CHAPTER 28
Steering Columns and Gears
OBJECTIVES

After studying Chapter 28, the reader will be able to:

1. Prepare for ASE Suspension and Steering (A4) certification test content area “A” (Steering System Diagnosis and Repair).
2. Discuss steering columns and intermediate shafts.
3. Explain how a recirculating ball-nut and worm gear steering gear system works.
4. Describe how a rack-and-pinion steering gear works.
KEY TERMS

- Collapsible column
- Flexible coupling
- Gear lash
- Inflator module
- Kickback
- Lock plate
- Overcenter adjustment
- Pinion torque
- Pitman arm
- Pitman shaft
- Preload
- Rack and pinion
- Rack support
- Sector gear
- Sector shaft
- Steering shaft
- Stub shaft
- Telescoping steering column
- Tilt steering column
- Universal joint
- Variable ratio
- Worm gear
STEERING WHEELS

- The steering wheel, which consists of a rigid rim and a number of spokes connecting the rim to a center hub, attaches to the top of the steering shaft at its center.
- Most steering wheel hubs have internal splines that fit over external splines on the steering shaft.
- A bolt or nut at the center of the hub secures the wheel to the shaft.
- The steering wheel may also contain controls for the cruise control and audio controls, as well as the driver’s airbag.
The horn circuit is in a series circuit in which electricity has one path that it can follow when the circuit is complete.

A normally open switch in an electrical circuit is inside the horn button.

When the driver pushes the horn button, the contacts on the switch close, allowing electrical current through the circuit to operate the horn.

**FIGURE 28–1** Most steering columns contain a horn switch. The horn button is a normally open (NO) switch. When the button is depressed, the switch closes, which allows electrical current to flow from the battery to sound the horn. Most horn circuits use a relay to conduct the horn current.
STEERING WHEELS
AIRBAGS

• An airbag is a device made of nylon cloth that is covered with neoprene.
• The airbag is folded and stored in the front center of the steering wheel.
• In a front-end collision, the airbag inflates in a fraction of a second to provide a cushion between the driver and the steering wheel and dashboard.

FIGURE 28–2 The airbag inflates at the same time the driver moves toward the steering wheel during a front-end collision and supplements the protection of the safety belt.
FIGURE 28–3 The airbag module attaches to the steering wheel and is removed as an assembly to service the steering wheel and column.
STEERING COLUMNS

• The steering shaft transmits rotary motion from the steering wheel to the steering gear, while the column jacket that encases it attaches to the vehicle body and offers a stationary mounting point for a number of switches and mechanisms.
FIGURE 28–4 The steering shaft links the steering wheel to the steering gear while the column jacket, which surrounds part of the shaft, holds support brackets and switches. This steering shaft has a small intermediate section between the main section and the steering gear.
STEERING COLUMNS

• STEERING SHAFT
• UNIVERSAL JOINT
• FLEXIBLE COUPLING
• COLUMN COVER
• COLLAPSIBLE COLUMN
• TILT MECHANISMS
• TELESCOPING STEERING COLUMNS
• STEERING COLUMN CONSTRUCTION
FIGURE 28–5 A pot joint is a flexible coupling used to join two shafts that allow plunging motion.
FIGURE 28–6 A typical intermediate steering shaft assembly showing a U-joint and related components.
FIGURE 28–7 A flexible coupling is used to isolate road noise and vibration from the steering shaft.
FIGURE 28–8 Steering column covers are often part of the interior trim.
FIGURE 28–9 Collapsible steering columns include a mesh design that crushes easily, a bearing design that allows one section of the column to slide into the other, and a breakaway device that separates the steering column from the body of the vehicle in the event of a front-end collision.
FIGURE 28–10 Tilt mechanisms vary by design and vehicle manufacturer, although most use a ratchet to position the top portion of the steering column.
FIGURE 28–11 Typical steering column showing all of the components from the steering wheel to the steering gear.
FIGURE 28–12 The steering shaft splines onto the steering wheel.
FIGURE 28–13 The toe plate seals the hole from the steering shaft and helps seal out noise and moisture.
FIGURE 28–14 The upper section of the steering column includes the lock housing and switches.
FIGURE 28–15 The upper section of the steering column contains the steering shaft bearing.
STEERING COLUMNS

FIGURE 28–16 The lock plate engages an ignition lock pawl to keep the steering wheel in one position when the ignition is off.
CONVENTIONAL STEERING GEARS

- All steering gears have an input gear, which transmits rotary movement from the steering wheel into the steering gear, and an output gear, which causes the steering linkage to move laterally.

- The rotation of the steering wheel is transferred to the front wheels through a steering gear and linkage.

- The intermediate shaft is splined to a **worm gear** inside a conventional steering gear.

- Around the worm gear is a nut with gear teeth that meshes with the teeth on a section of a gear called a **sector gear**.

- The sector gear is part of a **pitman shaft**, also known as a **sector shaft**.
FIGURE 28–17 As the steering wheel is turned, the nut moves up or down on the threads, shown using a bolt to represent the worm gear and the nut representing the gear nut that meshes with the teeth of the sector gear.
CONVENTIONAL STEERING GEARS
STEERING GEAR RATIO

- When the steering wheel is turned, the front wheels turn on their steering axis.
- If the steering wheel is rotated 20 degrees and results in the front wheels rotating 1 degree, then the steering gear ratio is 20:1 (read as “20 to 1”).

**FIGURE 28–18** Steering gear ratio is the ratio between the number of degrees the steering wheel is rotated to the number of degrees the front wheel turns.
FIGURE 28–19 Constant-ratio steering gear sector shaft. Notice that all three gear teeth are the same size.
FIGURE 28–20 Variable-ratio steering gear sector shaft. Notice the larger center gear tooth.
FIGURE 28–21 The sector gear meshes with the gear teeth on the ball nut.
A recirculating ball steering gear is the most commonly used conventional steering gear.

FIGURE 28–22 A typical manual recirculating ball steering gear.
FIGURE 28–23 The sector shaft is supported by bushings, one in the housing and one in the side cover.
STEERING GEAR ADJUSTMENTS

- For the steering gear to operate efficiently, the internal parts must be positioned correctly in relation to the housing and each other.
- As parts wear, clearances inside the housing and between parts increase, causing looseness and excessive play.
- The acceptable clearance between any two mechanical parts is called their tolerance.
- Insufficient tolerance causes binding between parts, increasing steering effort.
- Excessive tolerance causes delayed reaction to steering input and too much steering wheel freeplay.
STEERING GEAR ADJUSTMENTS

• Worm bearing preload, also referred to as worm endplay, is a measurement of how much force is required to turn the steering gear input shaft against the force, or **preload**, that the thrust bearings apply to the worm gear and shaft.

• Worm endplay, which is the distance the worm gear can move end-to-end between the thrust bearings, is directly related to preload.

• The higher the force the bearings push against the worm gear, the less endplay there is, and the more force it takes to turn the input shaft and worm gear.

• Worm bearing preload is adjusted by one of two methods: turning an adjustment nut or screw or installing selectively sized shims.

• Either adjustment method increases or decreases the worm endplay.
STEERING GEAR ADJUSTMENTS

WORM BEARING PRELOAD
AND GEAR MESH
PRELOAD

FIGURE 28–24 Worm bearing preload is a turning force measured in in.-lb or N-M, and worm endplay is axial movement measured in fractions of an inch or millimeters.
FIGURE 28–25 The first step to adjust worm gear freeplay is to bottom the worm gear nut, using a spanner wrench designed to fit into the two holes in the nut.
FIGURE 28–26 After the worm gear nut has been tightened, measure 1/2 inch (13 mm) and mark the case. Using the spanner wrench, rotate the worm gear nut counterclockwise 1/2 inch, align the marks, and then tighten the retaining the nut. This procedure gives the proper worm gear endplay.
**FIGURE 28–27** Performing an overcenter adjustment requires the use of a beam-type inch-lb torque wrench. After the worm bearing preload procedure has been completed, use the torque wrench to measure the rotating torque, which should be 6 to 15 lb-in. If the rotating torque is within the specified range, adjust the overcenter adjustment screw until you achieve 6 to 10 lb-in. more rotating torque and then tighten the retaining nut.
FIGURE 28–28 Sector shaft endplay is the measurement of how far the sector shaft can move axially and is measured in fractions of an inch or millimeters.
RACK-AND-PINION STEERING GEAR
PARTS AND OPERATION

- The term “rack and pinion” is simply a description of the basic design of this type of steering gear.
- The **rack-and-pinion** steering gear is widely used because it is light in weight and takes less space than a conventional steering gear.
- The input gear of a rack-and-pinion steering gear is a pinion gear that receives rotary input from the steering shaft.
- The rack is a rod with gear teeth machined into one side.
- The pinion gear teeth mesh with the teeth on the rack so that when the pinion gear turns, it pushes the rack from side to side.
RACK-AND-PINION STEERING GEAR
PARTS AND OPERATION

FIGURE 28–29 Rack-and-pinion steering gear operation is simple, direct, and the rack is in a straight line to the front wheels.
FIGURE 28–30 A typical manual rack-and-pinion steering gear used in a small front-wheel-drive vehicle.
The spring-loaded rack support positions the rack to keep it from rubbing against the housing and establishes the pinion torque.

**FIGURE 28–31**
FIGURE 28–32 To adjust the rack-and-pinion gear preload, loosen the retaining nut and tighten the adjuster nut until it bottoms. Then loosen 60 degrees (one “flat” of the six-sided retainer). Tighten retaining nut.
FIGURE 28–33 A small air tube is used to transfer air between the boots as they extend and compress during turns.
FIGURE 28–34 This manual rack-and-pinion steering gear mounts to the bulkhead (firewall), whereas others mount to the engine cradle or frame of the vehicle.
RACK-AND-PINION ADJUSTMENTS

- Some rack-and-pinion steering gears can be adjusted.
- **Pinion torque** is a measurement of how much turning force is needed at the input shaft for the pinion to overcome the resistance of the rack and move it.

**FIGURE 28–35** Pinion torque is a turning torque force measured in inch-pounds or Newton-meters. Tightening the rack support against the rack increases the pinion torque.
FIGURE 28–36 Pinion bearing preload is a measurement of the turning force required to overcome the resistance of the pinion shaft bearings.
1. Most horn circuits use a relay. The horn button or contact on the steering wheel completes the control circuit of the relay, which then completes the power circuit to the horn(s).

2. The driver’s side airbag uses a clockspring spiral cable in the steering column electronically connecting the airbag inflator module.

3. The steering column, which connects the steering wheel to the steering gear, includes the steering shaft universal joint and flexible coupling.

4. Conventional steering gears consist of an input gear and output gear, also called the sector gear.
SUMMARY

5. Steering gear ratio is the number of degrees the steering wheel is rotated compared to the number of degrees the front wheels are rotated. Most steering gears provide a ratio of between 14:1 and 22:1.

6. A recirculating-ball-type steering gear is the most commonly used conventional steering gear.

7. A rack-and-pinion steering gear ties the two tie rods together in a straight line.
REVIEW QUESTIONS

1. What components are included in a typical steering column assembly?
2. When the driver turns the steering wheel, how is the motion transferred to the front wheels through a conventional steering gear?
3. Why are recirculating balls used in the recirculating ball steering gear?
4. What steering gear adjustments are possible on a conventional recirculating-ball-type steering gear?
5. What steering gear adjustments are possible on a typical rack-and-pinion steering gear?
1. The circuit to the airbag inflation module is connected from the steering column to the steering wheel through what component?
   a. Slip ring and carbon brushes
   b. Clockspring (coil)
   c. Magnetic field sensor
   d. Hall-effect switch
2. Which part in the steering column allows for changes in the angle between the upper and lower shafts?

a. Flexible coupling
b. Column cover
c. Universal joint
d. Collapsible section
3. The rotation of the steering wheel causes which part to move the actual steering linkage in a conventional steering gear?
   a. Sector shaft
   b. Pitman arm
   c. Worm gear
   d. Gear nut
4. The pitman shaft is also called the __________.
   a. Sector
   b. Input
   c. Worm
   d. Spline
5. The driver rotates the steering wheel one-half of one revolution (180 degrees) on a vehicle equipped with a steering gear with a 20:1 gear ratio. How many degrees will the front wheels be rotated?

a. 9 degrees  
b. 0.1 degree  
c. 90 degrees  
d. 11.1 degrees
CHAPTER QUIZ

6. What causes a variable-ratio steering gear to be able to change the ratio as the steering wheel is turned?
   a. Using two or three different sector gears depending on design
   b. Using a variable-length pitman arm
   c. Changing the number of teeth on the worm gear
   d. Changing the length of the teeth on the sector gear
7. Recirculating steel balls are used in most conventional steering gears because they ________.

a. Provide for a variable ratio  

b. Keep the steering wheel centered 

c. Reduce friction 

d. Help provide feedback to the driver regarding the road surface
8. Which conventional steering gear adjustment should be the first performed?

a. Worm bearing preload
b. Tolerance adjustment
c. Gear mesh preload
d. Sector shaft endplay
9. The two rack-and-pinion steering gear adjustments include ________.
   a. Worm bearing preload and tolerance adjustment
   b. Pinion bearing preload and rack support
   c. Sector shaft and stub shaft preload
   d. Stub shaft endplay and sector shaft preload
10. A driver of a vehicle equipped with a rack-and-pinion steering gear complains that the steering wheel jerks whenever the vehicle is being driven into a curbed driveway approach at an angle. Technician A says that the rack-and-pinion gears may have too little clearance between the teeth of the gears. Technician B says that a lack of lubrication of the rack-and-pinion is the most likely cause. Which technician is correct?

a. Technician A only  
b. Technician B only  
c. Both Technicians A and B  
d. Neither Technician A nor B