

Module 11: Vehicle Alignment

- TERMS AND DEFINITIONS
- PURPOSES OF WHEEL ALIGNMENT
- REQUIRED TIMES TO PERFORM FRONT WHEEL ALIGNMENT
- CAMBER
- KINGPIN INCLINATION (KPI)
- CASTER
- TOE-IN AND TOE-OUT
- MAXIMUM TURNING ANGLE
- TURNING RADIUS ANGLE
- AXLE ALIGNMENT
- PINION ANGLE ADJUSTMENT
- MINOR FRONT WHEEL ALIGNMENTS
- MAJOR FRONT WHEEL ALIGNMENTS

Terms and Definitions

READY FOR REVIEW

- Alignment refers to the adjustments made in the relationship between axles, steering and suspension components, and tires to bring them into correct positions.
- Camber is the inward or outward tilt of the top of the tires when viewed from the front of the vehicle.
- Caster is the forward or rearward tilt of the kingpin centerline when viewed from the side of the vehicle.
- Kingpin inclination (KPI) is the angle measured between the centerline of the kingpin and the vertical position as viewed from the front of the vehicle.
- Maximum turning angle is the degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position, which is adjusted by stop screws on the steering knuckle.
- The Pythagorean theorem refers to the geometric formula that applies only to right (90°) triangles: $A^2 + B^2 = C^2$.
- Scrubbing is the condition of tires subjected to extreme friction, especially from misalignment.
- Thrust is the force that moves an object forward.
- Thrust angle is the angle between thrust lines and the vehicle's centerline.
- Thrust lines are marks or tracks that indicate forward movement of the rear wheels; they should be parallel to the vehicle's centerline.
- Toe is the angle of the tires from the true straight-ahead position when viewed from the top of the vehicle.
- Turning radius angle is the characteristic angle built into the steering linkage by the manufacturer to allow for the different radii used by the front wheels during a turn.

Note: Because the inner wheel of a vehicle must follow a smaller circle than the outer wheel, the inner and outer wheels must turn at different angles, and this is sometimes referred to as the steering geometry or Ackermann angle.

Purposes of Wheel Alignment

READY FOR REVIEW

- There are four primary purposes of wheel alignment:
 1. To correct steering and tire wear conditions.
 2. To maintain reliable and stable steering.
 3. To maintain steering handling.
 4. To maximize life of tires and suspension parts.

Required Times to Perform Front Wheel Alignment

READY FOR REVIEW

- Every 200,000 miles (320,000 km) or 24 months (normal maintenance).
- When the vehicle does not steer correctly.
- When tires are wearing rapidly or unusually.
- After extremely heavy service or severe impact loads.

Camber

READY FOR REVIEW

- Camber is the inward or outward tilt of the top of the tires when viewed from the front of the vehicle.
- If the top of the tire tilts outward, it has positive camber. If it tilts inward, it has negative camber.
- Incorrect camber angles affect both directional stability and tire wear.
- If there is significant difference in camber from one side of the vehicle to the other, the vehicle will pull to the side with the greater amount of positive camber.
- Excessive positive camber causes the tire to wear on its outside shoulder.
- Excessive negative camber causes the tire to wear on its inside shoulder.
- Use an alignment machine to check this angle, and refer to the equipment manufacturer's directions for operating the machine.
- The camber angle is not adjustable; it is machined into the axle beam. If the camber angle is not within specifications, check the axle beam and steering knuckle for damage, and service as necessary.

Kingpin Inclination (KPI)

READY FOR REVIEW

- KPI is the angle measured between the centerline of the kingpin (knuckle pin) and the vertical position as viewed from the front of the vehicle.
- KPI and camber angle put the approximate center of the tire tread in contact with the road, and this reduces steering effort and improves directional stability.
- Use an alignment machine to check this angle and refer to the equipment manufacturer's directions for operating the machine.
- The KPI is not adjustable. If the inclination is not within specifications, check the axle beam, kingpin, knuckle, or spindles for damage, and service as necessary. Do not bend the axle to alter dimension.

Caster

READY FOR REVIEW

- Caster is the forward or rearward tilt of the kingpin centerline when viewed from the side of the vehicle.
 - Positive caster indicates that the kingpin is tilted rearward.
 - Negative caster indicates that the kingpin is tilted forward.
- Caster is a directional stability angle only, and incorrect caster by itself does not affect tire wear.
- Caster angle helps the driver return the front wheels to a straight-ahead position.
- When two wheels have different caster angles, the vehicle pulls in the direction of the wheel with more negative caster, or less caster if both are positive.
- Use an alignment machine to check this angle, and refer to the equipment manufacturer's directions for operating the machine.
- Possible causes of incorrect caster are weak (sagging) or broken springs, bent or twisted axle, or unequally tightened spring U-bolts.
- Caster is adjusted with tapered shims (wedge-shaped caster plates) installed between the leaf springs and the axle; therefore, adjust caster according to the vehicle manufacturer's instructions.

Toe-In and Toe-Out

READY FOR REVIEW

- Toe is the angle of the tires from the true straight-ahead position when viewed from the top of the vehicle.
- When the tire centerline is parallel with the vehicle centerline, the toe is equal to zero.
- When the front end of the tire points inward toward the vehicle, the tire has toe-in.
- When the front of the tire points outward from the vehicle, the tire has toe-out.
- Toe-in is designed into the vehicle by the manufacturer to counteract the natural tendency of the tires to toe-out when the vehicle is driven.
- Incorrect toe angles usually do not affect directional stability of the vehicle; however, incorrect toe will result in rapid tire wear, and most tire wear is caused by incorrect toe settings.
 - Too much toe-in wears the outer edges of the tires.
 - Too much toe-out wears the inner edge of the tires.
- Toe is calculated in degrees, inches, or millimeters.
- Measuring toe involves marking tires with paint or chalk and measuring the front and back of the tires with a trammel bar. If the toe measurement is not within specifications, the cross tube or the tie rod ends will need to be adjusted; therefore, refer to the vehicle manufacturer's instructions for specifications and procedure.

Maximum Turning Angle

READY FOR REVIEW

- Maximum turning angle is the degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position.
- This angle can be adjusted only if the manufacturer of the vehicle specifies the adjustment; therefore, never increase this angle.
- Use an alignment machine to check this angle, and refer to the equipment manufacturer's directions for operating the machine.
- Adjustable stop screws located on the steering knuckle control this angle; therefore, refer to the service manual for the correct adjustment procedure.
- Proper turning angle prevents the tires from rubbing against the nearest point on the chassis or the steering gear from bottoming.

Turning Radius Angle

READY FOR REVIEW

- The turning radius angle is also called the Ackermann angle or toe-out on turns.
- During a turn, the inner wheel of a vehicle must follow a smaller circle than the outer wheel, which means that the inner and outer wheels must turn at different angles. This angle is called the turning radius angle (or Ackermann angle).
- This angle is built into the design of the tie rod arms, the tie rod ends, and the cross tube assembly by the manufacturer to give the best possible road contact and to minimize tire wear during turns.
- This angle can be checked using an alignment machine with radius plates; therefore, refer to the equipment manufacturer's directions for checking this angle.
- If this angle is not within specifications, inspect the knuckle, tie rod arms, tie rod ends, and cross tube for wear and damage, and service as necessary.

Axle Alignment

READY FOR REVIEW

- Ideally, the vehicle's axles should be perpendicular to the vehicle centerline, and the rear wheels should track directly behind the front wheels when the vehicle is moving straight ahead. When this happens, the thrust line created by the rear wheels is parallel to the vehicle centerline.
- If the axles are not perpendicular to the vehicle centerline, the rear wheels do not track directly behind the front wheels, and the thrust line of the rear wheels deviates from the centerline of the vehicle.
- Any deviation between the centerline and the thrust line is known as the thrust angle.
- Positive thrust angle means that tracking occurs to the right.
- Negative thrust angle means that tracking occurs to the left.
- Tandem-axle vehicles will have a thrust line for each rear axle.
- Axles out of alignment can cause the steering wheel to rest in an uncentered position, the front tires to scrub and wear quickly, and the vehicle to oversteer when turning in one direction and understeer when turning in the other direction.

Pinion Angle Adjustment

READY FOR REVIEW

- Pinion angle is the slope of the centerline of the axle pinion shaft.
 - Working angle of rear axle U-joint is the difference between the drive shaft slope and the pinion angle.
 - Working angle adjustment is for the toe angle and caster and must be held within one degree of each other to prevent driveline vibration problems.
 - The pinion angle may be adjusted by changing the angle of the axle seat or using tapered axle shims similar to caster shims used on front axles.
- Note:** Most rear axles are installed with the pinion sloping downward.
- Drive shaft slope is the angle of centerline of the driveshaft.
 - Engine/transmission slope is the angle of the centerline of the crankshaft/transmission mainshaft.
 - Working angle of transmission U-joint is the difference in angles between the engine slope and the drive shaft slope.
- Note:** On some rear suspensions, the pinion angle can be adjusted with torque rods, which connect the top of the axle to a frame cross member.

Minor Front Wheel Alignments

READY FOR REVIEW

- A minor front wheel alignment is done for all normal maintenance conditions.
- Check and adjust the wheel bearings.
- Inspect all systems that affect wheel alignment, including tire wear and inflation, wheel bearings, tie rods, steering gear, and shock absorbers.
- Check and adjust toe-in.

Major Front Wheel Alignments

READY FOR REVIEW

- A major front wheel alignment is done to correct steering and tire wear conditions.
- If the vehicle has power steering, check and adjust the pressure relief in the power steering system.
- Inspect all systems that affect wheel alignment, including tire wear and inflation, wheel bearings, tie rods, steering gear, and shock absorbers.
- Check the turning radius angle (Ackermann angle).
- Check the KPI.
- Check the camber angle.
- Check and adjust the wheel bearings.
- Check and adjust the caster angle.
- Check and adjust the maximum turning angle.
- Check and adjust toe-in.