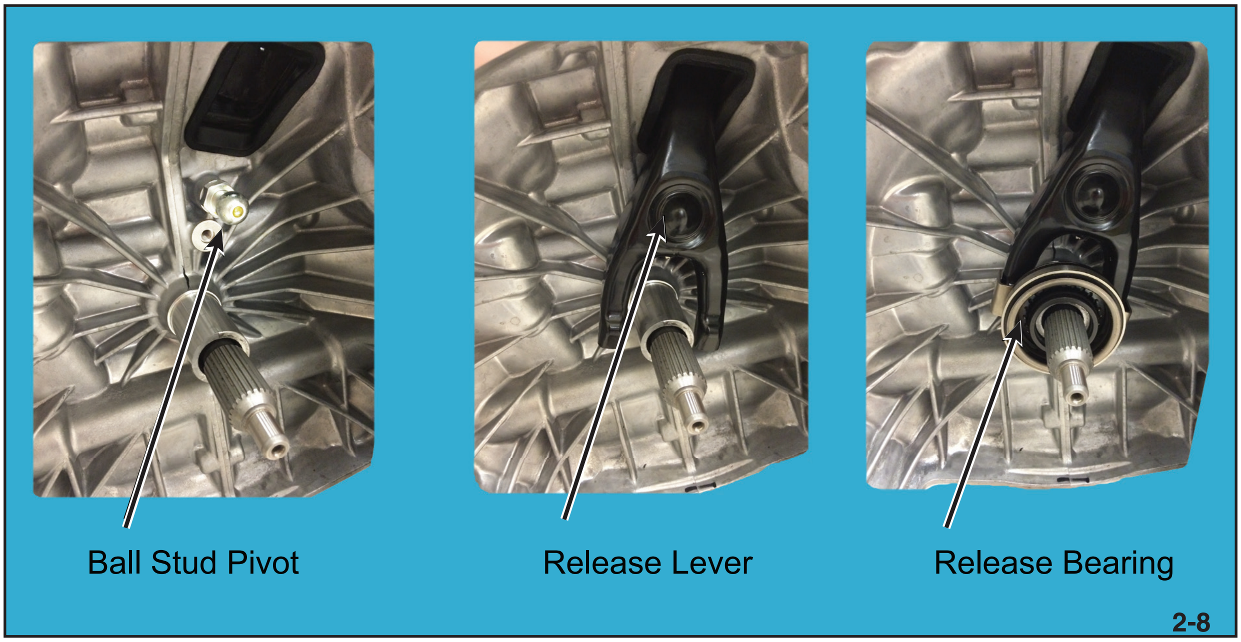
Subaru uses two types of clutch slave cylinders.

- The push-type clutch diaphragm slave cylinder, mounted forward of the release lever, pushes on the release lever, causing the lever to pivot toward the flywheel, pressing the release bearing against the diaphragm.
- The pull-type diaphragm slave cylinder, mounted rearward of the release lever, uses a push motion, causing the lever to pivot away from the flywheel, pulling the release bearing.

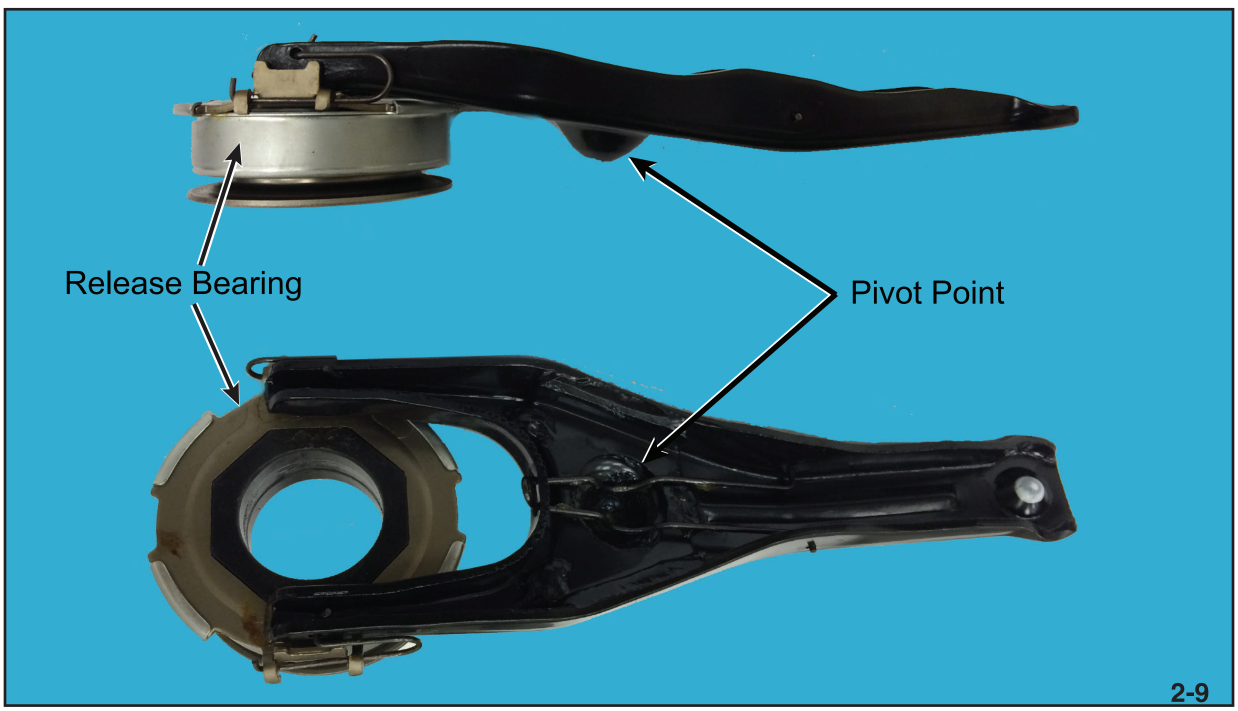
Both types of slave cylinders actuate the clutch cover; although, they are mounted in different configurations.

When the clutch pedal is released, the spring pressure from the clutch cover forces the hydraulic fluid to return from the slave to the master cylinder and fluid reservoir.

Release Levers

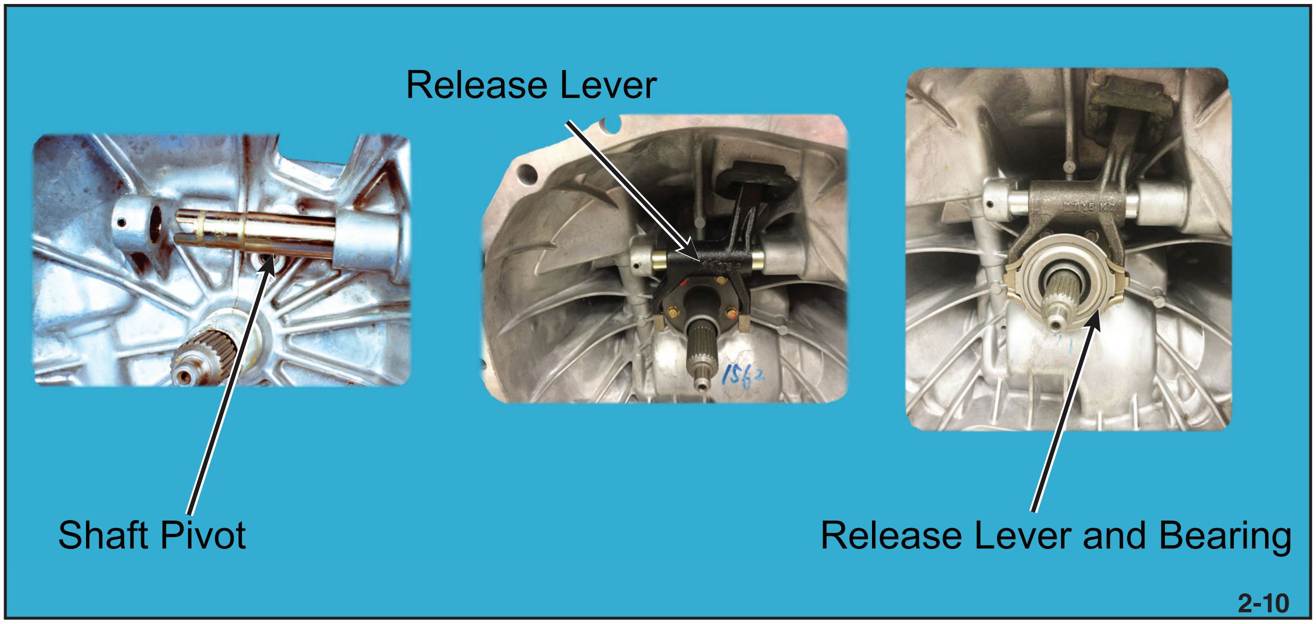


Push-type Release Lever Ball Stud Pivot

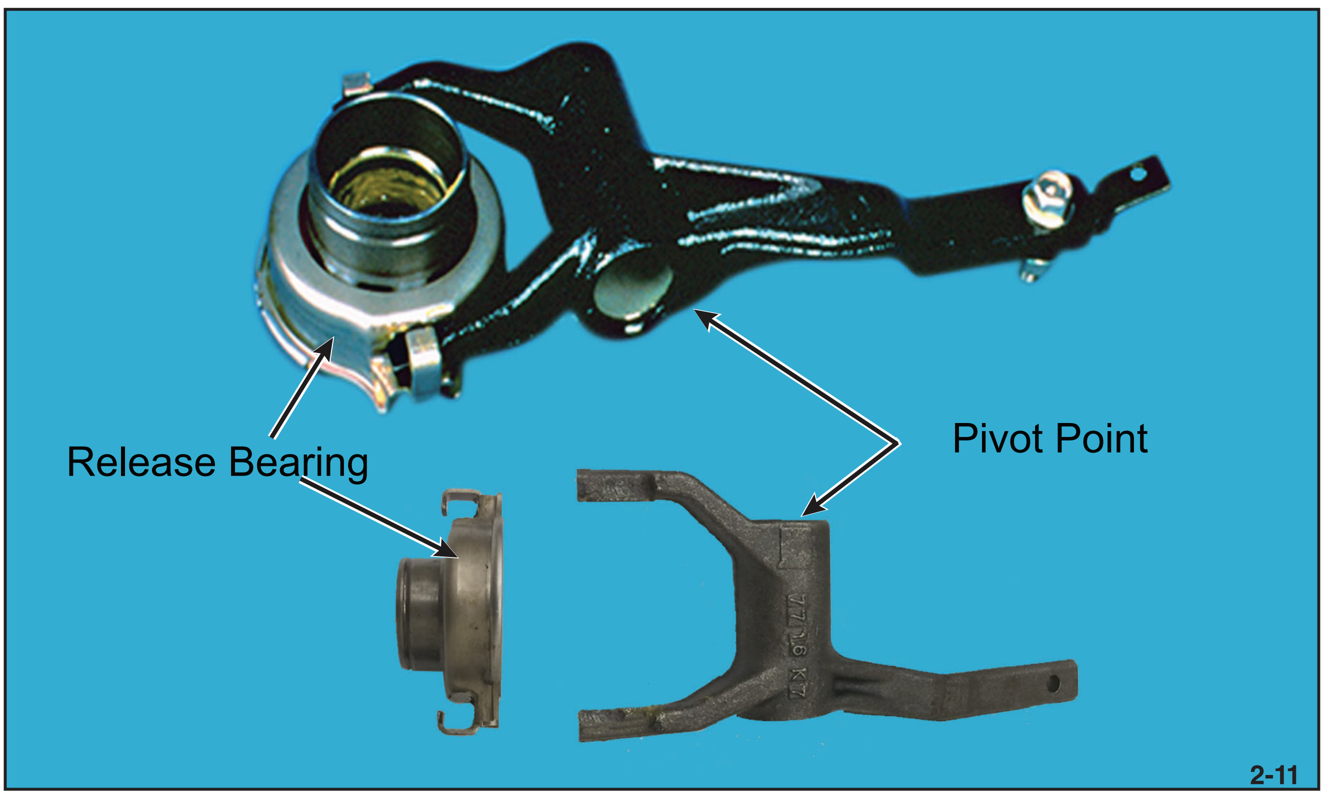


Push-type Release Lever and Bearing

When the clutch pedal is pressed, hydraulic pressure is applied to the release lever, which pivots on the release lever ball stud inside the transmission bell housing. The release bearing slides on a hollow shaft at the front of the transmission housing. The pivoting action of the release lever pushes the release bearing to activate the diaphragm clutch.



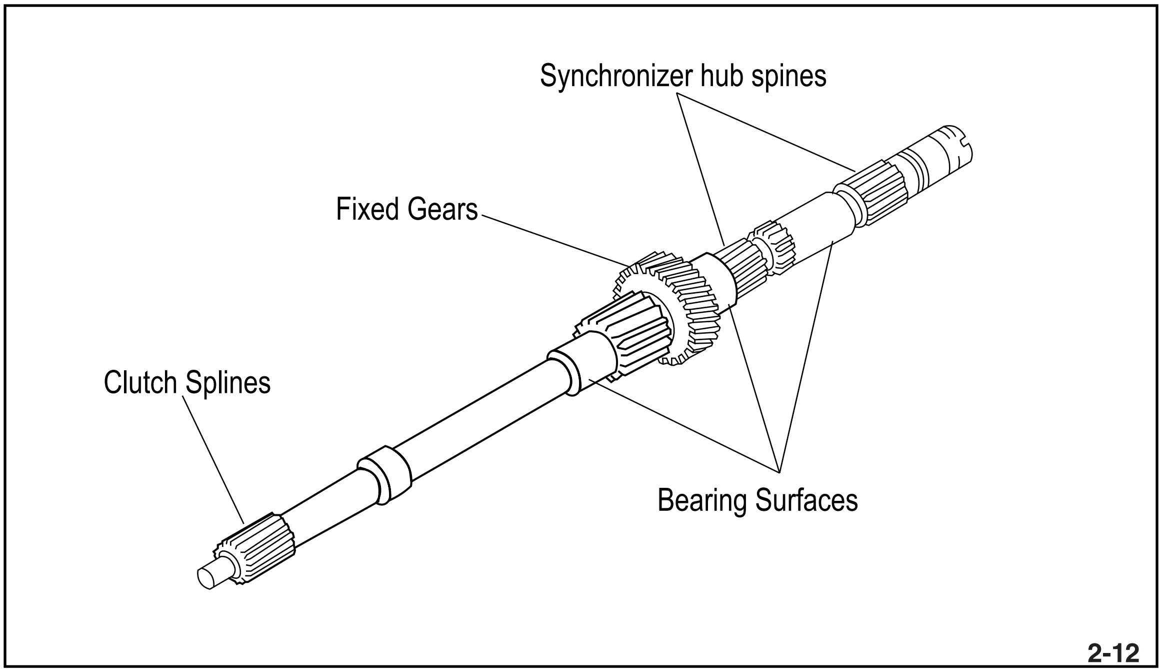
Pull-type Release Lever Shaft



Pull-type Release Lever and Bearing

When the clutch pedal is pressed, hydraulic pressure is applied to the release lever, which pivots on the release lever shaft inside the transmission bell housing. The release bearing slides on a hollow shaft at the front of the transmission housing. The pivoting action of the release lever pulls the release bearing to activate the diaphragm clutch.

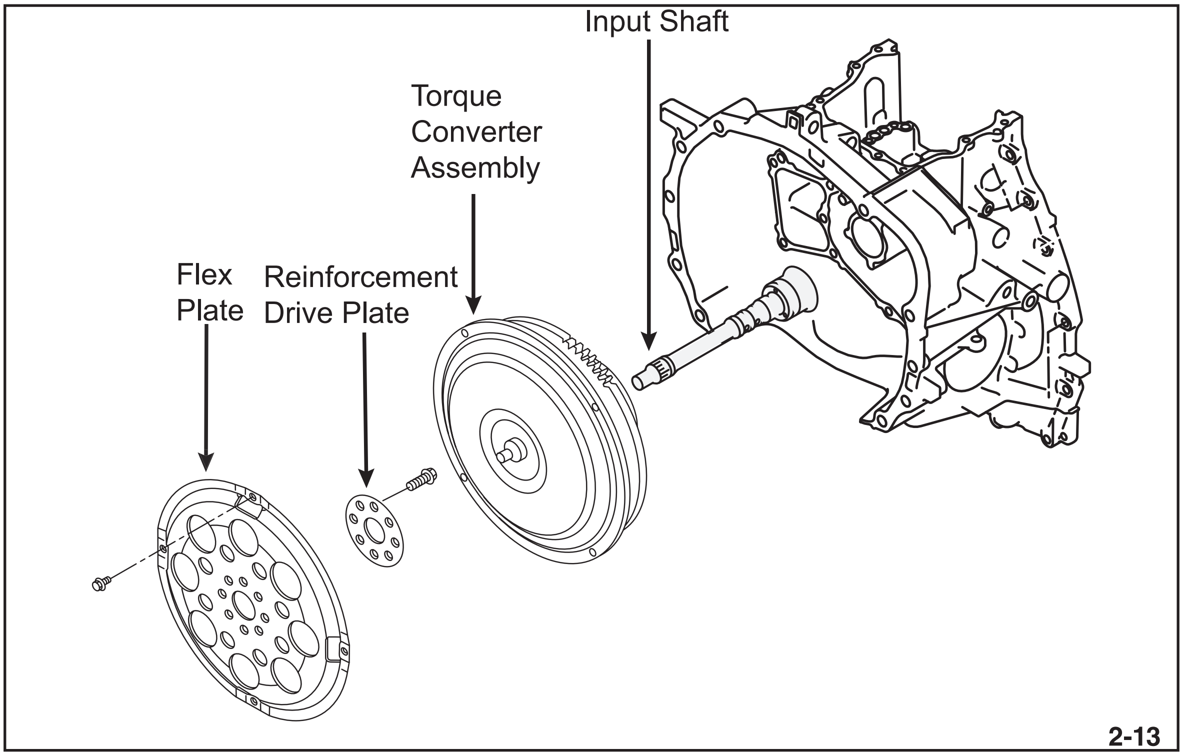
Manual Transmission Input Shaft



Input Shaft and Components

The input shaft is constructed of high-quality steel, incorporating fixed gears, splines, and multiple bearing surfaces for free-wheeling gears and synchronizers. The bearing surfaces, the splines, and the teeth of the fixed gears are machined to close tolerances. Fixed gears on the input shaft mesh with gears on the pinion output shaft.

Automatic Transmissions



Automatic Transmission Coupling Components

The engine power transmitted as torque to an automatic transmission requires a smooth transfer of power similar to a manual transmission. This is accomplished using a hydraulic fluid coupling rather than a mechanical clutch unit to engage and disengage the power flow.

The Subaru automatic transmission power coupling systems contain the following components: drive (flex) plate, torque converter, and transmission input shaft.

Drive (Flex) Plate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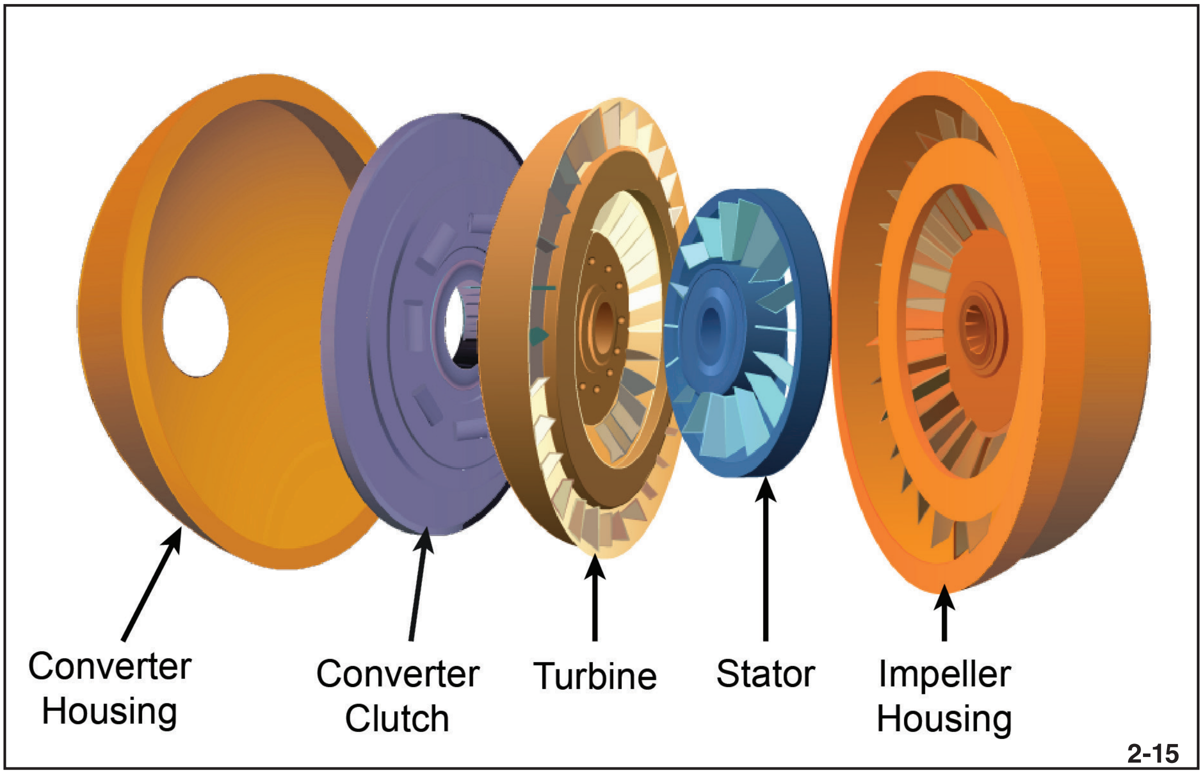
Flex Plate

Automatic transmissions use a drive (flex) plate to transfer power from the engine to the transmission through the torque converter. The drive plate mounts to the rear of the engine crankshaft and rotates at engine speed.

The drive plate is constructed of stamped steel with mounting holes for attachment to the engine crankshaft and torque converter. The drive plate may include a ring gear for the starter.

Torque Converter

Torque Converter Components



Torque Converter Components

The torque converter is a fluid coupling that uses Automatic Transmission Fluid (ATF) to connect the engine output to the transmission input. The torque converter allows for smooth transfer of engine torque and allows the engine to remain running when the vehicle is stopped and in gear. The torque converter housing may incorporate a ring gear for the starter motor.

The torque converter mounts to the engine drive plate and is made up of three major components that are contained within the housing: the impeller, stator, and turbine. The torque converter is filled with ATF that is fed by the transmission oil pump.

The impeller is fastened to the converter housing and consists of a circular frame that looks like a sliced doughnut and has many vanes attached to its inside. The impeller spins at engine speed and moves the transmission fluid in the same direction of engine rotation.

The turbine is also made up of a circular frame that also looks like a sliced doughnut with vanes attached to its inside. The turbine resides opposite the impeller within the converter housing. The turbine is the output unit of the torque converter and is coupled to the transmission input shaft.

The stator resides between the impeller and the turbine; its purpose is to redirect impeller fluid flow and promote torque multiplication. The stator is mounted to the converter hub via a one-way clutch, this clutch allows the stator to remain fixed when impeller and turbine speeds differ and spin freely when impeller and turbine speeds are the same. This allows the converter to be more efficient during both modes of operation.

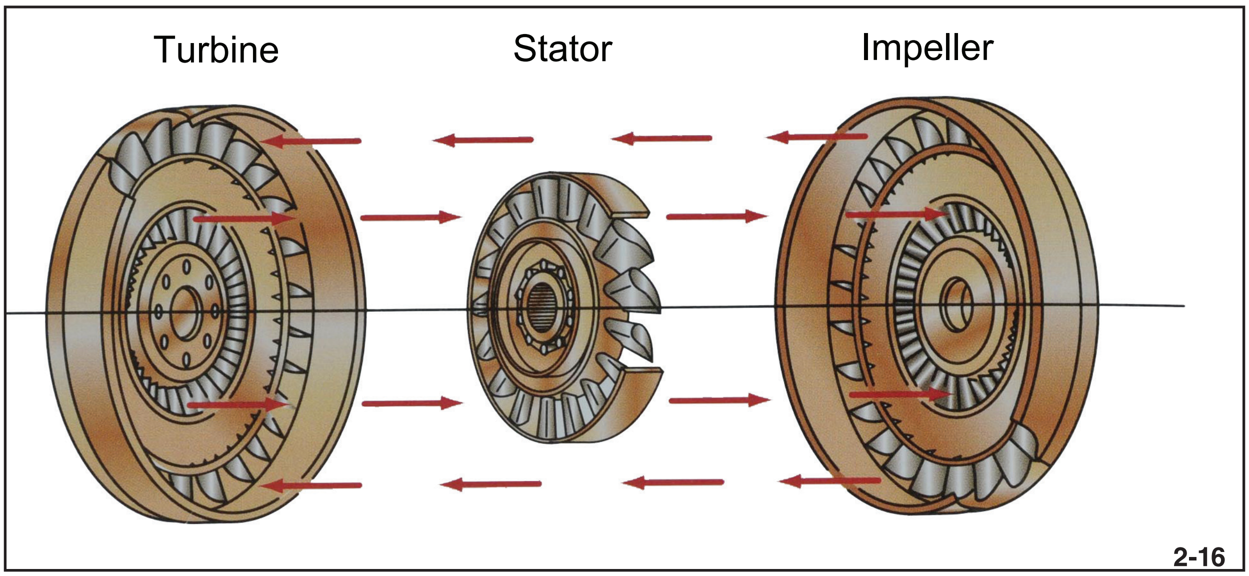
Torque Converter Operation

With the engine running and the transmission in gear, the torque converter allows the vehicle to stop without stalling the engine because the impeller is not rotating fast enough to move the turbine.

When the engine speed is increased, fluid from the impeller is pushed through the stator (held in place by the one-way clutch) and into the turbine blades. The hydraulic force applied on the turbine blades causes the turbine to rotate in the same direction as the impeller.

The fluid flow from the impeller to the turbine determines how much force can be transmitted from the impeller to the turbine. This can be very little force to maximum force, depending on the torque converter's design. Maximum efficiency is approximately 90%, but varies by torque converter design, fluid type, vehicle load, and engine torque.

Fluid Flow

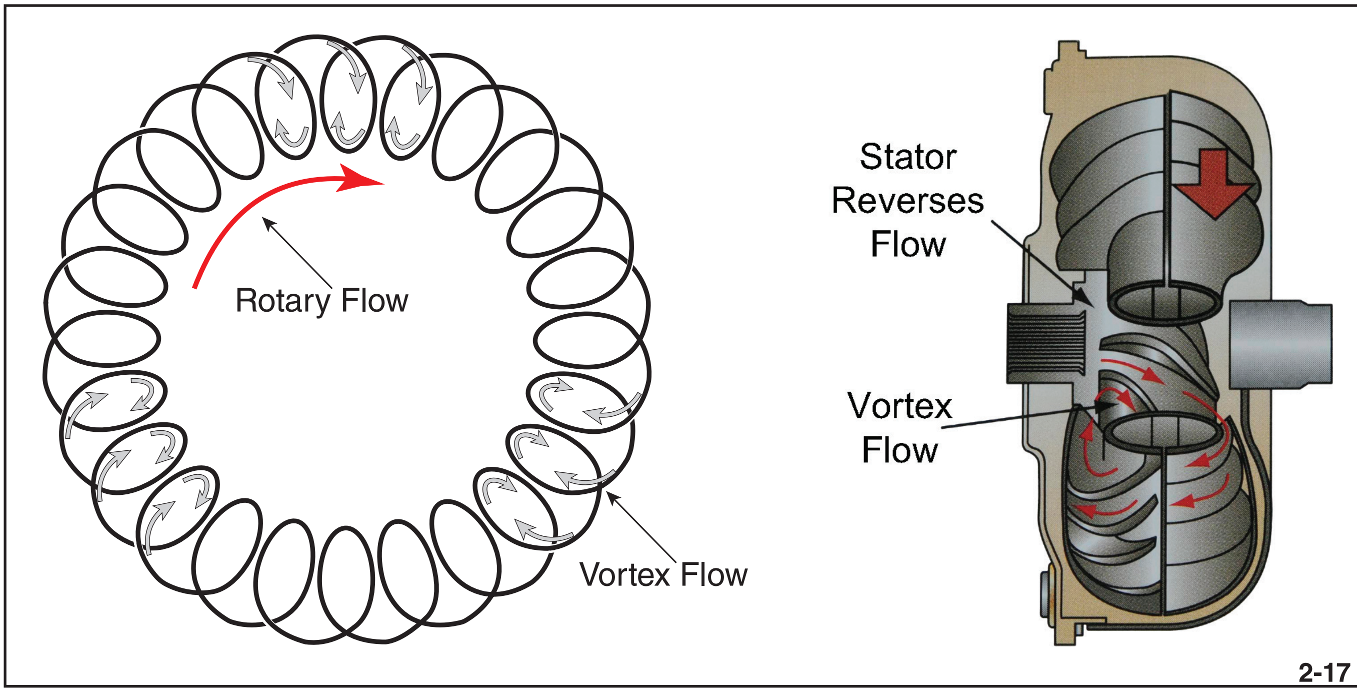


Fluid Flow

There are two types of fluid flow within the torque converter, rotary, and vortex.

Vortex flow is present whenever the speed of the impeller and turbine do not match; this is when torque multiplication occurs. When impeller and turbine speed are within approximately 10% of each other, rotary flow is present and torque multiplication is minimal.

Vortex Flow

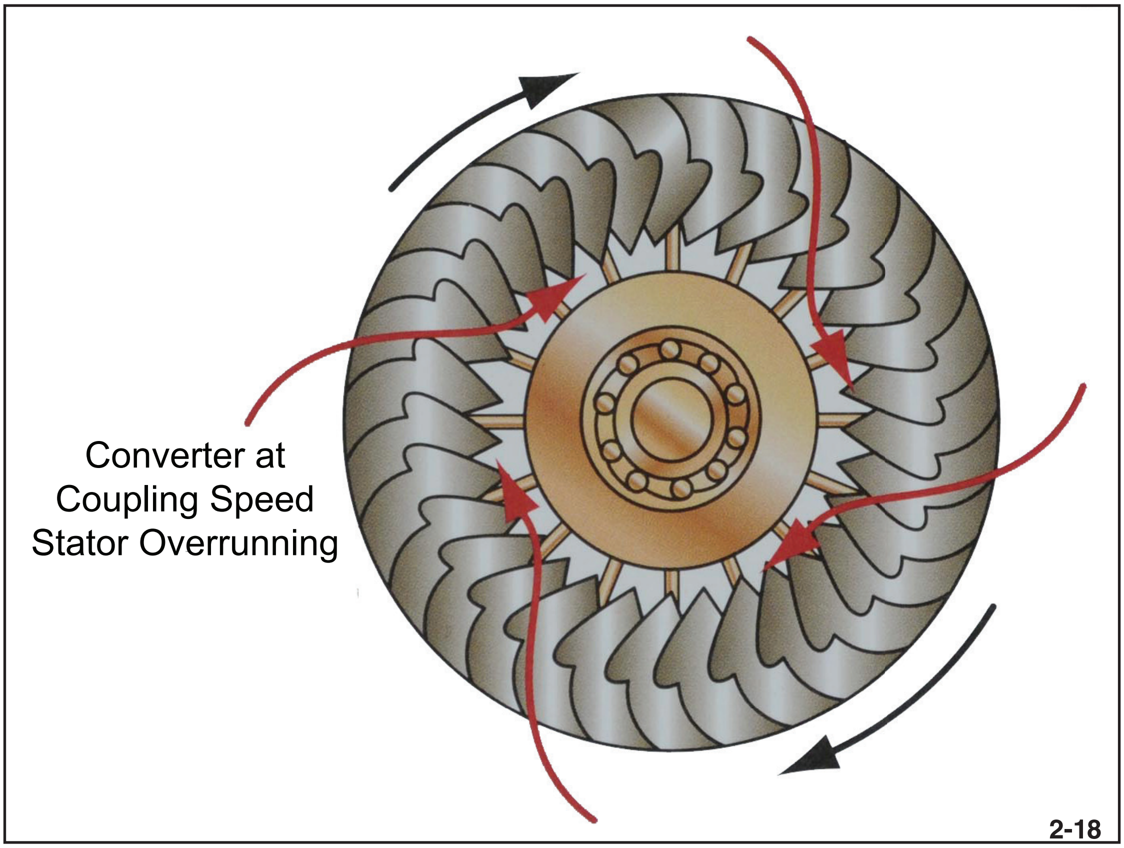


Vortex Flow

Vortex flow is the fluid flow circulating between the impeller and the turbine as the fluid moves from the impeller to the turbine and back to the impeller. The fluid moves due to the vanes and centrifugal force. This force is what multiplies torque.

Vortex flow only occurs when there is a difference in rotational speed between the impeller and the turbine. In this mode, the stator is locked to the hub via the one-way clutch to act as a reactory member and assist in directing the fluid in the vortex flow.

Rotary Flow



Rotary Flow

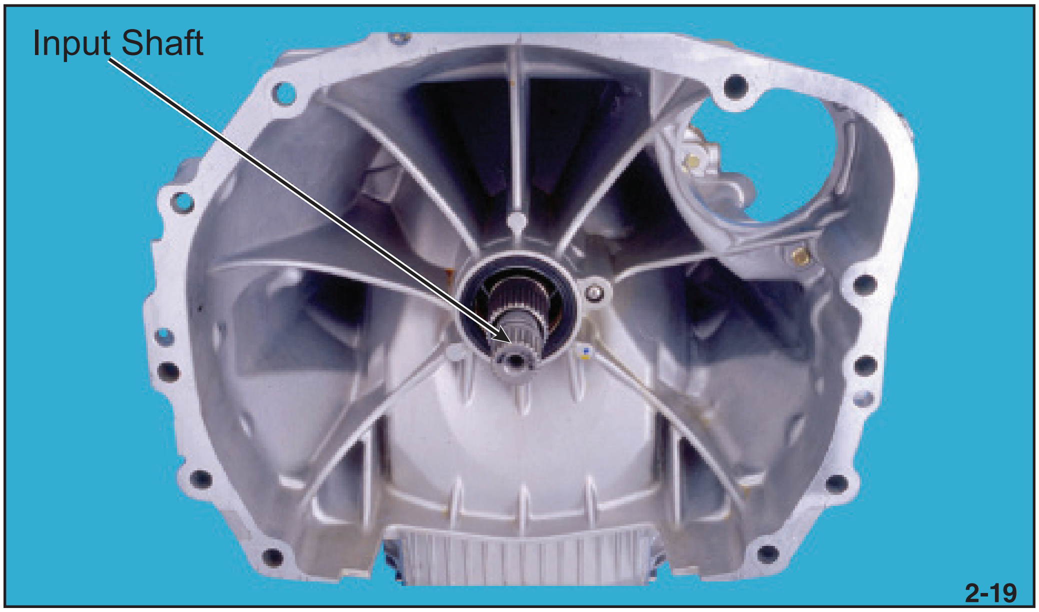
Rotary flow is the flow of fluid movement in the direction of impeller rotation and is a result of the paddle action of the impeller vanes against the turbine blades. Rotary flow occurs when the fluid path is in the same direction as the rotation of the impeller. In this mode, the stator free-wheels in the same direction as the fluid flow, promoting efficiency.

Torque Converter Lock-up

A torque converter can waste up to 10% of the engine's efficiency due to slippage. To help eliminate slippage and promote fuel efficiency, the torque converter can go into lock-up, providing a direct drive coupling of the engine and transmission.

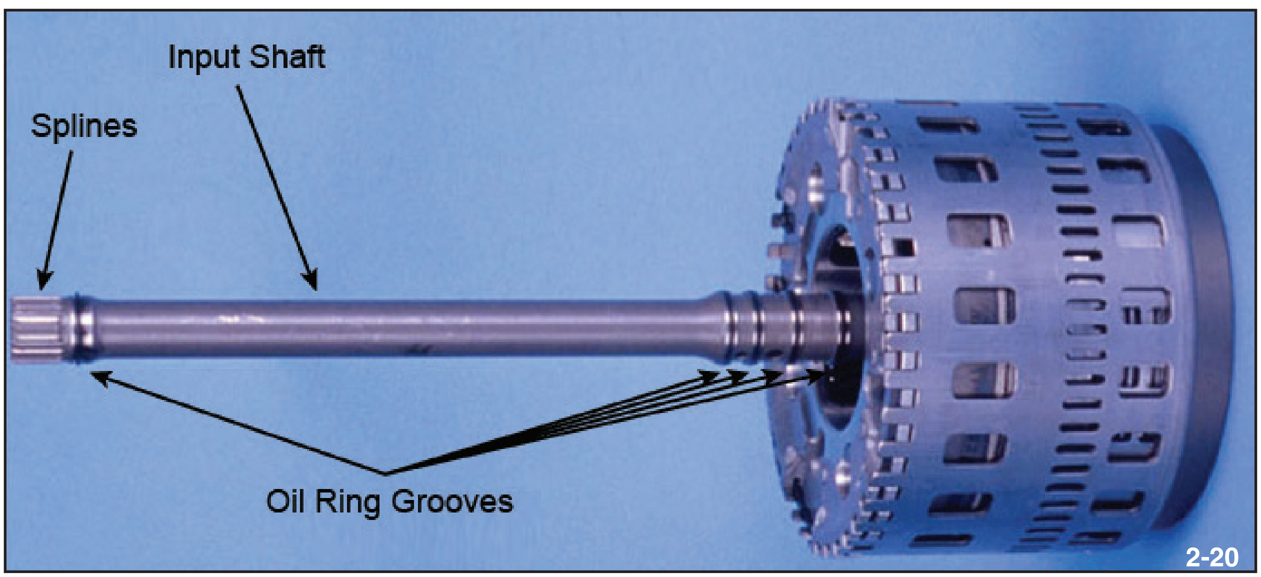
When activated, the converter clutch couples the turbine to the torque converter housing. Torque converter lock-up is controlled by the Transmission Control Module (TCM), a solenoid, and a hydraulic control circuit. Lock-up occurs when hydraulic pressure is applied to the lock-up mechanism piston. Engagement can occur at speeds as low as 30 mph when the ideal conditions are present.

Input Shaft



Input Shaft Installed

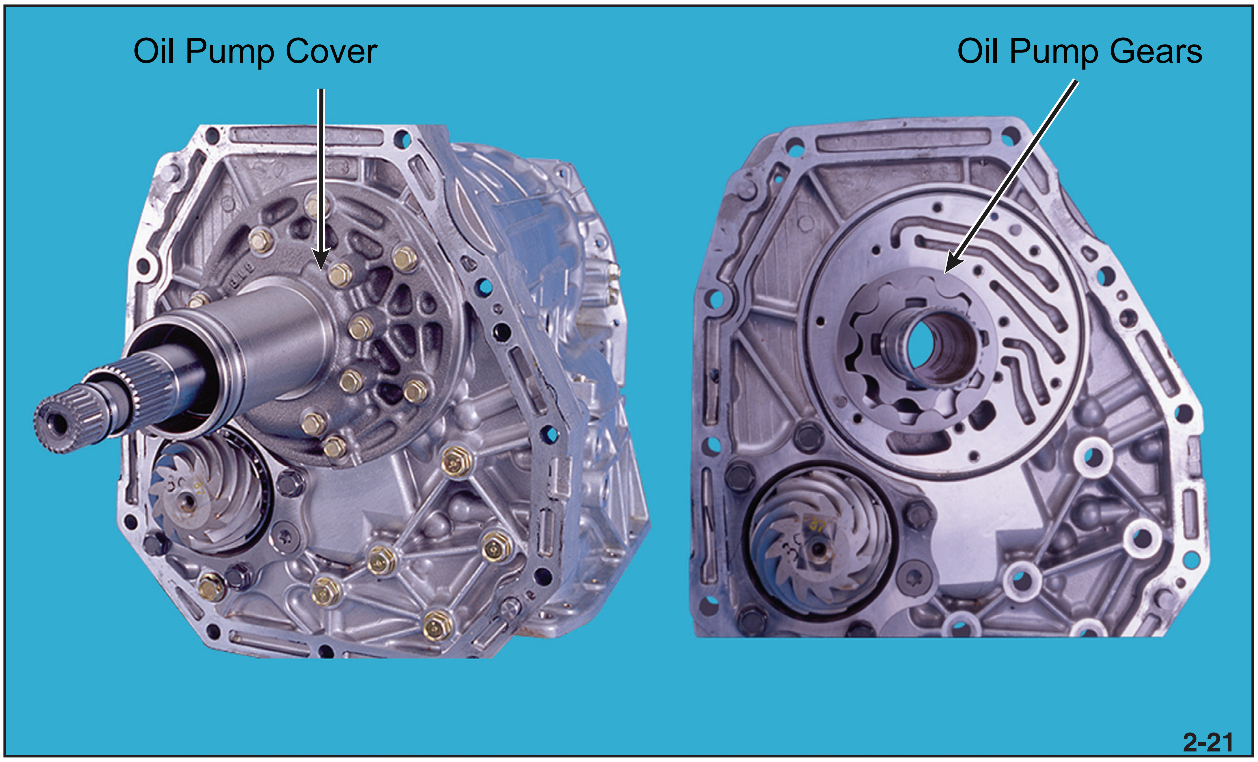
The automatic transmission input shaft transfers power from the torque converter to the transmission. It is splined to match the turbine side of the torque converter and rotates at the same speed.



Input Shaft with Clutch Pack

The transmission input shaft assembly has oil ring grooves machined into the front and rear of the shaft to seal the torque converter from the input shaft. The rear portion of the input shaft used in this design is machined for the front planetary gear set and clutch pack components.

Oil Pump



Oil Pump

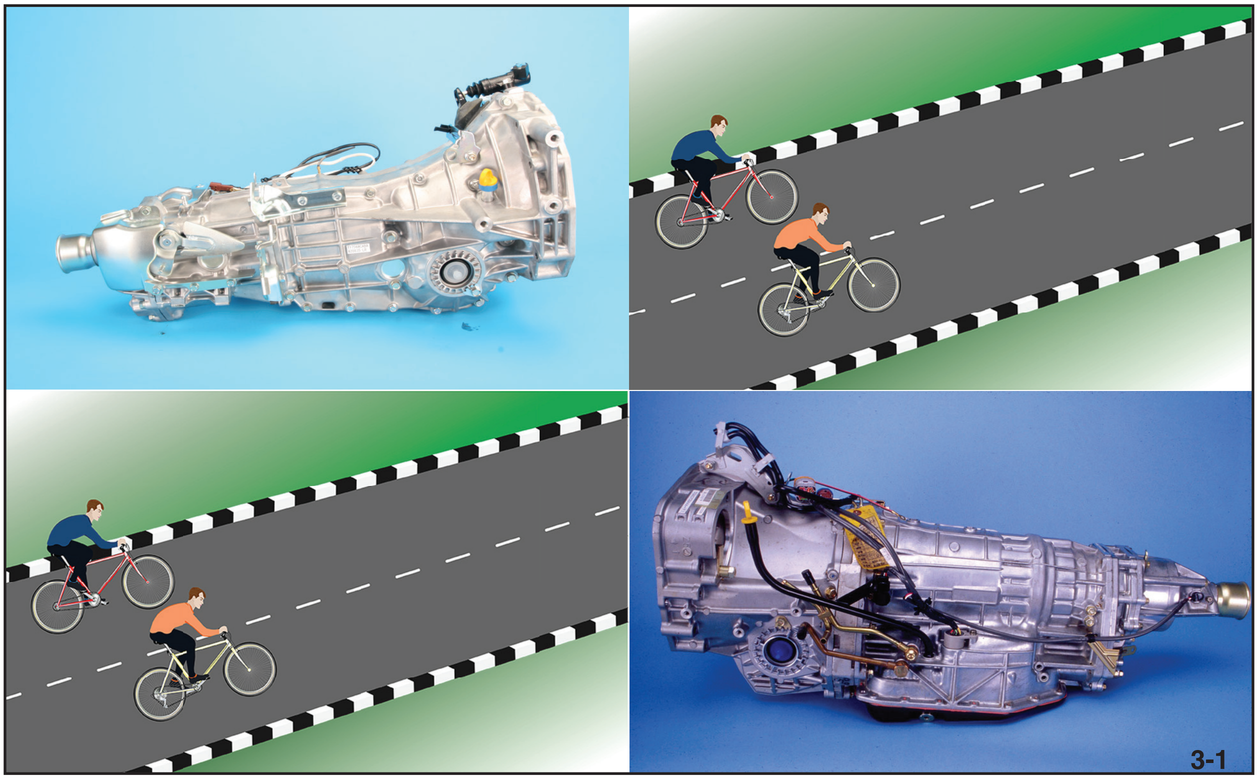
An oil pump provides the necessary transmission oil pressure to operate the clutches, brakes, and torque converter and lubricate components within the automatic transmission. The oil pump is driven by the torque converter housing at engine speed and is regulated by an internal valve. The oil pump installed in this illustration is mounted to the front of the transmission case under the oil pump cover and is directly connected to a flange on the oil pump drive shaft. The pump produces pressure whenever the engine is running, as long as there is enough transmission fluid available.

The pump draws ATF from the oil pan through the oil strainer located under the control valve assembly. The ATF then flows through a passage in the transmission case, and after passing through the oil pump housing and oil pump cover, it enters the suction port of the pump.

The discharged ATF flows through a passage in the oil pump cover and then a passage in the oil pump housing. It then goes through a passage in the transmission case to the control valve assembly where the ATF is directed to various clutches, brakes, and the torque converter lockup clutch, acting as hydraulic fluid and lubricating oil.

Driveline Gearing

Transmission Overview



Purpose of the Transmission

Internal combustion engines provide the power to propel the drive wheels of most automotive vehicles. The engine alone cannot support all of the varying speed and power demands of the vehicle; therefore, a transmission is used to overcome the demands.

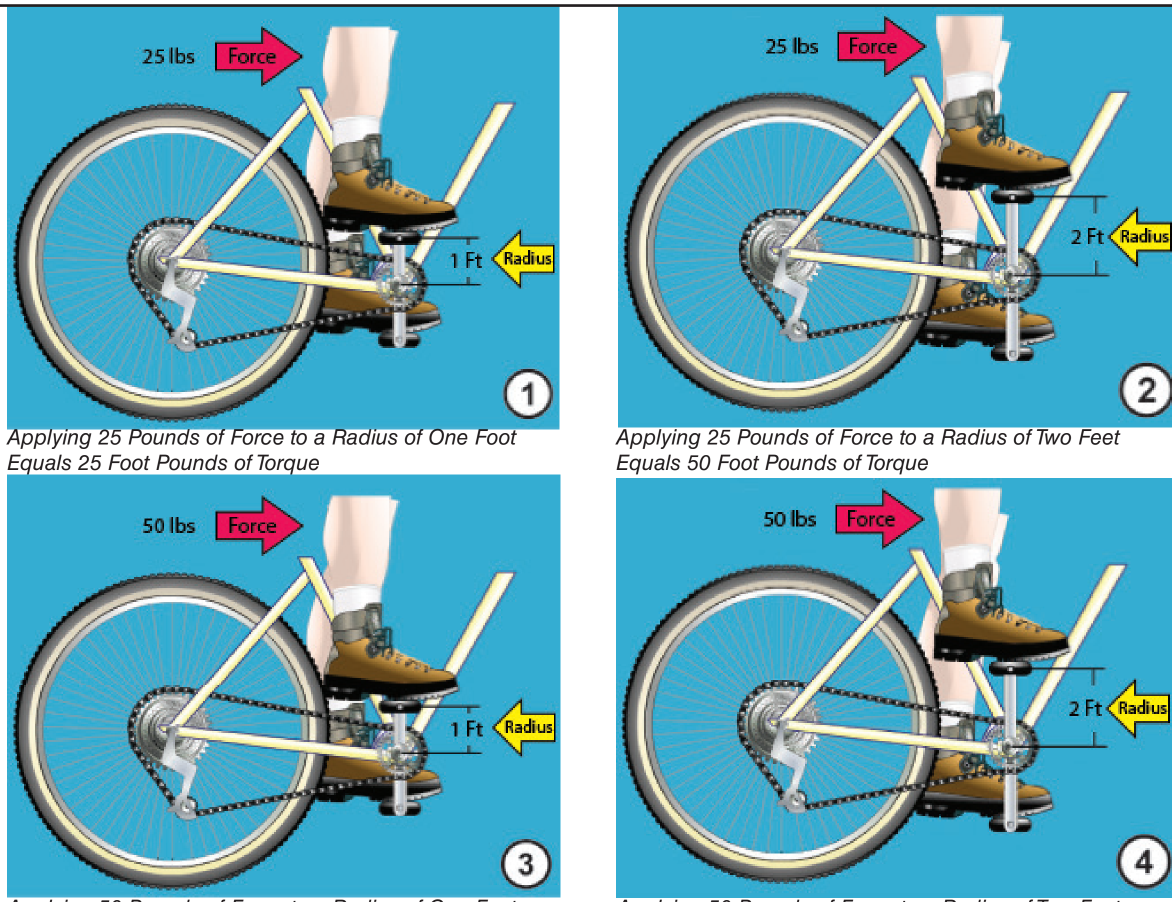
At low speeds, the transmission multiplies the torque output of the engine to increase power. At higher speeds, the transmission multiplies engine speed to improve fuel economy. In backup maneuvers, the transmission reverses the direction of rotation so that the vehicle can move backwards while the engine operates in the same direction.

The transmission can completely disconnect the engine from the driveline at a stop, allowing idle, or can completely lock the engine to the driveline at highway speeds for optimum fuel economy.

Torque Multiplication

The production of torque or twisting force is simplified by comparing a bicyclist using leg muscles to exert a force on the pedal crank.

An engine exerts force on the gears inside a transmission. In the case of the bicyclist, torque is determined based on how far the pedal is from the gear sprocket (or radius) and how much force is applied. The more force applied, or the longer the radius, the greater the torque. Torque equals force times radius.



Applying 25 Pounds of Force to a Radius of One Foot Equals 25 Foot Pounds of Torque

Applying 25 Pounds of Force to a Radius of Two Feet Equals 50 Foot Pounds of Torque

Applying 50 Pounds of Force to a Radius of One Foot Equals 50 Foot Pounds of Torque

Applying 50 Pounds of Force to a Radius of Two Feet Equals 100 Foot Pounds of Torque

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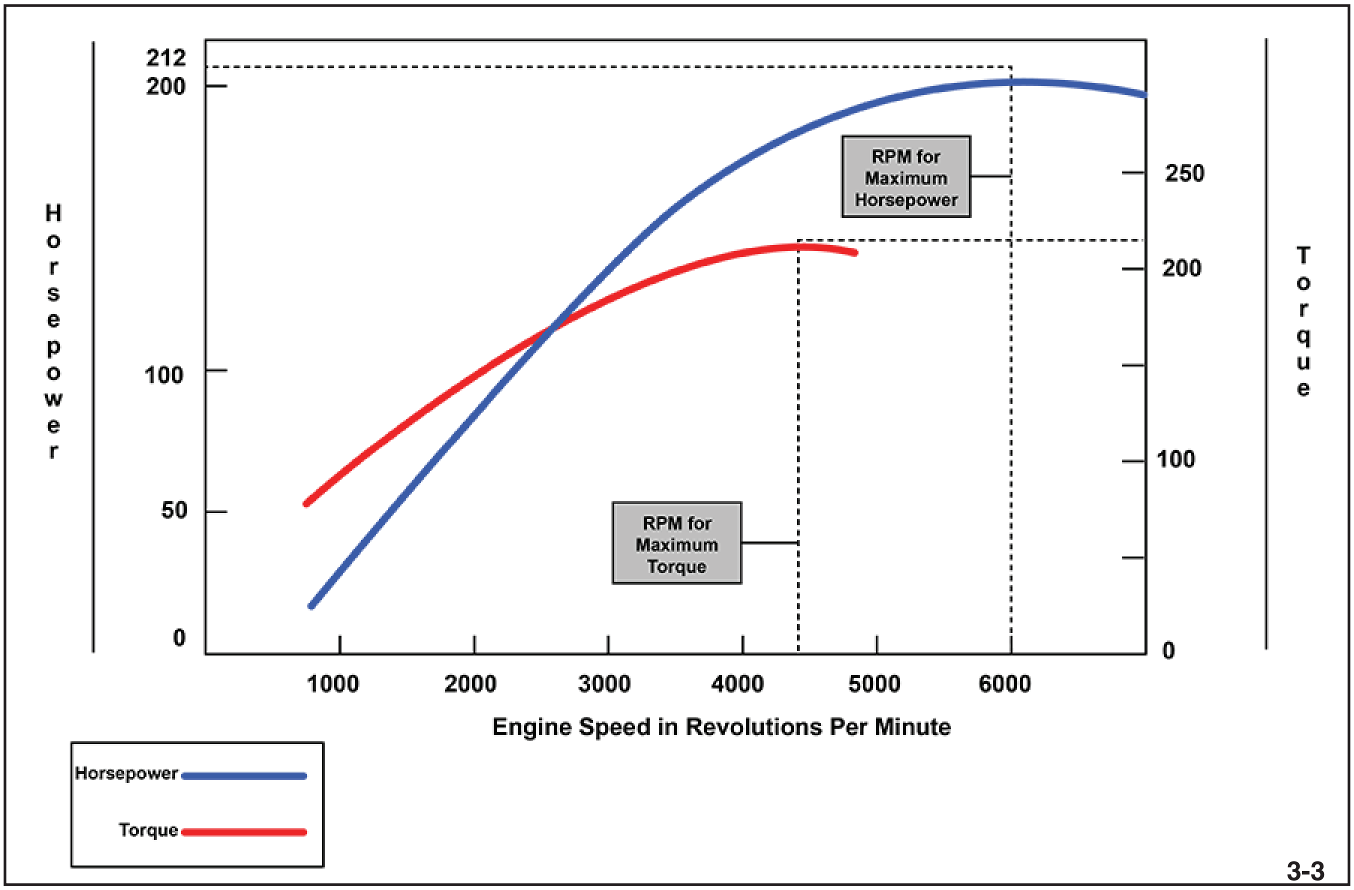
Torque Multiplication

Power Measurements

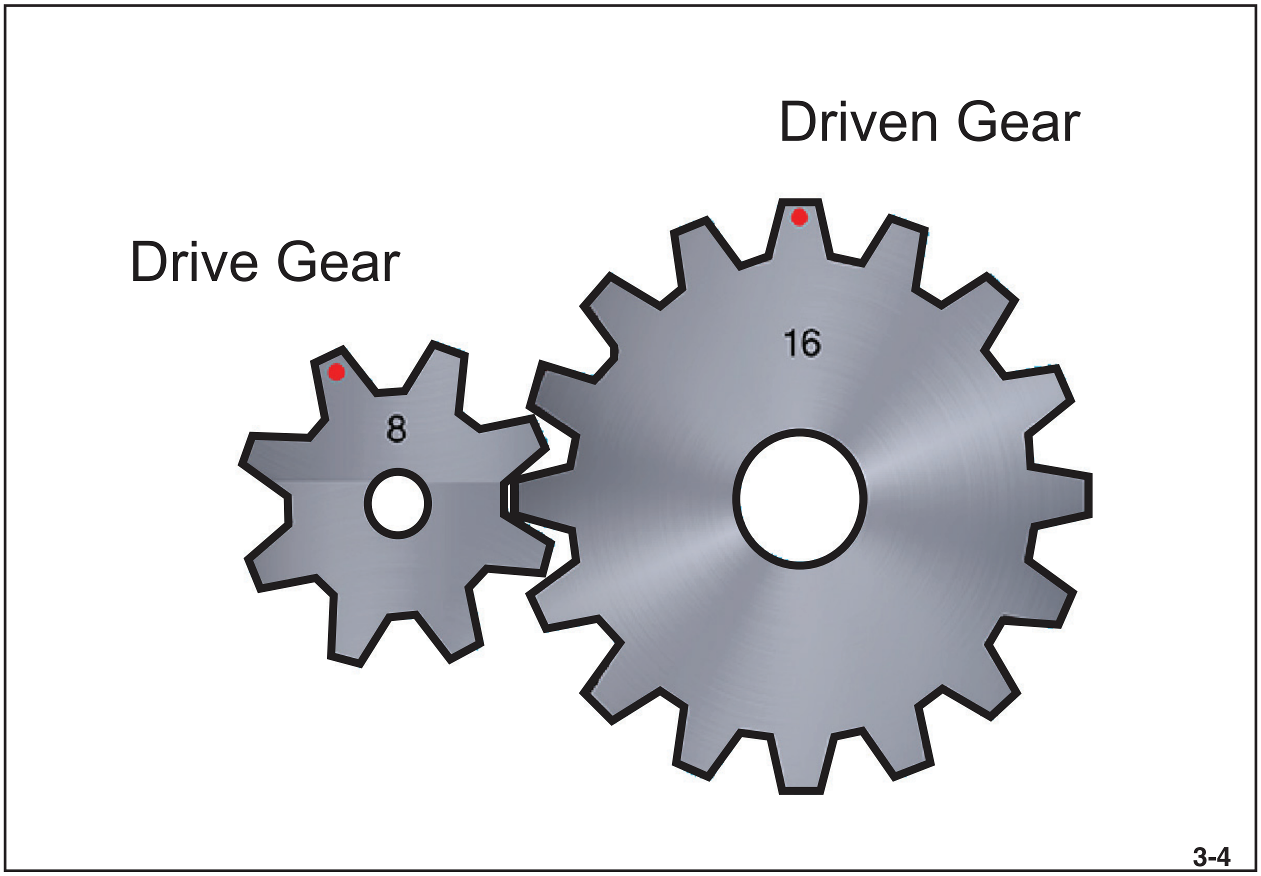


Power Curves

An engine produces power through a rotating crankshaft that exerts a given amount of force on a load at a given rpm. The amount of torque the engine can exert usually varies with rpm.

Torque measured on a dynamometer is recorded on a graph. Horsepower, calculated from torque and rpm, is also charted on a graph. This graph allows both horsepower and torque to be compared to engine operating speed. The relationship between the horsepower and torque curves shows how the engine performs at different loads and speeds.

Gear Ratios

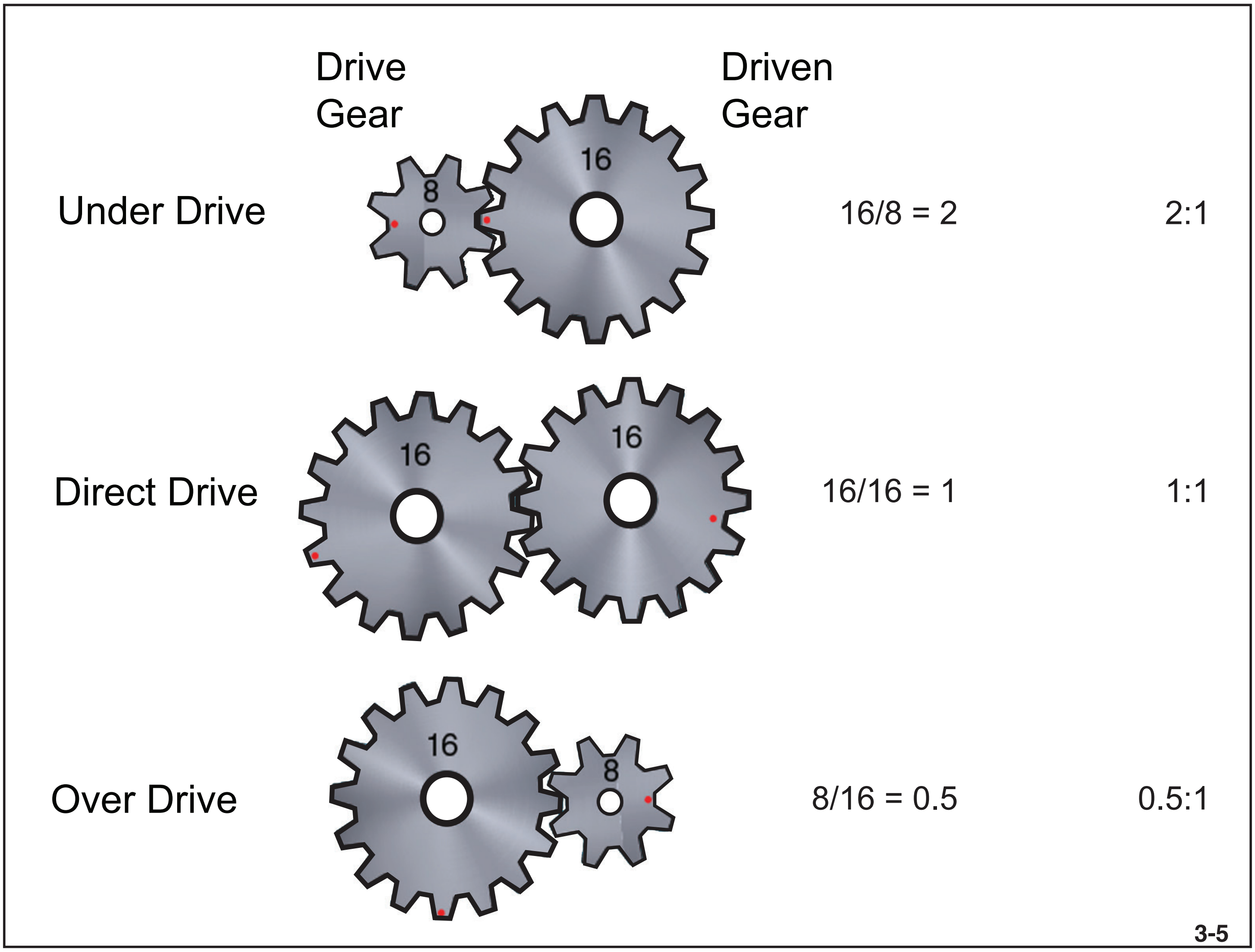


Drive and Driven Gears

Gear ratios are a comparison of gear size and tooth counts between two meshed gears. The numbers applied to gear ratios are assigned to identify the drive gear rotations required to rotate the driven gear once.

To calculate the ratio for the two gears, consider the drive gear has one-half the number of teeth of the driven gear; the ratio is 2:1. For example, the large gear shown is the driven gear and has 16 teeth. The small gear shown is the drive gear, and has eight teeth. Divide the large gear number of teeth by the small gear number of teeth: 16 divided by eight equals two. This is a 2:1 gear ratio.

Gear Ratio Conditions



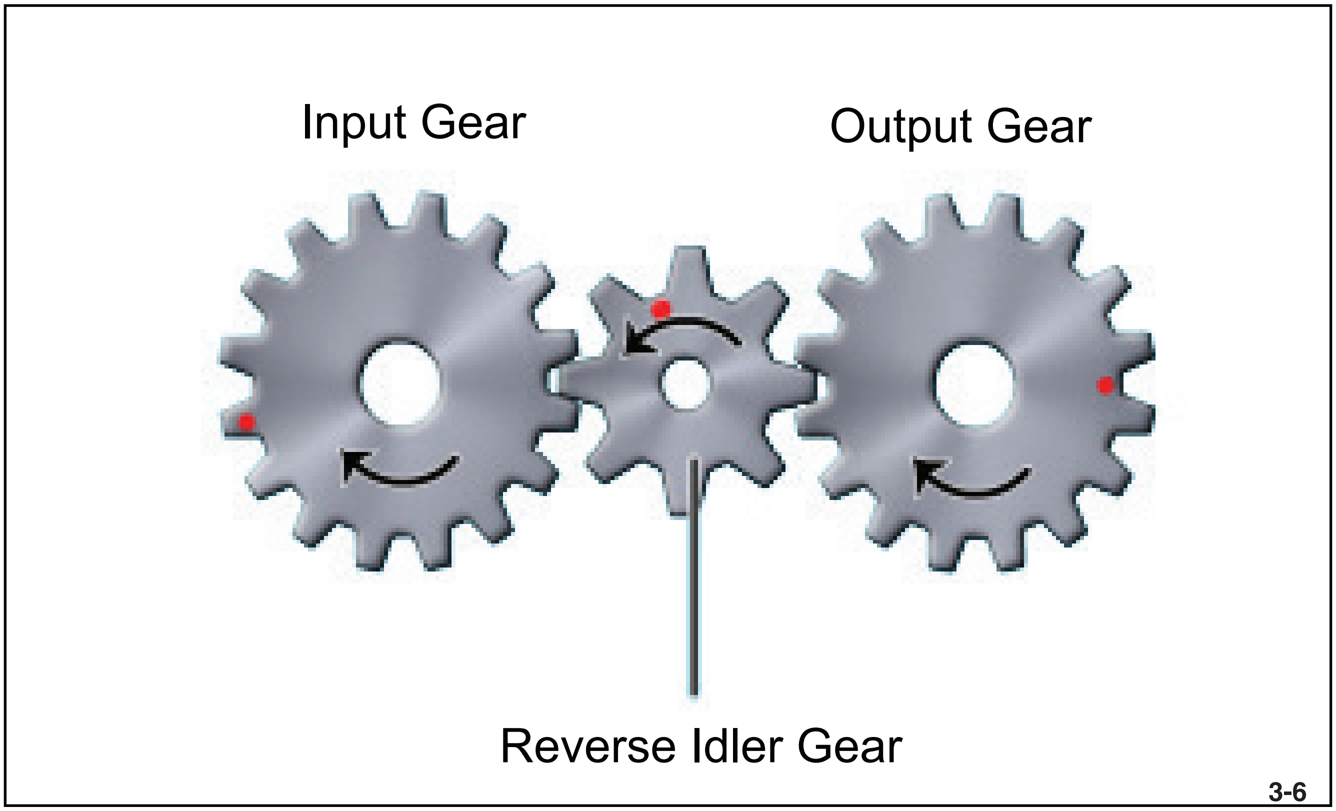
Modes of Operation

Generally, there are three modes of operation: under drive, direct drive, and over drive.

When a small gear drives a large gear, the condition is termed under drive.

- When a gear drives a gear of the same size or tooth count, the condition is termed direct drive.
- When a large gear drives a small gear, the condition is termed over drive.
- To determine the gear ratio mode of operation, divide the number of teeth of the driven gear by the number of teeth of the drive gear. For example, in the direct drive mode, the drive gear has 16 teeth, and the driven gear has 16 teeth. 16 divided by 16 equals 1. This is a 1:1 gear ratio. The other examples use the same formula to calculate the ratio and mode.

Reverse Gears

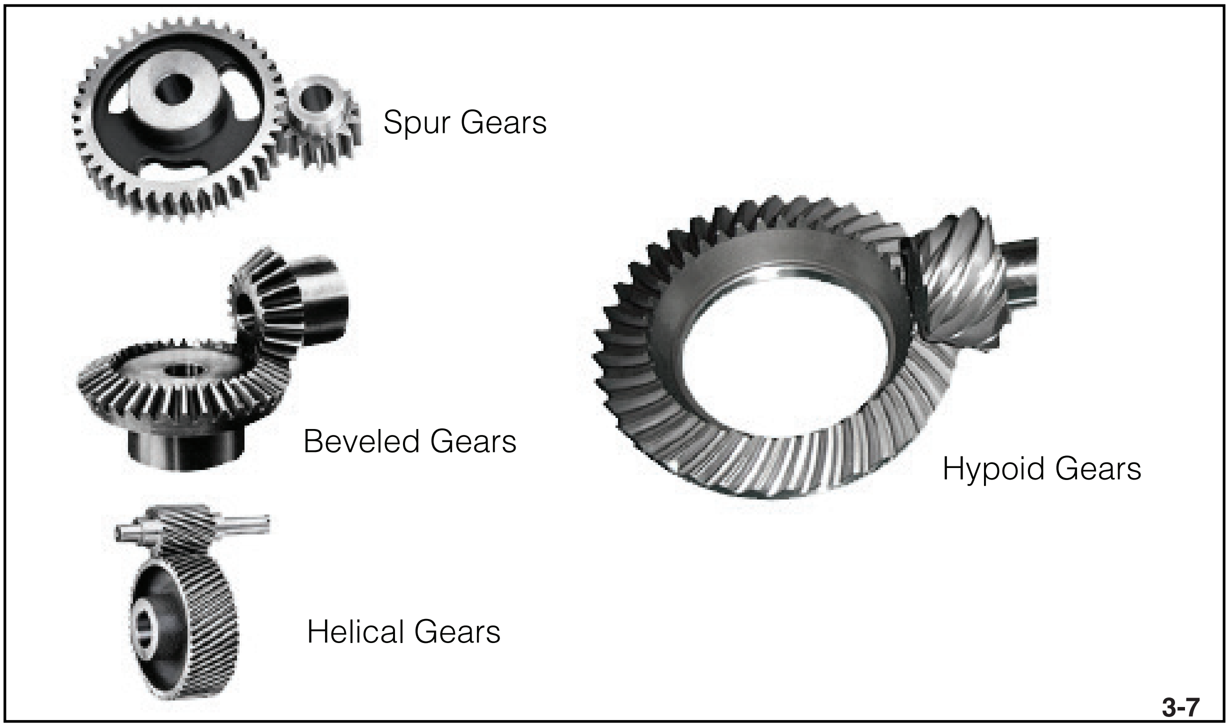


Reverse Idler Gear

A manual transmission must be able to change the output shaft direction of rotation without changing the direction of engine rotation. Changing the driven gear direction of rotation, and causing it to rotate in the same direction as the drive gear, requires an intermediate gear. Placing an extra gear between the drive and driven gears, all having external teeth, causes the driven gear to rotate in the same direction as the drive gear.

The reverse idler shaft supports the reverse idler gear. The reverse idler free-wheeling gear is in constant mesh with the gears on the input and output shafts. It is free to rotate on the shaft without transferring torque from the input to the output shaft until needed for reverse operation of the transmission.

Gear Types

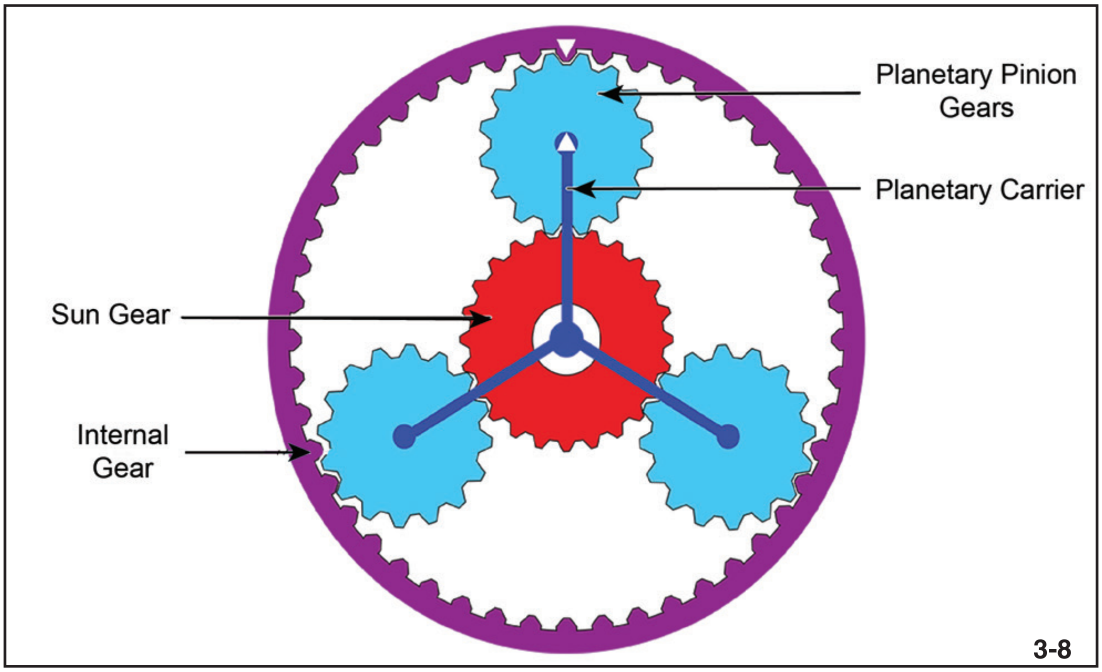


Gear Types

A vehicle driveline uses multiple types of gears to transfer engine power to the drive wheels. Each type of gear has characteristics that perform a specific purpose.

- Spur gears have straight teeth and are mounted on parallel shafts for their teeth to mesh with those of other gears. The straight-cut design of spur gears causes them to create noise at high speeds.
- Beveled gears are used when the transmitted torque needs to change planes (from one axis to another). They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. Beveled gear sets are typically used in combination with other beveled gear sets in final drives, such as differential units.
- Helical gears are cut at an angle to increase individual tooth strength. When two teeth on a helical gear set engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate until the two teeth are in full engagement. The gradual engagement causes helical gears to operate more smoothly and quietly than spur gears. Helically cut gears are used in the transmission to reduce noise.
- Hypoid gears are a subtype of beveled gears. The main differences between straight gears, beveled gears, and hypoid gears are the input and the output gears can be off-center, and they are helically cut. This allows for changing rotational planes while being offset and quiet operation.

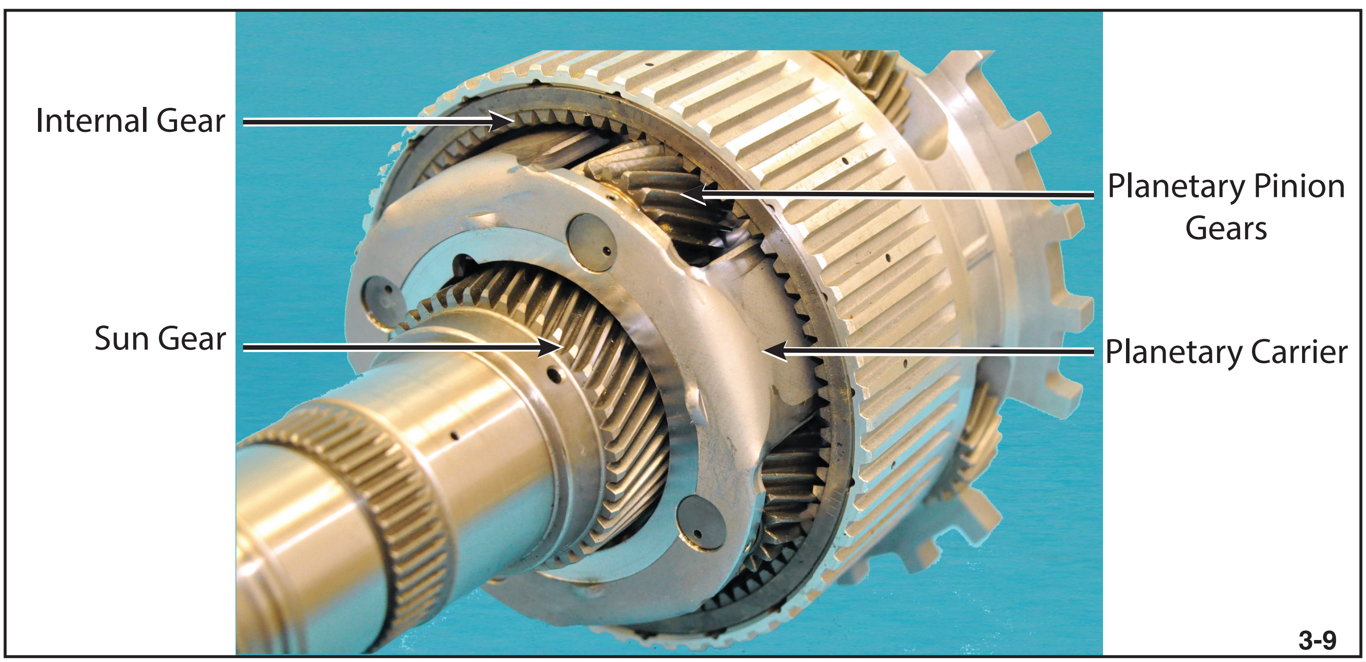
Planetary Gear Sets



Typical Planetary Gear Set Components

A planetary gear set is made up of several components: the sun gear, the planetary pinion gears and carrier, and the internal gear.

The sun gear is at the center of the gear set; it has external teeth. The internal gear is at the outer part of the gear set; it has internal teeth. The planetary pinion gears are in between the sun and internal gear; these gears have external teeth.



Planetary Gear Set

The planetary pinion gears are mounted to a carrier. The carrier acts as an assembly containing multiple idler gears to transmit torque between the sun and internal gear. The carrier keeps the planetary gears equally spaced within the gearset and also provides an input or output of the gearset. There may be three, four, or five planet pinions attached to the carrier; the more pinion gears in the gear set, the stronger the gear set becomes because more gear teeth are making contact within the gearset.

Typically, three pinion gears are used for small and midsize cars, and four or five pinion gear sets are used in trucks and heavy-duty applications.

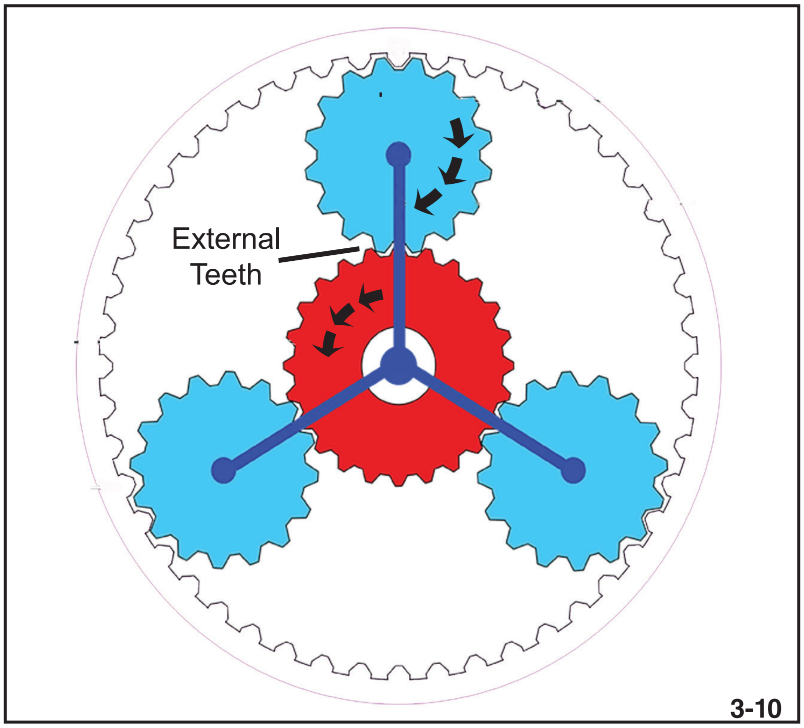
Planetary gear sets are used to produce various gear ratios to reduce or multiply torque and change speed or direction between the input (drive component) and output sides (driven component) of the gear set. Two or three gear sets can be combined to create multiple output speeds. Typically, four forward speeds are common, but for better fuel economy five-, six-, seven-, eight-, and nine-speed transmissions are becoming more common.

When the internal gear (internal teeth) is meshed with a planet pinion gear (external teeth), they rotate in the same direction.

Basic gear theory applies to the planetary gear set, the same as in a manual transmission:

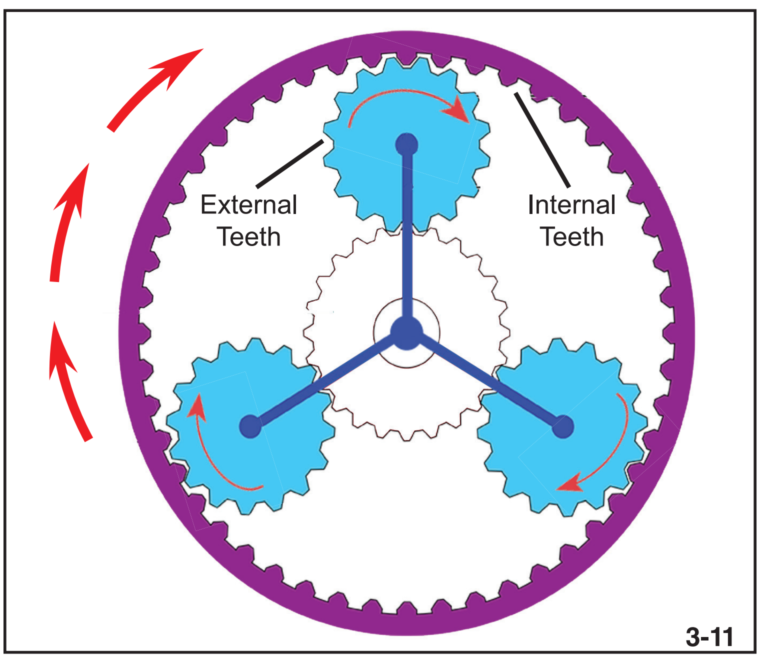
- A small gear driving a larger gear produces higher torque, but at reduced output speed.
- A large gear driving a small gear will produce less torque, but at increased output speed.

Gear Meshing Properties



External Teeth Meshing (Opposite Direction of Rotation)

When the sun gear (external teeth) is meshed with a planet pinion gear (external teeth) the rotation is in opposite directions.

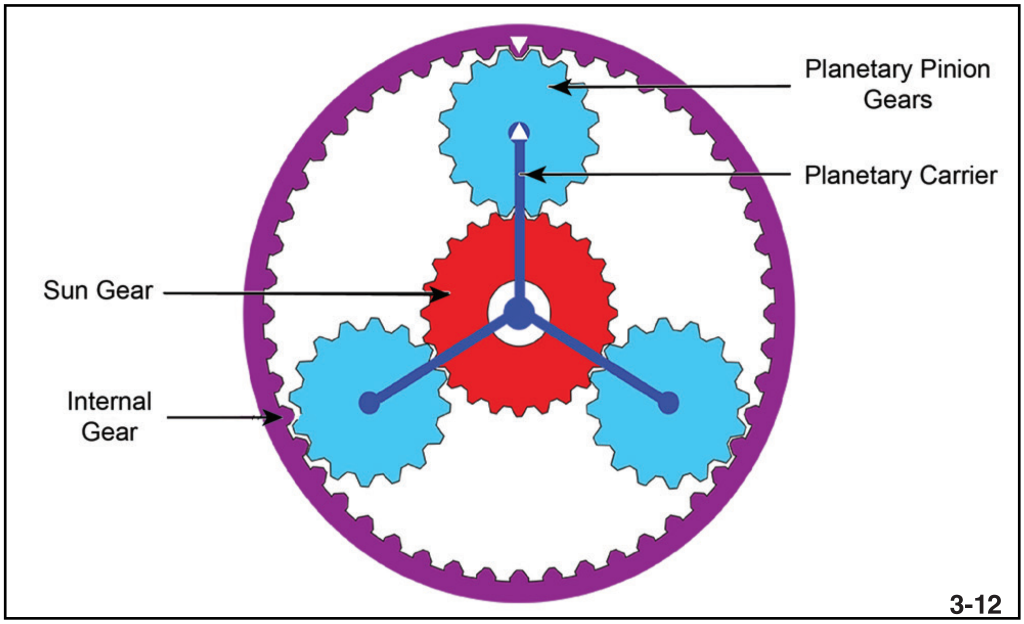


Internal and External Teeth Meshing (Same Direction of Rotation)

When the internal gear (internal teeth) is meshed with a planet pinion gear (external teeth), the rotation is in the same direction.

Planetary Gear Set Rules

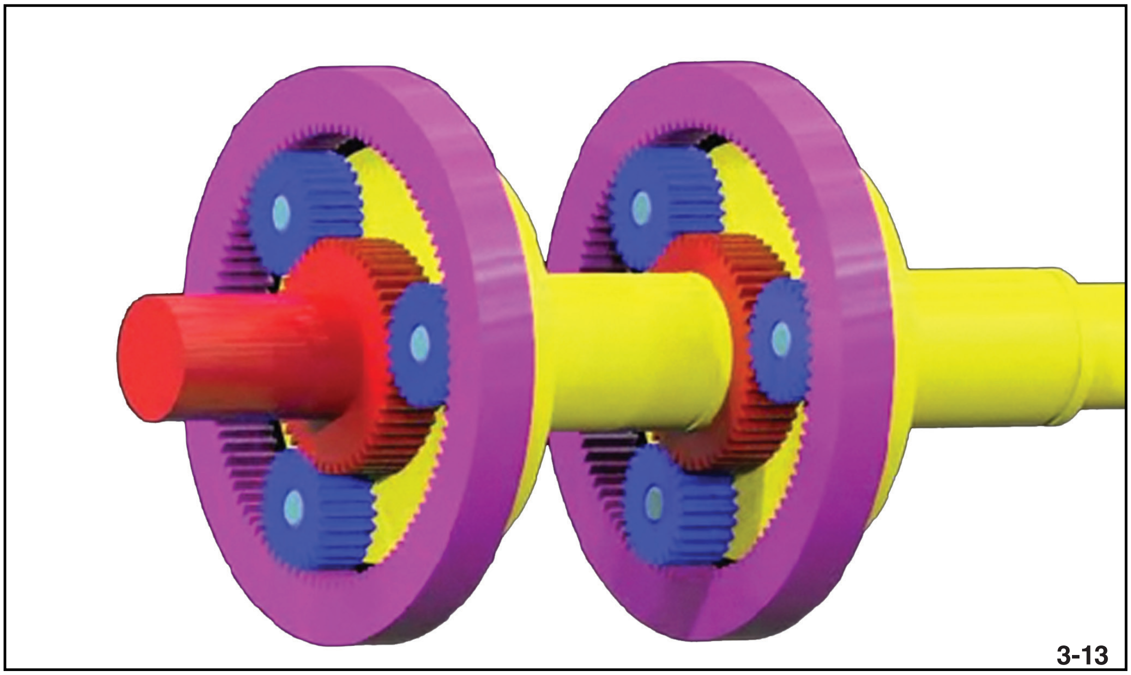
Sun	Carrier	Internal	Speed	Torque	Direction
Input	Output	Fixed	Maximum Reduction	Maximum Increase	Same as Input
Fixed	Output	Input	Maximum Reduction	Maximum Increase	Same as Input
Output	Input	Fixed	Maximum Increase	Maximum Reduction	Same as Input
Fixed	Input	Output	Maximum Increase	Maximum Reduction	Same as Input
Input	Fixed	Output	Reduction	Increase	Opposite of Input
Output	Fixed	Input	Increase	Reduction	Opposite of Input
When any two members are held together, speed and direction are the same as the input Direct drive 1:1					
When no member is held or locked together, output cannot occur. The result is a neutral condition.					



Simple Planetary Gear Set

- When the sun gear is the driven member, the internal gear is the fixed member, and the carrier is the output member, gear reduction or under drive occurs.
- When the internal gear is the driven member, the sun gear is the fixed member, and the carrier is the output member, gear reduction or under drive occurs.
- When the carrier is the driven member, the sun gear is the fixed member, and the internal gear is the output member, multiplication or overdrive occurs.
- When the carrier is the driven member, the internal gear is the fixed member, and the sun gear is the output member, multiplication or overdrive occurs.
- When the sun gear is the driven member, the carrier is the fixed member, and the internal gear is the output member, reduction or under drive reverse occurs.
- When the internal gear is the driven member, the carrier is the fixed member, and the sun gear is the output member, multiplication or over driven reverse occurs.

Compound Planetary Gear Sets

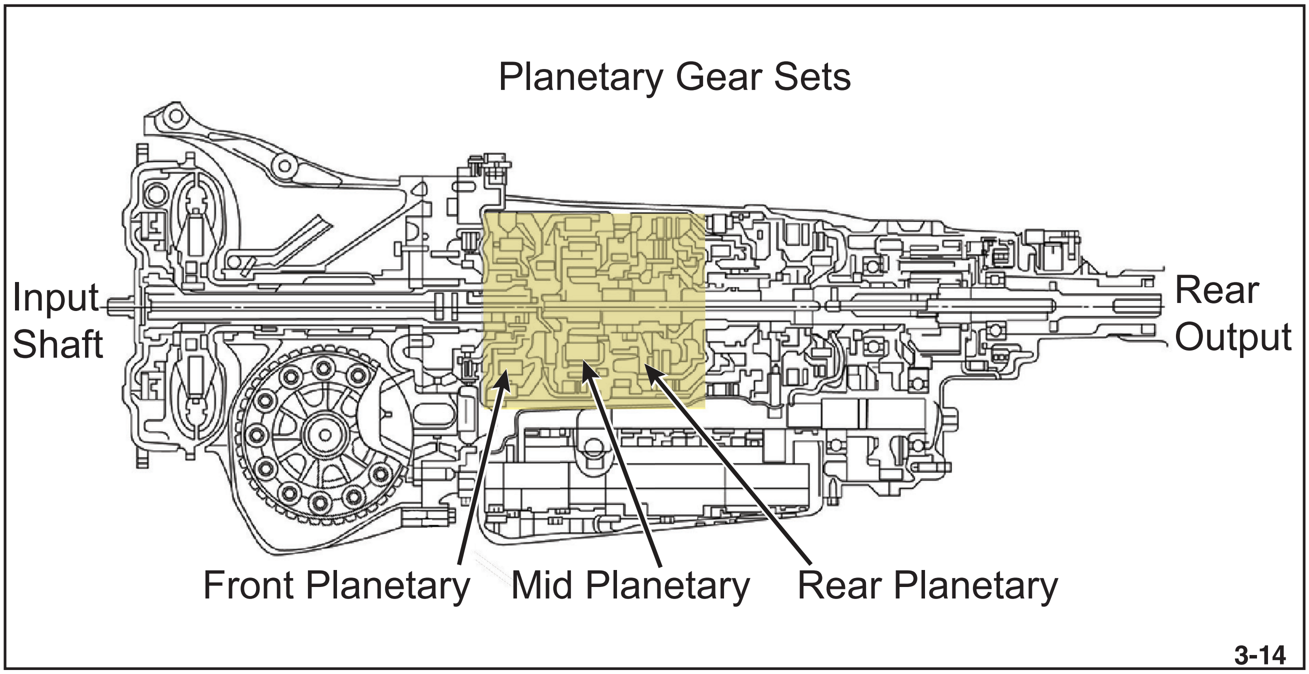


Compound Planetary Gear Set

A limited number of gear ratios is available from a single planetary gear set. Gear sets can be combined, or different types of planetary gear sets are used to increase the number of available gear ratios.

Most automatic transmissions use compound gear sets, two gearsets that share a common member. This allows the connected members to be controlled by one reaction element, either a brake or a clutch.

Automatic Transmissions

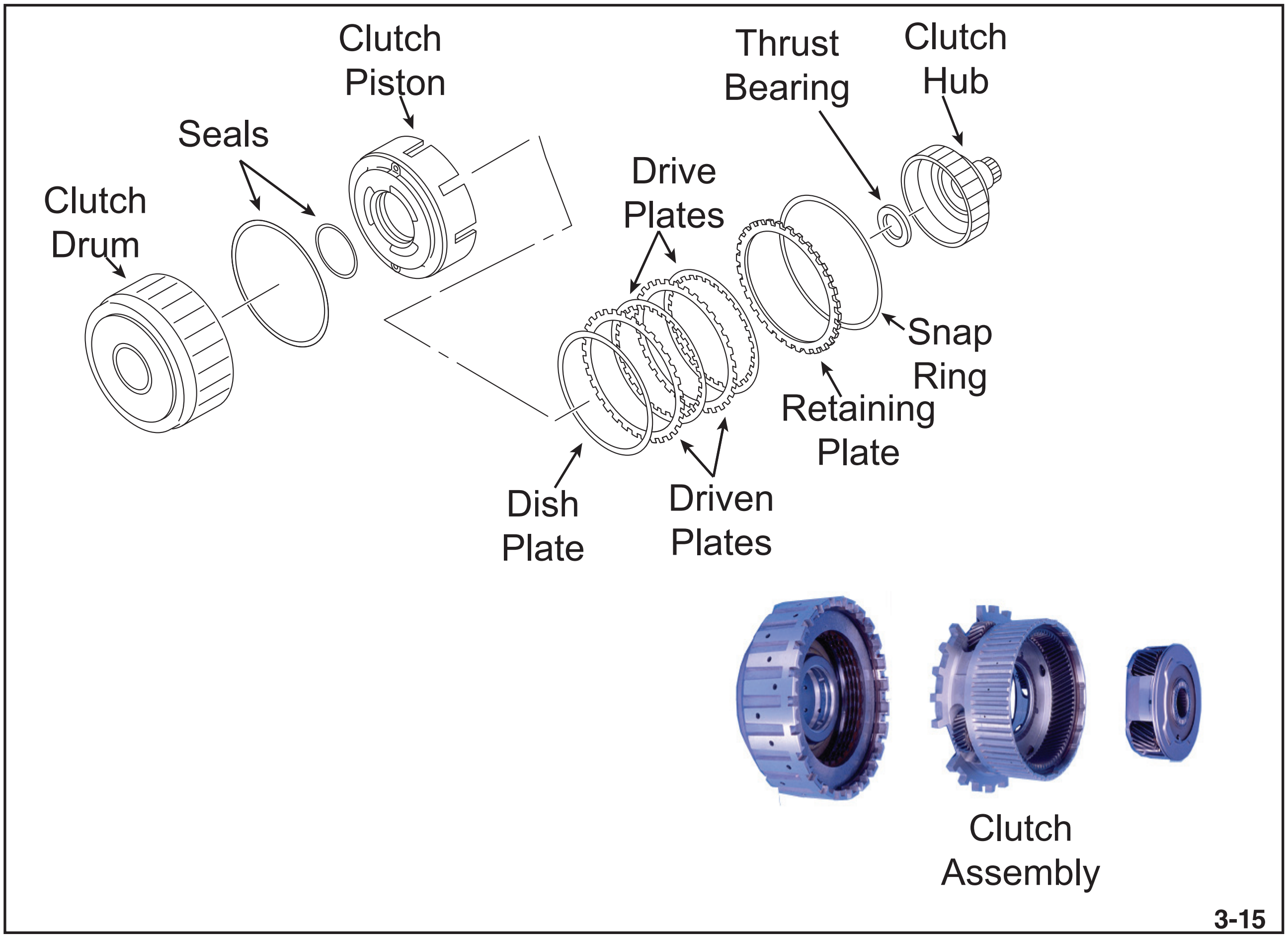


Automatic Transmission Gears

Changing gears (ratios) in an automatic transmission is accomplished by combining the output of a driven planetary gear set with the input of another planetary gear set. The input shaft transmits power from the engine to the front planetary set and drives internal shafts.

The gear sets are arranged in line with each other and driven by the gear set hydraulic brake assemblies. Hydraulic pressure is routed though the transmission electronically operated valve body to activate the high, low, or reverse brakes. The brake assemblies operate to hold the sun gears, planetary carriers, or the hub gears of the gear sets, producing a specific gear ratio. The output of the combined gear sets produce the torque applied to the drive train.

Clutch Packs



Clutch Pack Components

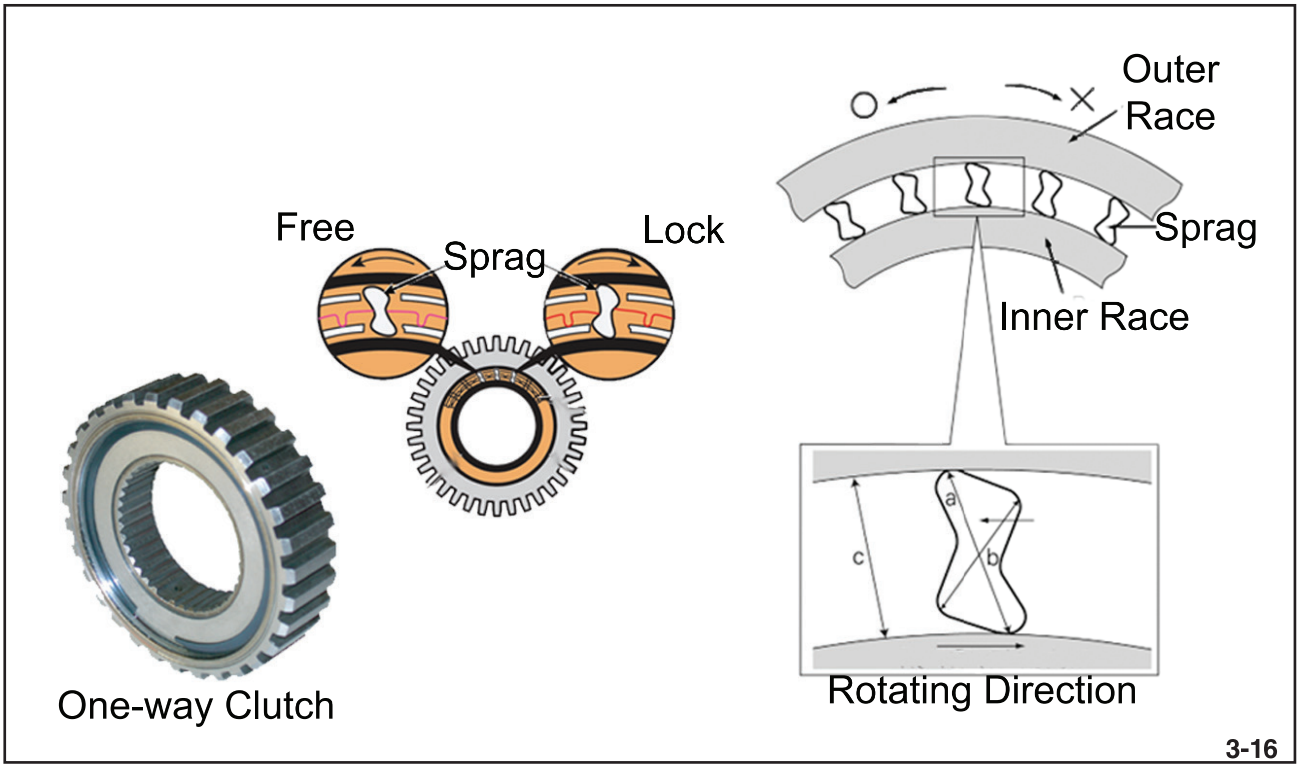
Clutches and brakes hold parts of the planetary gear sets, causing them to spin together or be held in place. A clutch locks two rotating components together; a brake locks a rotating component to a fixed component, normally the transmission case.

Clutches and brakes are a series of friction plates and steel plates alternately splined between two components. When the clutch piston squeezes these plates together, the two components lock together, either turning or holding a gear train component.

The clutch packs are hydraulically activated by the valve body solenoids. Pressurized transmission fluid acts on the back of the piston to compress the plates. Under pressure, the plates are locked together and hold a component of the planetary gear set.

One-way Clutch

Sometimes rotating components need to be used as reactionary members (like clutches), but also need to be able to rotate in a certain direction during some operating conditions. One-way clutches are holding devices that allow rotation in one direction and hold or lock when force is applied in the opposite direction. One-way clutches prevent a member of the gear set from rotating in the direction it would otherwise tend to rotate. One-way clutches transmit torque from one member to another.



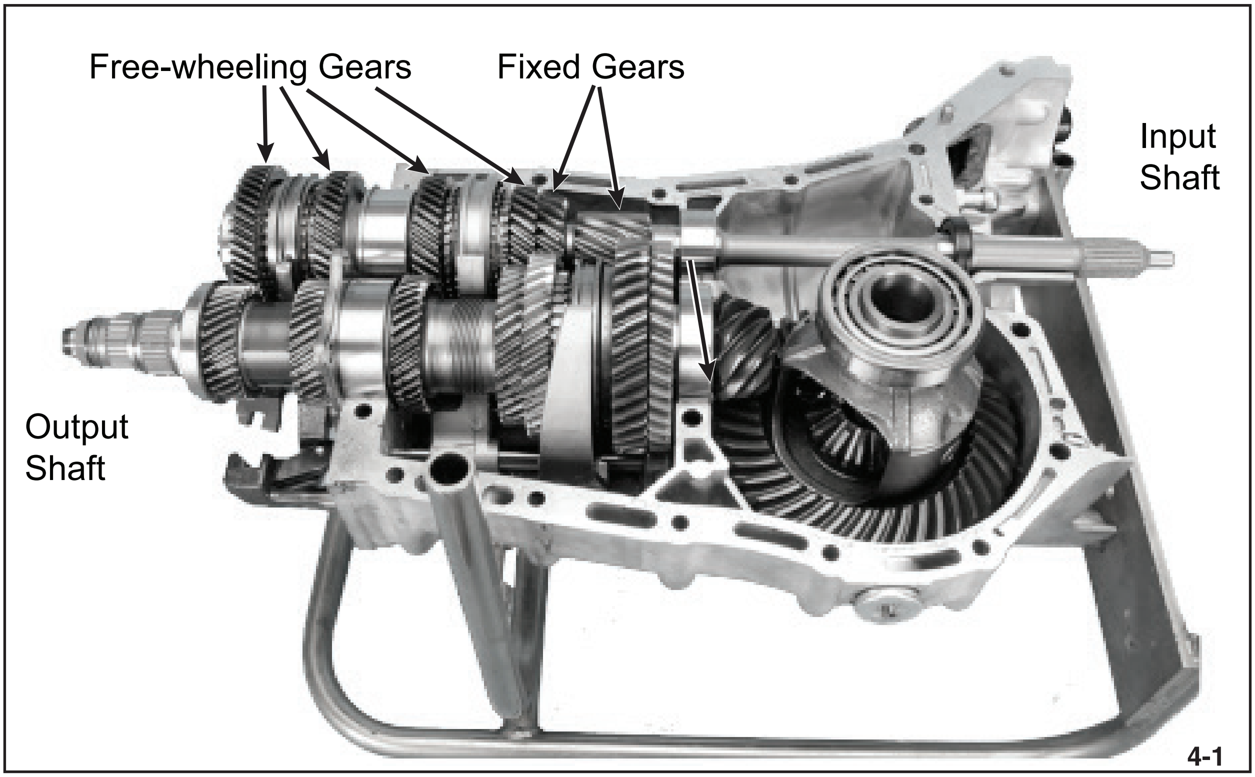
Sprag-type One-way Clutch

On the right side of the above illustration, the Sprag diameters (a) and (b) are different. When the inner race tries to turn toward the left, it is locked. The Sprag radius (a) is larger than the gap between the races (c). This firmly locks the Sprag to prevent the inner race from moving to the left. The one-way clutch inner race is splined to one member of the gear set, and the outer race is splined to another member.

Notes

Changing Gear Ratios

Manual Transmissions



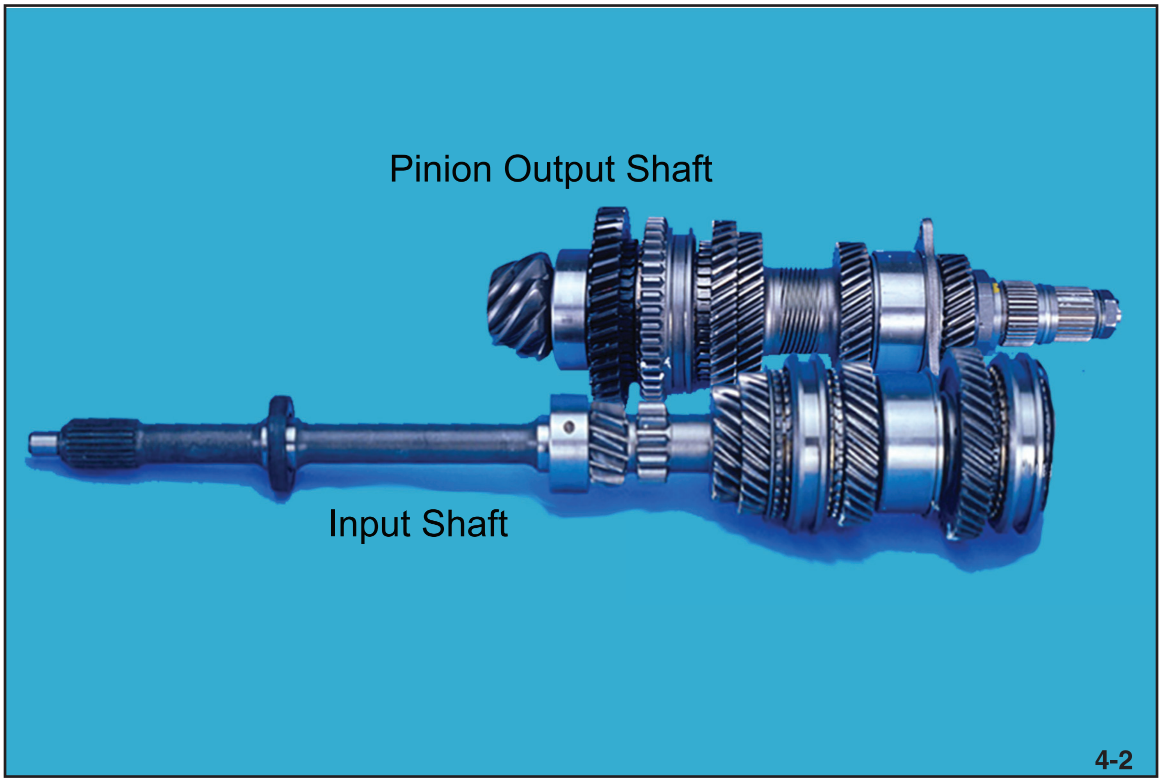
Manual Transmission Gears

In a manual transmission, changing gears (ratios) is accomplished by locking two meshed gears together: one gear on the input shaft, and the other on the output shaft.

There are two ways gears are connected to the shafts inside the transmission: fixed gears and free-wheeling gears.

- Fixed gears are splined to or are part of the shaft they ride on.
- Free-wheeling gears are supported by bearings and transmit torque through synchronizers to the shaft. Both types of gears can be used in a transmission and can be located on the input and output shafts.

Manual Transmission Shafts

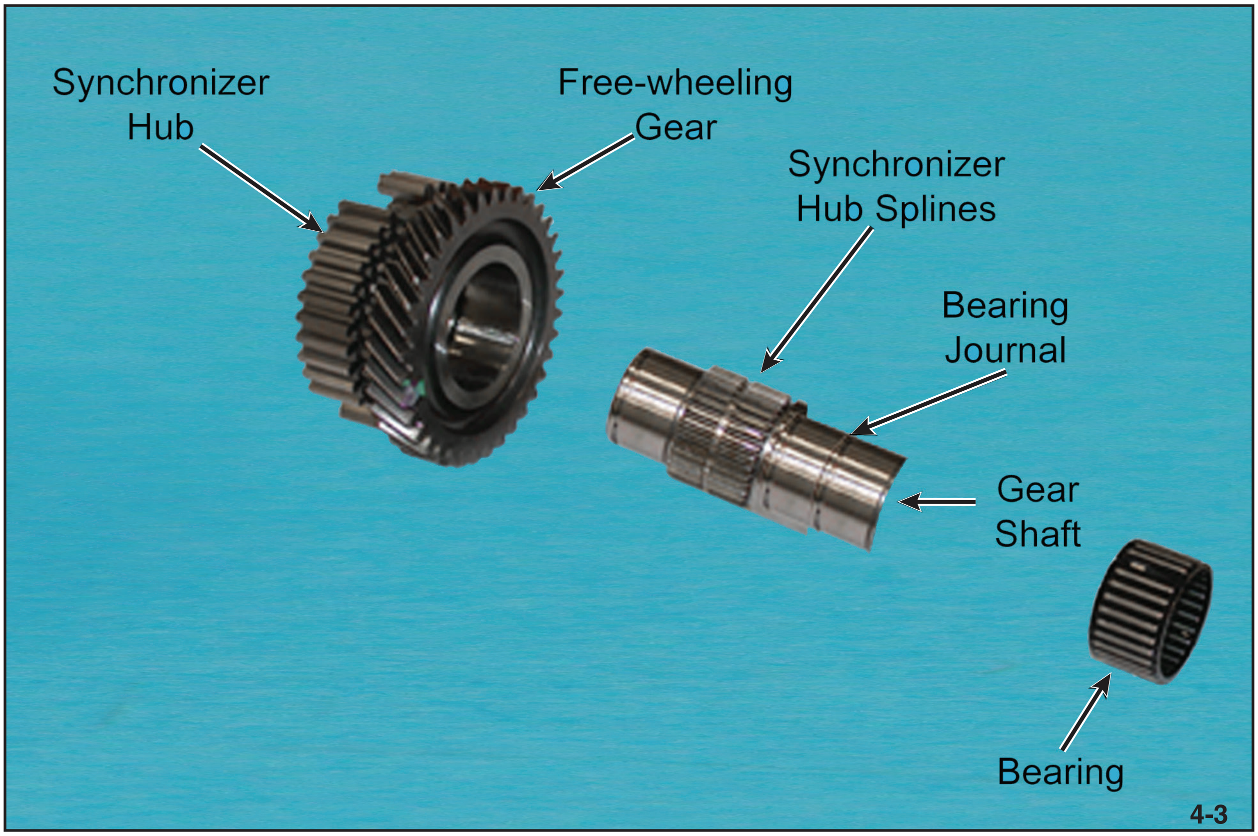


Manual Shafts

The input shaft is always rotating when the clutch is engaged, even when no gears are selected (neutral). Power entering the transmission on the input shaft is transferred to the output shaft through constantly meshed gears.

The output shaft transmits power from the transmission input (main shaft) to the remainder of the vehicle drive train. Surfaces and splines on both shafts are precisely machined to accept the various gear types and sizes. Bearing surfaces are used to support free-wheeling gears that are free to rotate on the shafts without transferring torque. Because the fixed gears are part of the shaft, they cannot be serviced separately.

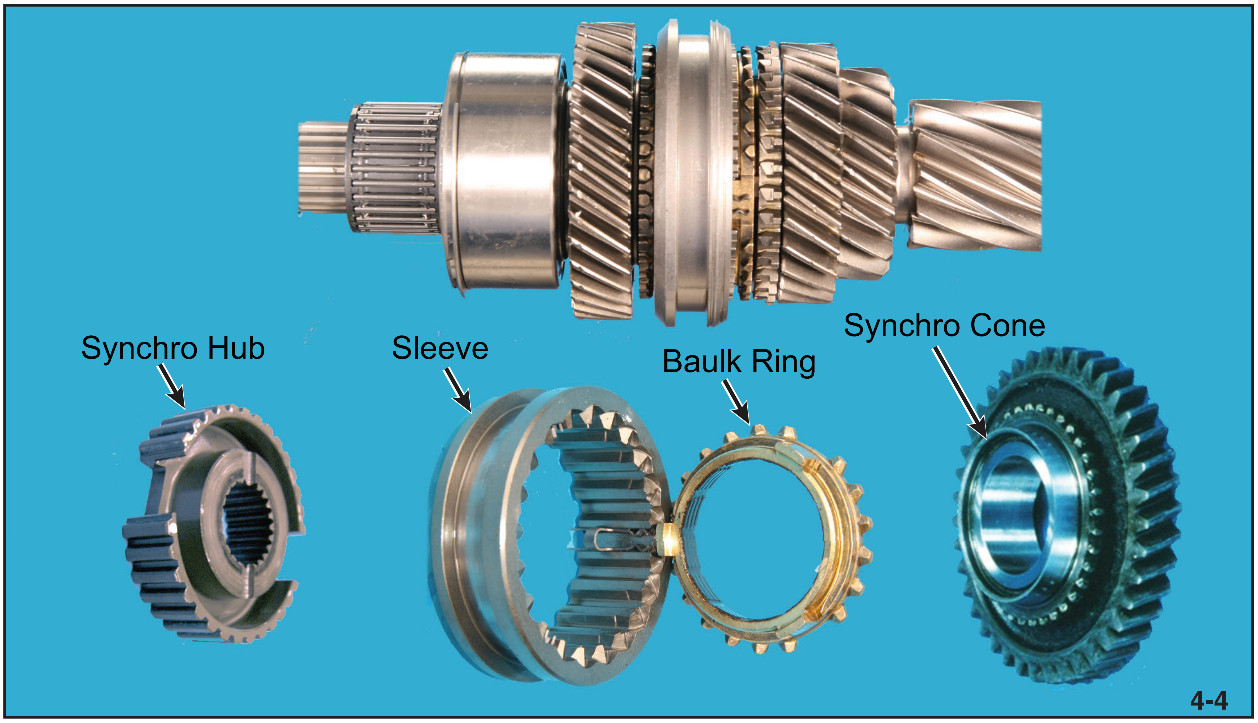
Free-wheeling Gears



Free-wheeling Gear Components

Free-wheeling gears on the input and output shaft ride on bearings and journals and turn independently of the shaft. Synchronizer hub splines that mechanically connect the synchronizer hubs to the output shaft are machined into the shaft.

Synchronizer Assemblies



Synchronizer Components

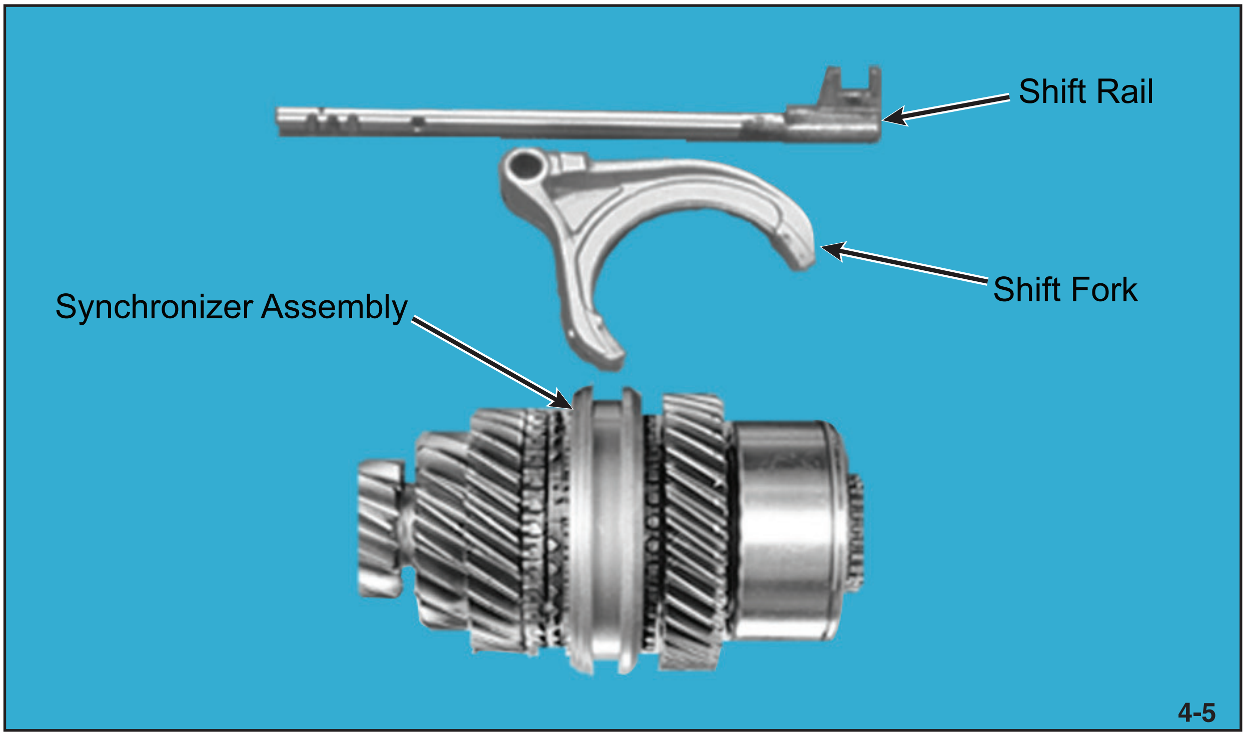
A synchronizer brings two rotating components to the same speed. They are used in transmissions to allow smooth engagement of an input and an output gear.

The synchronizer assemblies, which are splined to the shaft they ride on, speed up or slow down the selected gear to match its speed to the speed of the shaft.

There are many different designs of synchronizers used in vehicles today. Typically, they all work the same way.

Most synchronizers consist of an inner splined hub, spring-loaded detents, a synchronizer sleeve, and baulk rings used to match gear and shaft speeds for smooth gear cone engagement.

Shifting Mechanism

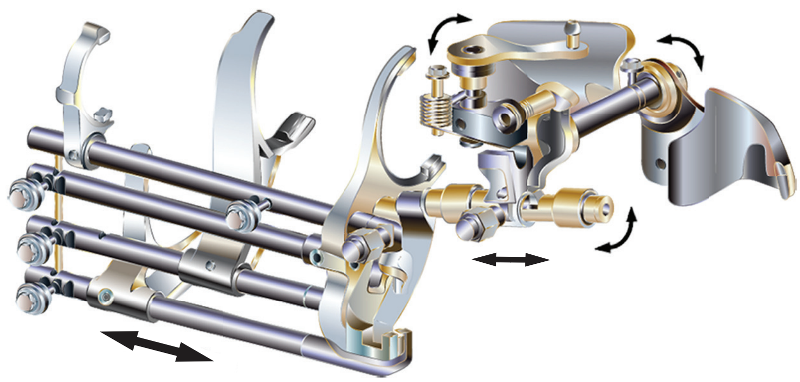


Internal Shifting Components

The shift mechanism is the link between the driver and the transmission. The shift linkage, connected to the shift rail, moves the shift fork assemblies fore and aft to engage synchronizers for gear selection.

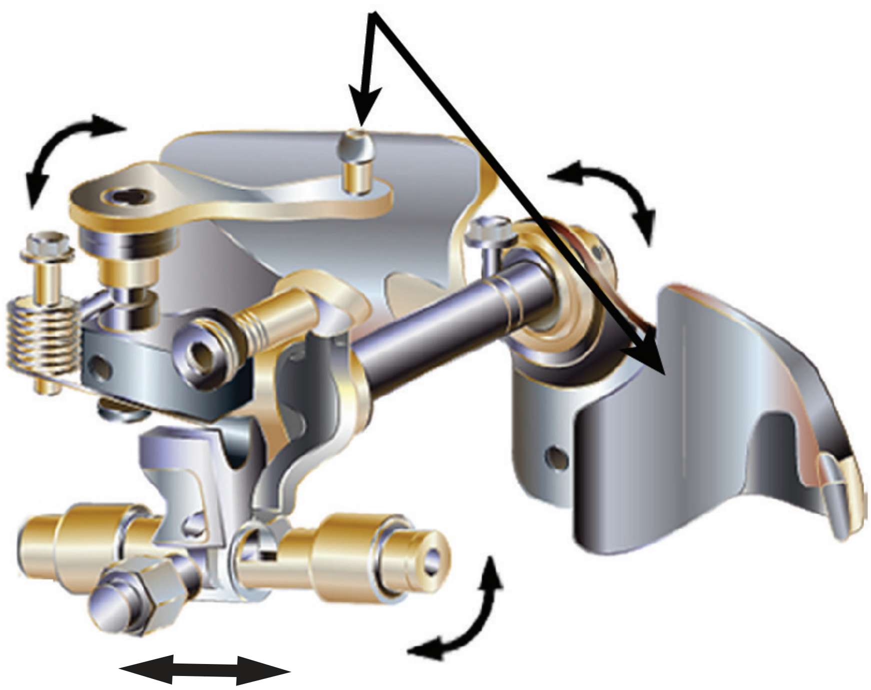
Most shift forks have two fingers that ride on the groove around the synchronizer sleeves. The shift fork has inserts installed on the tips of the fork to reduce noise during gear changes.

Shift Mechanism



4-6

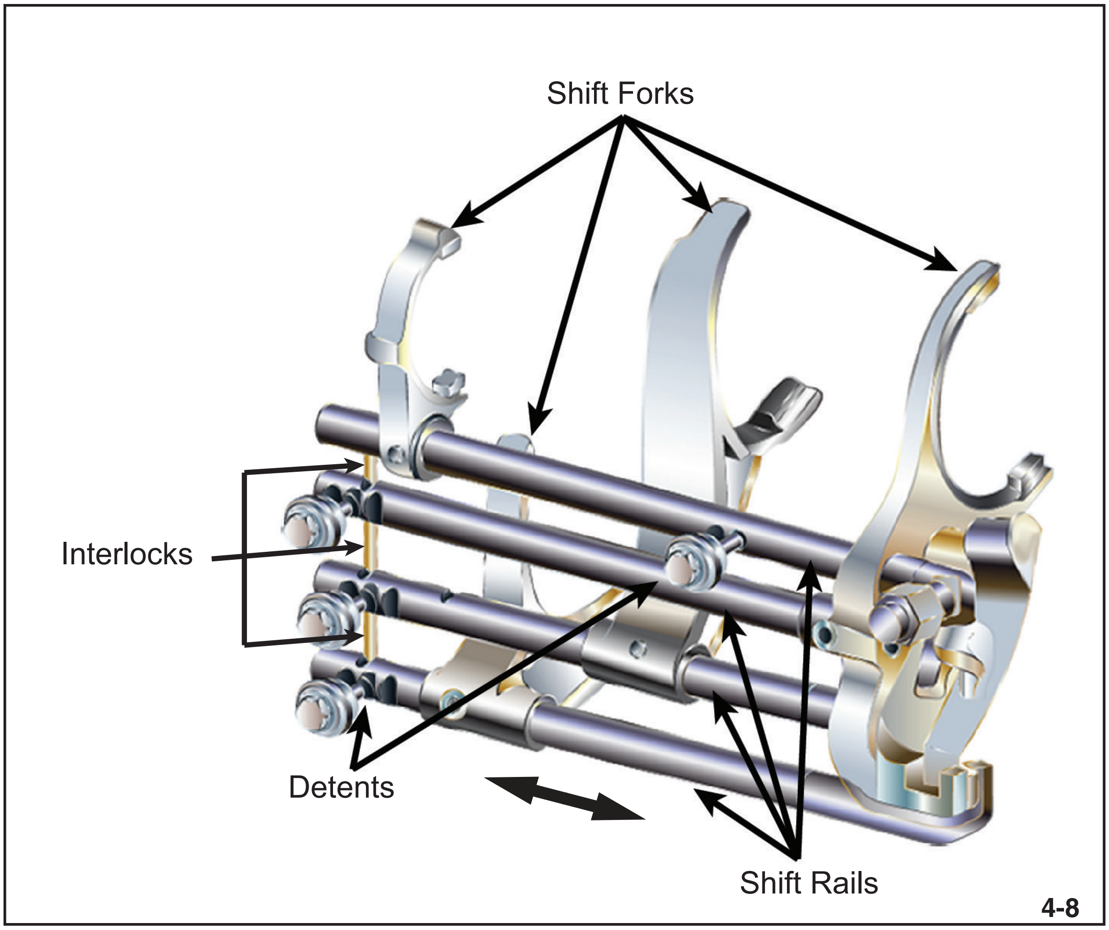
Shift Mechanism



4-7

Shift Levers

The shifter mechanism is cable operated. The cables are routed from the shift lever assembly to the shift levers located on the transmission case. The cables control the selection of the shift rails, making pairs of gears selectable. The cables push or pull to move the shift rails and forks to engage a single gear after the correct shift rail has been selected.



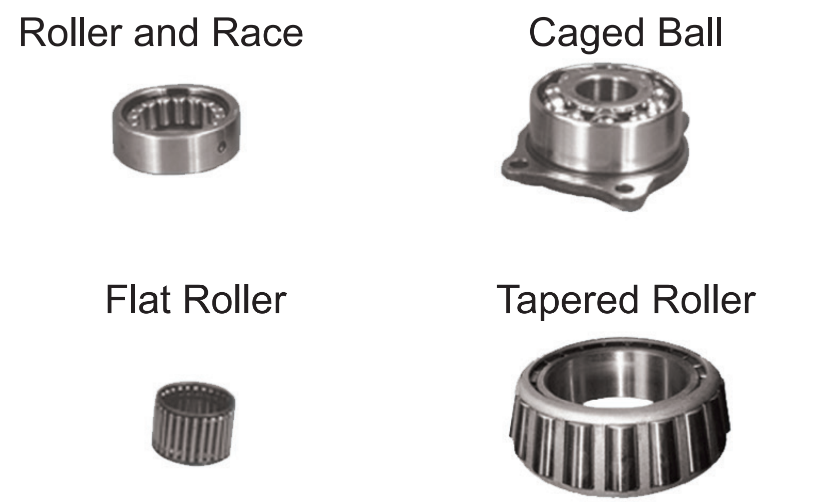
Shift Rails and Forks

The shift interlock mechanism prevents more than one rail from being out of the neutral position at the same time. This prevents engagement of two gears at the same time.

Shift rails are steel rods that are mounted on the same axis as the main and counter shafts within the transmission. The shift rails transmit shifter movement to the shift forks, engaging and disengaging individual synchronizers to allow gear changes.

The shift rails are equipped with detents (or notches), and spring-loaded ball bearings hold them in their positions. Whenever one shift shaft is moved, the detent pins slide into the slots of two of the shift shafts and hold them in the neutral position.

Bearings and Bushings



4-9

Bearings

Bearings and bushings are used throughout the drive line to reduce friction and allow components to turn freely. Bearings are used with rotating components that require support when rotating at high-speed under the greatest loads.

- Bearings typically incorporate a rolling component held in alignment within a cage. Roller and race and caged ball bearings are used to support rotating shafts in the transmission.
- Flat roller bearings (sometimes called needle bearings) are commonly used to support free-wheeling gears and synchronizer hubs.
- Tapered roller bearings support the ends of shafts and incorporate shims for setting preloads on the shaft or component they support.

4-10

Bushing

- Bushings provide a way to support components that rotate at slower speeds, but still require low friction.
- Some bushings have precision holes in them to provide lubrication for the component they support. Refer to service information for the proper removal and installation procedures.

Transmission Sealing

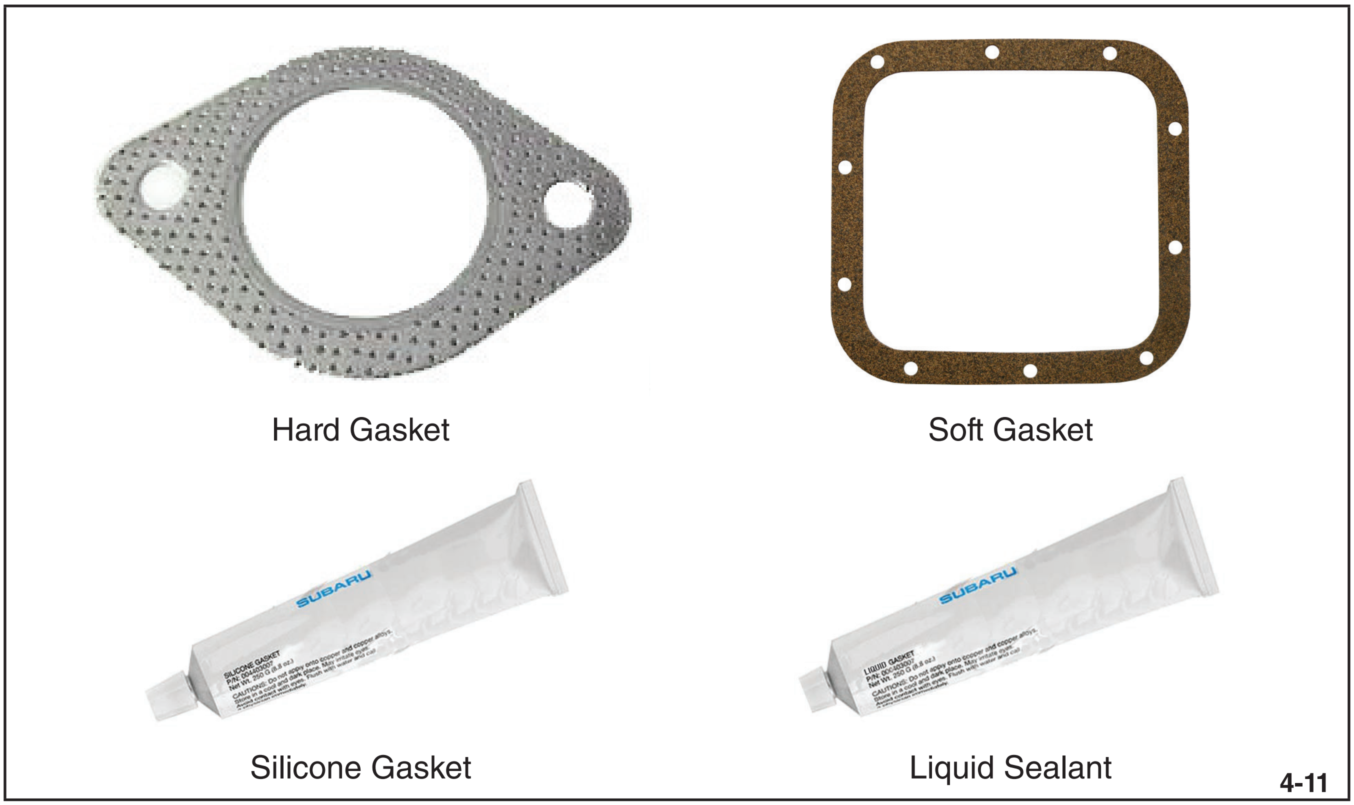
Manual and automatic transmissions are filled with multiple types of fluids for lubrication or power transfer. Retention and protection from contamination of these fluids within the various areas of a transmission is accomplished with seals and gaskets. The seals and gaskets are designed for the type of sealing action required.

Generally, a sealing device is designed to form a seal between surfaces that are exposed to radial or axial movement and stationary non-moving surfaces.

- Radial movement is the rotational motion of a shaft around its circumference.
- Axial movement is a linear motion of a shaft along its axis.
- Stationary components are any two or more surfaces fastened to each other.

Gaskets

Gaskets are used to keep liquids or gases from escaping between two parts that are fastened together or serve as spacers or vibration dampeners.



Gasket Types

Four different types of gaskets are used in transmission assemblies:

- Hard gaskets
  - Used in automatic transmissions
  - Made of steel
- Soft gaskets
  - Typically made of cork, rubber, or a combination of both compounds
  - May be reinforced with a metal layer in-between the two soft gasket materials
- Silicone gasket sealant (hardening type)
  - Made of silicone based material used in conjunction with a soft or hard gasket
  - Used to seal intersecting corners or uneven surface areas
- Liquid sealants and adhesive gaskets (non-hardening type)
  - Made of a polymer whose major component is special synthetic rubber used with all metal gaskets
  - Creates a flexible non-hardening seal that prevents water, oil, gasoline, air pressure, or vacuum from leaking

Transmission Theory and Diagnosis Part 2

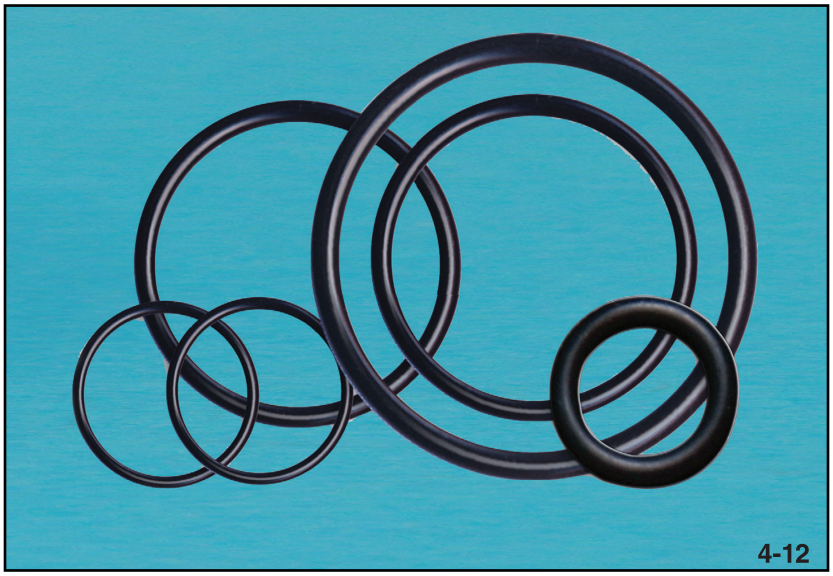
Always follow the Subaru Technical Information System (STIS) for guidance when determining the type of silicone or liquid sealant to be used. The recommended sealant is located in the GENERAL INFORMATION section for the vehicle being serviced. Selecting the Recommended Materials link displays information covering fuel, lubricants, fluids, coolant, refrigerant, grease, adhesive, and seal material.

Use the seal material shown in the table below or an equivalent.

Seal Material	Application Point	Recommended Materials	Item number	Alternative
Seal Material	• CVT extension case • CVT transmission case • CVT drive pinion retainer • CVT oil pump chain cover • MT transmission case • MT transfer case	THREE BOND 1215	004403007	DOW CORNING No. 7038
	• Transmission oil pan (CVT model)	THREE BOND 1217B	K0877YA020	—
	• Rear differential • Oil pressure switch • PCV valve	THREE BOND 1324	004403042	—
	• Rear differential • Service hole plug	THREE BOND 1105	004403010	DOW CORNING No. 7038
	• Steering adjusting screw (electric power steering)	THREE BOND 1111B	—	—
	• Front sealing cover • Rear sealing cover	3M butyl Rubber 8626	—	—
	• Engine oil pan • Separator cover • Camshaft cap • Cylinder block • Rocker cover • Chain cover • Oil pan upper • Cylinder head • Camshaft carrier • Camshaft bearing cap	THREE BOND 1217G	K0877Y0100	
	• Rear differential	THREE BOND 1110F	—	THREE BOND 1110B

Recommended Materials

O-rings



O-ring Seal

O-rings have a circular cross section, allowing them to be placed between two components. The O-ring creates a sealing surface when compressed between the two components.

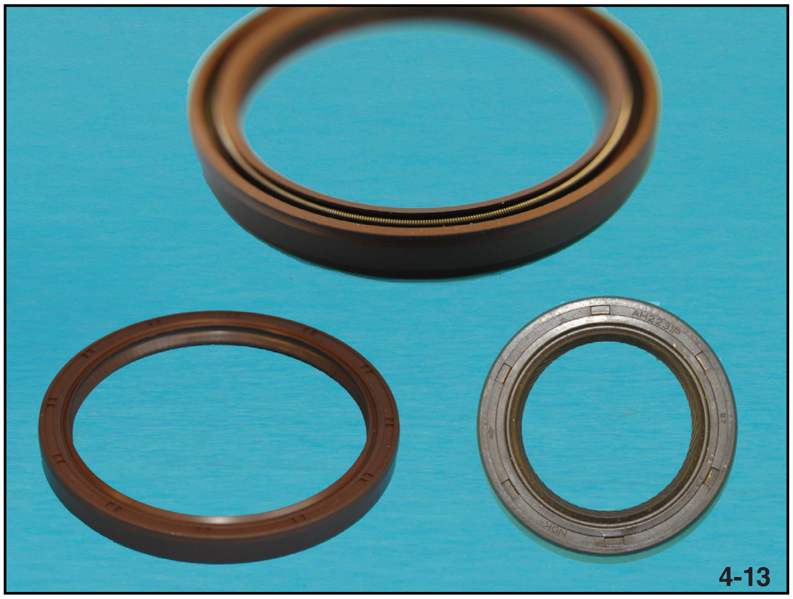
O-rings function best as static seals; they can be used as dynamic seals in applications where low axial movement occurs. O-rings must never be used to seal a shaft that has radial movement.

Seals

Seals are used to keep fluids within the transmission and in their respective areas. There are different types of rubber seals: lip, square-cut, and O-rings. Seals are categorized as static, dynamic, positive, and non-positive.

- Static seals are used between components that do not move, such as case-to-case or case to non-moving components.
- Dynamic seals are used between components that do move, either radial or axially, such as rotating shaft or sliding shafts.
- Positive seals are used to prevent fluid leakage between two components.
- Non-positive seals are used to allow a controlled amount of leakage between two parts or provide controlled lubrication of a moving part.

Garter Seals



Garter Seal

Garter-type seals are used on component cases where a rotating (radial) or reciprocating (axial) component passes through the case and must retain the fluids that the case holds. The garter seal is made of rubber coated steel that is pressed into place using a seal driving tool. Pressing the solid part of the seal in the case seals the case.

The inner part of the seal is made of rubber and is formed to produce a small lip; this lip makes contact with the component and provides sealing between the seal and the rotating shaft.

To increase the sealing effect, a small spring (called a garter spring) is wrapped around the inner part of the seal to provide equal pressure around the seal's lip. The additional equal pressure keeps the proper tension around the shaft as the case's internal pressure fluctuates.

In Subaru automatic transmissions, gear lubricant is in the differential case, and transmission fluid is in the transmission case. Garter seals with double lips are used to keep the two fluid types from cross-contamination.

Many garter seals are directional and must be installed so the open edge of the seal faces the fluid it is designed to contain. For example: axle seals and propeller shaft yoke seals are used in drivelines.

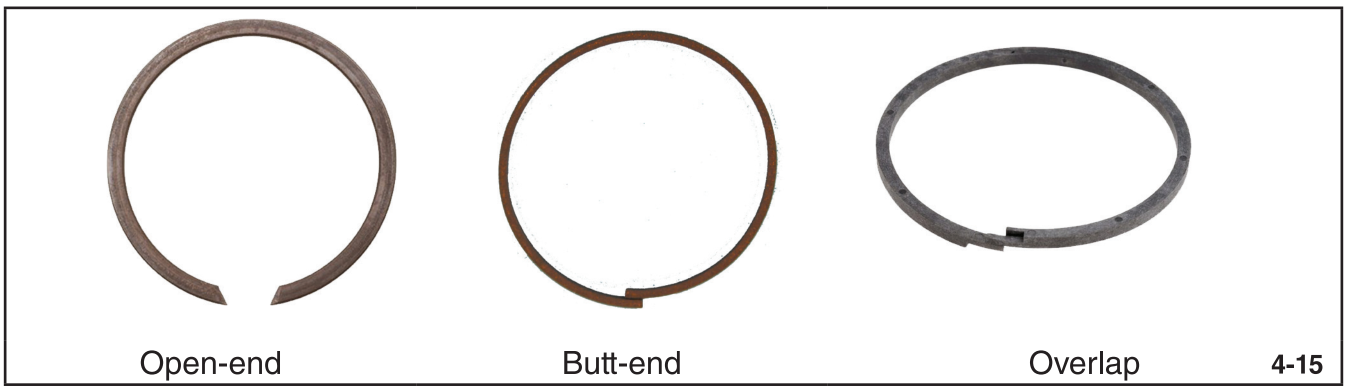
Garter seals used in reciprocating (axial) motion applications are called wiper seals. These seals are used to retain fluid and prevent dirt from entering the device.

Square-cut Seals

Square-cut Seal

A square-cut seal is similar to an O-ring. Square-cut seals are less susceptible to rolling during axial movement because of their flat surfaces and square cross section. An installed square-cut seal is slightly compressed, and when the shaft or component it seals moves, the outer sealing edge distorts, causing the sealing surface to increase.

Sealing Rings



Sealing Ring

Sealing rings are used within the transmission where a non-positive seal is acceptable. Sealing rings fit into grooves cut into the shaft. The outside diameter of the sealing ring sits against the bore walls into which the shaft is set. The rings can be made of cast iron, nylon, or Teflon.

Three types of ends are used in a sealing ring: butt-end, open-end, and hook-end.

- On an open-end sealing ring, when the sealing ring is installed, the ends of the ring do not touch each other.
- On a butt-end sealing ring, when the sealing ring is installed, the ends of the ring butt together and create a tight seal.
- On a overlap sealing ring, when the sealing ring is installed, the ends are locked together before installing the shaft. This type provides better sealing than both the open and butt-end sealing rings.

Precision Measuring

Transmission inspection and repair often requires precise measurements. These measurements can help determine if components are worn or if adjustments are necessary.

Many adjustments within a transmission are made by installing specific size shims and thrust washers.

Bearing preload is typically set with shims. Clearances for shaft endplay and gear spacing are typically adjusted by inserting precision thrust washers or combinations of precision shims. The thickness of shims and thrust washers can be verified with dial calipers and micrometers.

Depending on the type of measurement, basic measuring tools like feeler gauges and steel rules may be required. To make more precise measurements, precision tools like micrometers, calipers, and dial indicators are required. This section covers the most common tools that are used to perform precision measurements.

Micrometers and Calipers

Micrometers and dial calipers are delicate measurement tools that must be cared for and maintained to ensure their precision and smooth operation. These precision measuring tools should always be stored in their protective cases. In addition, they should be inspected regularly and calibrated if necessary. Always clean the tool measuring surfaces and make sure the surfaces to be measured are also clean and dry. Any debris left on the surfaces can produce inaccurate measurements.

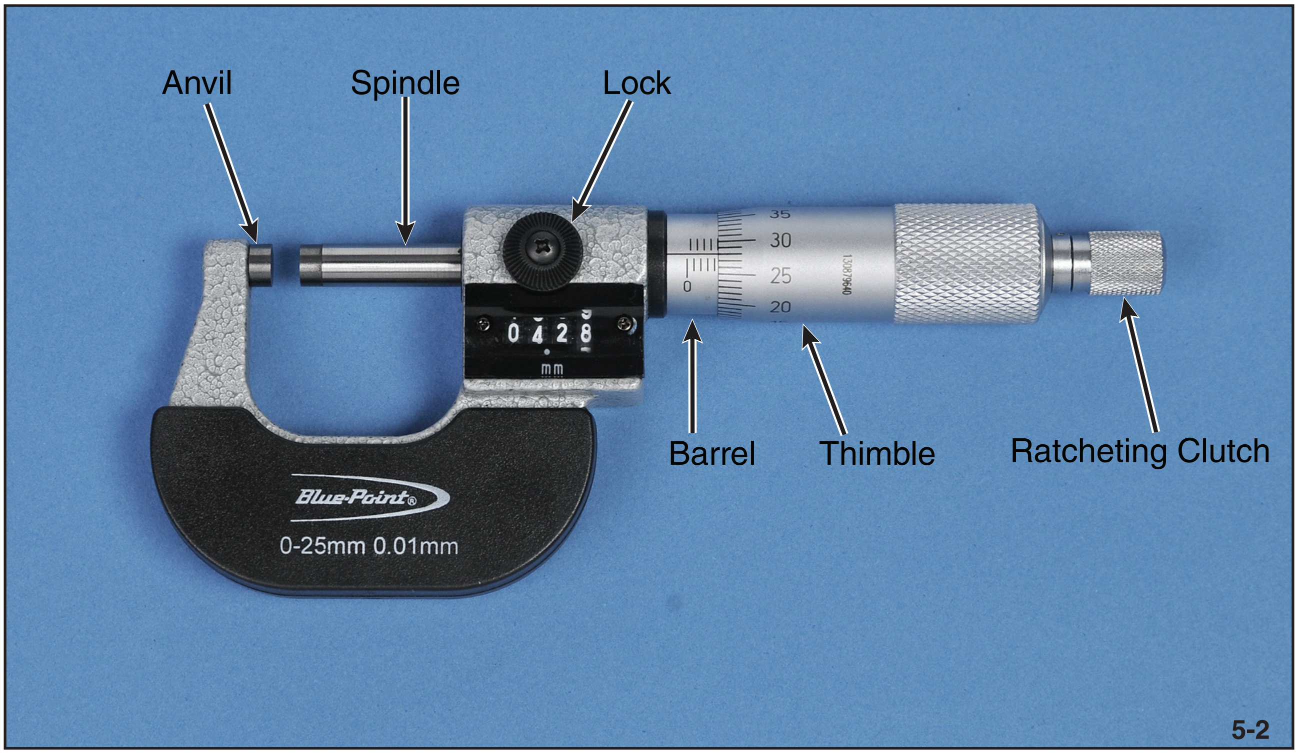
Micrometer

Dial Caliper

5-1

Precision Measuring Tools

Metric Micrometer

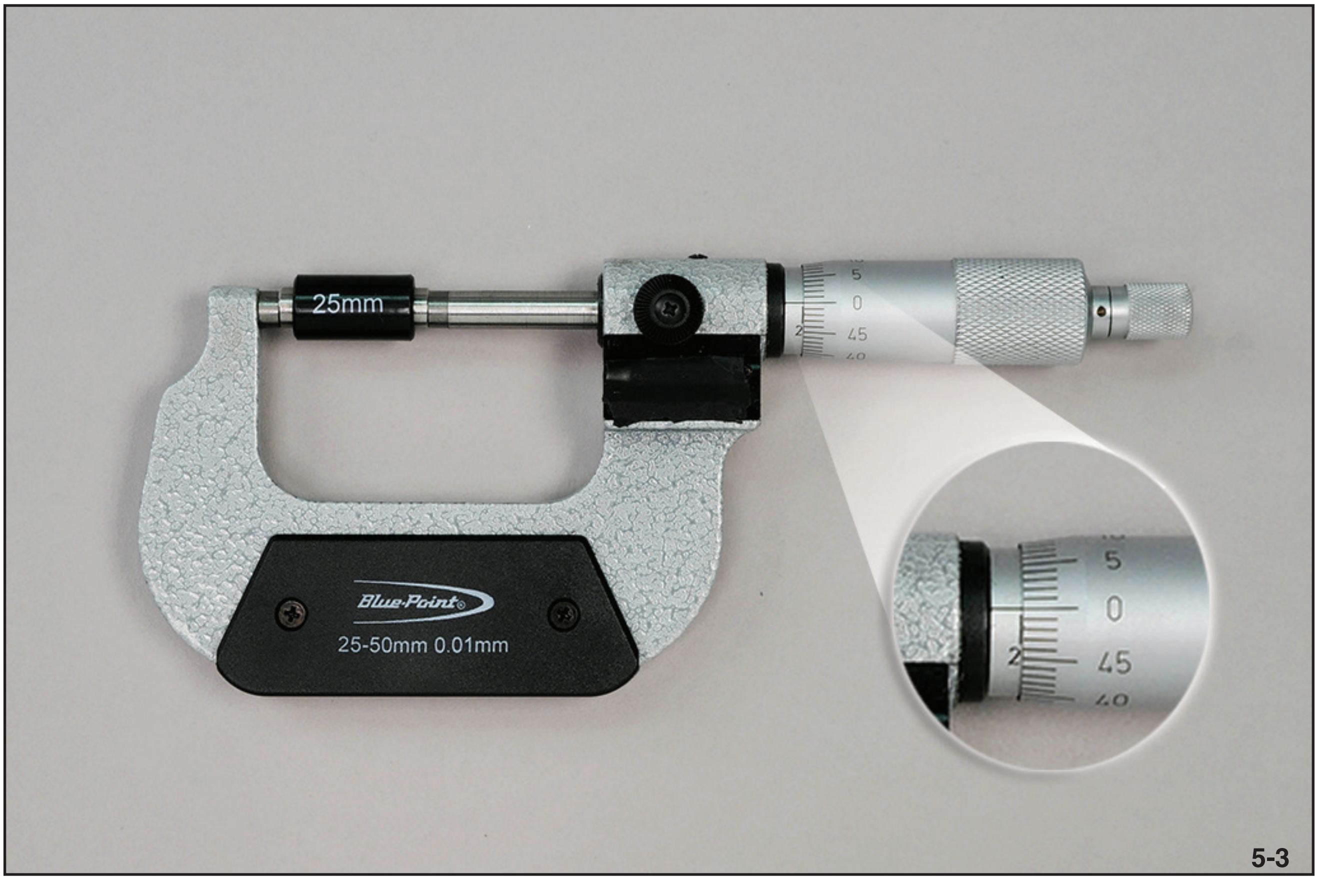


Micrometer Components

The micrometer measures items to the hundredth of a milimeter (.01).

Place the item being measured between the spindle and the anvil. Spin the thimble to extend or retract the spindle. The ratcheting clutch properly tensions the thimble and spindle to attain a consistent reading. The lock holds the spindle and thimble in place so the micrometer can be removed from the item for easier reading of the measurement.

Use a combination of the barrel scale and the thimble scale to calculate the measurement.

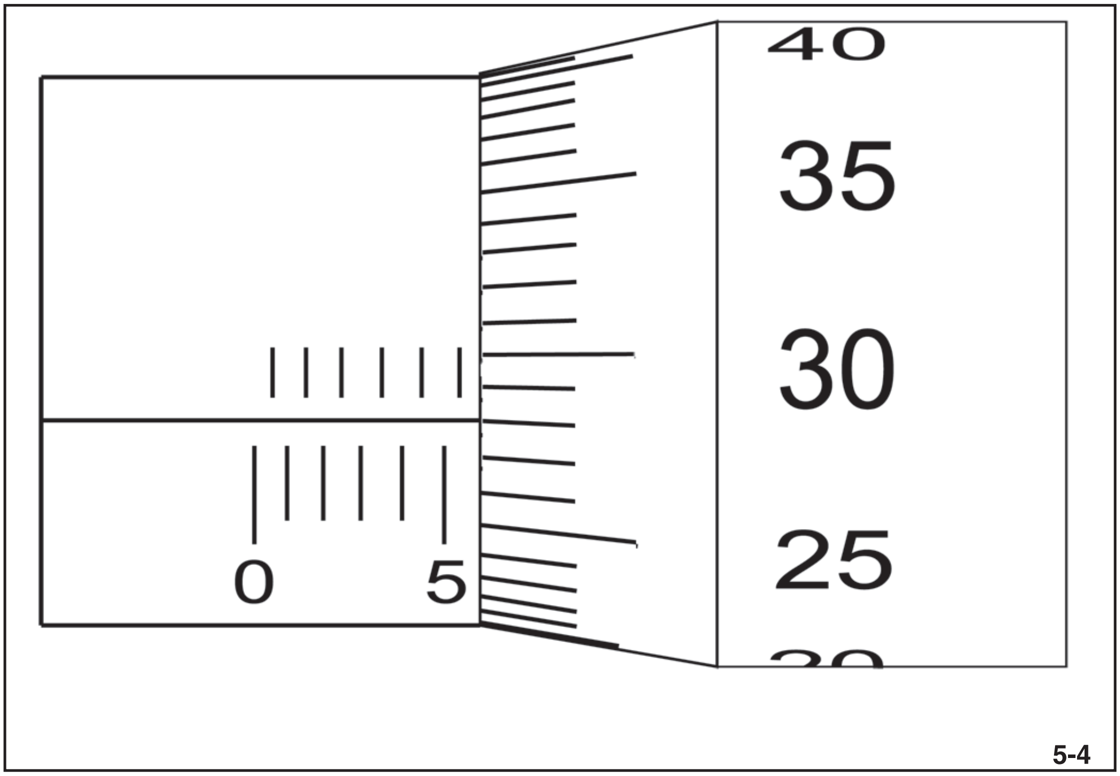


Micrometer Calibration

Before using the micrometer, clean the measuring faces of the anvil and the spindle. Bring the anvils together by turning the ratchet. If the line marked zero on the thimble does not coincide with the reference line on the barrel, follow the manufacturer's instructions on how to adjust it to read zero. Larger diameter micrometers use special calibration rods to calibrate their zero mark because the anvil and spindle cannot physically reach each other.

Reading the Micrometer Scale

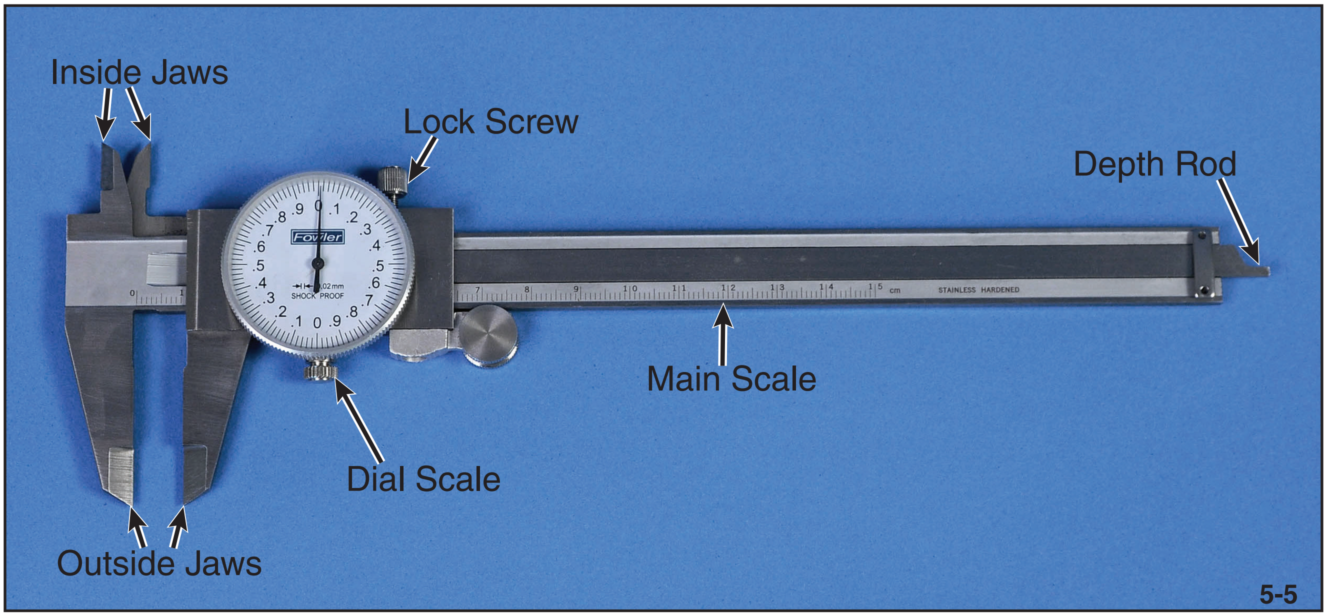
1. Note the largest number visible on the barrel. Each long line equals 1.0 mm.
2. Count the number of graduation lines to the right of the barrel number. Each short line on the barrel equals 0.5 mm.
3. Note the thimble graduation aligned with the horizontal barrel line. Each thimble graduation equals 0.01 mm.
4. Add the decimal values from steps 1, 2, and 3. The sum is the micrometer reading in millimeters. This example shows a reading of 5.78 mm.



Reading a Micrometer

Barrel Number	5	5.0 mm
Barrel Graduation	Half Line	0.5 mm
Thimble Graduation	28	0.28 mm
Total Reading		5.78 mm

Dial Caliper



Dial Caliper Components

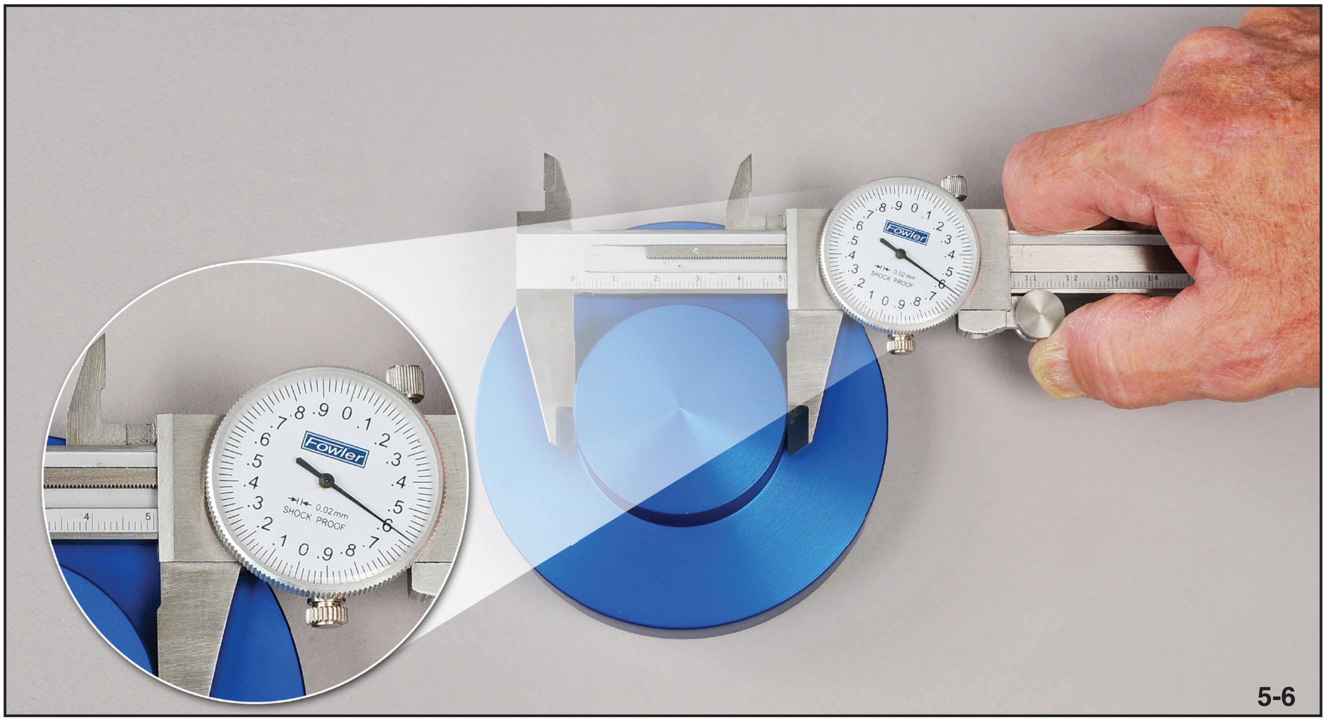
The dial caliper measures items to hundredth of a millimeter (.01 mm).

The dial caliper can measure the internal diameter, external diameter, depth, and height of an item.

Place the item being measured within the outside jaws, inside jaws, or the base of the main scale. The lock screw locks the two pieces of the caliper together so the caliper can be removed from the component for easier reading of the measurement.

A combination of the main scale and the dial scale are used to calculate the measurement

Reading the Dial Caliper Scale - Outside Diameter

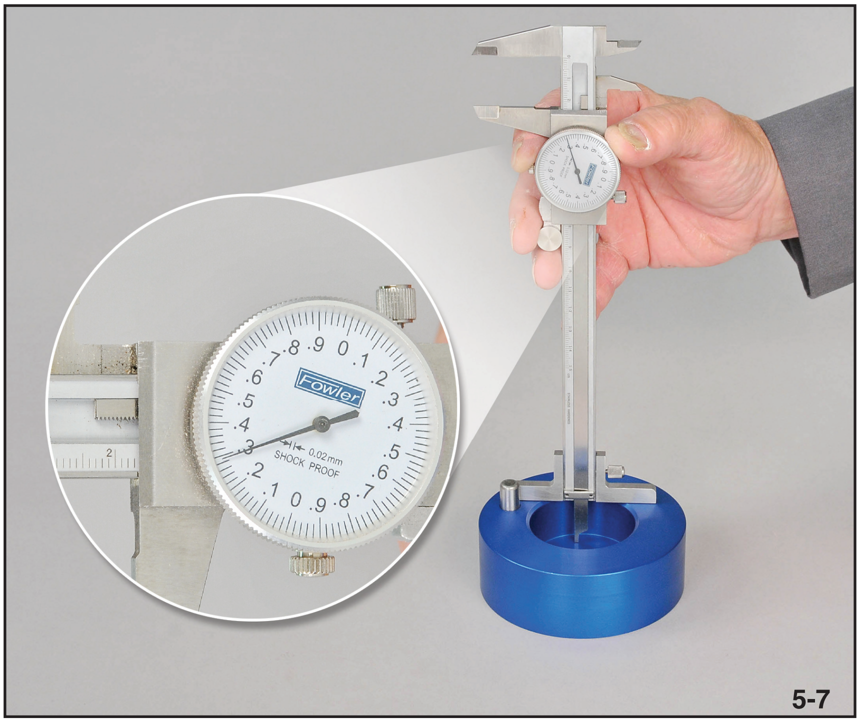


Dial Caliper Scale

1. Read the base measurement in millimeters from the main scale. The reading lines up either directly on or in between a main numbered centimeter marking on the main scale.
2. Read the dial measurement. Each graduation on the dial equals 0.02 mm.
3. Add the decimal values from steps 1 and 2. The sum is the dial caliper reading in millimeters. This example shows a reading of 50.60 mm.

Base Measurement	5.0	50 mm
Dial Scale	.60	.60 mm
Total Reading		50.60 mm

Reading the Dial Caliper Scale - Depth

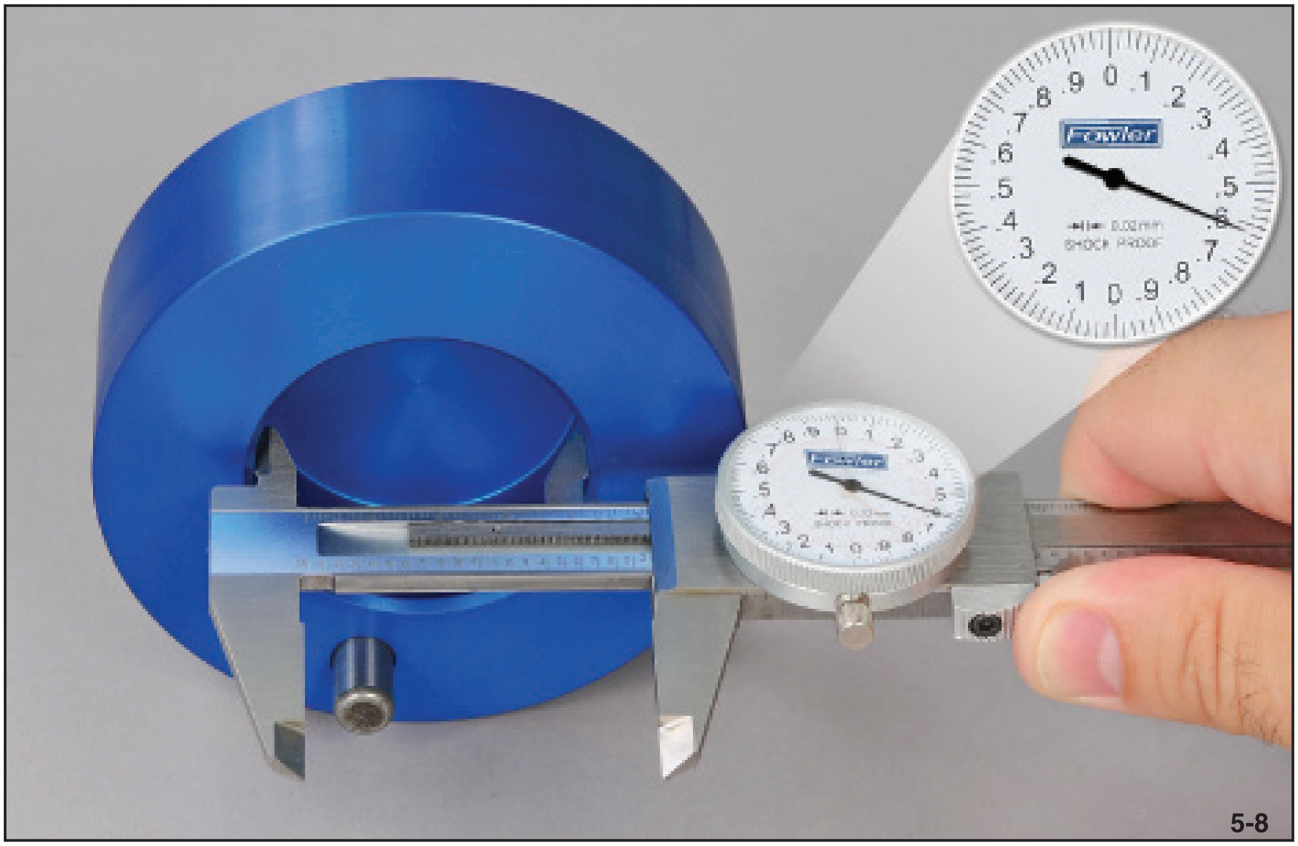


Dial Caliper Measuring Depth

1. Position the caliper squarely over the cavity to be measured.
2. Extend the depth rod to contact the desired surface within the cavity.
3. Read the base measurement in millimeters from the main scale. The reading lines up either directly on or in between a main numbered centimeter marking on the main scale.
4. Read the dial measurement. Each graduation on the dial equals 0.02 mm.
5. Add the decimal values from steps 3 and 4. The sum is the dial caliper reading in millimeters. This example shows a reading of 23.29 mm.

Base Measurement	2.3	23 mm
Dial Scale	.29	.29 mm
Total Reading		23.29 mm

Reading the Dial Caliper Scale - Inside Diameter

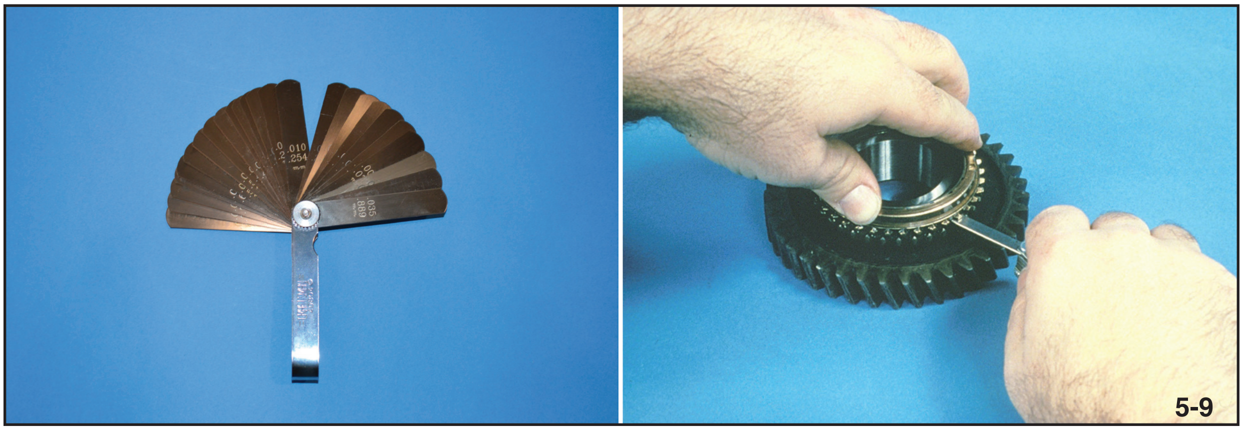


Dial Caliper Measuring Inside Diameter

1. Position the caliper inside jaws squarely into the bore to be measured.
2. Extend the jaws to contact the internal surfaces of the bore at its widest point.
3. Read the base measurement in millimeters from the main scale. The reading lines up either directly on or in between a main numbered centimeter marking on the main scale.
4. Read the dial measurement. Each graduation on the dial equals 0.02 mm.
5. Add the decimal values from steps 3 and 4. The sum is the dial caliper reading in millimeters. This example shows a reading of 50.62 mm.

Base Measurement	5.0	50 mm
Dial Scale	.62	.62 mm
Total Reading		50.62 mm

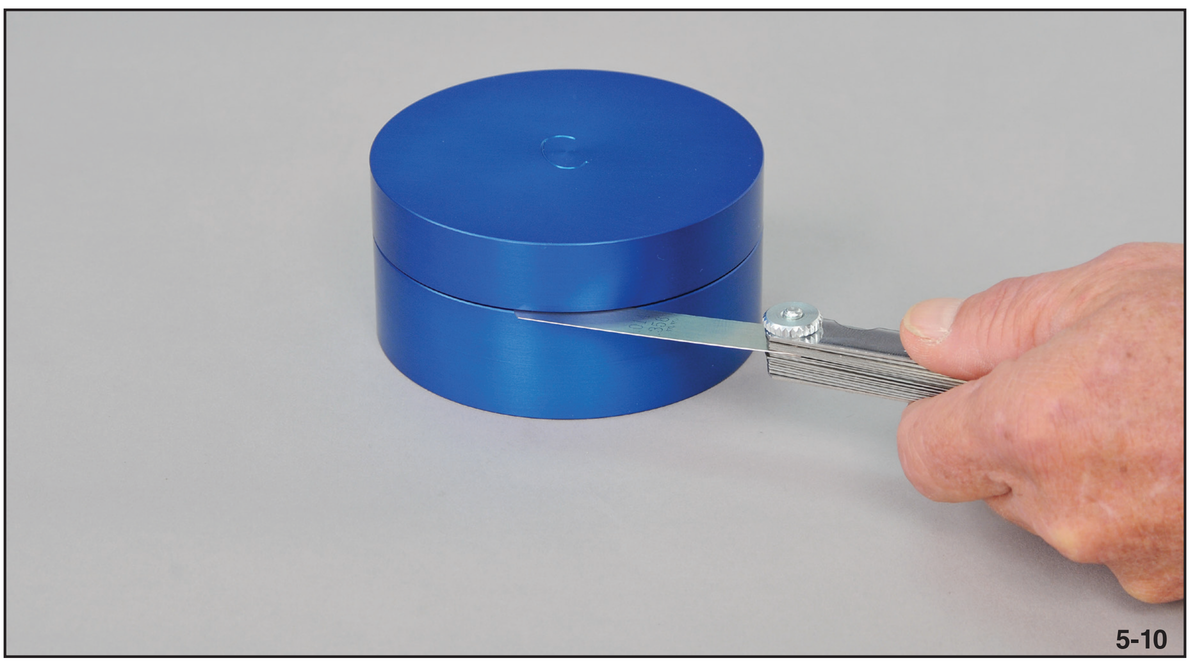
Feeler Gauge



5-9

Feeler Gauges

Feeler gauges are precision ground blades of steel or brass. Each gauge set has several different blades. Each blade is a different thickness and marked as such. This precision tool is used to measure the gap or space between two components.

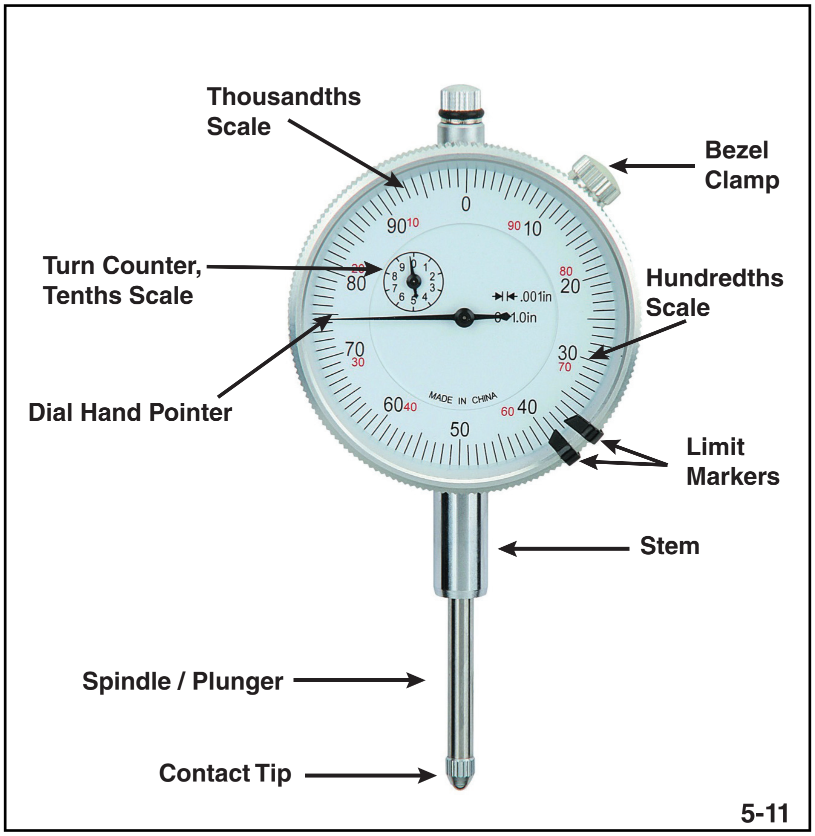


5-10

Measuring Clearance with Feeler Gauge

Insert a feeler gauge blade approximately the size of the gap between surfaces. Move the blade in and out of the gap feeling for a smooth drag on the blade. When the correct size blade is determined, make note of the dimension printed on the blade for comparison with specifications.

Dial Indicator



Dial Indicator Components

A dial indicator is a precision tool that measures relative distances in very small increments, down to .001 inch (one thousandth of an inch). It is typically used in a machining process for quantifying precision metal parts. In the automotive industry, the dial indicator is used to measure endplay and backlash in driveline components. In addition, it can be used to measure the disc brake rotor or wheel hub for excessive runout and critical dimensions in an engine.

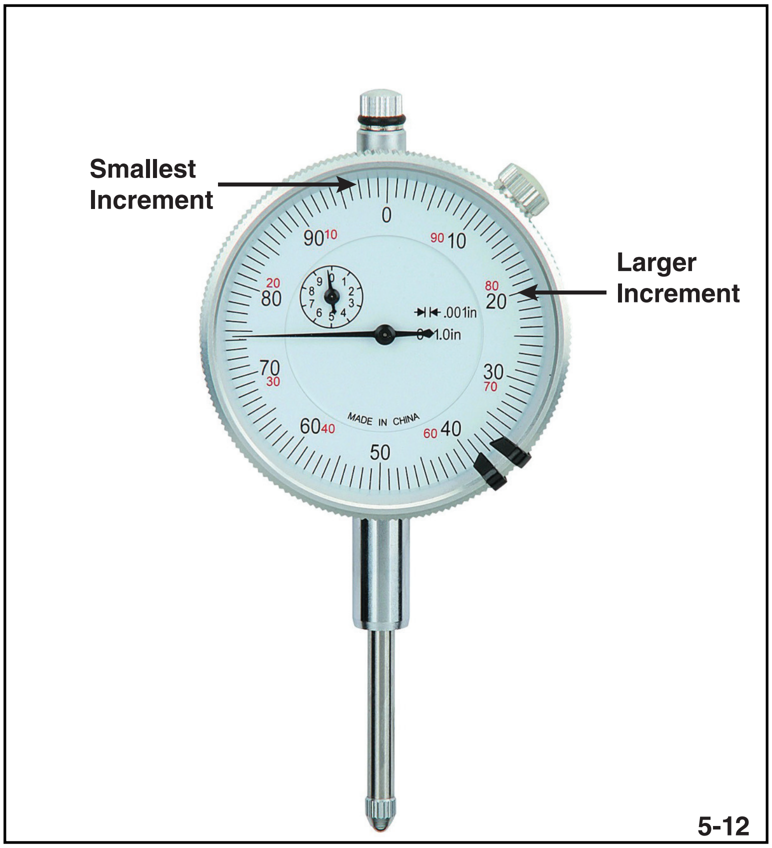
A dial indicator is delicate and must be handled carefully and maintained to ensure its precision and smooth operation. Store dial indicators in a protective case when not in use. Store dial indicators in a dry location; moisture can corrode the internal components and damage the precision movement.

When moving a dial indicator from a cold area to a warm area, allow the dial indicator to acclimate to the ambient temperature.

Keep the dial indicator away from oil, chemicals, and other fluids commonly used in a shop environment. These compounds can damage the internal mechanisms.

Regularly inspect and, if necessary, calibrate the dial indicator.

Reading the Dial Indicator (0–1 inch)



Dial Indicator Increments

The dial indicator has two dials: a large, outside diameter dial and a smaller dial in the center. The larger pointer turns clockwise while the smaller dial turns counterclockwise.

The smaller revolution (or turn counter) dial counts the number of times the larger dial pointer makes one complete revolution.

- On a 0–1 inch dial indicator, one complete revolution of the large pointer is equal to 0.01 in. (one hundredth of an inch).
- Ten turns of the large pointer is equal to 1.0 in.
- One turn of the smaller dial pointer is equal to 1.0 in.
- The smaller dial reads each revolution of the larger dial in increments of 0.01 in. (one hundredth of an inch).

Dial indicators have a bezel that rotates to allow the user to zero the indicator before taking measurements. A bezel lock prevents the bezel from moving.

Most dial indicators have moveable markers that can be used to record the maximum amount of needle travel in each direction.

The dial indicator must be mounted securely. If any movement is detected, the reading will not be accurate. After properly mounting the dial indicator, perform the following steps:

Zero the scale by setting both dials to 0.

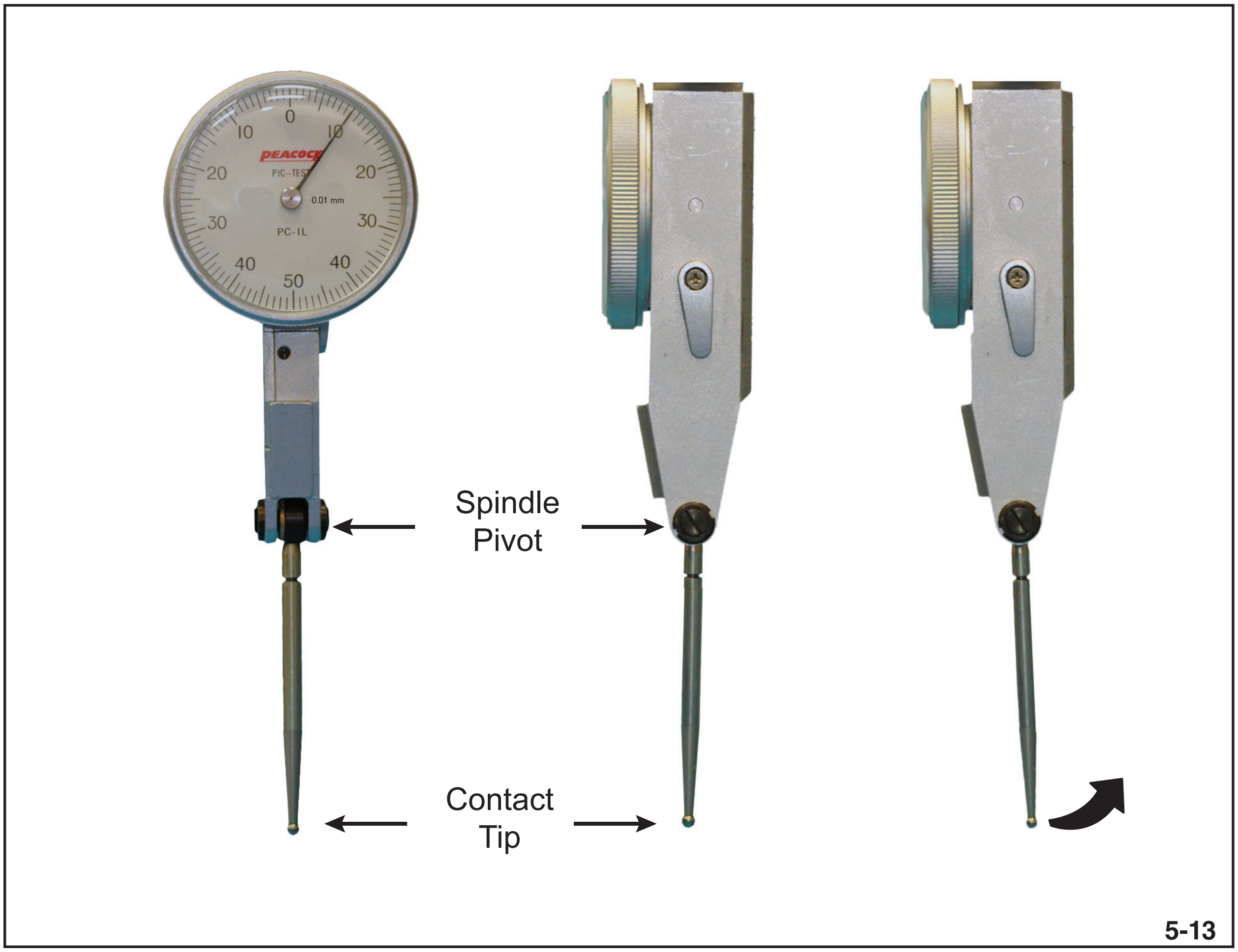
- Observe the large dial face on the indicator. The larger dial numbers are graduated by 10, from 0 through 90. Between each of the large increment numbers are smaller increments that are equal to .001 in. (one thousandth of an inch) each.
- Observe the smaller dial. The increments are equal to 0.100 in. (one tenth of an inch). There are numbers on the small dial face that are broken into 10 separate numbers. The range is 0 to 9, with 9 representing to 0.900 in. (nine tenths of an inch).

1. Adjust the scale to zero by loosening the outer indicator bezel clamp. Rotate the bezel and tighten to adjust the .001 in. measurement ring. By moving the bezel, the calibration range can be zeroed to any position.
2. If the indicator plunger is pressed so the inner smaller dial is at 4 and the larger dial is at 0.010 in., the inch reading is 0.410 in. (four hundred ten thousandths of an inch), which is just under a ½ inch.
3. If the indicator plunger pressure is reduced, so the large dial reads between the 0 and 0.010 in., the reading is 0.405 in. (four hundred five thousandths).
4. If the small dial is placed at the 0.1 in. (one tenth of an inch) increment, and the larger dial is at five increment lines past the 20, the reading indicates 0.125 in. (one hundred twenty-five thousandths) or 1/8 of an inch.

In summary, the first digit of the reading is the small dial reading, the second digit is the large number on the large dial, and the third reading comes from the small increments on the large dial between the numbers.

Each line on the large dial is the smallest increment reading. Each number on the small dial is the largest increment reading.

Lever-type Dial Indicator



Pic Gauge

The lever-type dial indicator is used to measure backlash in differential units. It is read like all other dial indicators. The lever action of the spindle dectects lateral motion, unlike a standard dial indicator that detects linear motion. The dial face has a single zero point with graduations in both directions. This allows mounting the tool in multiple positions. The pointer rotates only one revolution in either direction.

A miniature bearing is used at the pivot of the contact point tip and provides good indication stability. The contact tip is inserted through the transaxle oil drain hole and contacts a tooth on the ring gear. Movement of the ring gear with the pinion gear held stationary indicates backlash. Always compare the backlash measurment with specifications when servicing a front differential.

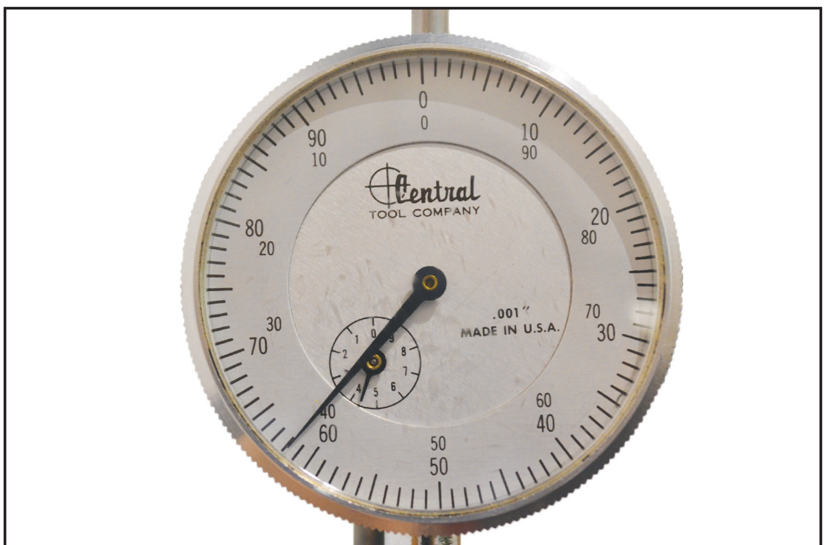
The following are examples of dial indicator readings:

5-14

Dial Indicator Reading of 0.074 in.

The dial indicator above is reading 0.074 in. (seventy-four thousandths of an inch).

0.070 + 0.004 (small increments) marks = 0.074 thousandths of an inch.



5-15

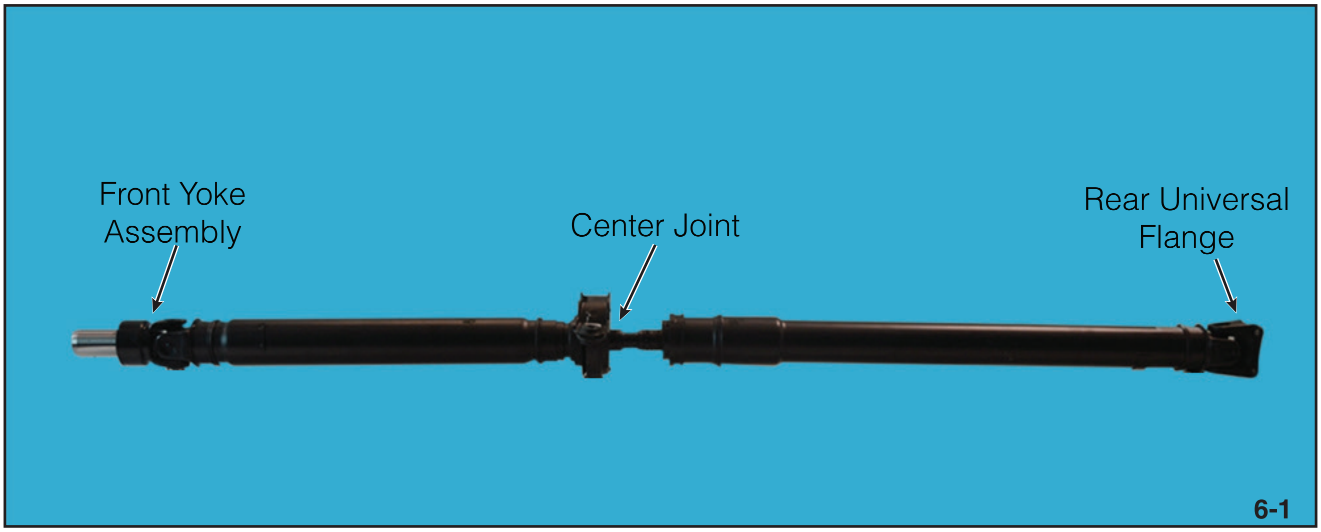
Dial Indicator Reading of 0.462 in.

The dial indicator above is reading 0.462 in. (four hundred sixty-two thousandths of an inch).

0.400 + 0.062 (small increments) marks = 0.462 thousandths of an inch.

Final Drives

Propeller Shafts

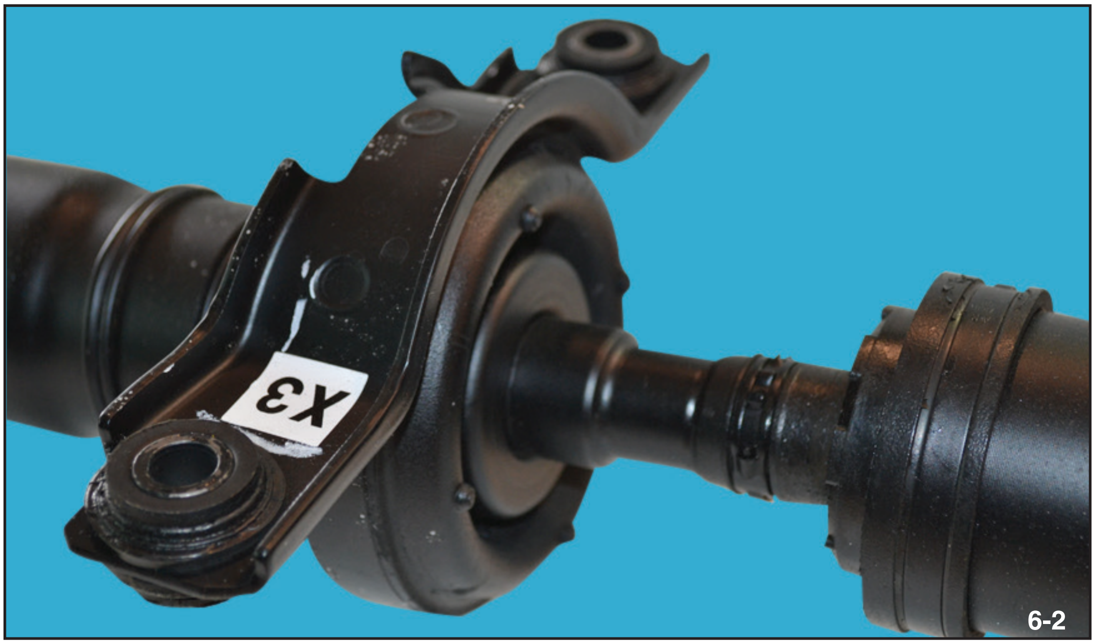


Two Piece Propeller Shaft

The propeller shaft transfers power from the transmission driven transfer gear to the rear differential to drive the rear wheels. The two-piece propeller shaft cuts the length of the shaft to avoid drive line vibration.

The propeller shafts are hollow steel tubes with yokes welded on the front of the front shaft and on the rear of the rear shaft. The tubular design makes the propeller shaft strong and light. The propeller shaft is not serviceable and must be replaced as an assembly if defects are present in any of its components.

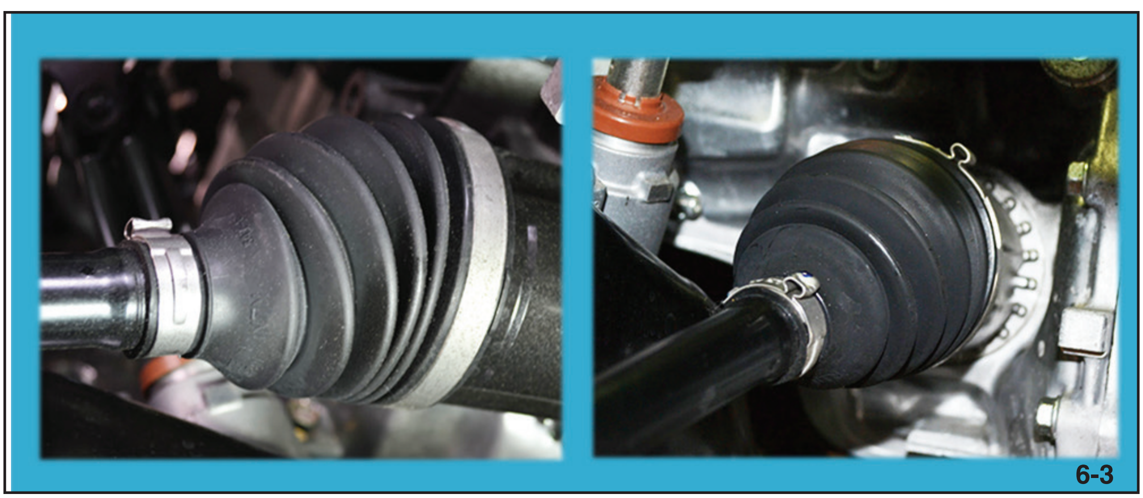
Constant Velocity Center Joint



Center Joint and Mounting Bracket

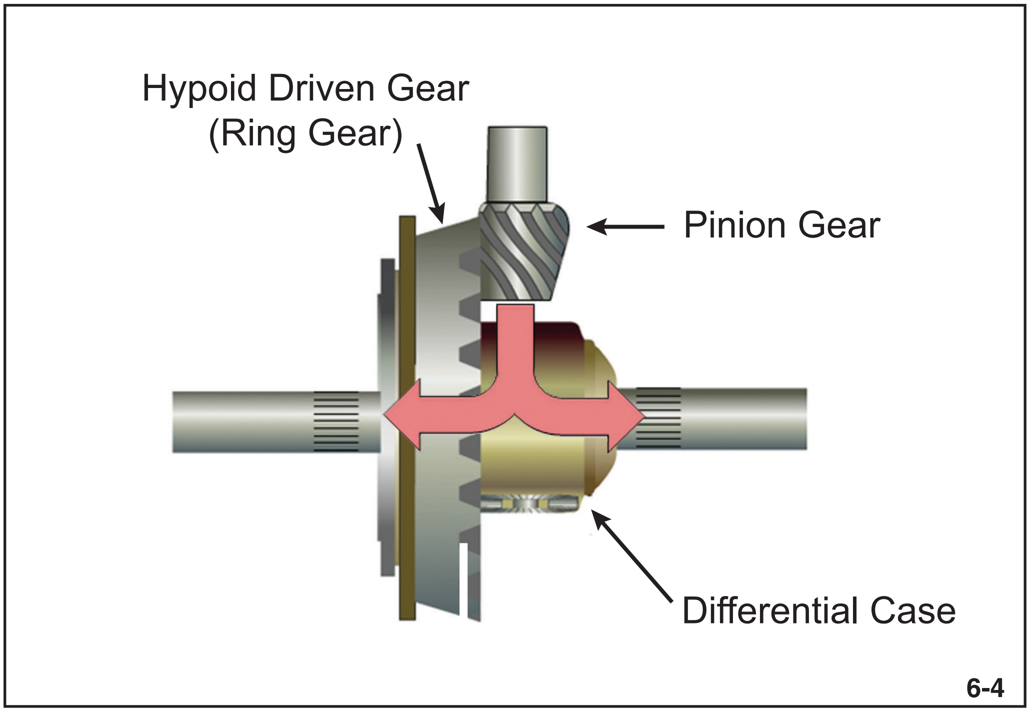
To reduce noise, a constant velocity (CV) joint is located between the front and rear portions of the propeller shaft. The center joint is not serviceable, and the two shafts must not be separated when servicing.

Drive Shafts



Drive Shaft Boots

Protective boots keep dirt and debris away from the flexible joint bearing surfaces. When servicing any drive shaft, ensure the protective boots are in good condition and fastened securely with the boot banding clamp. If a boot is damaged or leaking, replace it.

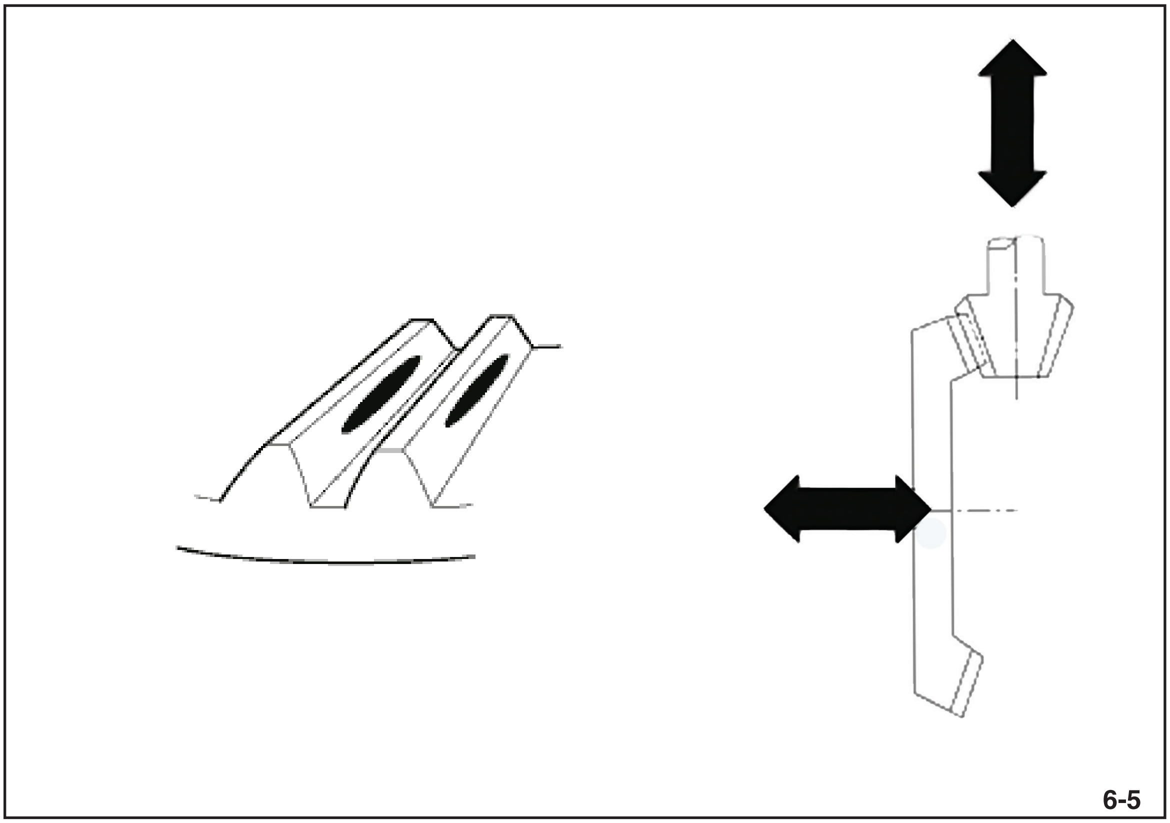


Differential

Engine power enters the differential assembly through the pinion gear and rotates the ring gear, which is attached to the differential case. The axle drive shafts, which are engaged in the side gears, rotate at the same speed because each side gear receives the same amount of rotation from the pinion mate gears, which are driven by the differential case. When a vehicle is moving straight-ahead, there is no differential action, and equal torque is supplied to both axle drive shafts.

When the vehicle travels around a corner, the differential becomes effective, allowing the axle shafts to rotate at different speeds. The outside wheel has a farther distance to travel, so it turns faster than the inside wheel to prevent tire scuffing and sliding.

Ring and Pinion Gear Alignment



Ring and Pinion Adjustment

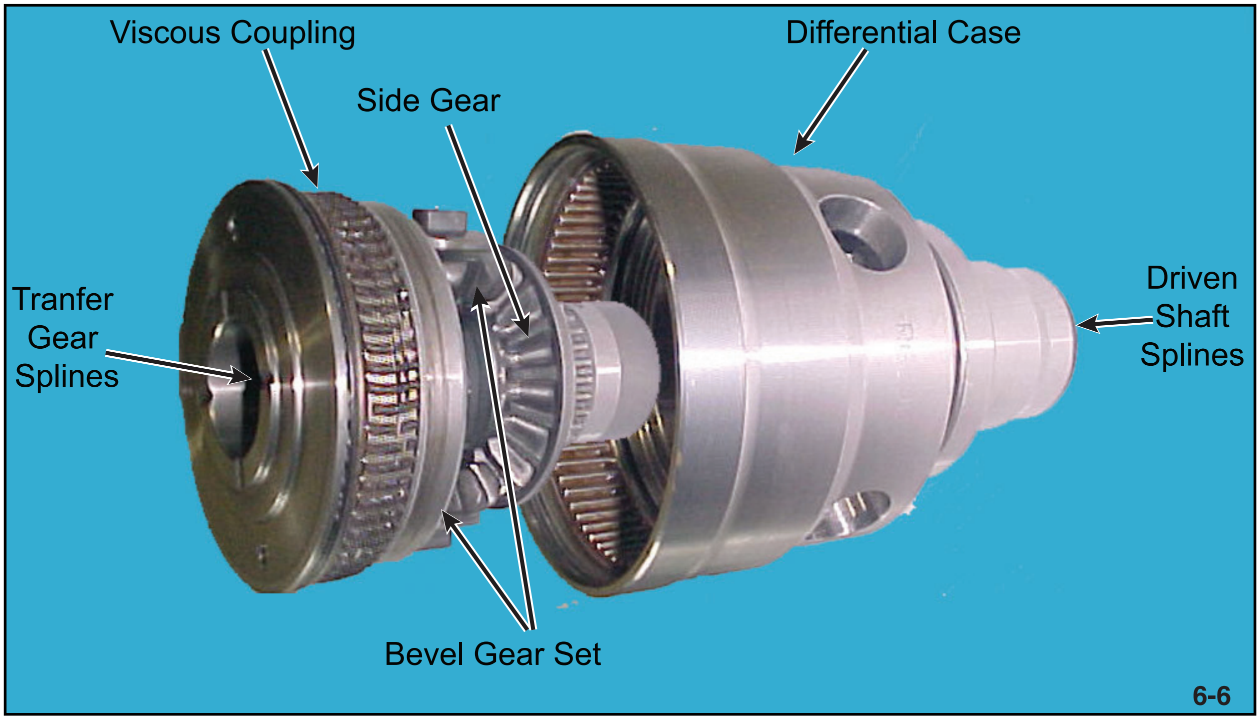
There are three major adjustments possible on a Subaru front ring and pinion gear set. When these three adjustments are correct, the mesh pattern should be correct.

Pinion depth is the distance the pinion gear extends into the front differential case. The depth is determined by the thickness of the shim placed between the pinion bearing flange and the transmission extension case. Thinner shims move the pinion gear away from the ring gear. Thicker shims move the pinion gear deeper into the ring gear.

Differential bearing preload sets the position of the ring gear laterally closer or farther away from the pinion gear. Preload is adjusted by tightening or loosening the differential side retainers. The side retainers move in the same direction as the ring gear. Tightening the right side differential retainer pushes the differential carrier and ring gear to the left and away from the pinion gear. Loosening the right side retainer or tightening the left side retainer has the opposite effect.

Backlash is the clearance between the pinion and ring gear. Some backlash is necessary for lubrication and heat expansion. Moving the ring gear toward or away from the pinion will change backlash. Backlash is measured with a dial indicator and adjusted to specification using the differential side retainers. Do not use backlash to compensate for incorrect pinion depth.

Center Differential



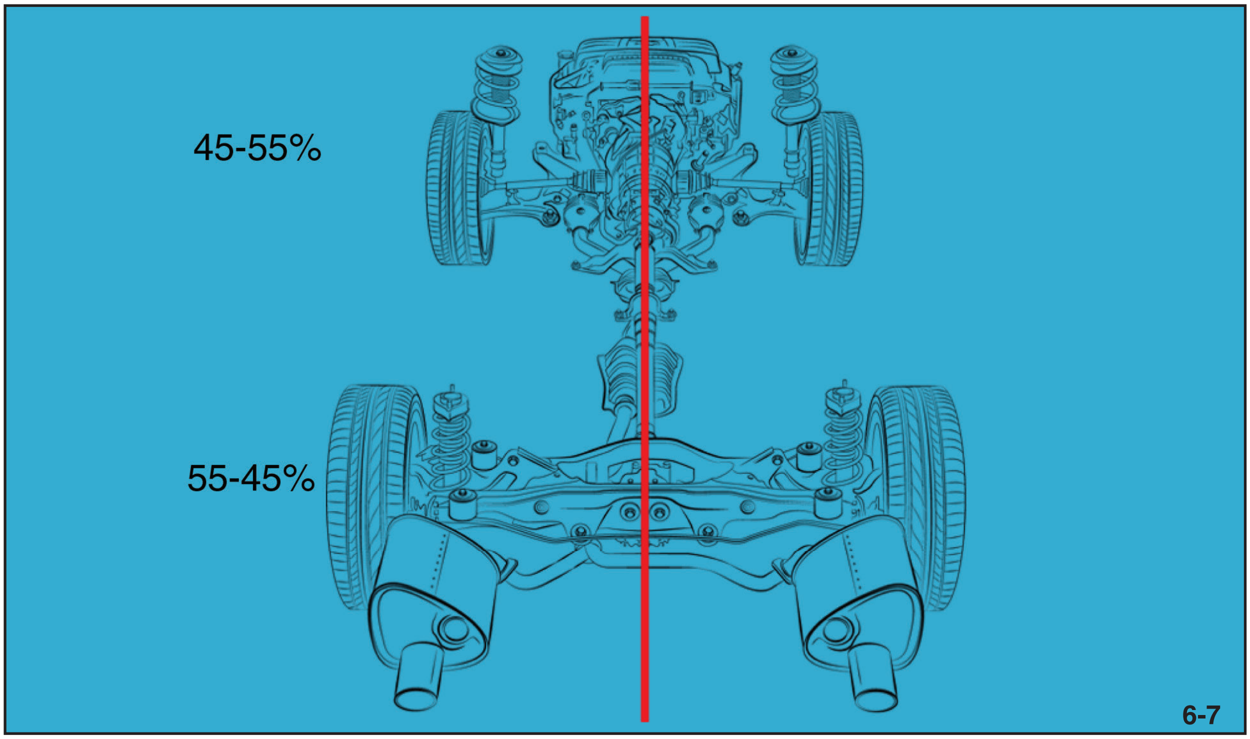
Center Differential

The center differential has two functions, distributing the engine torque to the front and rear wheel drive shafts and absorbing the difference in rotating speed between the front and rear wheels. Differential action is similar to the front and rear axle differentials.

The center differential absorbs the difference in rotating speed between the front and rear wheels. The center differential is located at rear of the transmission in the transfer case of all Subaru vehicles.

Engine torque enters the center differential case from the transmission driven shaft. The engine torque is distributed through the bevel gear set directly to the drive pinion shaft and transfer gears to the rear drive shaft. The viscous coupling limits the differential action of the bevel gear set when either front or rear wheels spin. The required torque is transmitted to the front and rear wheels to obtain proper traction.

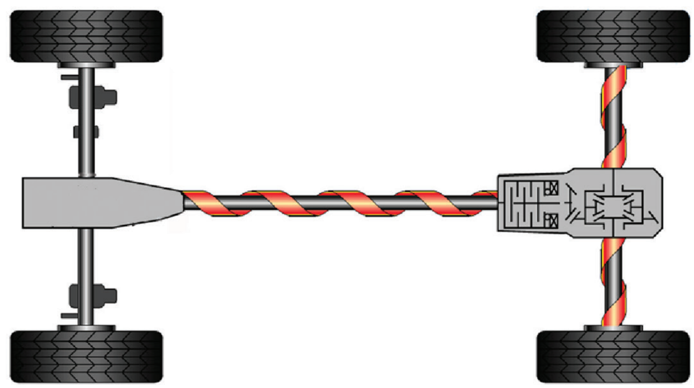
All-wheel Drive Traction Characteristics



Symmetrical All-wheel Drive

Subaru symmetrical all-wheel drive is balanced from side-to-side. Axle drive shafts have equal lengths to prevent torque steer. The horizontally opposed Boxer engine distributes weight equally also. The balanced weight ratio increases control, regardless of a sharp right or left curves. Engine torque is delivered to the front and rear axles at ratios between 45 to 55%, and 55 to 45% respectively through the transfer portion of the transmission.

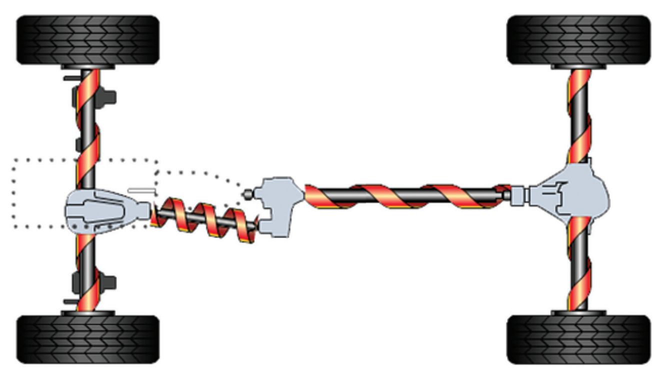
Two-wheel Drive Traction Characteristics


6-8

Two-wheel Drive

Two-wheel drive vehicles deliver engine torque through a conventional differential to one axle set, either the front axles or the rear axles. Engine torque is not delivered evenly to both wheels through a conventional differential. The wheels are free to slip in all road conditions and do not provide additional traction for vehicle control.

Four-wheel Drive Traction Characteristics


6-9

Four-wheel Drive

Conventional four-wheel drive systems apply torque to the front and rear drive shafts equally through a separate transfer case. They do not distribute torque proportionately between the front and rear axle drive shafts. Wheel slip is controlled by individual differentials and does not improve vehicle control.

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