INTRODUCTION

A wheel alignment is the adjustment of the suspension and steering to ensure proper vehicle handling with minimum tire wear. After many miles and/or months of driving, the alignment angles can change slightly. By adjusting the suspension and steering components, proper alignment angles can be restored. An alignment includes checking and adjusting, if necessary, both front and rear wheels. Following are the major alignment angles.

Camber is the inward or outward tilt of the wheels from true vertical as viewed from the front or rear of the vehicle. Figure 1.

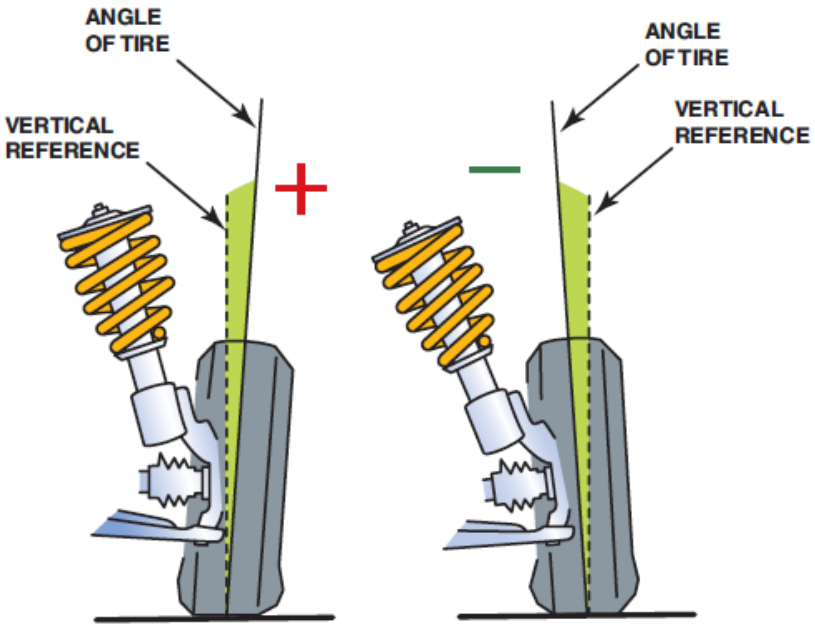

Figure 1. Positive and negative camber.

Camber can cause tire wear if not correct. For example, excessive positive camber causes scuffing and wear on the outside edge of the tire. Camber is not adjustable on many vehicles. Incorrect camber is usually the result of damaged, bent, or worn out components.

Caster is the forward or rearward tilt of the steering axis in reference to a vertical line as viewed from the side of the vehicle. Figure 2.

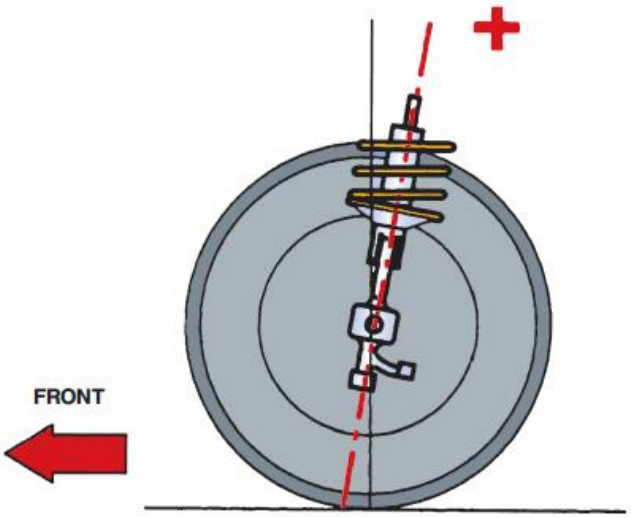

Figure 2. Positive caster.

Caster is a stability angle. If caster is positive, the vehicle steering will be very stable (will tend to go straight with little steering wheel correction needed). This degree of caster helps with steering wheel returnability after a turn.

Caster can cause pull if unequal; the vehicle will pull toward the side with the least positive caster. Caster is not adjustable on many vehicles.

Toe is the difference in distance between the front and rear of the tires. Toe is the most important of the alignment angles. As viewed from the top of the vehicle (a bird's-eye view), zero toe means that both wheels on the same axle are parallel. Incorrect toe is the major cause of excessive tire wear. If not correct, toe causes wear on one side of the tire. Figures 3, 4, and 5.

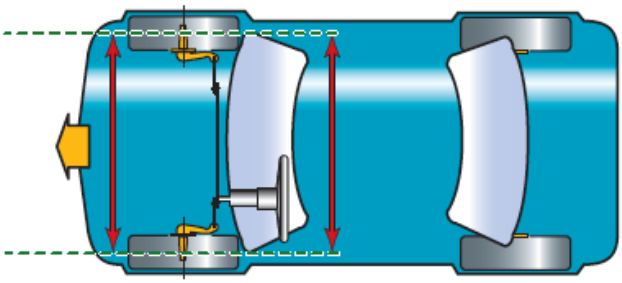

Figure 3. Front toe set to zero.

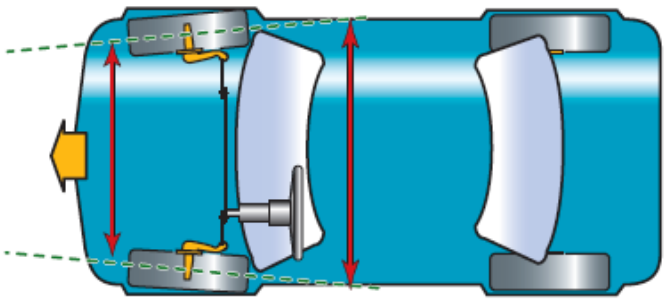

Figure 4. Toe-in (positive toe).

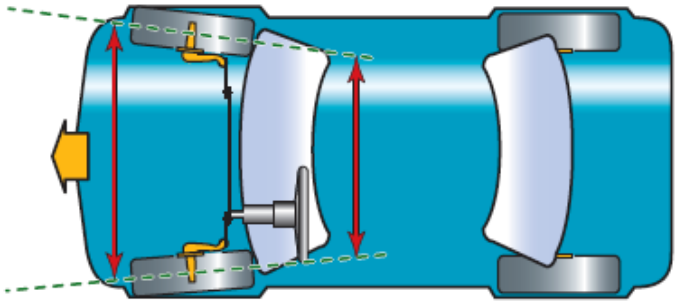

Figure 5. Toe-out (negative toe).

All vehicles can be adjusted for front toe. Some vehicles also have adjustments for rear toe. Front toe adjustment is made by adjusting the tie rod sleeves. Incorrect toe is the major cause of excessive tire wear. If not correct, toe causes wear on one side of the tire. If the toe of the rear wheels is not equal, the steering wheel will not be straight.

ASE TEST TOPICS

1. Diagnose vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return concerns; determine needed action.

Most alignment diagnosis is symptom-based diagnosis. This means that the problem with the alignment is determined from symptoms such as excessive tire wear or a pull to one side of the road. Some conditions are:

PULL A pull is generally defined as a definite tug on the steering wheel toward the left or the right while driving straight on a level road. Bent, damaged, or worn suspension and/or steering components can cause this problem, as well as a tire problem.

LEAD OR DRIFT A lead or drift is a mild pull that does not cause a force on the steering wheel that the driver must counteract. A lead or drift is observed by momentarily removing your hands from the steering wheel while driving on a straight, level road.

WANDER A wander is a condition where constant steering wheel corrections are necessary to maintain a straight-ahead direction on a straight, level road. Worn suspension and/or steering components are the most likely cause of this condition. Incorrect or unequal alignment angles such as caster and toe, as well as defective tire(s), can also cause this condition.

SLOW RETURN TO CENTER Hard-to-steer problems are commonly caused by leaks, either low tire pressure (due to the leak of air) or lack of proper power steering (due to the leak of power steering fluid). Other causes include excessive positive caster on the front wheels or binding steering linkage.

TORQUE STEER Torque steer occurs in front-wheel-drive vehicles when engine torque causes a front wheel to change its angle from straight ahead. Most manufacturers try to reduce torque steer in the

design of their vehicles by keeping drive axle angles low and equal side to side. Check to be sure that the condition is not normal. Figure 6.

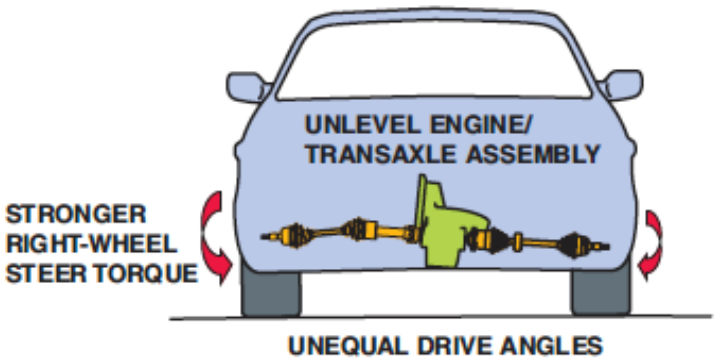

Figure 6. A broken engine mount can cause torque steer.

MEMORY STEER is a term used to describe the lead or pull of a vehicle caused by faults in the steering or suspension system. Often a defective upper strut bearing or steering gear can cause a pulling condition in one direction after making a turn in the same direction.

2. Measure vehicle ride height; determine needed action.

Check ride height according to the manufacturer's specifications. Figure 7.

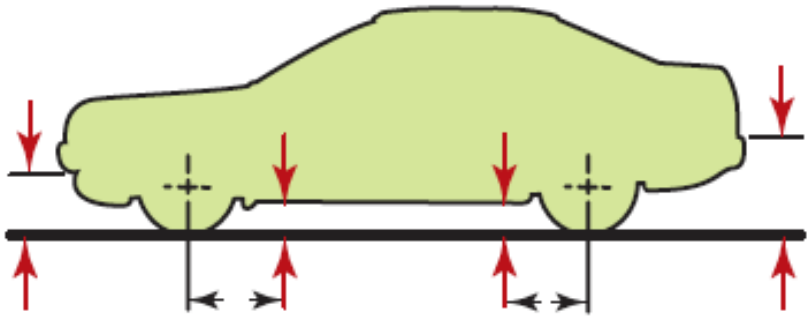

Figure 7. Service information will specify where to make ride height measurements.

3. Measure front and rear wheel camber; determine needed action.

After the alignment equipment is installed and compensated, the front and rear camber angles are displayed. Figure 8.

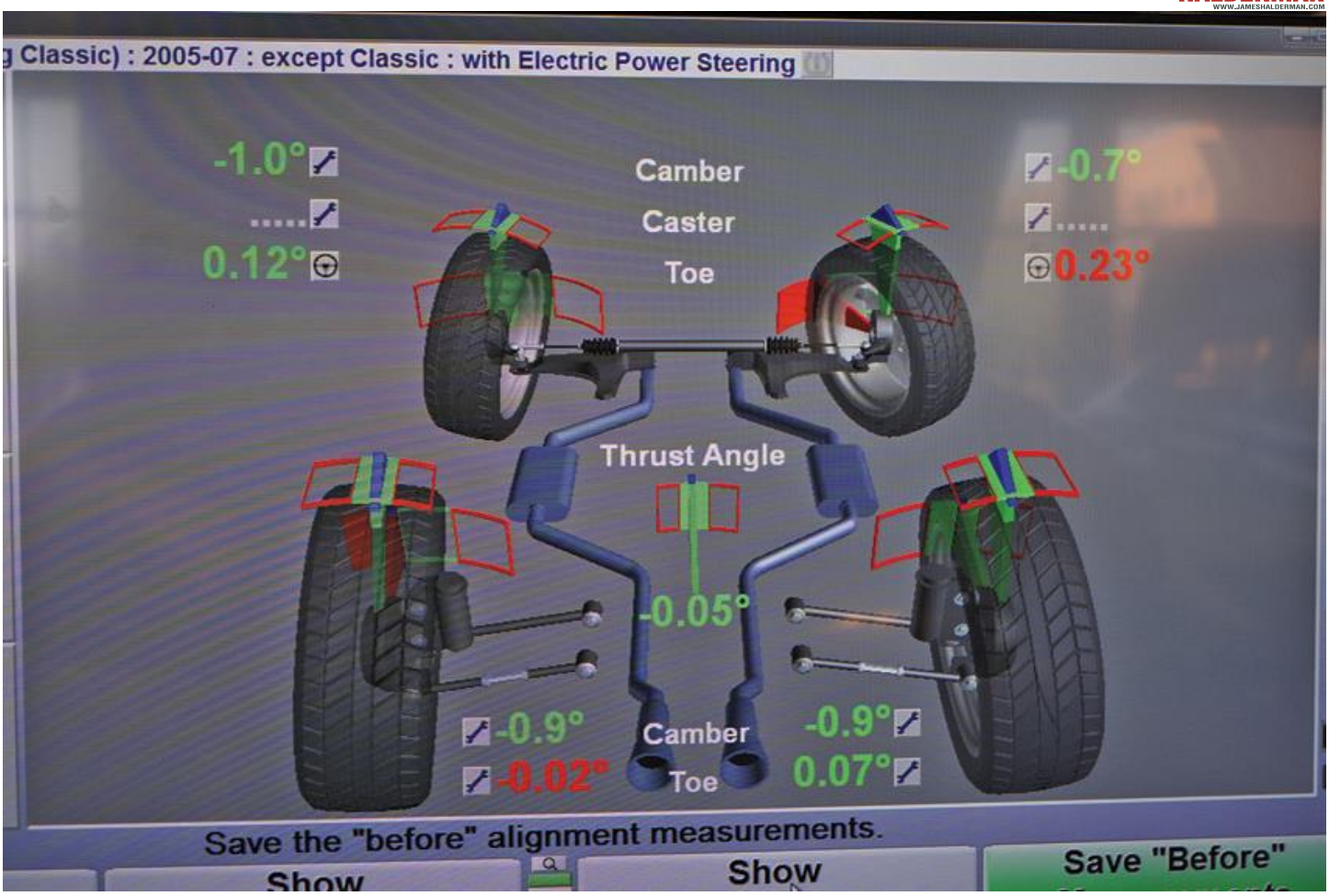

Figure 8. Front and rear camber angles are displayed.

4. Adjust front and/or rear wheel camber on suspension systems with a camber adjustment.

Adjusting rear camber is the first step in the four-wheel alignment process. Figure 9.

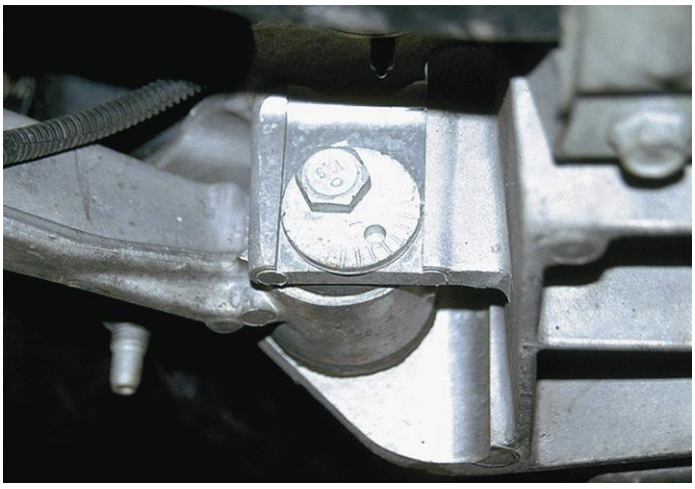

Figure 9. Rear camber may be adjusted with eccentric bolts or threaded rods.

Most vehicles with struts are not adjustable for caster or camber. If incorrect, inspect for damaged or bent components. Many SLA-type suspensions can be adjusted for caster and camber. Most manufacturers recommend adjusting caster, then camber, before adjusting the toe. Figure 10.

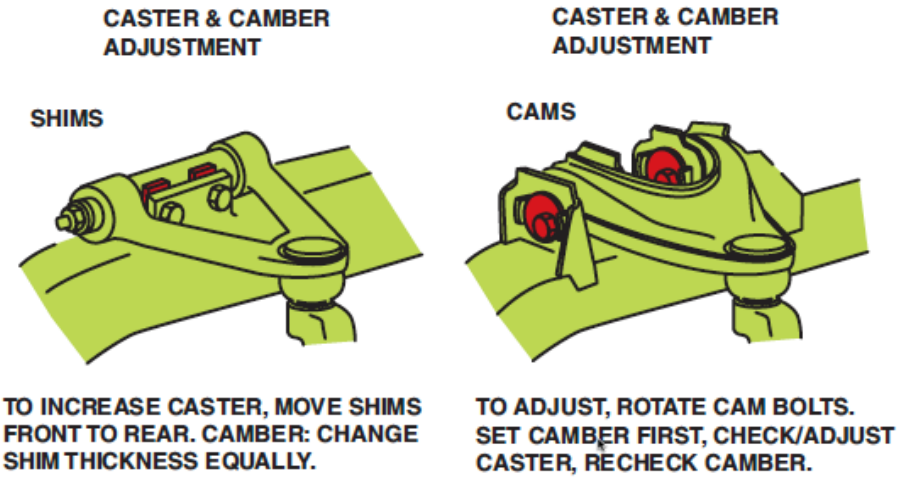

Figure 10. Typical front camber/caster adjustments.

5. Measure caster; determine needed action.

Follow the alignment equipment instructions to display front caster angles. At this point all the alignment angles are displayed. Figure 11.

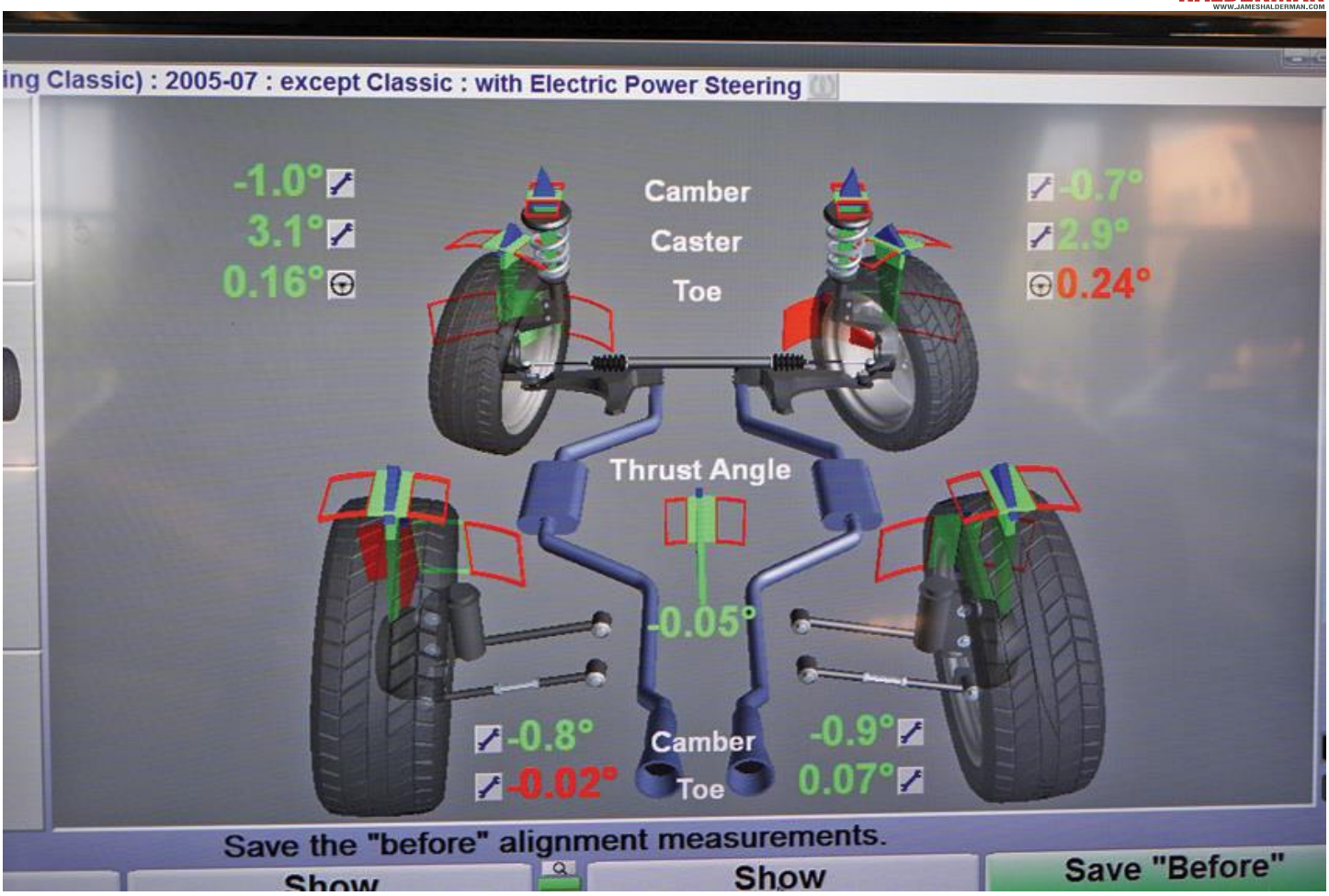

Figure 11. Showing the as-is angles, including caster. Rear toe and front toe need adjustment.

6. Adjust caster on suspension systems with a caster adjustment.

Most vehicles with struts are not adjustable for caster or camber. If incorrect, inspect for damaged or bent components. For caster adjustments many SLA vehicles use shims. Figure 12.

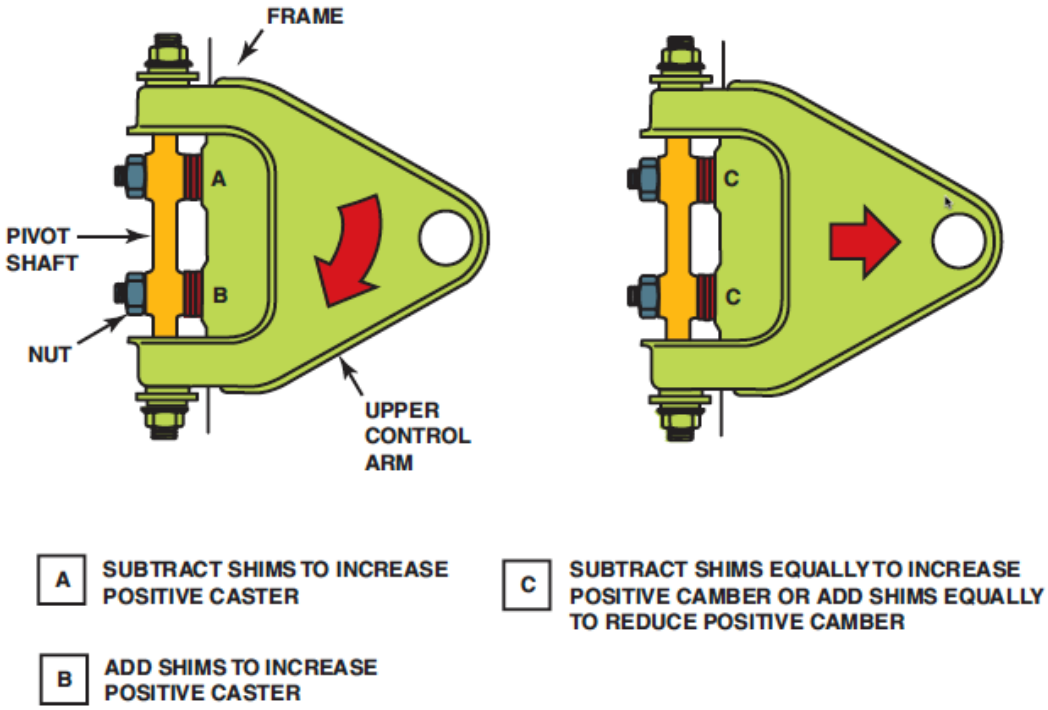

Figure 12. Camber/caster adjustments.

7. Measure and adjust front wheel toe.

Figure 11. shows the toe angles as measured by the alignment machine. Left and right toe angles are corrected by locking the steering wheel in the straight ahead position and adjusting the threaded tie rod ends or tie rod sleeves Figures 13 and 14.

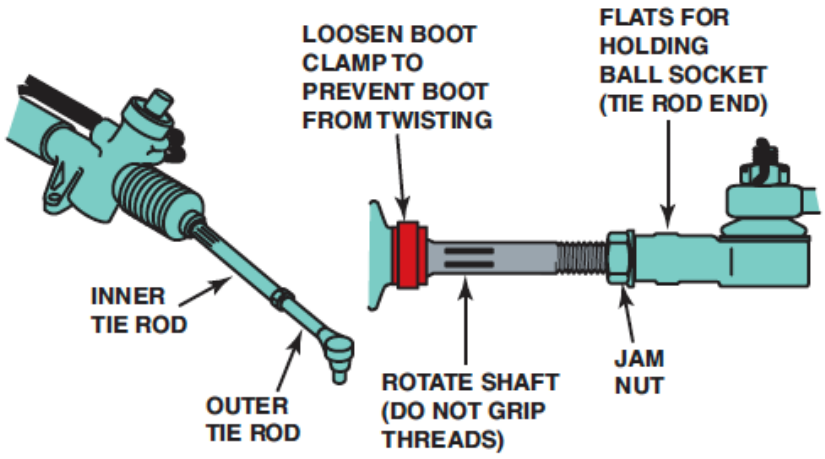

Figure 13. Toe adjustments on rack-and-pinion steering.

Figure 14. A special tie rod adjusting tool is used to rotate the tie rod adjusting sleeves.

8. Center the steering wheel.

Centerline steering is accomplished by adjusting the tie rod length on either side of the vehicle as the toe is being adjusted. Many procedures for setting toe specify that the steering wheel be held in the straight-ahead position using a steering wheel lock. Figure 15.

Figure 15. Before adjusting toe, the steering wheel is centered and leveled, then locked in place.

9. Measure toe-out-on-turns (turning radius/angle); determine needed action.

Toe-out on turns (TOOT) is a diagnostic angle and is normally not measured as part of a regular alignment, but it is recommended to be performed as part of a total alignment check. TOOT is measured

by recording the angle of the front wheels as indicated on the alignment machine display or on the front turn plates.

If, for example, the inside wheel is turned 20 degrees, then the outside wheel should indicate about 18 degrees on the turn plate. Figure 16.

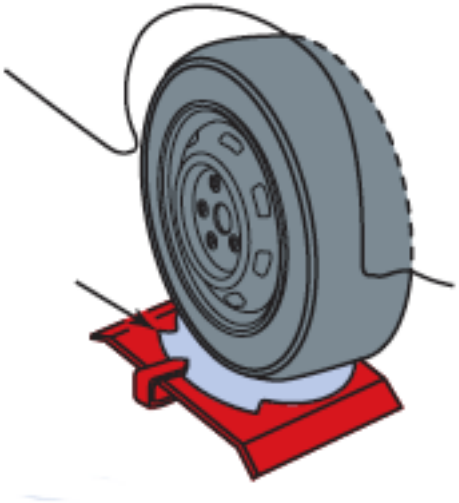

Figure 16. Measuring toe-out on turns (TOOT) angle.

If the TOOT is not correct, a bent steering arm is the usual cause. If TOOT is not correct, tire squealing noise is usually noticed while cornering and excessive tire wear may occur.

10. Measure SAI/KPI (steering axis inclination/king pin inclination); determine needed action.

The steering axis is the angle formed between true vertical, and an imaginary line drawn between the upper and lower pivot points of the spindle. Steering axis inclination (SAI) is the inward tilt of the steering axis. SAI is also known as kingpin inclination (KPI). Figure 17.

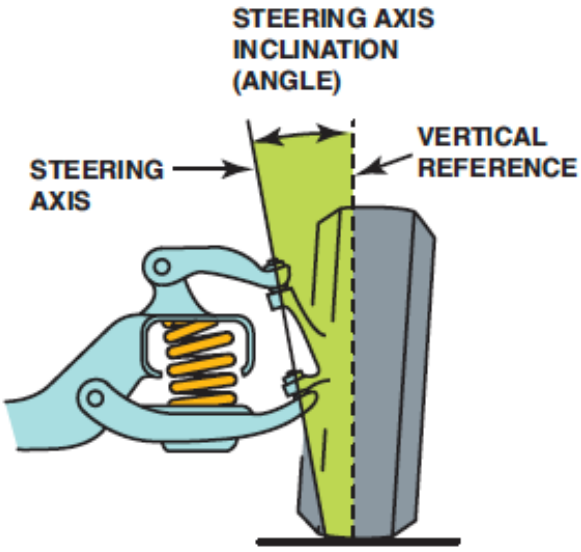

Figure 17. Steering axis inclination.

Steering axis inclination (SAI) is measured while performing a caster sweep of the front wheels.

11. Measure included angle; determine needed action.

The included angle is the SAI added to the camber reading of the front wheels only. The included angle is determined by the design of the steering knuckle, or strut construction. Figure 18.

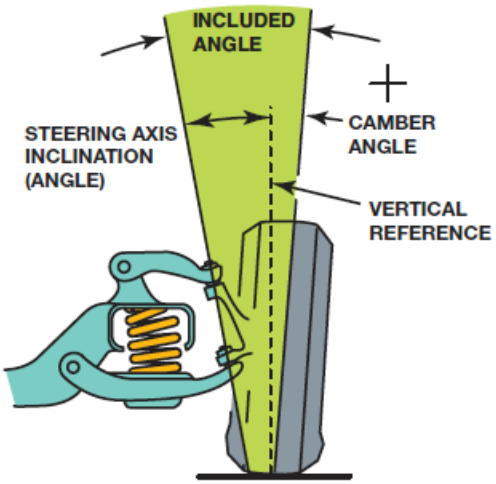

Figure 18. Included angle.

SAI, camber, and included angle measurements are used in diagnosing bent or damaged suspension components. Figure 19.

DIAGNOSING SAI, CAMBER, AND INCLUDED ANGLE			
SLA AND STRUT/SLA SUSPENSIONS			
SAI	**CAMBER**	**INCLUDED ANGLE**	**DIAGNOSIS**
CORRECT	LESS THAN SPECS	LESS THAN SPECS	BENT STEERING KNUCKLE OR SPINDLE
LESS THAN SPECS	GREATER THAN SPECS	CORRECT	BENT LOWER CONTROL ARM
LESS THAN SPECS	GREATER THAN SPECS	GREATER THAN SPECS	BENT LOWER CONTROL ARM AND STEERING KNUCKLE OR SPINDLE
GREATER THAN SPECS	LESS THAN SPECS	CORRECT	BENT UPPER CONTROL ARM

Figure 19. Diagnostic angles chart.

12. Measure rear wheel toe; determine needed action.

13. Measure thrust angle; determine needed action.

Thrust angle is the angle of the rear wheels as determined by the total rear toe. The total of the rear toe setting determines the thrust line, or the direction the rear wheels are pointed. Unequal toe in the rear can cause the vehicle to pull or lead.

Rear toe and thrust angles are displayed by the alignment equipment. In this example both the toe and thrust angles are slightly out of adjustment. Figures 20 and 21.

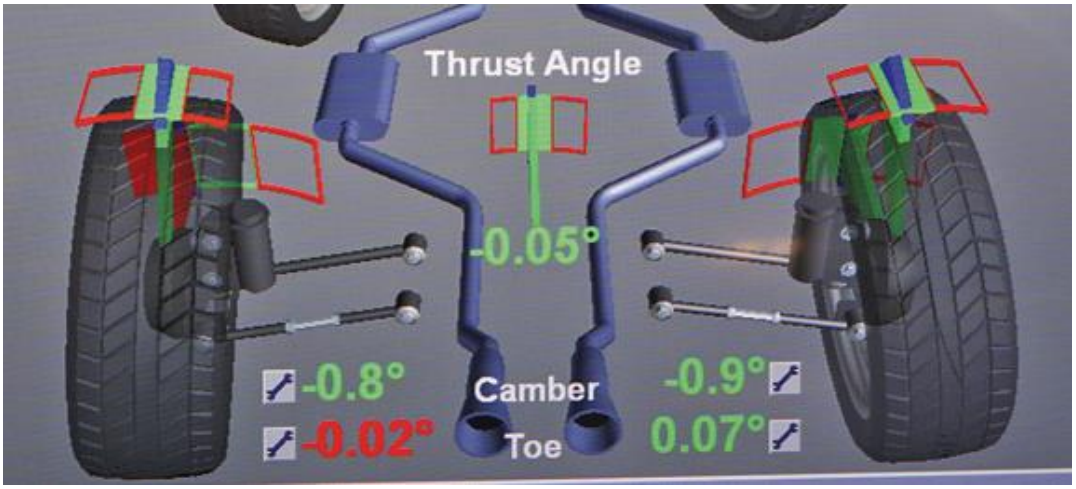

Figure 20. Rear toe and thrust angle. Adjusting toe to a positive reading will also correct the thrust angle.

Figure 21. Rear toe adjustment.

14. Measure wheelbase setback/offset; determine needed action.

Setback is the angle formed by a line drawn perpendicular (at 90 degrees) to the front axles. Setback can be measured with a four-wheel alignment machine or can be determined by measuring the wheelbase on both sides of the vehicle. Figure 22.

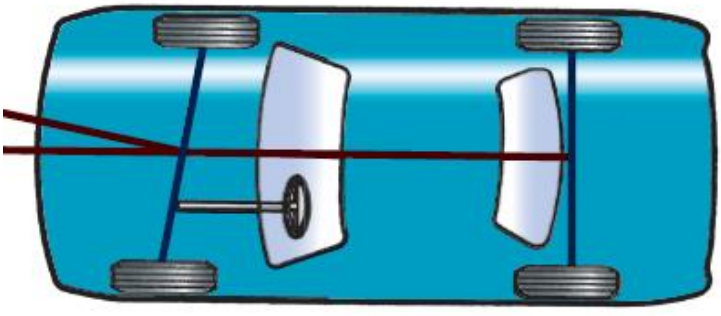

Figure 22. Illustration of setback.

The causes of setback include the following:

- Cradle placement is not correct on a front-wheel-drive vehicle. This can be caused by incorrectly installing the cradle after a transmission, clutch, or engine replacement or service. Figure 23.
- An accident that affected the frame or cradle of the vehicle and was unnoticed or not repaired.

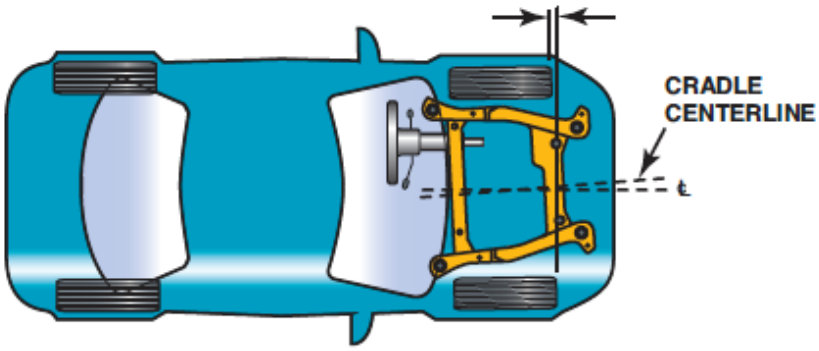

Figure 23. Incorrect cradle position.

15. Check front and/or rear subframe/cradle/crossmember alignment; determine needed action.

If the cradle is out of location due to previous service work or an accident, knowing SAI, camber, and the included angle can help in determining what needs to be done to correct the problem. The example below shows that the included angle is equal on both sides, but the camber and SAI are not equal. Figure 24.

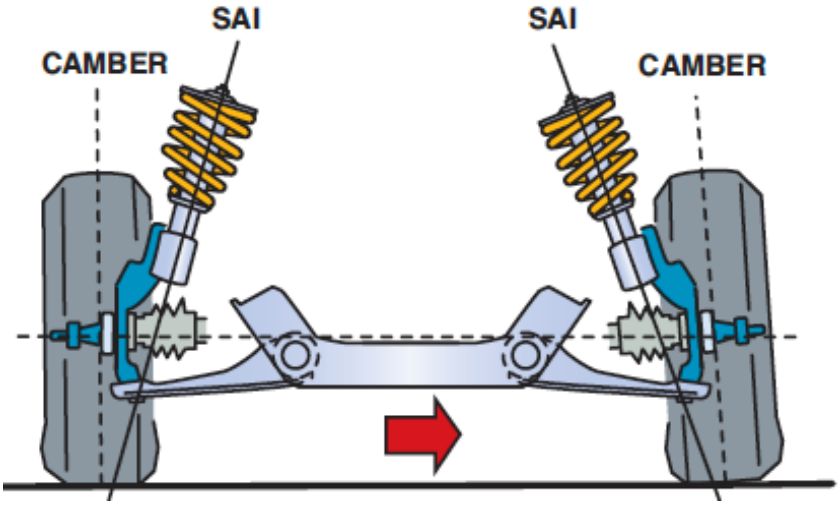

Figure 24. Front cradle is shifted to the right, causing unequal camber readings.

16. Perform electronic control module calibration/recalibration; perform initialization or relearn procedure as required.

When aligning a vehicle equipped with an electronic suspension, several additional steps may be required. The steering wheel angle, as well as the radar cruise control sensor, will often need to be recalibrated using a scan tool.

- The radar cruise control needs to be calibrated to the revised rear thrust angle using a scan tool.
- Some newer vehicles can self-calibrate by having the wheel turned from lock to lock and then centered and cycling the key or when they are driven straight on a level road for a certain amount of time.
- Many systems require recalibration using a scan tool or a special tester that plugs into the data link connector (DLC). Figures 25 and 26.

Figure 25. The wireless reset tool is attached to the DLC.

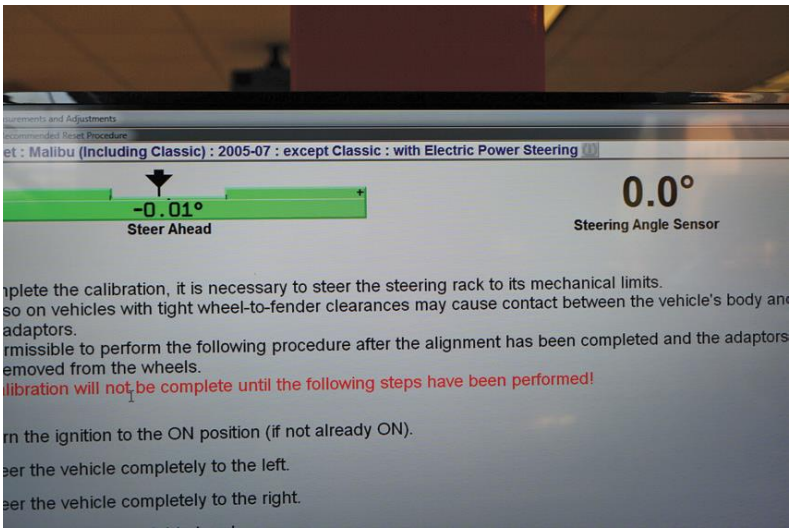

Figure 26. Steering angle sensor reset to zero degrees with the wheels straight ahead.

17. Diagnose wheel alignment problems caused by damaged component mounting locations; determine needed action.

Many accidents result in hidden structural damage that can cause alignment angles to be out of specification. If alignment angles are out-of-specification tolerances, then accident damage should be suspected. This type of damage often shows up as setback or thrust line errors. Figure 27.

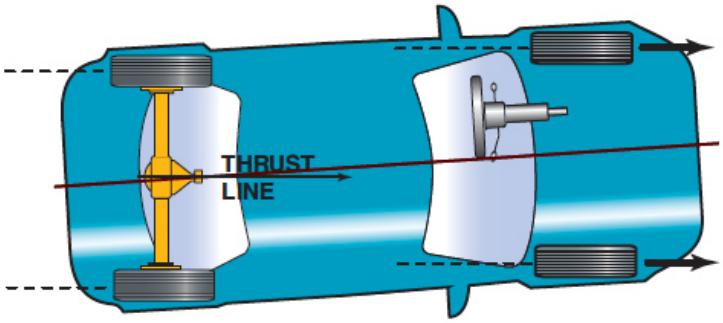

Figure 27. Thrust line error caused by displaced rear axle mounts.

Jig holes are used at the assembly plant to precisely locate suspension and drivetrain components. When checking for body or frame damage, check service information for the exact place to measure and the specified dimensions. Figure 28.

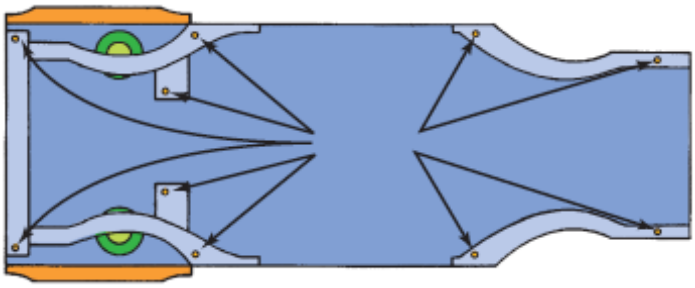

Figure 28. Frame measurement points.