Figure 118.6: Hydraulic fluid transmits the same force whether it passes through a single chamber or two chambers connected by a narrow passage.

Figure 118.7: A fluid applies a force equal to the applied force on a surface that is equal in size to the applying surface. If the surface is half the size, then the fluid exerts half the force. If the surface is twice as large, the fluid exerts twice the force.
Figure 118-3  A typical integral power steering pump when the pump is mounted inside the reservoir.

Figure 118-4  Typical remote reservoir.

Figure 118-5  Typical power steering pump assemblies.
Figure 118-6  General Motors vane-type pump.

Figure 118-7  Vane pump operation. In phase 1, the rotor moves past the opposed suction ports, and the vanes move out to maintain contact with the ring. This creates a low-pressure area, allowing fluid into the cavities formed by the vanes. As the rotor continues to move, phase 2, the vanes follow the contour of the ring. The contour of the ring forms a larger cavity between the vanes. This increases the suction and draws more fluid into the pump.

Figure 118-8  Vane pump operation—continued. At phase 3, the vanes are at the end of the intake port of the pump. The cavity has reached its maximum volume. In phase 4, the rotor moves into alignment with the opposed discharge port.
Figure 118-9 Vane pump operation—continued. As the rotor continues to move during phase 5, the volume of the cavity decreases, which increases the discharge pressure. At phase 6, the bolt hole, the contour of the ring results in the minimum cavity volume, and the discharge of fluid is completed.

Figure 118-10 Flow control valve.

Figure 118-11 The pressure-relief check ball unseats, allowing fluid to flow back into the pump inlet if the pressure rises above a certain limit.
The power steering fluid cooler, if used, is located in the return hose. Often the cooler is a length of return metal line that is arranged in a loop and routed near the front of the vehicle. The airflow past the return line helps reduce the temperature of the fluid.

Forces acting on the rack piston of an integral power steering gear:

The rotary valve consists of inner and outer elements. The worm gear is part of the inner element and the torsion bar is part of the outer element. A pin attaches the worm gear to the torsion bar. The full diagram is not visible, but it shows the interaction between these components.
When the steering wheel is in the straight-ahead position, all of the ports in a rotary valve are open equally to the pressure and return circuits.

During a left turn, the inner element turns so that the left-turn circuits are open to pressure and the right-turn circuits are open to the return circuit.

During a left turn, the high-pressure fluid helps push the piston along the worm gear, thereby reducing the steering effort from the driver.
Figure 118-18 During a right turn, the inner element turns so that the right-turn outlets are open to pressure and the left-turn outlets are open to the return circuit.

Figure 118-19 During a right turn, high-pressure fluid pushes the piston up the worm gear, rotating the sector shaft and pitman arm to provide assist during a right turn.

Figure 118-20 During a left turn, the control valve directs pressure into the left-turn fluid line and the rack moves left. Fluid pushed out of the right-turn fluid chamber travels back through the right-turn fluid line and control valve to the return circuit.
Figure 118-21 The control valve routes high-pressure fluid to the left-hand side of the power piston, which moves the piston and assists in turning the rack toward the right when the steering wheel is turned left.

Figure 118-22 Low-speed flow control.

Figure 118-23 High-speed flow control operation.
Pressure-relief mode. In this mode, the steering gear has blocked the flow of fluid from the pump and the pressure rises, which unseats the pressure-relief valve. Now fluid flows back to the tank through the pressure-relief orifice and passage.

Figure 118-25 EVO actuator assembly.

Figure 118-26 Integrated with the pinion shaft is a spool valve that senses the level of torque in the shaft and applies hydraulic pressure to the steering rack whenever assistance is needed. The electromagnet acts in parallel with the input shaft from the steering wheel to open or close the spool valve. The electromagnet generates variable torque, which can either increase or decrease the amount of steering torque that is needed to open the spool valve.
Figure 118-27  Magnasteer system.

Figure 118-28  A Toyota Prius ESP assembly. (Courtesy of Tony Martin)

Figure 118-29  The torque sensor converts the torque the driver is applying to the steering wheel into a voltage signal.
Figure 118-30 The electric power steering in Toyota/Lexus SUVs uses a brushless DC motor inside the rack of the unit and operates on 42 volts.

Figure 118-31 Photo of the electric power steering gear on a Lexus RX 400h taken from underneath the vehicle.

Figure 118-32 A cross-sectional view of a Honda electric power steering (EPS) gear.
Figure 118-33 Honda electric power steering unit cutaway.

Figure 118-34 The Power Steering Control Module (PSCM) is attached to the motor of the electric power steering assembly.

Figure 118-35 Schematic showing the electric power steering and the torque/position sensor.
An electrohydraulic power steering assembly on a Chevrolet hybrid pickup truck.

A typical service manual illustration showing the method to use to properly tension the accessory drive belt.

TECH TIP: The Visual Test
Whenever diagnosing any power steering complaint, check the level and condition of the power steering fluid. Often this is best accomplished by putting your finger down into the power steering fluid reservoir and pulling it out to observe the texture and color of the fluid.

A common problem with some power rack-and-pinion units is the wearing of grooves in the housing by the Teflon sealing rings of the spool (control) valve. When this wear occurs, aluminum particles become suspended in the power steering fluid, giving it a grayish color and thickening the fluid. Normally clear power steering fluid that is found to be grayish in color and steering that is difficult when cold are clear indications as to what has occurred and why the steering is not functioning correctly.
A check of the power steering fluid should include inspecting not only the level but the condition and color of the fluid, which could indicate a possible problem with other components of the steering system.

Some power steering fluid is unique to the climate, such as this cold climate fluid recommended for use in General Motors vehicles when temperatures are low.

Inspect both high-pressure and return power steering hoses. Make sure the hoses are routed correctly and not touching sections of the body to prevent power steering noise from being transmitted to the passenger compartment.
Figure 118-41  A drawing showing how to connect a power steering pressure gauge to the system.

Figure 118-42  A power steering analyzer that measures both pressure and volume. The shut-off valve is used to test the maximum pressure of the pump.

Figure 118-43  Typical power steering pump showing the order of assembly. The high-pressure hose is connected to the fitting (16). The flow control valve can be removed from the pump by removing the fitting.
Figure 118-44  Typical tools required to remove and install a drive pulley on a power steering pump. These tools can be purchased at a relatively low cost from automotive parts stores and will work on many different makes of vehicles. Most replacement pumps are not equipped with a pulley. The old pulley must be removed and installed on the new pump. The old pulley should be carefully inspected for dents, cracks, or warpage. If the pulley is damaged, it must be replaced.

Figure 118-45  A typical submerged-type power steering pump. The pump is housed inside the fluid reservoir. (Courtesy of Chrysler Corporation)

Figure 118-46  A punch is used to dislodge the retaining ring.
The driveshaft attaches to the drive pulley at one end and is splined to the pump rotor at the other end. The vanes are placed in the slots of the rotor.

The pump ring must be installed correctly. If it is installed upside down, the internal passages will not line up and the pump will have no output.

The shaft seal must be chiseled out. A thin metal shim stock should be used to protect the shaft from damage. A self-tapping sheet metal screw is then threaded into a small hole in the seal, then pliers are used to pull out the old seal.
TECH TIP

Pocket the Ignition Key to Be Safe

When replacing any steering gear such as a rack-and-pinion steering unit, be sure that no one accidentally turns the steering wheel if the steering wheel is turned without being connected to the steering gear. The airbag wire (clock spring) can become off-center. This can cause the wiring to break when the steering wheel is rotated after the steering gear has been replaced. To help prevent this from occurring, simply remove the ignition key from the ignition (make sure the steering wheel is locked) and put it in your pocket while servicing the steering gear.

POWER STEERING RACK REMOVAL AND INSTALLATION 1

The tools required include a tie rod end puller and basic hand tools.

POWER STEERING RACK REMOVAL AND INSTALLATION 2

To help keep the steering wheel from rotating when the steering rack assembly is removed, a steering wheel lock is being used.
After safely hoisting the vehicle and removing the front wheels, the outer tie rod end retaining nuts are removed.

Using a tie rod taper breaker to separate the outer tie rods from the steering knuckle without harming the rubber grease boots.

After moving the protective cover aside, the bolt used to retain the intermediate shaft to the steering gear stub shaft is removed.
POWER STEERING RACK REMOVAL AND INSTALLATION 6

The hydraulic lines attached to the steering rack to the power steering rack assembly are removed using a line wrench.

POWER STEERING RACK REMOVAL AND INSTALLATION 7

After supporting the engine cradle using a safety stand, an air impact wrench with a long extension is used to remove the engine cradle bolts.

POWER STEERING RACK REMOVAL AND INSTALLATION 8

Removing the lower engine cradle bolts. This will allow the cradle to be lowered to gain access to the steering rack assembly.
POWER STEERING RACK REMOVAL AND INSTALLATION

9 The screw jack on the tall safety stands is rotated allowing the engine crane to be lowered.

POWER STEERING RACK REMOVAL AND INSTALLATION

10 Removing the steering rack attachment bolts.

POWER STEERING RACK REMOVAL AND INSTALLATION

11 The steering rack assembly can be lifted out of the support brackets.
On this General Motors vehicle, the steering rack assembly is removed from the driver’s side.

Before reinstalling the steering gear assembly, note the notch on the stub shaft. This notch has to be aligned with the intermediate shaft retaining bolt when it is placed back into the vehicle.

Installation is the reverse of removal. Be sure that the rack is centered and check that the throughbolt is properly aligned with the notch on the steering rack stub shaft.
 While using a tall safety stand to support the engine cradle, the retaining bolts are installed.

A socket is being used to keep the tapered tie rod end from rotating while the retaining nut is tightened with a wrench.

After the hydraulic lines and retaining bolts have been installed, the power steering pump reservoir is filled using the specified fluid.

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To bleed the trapped air out of the system, the steering wheel is rotated lock to lock with engine off and the wheels off the ground. Check for leaks after performing a few more lock-to-lock rotations and a test drive.