TECH TIP: Align and Replace at the Same Time

Magnetic bubble-type camber/caster gauges can be mounted directly on the hub or on an adapter attached to the wheel or spindle nut on front-wheel-drive vehicles. - SEE FIGURE 120–2. Besides being used as an alignment setting tool, a magnetic alignment head is a great tool to use whenever replacing suspension components. Any time a suspension component is replaced, the wheel alignment should be checked and corrected as necessary. An easy way to avoid having to make many adjustments is to use a magnetic alignment head on the front wheels to check camber with the vehicle hoisted in the air before replacing front components, such as new MacPherson struts. Then, before tightening all of the fasteners, check the front camber readings again to make sure they match the original setting. This is best done when the vehicle is still off the ground. For example, a typical front-wheel-drive vehicle with a MacPherson strut suspension may have a camber reading of +1/4 degree on the ground and +2 degrees while on the hoist with the wheels off the ground. After replacing the struts, simply return the camber reading to +2 degrees and it should return to the same +1/4 degree when lowered to the ground.

Though checking and adjusting camber before and after suspension service work does not guarantee a proper alignment, it does permit the vehicle to be moved around with the alignment fairly accurate until a final alignment can be performed.

Figure 120–5. The owner of this Honda thought that all it needed was an alignment. Obviously, something more serious than an alignment caused the left rear wheel to angle inward at the top.
Figure 120-2 Magnetic bubble-type camber/caster gauge. To help it keep its strong magnetism, it is best to keep it stored stuck to a metal plate or metal tool box.

Figure 120-3 Typical tire wear chart as found in a service manual. Abnormal tire wear usually indicates faults in a steering or suspension component that should be corrected or replaced before an alignment is performed.

Figure 120-4 Measuring points for ride (trim) height vary by manufacturer. (Courtesy of Hunter Engineering Company)
Figure 120-5  Measuring to be sure the left and right sides of the vehicle are of equal height. If this measurement is not equal side-to-side by as little as 0.06 in. (1.6 mm), it can affect the handling of the vehicle.

Figure 120-6  The bulge in this tire was not noticed until it was removed from the vehicle as part of a routine brake inspection. After replacing this tire, the vehicle stopped pulling and vibrating.

Figure 120-7  Equal outer CV joint angles produce equal steer torque (toe-in). If one side receives more engine torque, that side creates more toe-in and the result is a pull toward one side, especially during acceleration.
REAL WORLD FIX: The Five-Wheel Alignment

The steering wheel should always be straight when driving on a straight, level road. If the steering wheel is not straight, the customer will think the steering alignment is not correct. One such customer complained that the vehicle was pulling while driving on a straight road. The service manager drove the car and everything was perfect, except that the steering wheel was not perfectly straight, even though the toe setting was correct. Whenever steering on a straight road, the customer insisted, the steering wheel and the vehicle would move to one side. The technician determined that regardless of the toe settings, the steering wheel must be straight; it is the "fifth wheel" that the customer notices most. Therefore, a five-wheel alignment rule includes a check of the steering wheel.

NOTE: Many vehicle manufacturers now include the maximum allowable steering wheel angle variation from straight. This specification is commonly ±3 degrees (plus or minus 3 degrees) or less.
CHART 120–1  This vehicle alignment specification chart indicates the preferred setting with a
plus or minus tolerance.

<table>
<thead>
<tr>
<th>FRONT</th>
<th>LEFT</th>
<th>CENTER</th>
<th>RIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>0°</td>
<td>±1°</td>
<td>±1°</td>
</tr>
<tr>
<td>0°</td>
<td>0°</td>
<td>±1°</td>
<td>±1°</td>
</tr>
</tbody>
</table>

Figure 120–9  Using the alignment rack hydraulic jacks, raise the tires off the rack so that they
can be rotated as part of the compensating process.

Figure 120–10  This wheel sensor has a safety wire that screws to the valve stem to keep the
sensor from falling onto the ground if the clamps slip on the wheel lip.
Figure 120-11 If toe for an oversize tire is set by distance, the toe angle will be too small. Toe angle is the same regardless of tire size.

Figure 120-12 The protractor scale on the front turn plates allows the technician to test the turning radius by turning one wheel to an angle specified by the manufacturer and observing the angle of the other front wheel. Most newer alignment machines can display turning angle based on sensor readings, and therefore the protractor scale on the turn plate is not needed or used.

TECH TIP: Damage Analysis Tips
To check if a vehicle has been in a collision, technicians should look for the following:
1. Drive the vehicle through a water puddle to see if the tire marks are wider than the tires. If they are, then the front and rear wheels are not tracking correctly.
2. If the setback is out of specifications, then the front of the vehicle may be damaged.
3. If the thrust angle is out of specifications, then rear suspension damage is likely.
By checking the SAI, camber, and included angle, a damaged suspension component can be determined by using this chart.

In this example, both SAI and camber are far from being equal side-to-side. However, both sides have the same included angle, indicating that the frame may be out of alignment. An attempt to align this vehicle by adjusting the camber on both sides with either factory or aftermarket kits would result in a totally incorrect alignment.
Figure 120-14 This is the same vehicle as shown in Figure 120–13, except now the frame (cradle) has been shifted over and correctly positioned. Notice how both the SAI and camber become equal without any other adjustments necessary.

Figure 120-15 Geometric-centerline-type alignment sets the front toe readings based on the geometric centerline of the vehicle and does not consider the thrust line of the rear wheel toe angles. (Courtesy of Hunter Engineering Company)

Figure 120-16 Thrust line alignment sets the front toe parallel with the rear-wheel toe. (Courtesy of Hunter Engineering Company)
Figure 120-17  Front-wheel alignment corrects for any rear-wheel toe to make the thrust line and the geometric centerline of the vehicle both the same. (Courtesy of Hunter Engineering Company)

TECH TIP: Ask Yourself These Three Questions
An older technician told a beginning technician that the key to success in doing a proper alignment is to ask yourself three questions about the alignment angles:

Question 1. "Is it within specifications?" For example, if the specification reads 1° ± 1/2°, any reading between +1/2° and 1 1/2° is within specifications. All vehicles should be aligned within this range. Individual opinions and experience can assist the technician as to whether the actual setting should be at one extreme or the other or held to the center of the specification range.

Question 2. "Is it within 1/2° of the other side of the vehicle?" Not only should the alignment be within specifications, but it should also be as equal as possible from one side to the other. The difference between the camber from one side to the other side is called cross camber. Cross caster is the difference between the caster angle from one side to another. Some manufacturers and technicians recommend that this side-to-side difference be limited to just 1/4 degree!

Question 3. "If the camber and caster cannot be exactly equal side-to-side in the front, is there more camber on the left and more caster on the right to help compensate for road crown?" Seldom, if ever, are the alignment angles perfectly equal. Sometimes one side of the vehicle is more difficult to adjust than the other side. Regardless of the reasons, if there has to be a difference in front camber and/or caster angle, follow this advice to avoid a possible lead or drift problem even if the answers to the first two questions are yes.
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Question 3. If the camber and caster cannot be exactly equal side-to-side in the front, is there more camber on the left and more caster on the right to help compensate for road crown? Seldom, if ever, are the alignment angles perfectly equal. Sometimes one side of the vehicle is more difficult to adjust than the other side. Regardless of the reasons, if there has to be a difference in front camber and/or caster angle, follow this advice to avoid a possible lead or drift problem even if the answers to the first two questions are "yes."

FREQUENTLY ASKED QUESTION: How Does Normal Wear Affect the Alignment Angles?

As a vehicle ages, the springs sag and steering and suspension components wear.

- When springs sag the ride height changes and the camber usually is reduced and often becomes negative. The negative camber will be higher position under the sweetside extreme in vehicle.
- When tie rod ends and other steering components wear, the front wheels tend to toe out.
- Worn suspension components can cause excessive play making the vehicle unstable and cause the tires to wear abnormally.

Alignment alone cannot take the place of worn parts. All an alignment can do is try to compensate for the worn parts.

Figure 120-18 - The rear camber is adjustable on this vehicle by rotating the eccentric cam and watching the alignment machine display.
Figure 120-19: Some vehicles use a threaded fastener similar to a tie rod to adjust camber on the rear suspension.

**TECH TIP: The Gritty Solution**

Many times it is difficult to loosen a Torx bolt, especially those used to hold the backing plate onto the rear axle on many GM vehicles. **SEE FIGURE 120–21.**

A technique that always seems to work is to place some valve grinding compound on the fastener. The gritty compound keeps the Torx socket from slipping up and out of the fastener, and more force can be exerted to break loose a tight bolt. Valve grinding compound can also be used on Phillips head screws as well as other types of bolts, nuts, and sockets.

Figure 120-20: Aftermarket alignment parts or kits are available to change the rear camber.
Full-contact plastic or metal shims can be placed between the axle housing and the brake backing plate to change rear camber, toe, or both. (Courtesy of Northstar Manufacturing Company, 2011)

The rear toe was easily set on this vehicle. The adjusting nuts were easy to get to and turn. Adjusting rear toe is not this easy on every vehicle.

By moving various rear suspension members, the rear toe can be changed.
The use of these plastic or metal shims requires that the rear wheel as well as the hub assembly and/or backing plate be removed. Proper torque during reassembly is critical to avoid damage to the shims.

Many struts allow camber adjustment at the strut-to-knuckle fasteners. Here a special tool is being used to hold and move the strut into alignment with the fasteners loosened. Once the desired camber angle is achieved, the strut nuts are tightened and the tool is removed.

Some struts require modifications of the upper mount for camber adjustment.
Figure 120-27  An example of the many methods that are commonly used to adjust front caster and camber.

Figure 120-28  If there is a nut on both sides of the strut rod bushing, then the length of the rod can be adjusted to change caster.

Figure 120-29  Placing shims between the frame and the upper control arm pivot shaft is a popular method of alignment for many SLA suspensions. Both camber and caster can be easily changed by adding or removing shims.
The general rule of thumb is that a 1/8-in. shim added or removed from both shim locations changes the camber angle about 1/2 degree. Adding or removing a 1/8-in. shim from one shim location changes the caster by about 1/4 degree.

Some SLA-type suspensions use slotted holes for alignment angle adjustments. When the pivot shaft bolts are loosened, the pivot shaft is free to move unless held by special clamps as shown. By turning the threaded portion of the clamps, the camber and caster can be set and checked before tightening the pivot shaft bolt.

When the nut is loosened and the bolt on the eccentric cam is rotated, the upper control arm moves in and out. By adjusting both eccentric cams, both camber and caster can be adjusted.
TECH TIP: Race Vehicle Alignment

Vehicles used in autocrossing (individual timed runs through cones in a parking lot) or road racing usually perform best if the following alignment steps are followed:

1. Increase caster (+). Not only will the caster provide a good solid feel for the driver during high speed on a straight section of the course, but it will also provide some lean into the corners due to the camber change during cornering. A setting of 5 to 9 degrees positive caster is typical depending on the type of vehicle and the type of course.

2. Adjust for 1 to 2 degrees of negative camber. As a race vehicle corners, the body and chassis lean. As the chassis leans, the top of the tire also leans outward. By setting the camber to 1 to 2 degrees negative, the tires will be neutral while cornering, thereby having as much rubber contacting the road as possible.

NOTE: Though setting negative camber on a street-driven vehicle will decrease tire life, the negative setting on a race vehicle is used to increase cornering speeds, and tire life is not a primary consideration.

3. Set toe to a slight toe-out position. When the front toe is set negative (toe-out), the vehicle is more responsive to steering commands from the driver. With a slight toe-out setting, one wheel is already pointed in the direction of a corner or curve. Set the toe-out to -3/8 to -1/2 degree depending on the type of vehicle and the type of race course.

Figure 120-33 Typical shim alignment chart. As noted, 1/8-in. (0.125) shims can be substituted for 1/16-in. (0.0625) shims and 1/32-in. (0.060-in.) shims can be substituted for the 0.060-in. shims.

Figure 120-34 Many procedures for setting toe specify that the steering wheel be held in the center-ahead position using a steering wheel lock, as shown. One method recommended by Hunter Engineering sets toe without using a steering wheel lock.
Adjusting toe by rotating the tie rod on a vehicle equipped with rack-and-pinion steering.

FLATS FOR HOLDING BALL SOCKET (TIE ROD END)

LOosen BOOt CLAMP TO PREVENT BOOt FROM TWISTING

INNER TIE ROD

OUTER TIE ROD

ROTATE SHAFT (DO NOT GRIP THREADS)

JAM NUT

Special tie rod adjusting tools should be used to rotate the tie rod adjusting sleeve. The tool grips the slot in the sleeve and allows the service technician to rotate the sleeve without squeezing or damaging the sleeve.
TECH TIP: Locking Pliers to the Rescue

Many vehicles use a jam nut on the tie rod end. This jam nut must be loosened to adjust the toe. Because the end of the tie rod is attached to a tie rod end that is movable, loosening the nut is often difficult. Every time force is applied to the nut, the tie rod end socket moves and prevents the full force of the wrench from being applied to the nut. To prevent this movement, simply attach locking pliers (Vise Grip™) to hold the tie rod. Wedge the pliers against the control arm to prevent any movement of the tie rod. By preventing the tie rod from moving, full force can be put on a wrench to loosen the jam nut without doing any harm to the tie rod end.

Figure 120-38 Most vehicles have alignment marks made at the factory on the steering shaft and steering wheel to help the service technician keep the steering wheel in the center position.

Figure 120-39 A puller being used to remove a steering wheel after the steering wheel retaining nut has been removed.
REAL WORLD FIX: Left Thrust Line, but a Pull to the Right!

A new four-door sport sedan had been aligned several times at the dealership in an attempt to solve a pull to the right. The car had front-wheel-drive and four-wheel independent suspension. The dealer rotated the tires, and it made no difference. The alignment angles of all four wheels were in the center of specifications. The dealer even switched all four tires from another car in an attempt to solve the problem.

In frustration, the owner took the car to an alignment shop. Almost immediately the alignment technician discovered that the right rear wheel was slightly toed-in. This caused a pull to the right. - SEE FIGURE 120–40.

The alignment technician adjusted the toe on the right rear wheel and reset the front toe. The car drove beautifully.

The owner was puzzled about why the new car dealer was unable to correct the problem. It was later discovered that the alignment machine at the dealership was out of calibration by the exact amount that the right rear wheel was out of specification. The car pulled to the right because the independent suspension created a rear steering force toward the left that caused the front to pull to the right. Alignment equipment manufacturers recommend that alignment equipment be calibrated regularly.
Figure 120-41 (b) Installation of this kit requires that the upper control arm shaft be removed. Note that the upper control arm was simply rotated out over the wheel pivoting on the upper ball Joint.

Figure 120-42 (a) The installation of some aftermarket alignment kits requires the use of special tools such as the cutter being used to drill out spot welds on the original alignment plate on a strut tower.

Figure 120-42 (b) Original plate being removed.
Figure 120-42  (c) Note the amount of movement the upper strut bearing mount has around the square openings in the strut tower. An aftermarket plate can now be installed to allow both camber and caster adjustments.

Figure 120-43  A typical tire temperature pyrometer. The probe used is a needle that penetrates about 1/4 inch (7 mm) into the tread of the tire for most accurate readings.

Figure 120-44  Jig holes used at the assembly plant to locate suspension and drivetrain components. Check service information for the exact place to measure and the specified dimension when checking for body or frame damage.
ALIGNMENT DIAGNOSIS AND SERVICE

TECH TIP: TSBs Can Save Time

Technical service bulletins (TSBs) are issued by vehicle and aftermarket manufacturers to inform technicians of a solution or technical problem and give the correct or parts needed to solve the problem. TSBs are often released by new vehicle manufacturers to the dealership service department. They usually involve the current-year vehicle or a similar model. Most TSBs concern repair problems or minor problems. They often contain very helpful solutions to hard-to-find problems. Most TSBs can be purchased directly from the manufacturer, but the cost is usually very high. TSBs can also be purchased through aftermarket companies that sell them and are available on a website. Go to the National Automotive Service Task Force (NASTF) website (www.NASTF.org) for a list of the websites for all vehicle manufacturer’s websites. TSBs can be purchased directly. Factory TSBs can often save the technician many hours of troubleshooting.

ALIGNMENT DIAGNOSIS AND SERVICE

ALIGNMENT 1 Begin the alignment procedure by first driving the vehicle onto the alignment rack as straight as possible.

ALIGNMENT 2 Position the front tires in the center of the turn plates. These turn plates can be moved in and out to match a vehicle of any width.
ALIGNMENT 3
Raise the vehicle and position the alignment rack following the rack manufacturer's instructions.

ALIGNMENT 4
Check and adjust tire pressures and perform the prealignment checks necessary to be assured of proper alignment.

ALIGNMENT 5
Select the exact vehicle on the alignment machine.
ALIGNMENT 6  Securely mount the alignment heads or target wheels.

ALIGNMENT 7  If mounting a transmitter-type alignment head, be sure to attach the retaining wire to the tire valve.

ALIGNMENT 8  After installation of the heads, follow the specified procedure for compensation, which shows accurate alignment readings.
ALIGNMENT 9  Rolling compensation is used on machines that use lasers and wheel targets.

ALIGNMENT 10  An alignment reading is displayed even though caster has not yet been measured. The readings marked in red indicate that they are not within specifications.

ALIGNMENT 11  Before performing a caster sweep, install a brake pedal depressor to keep the front wheels from rotating when the steering wheel is turned.
ALIGNMENT 12 Perform the caster sweep by turning the front wheels inward, and then outward following the instructions on the screen.

ALIGNMENT 13 Most alignment machines will display where to make the alignment correction and will often include drawings and live-action videos that show the procedure.

ALIGNMENT 14 The rear toe is being adjusted by rotating the eccentric cam on the lower control arm while watching the display.
ALIGNMENT 15

The alignment machine display indicates that front caster is not a factory-adjustable angle.

ALIGNMENT 16

Adjusting the front toe on this vehicle involves loosening the jam nut (left wrench) and rotating the tie rod using the right wrench.

ALIGNMENT 17

One last adjustment of the left front toe is needed to achieve a perfect alignment. The final alignment reading can be printed and attached to the work order.
After disconnecting all of the attachments, reinstalling the valve caps, and returning the steering wheel holder, the vehicle should be test driven to check for proper alignment before returning it to the customer.