MODULE CONTENT

| Unit of Competency | **DIAGNOSE AND REPAIR STEERING SYSTEM** |
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| Module Title | **DIAGNOSING AND REPAIRING STEERING SYSTEM** |
| Module Descriptor | This unit identifies the competence required to perform basic diagnose and repair the clutch system. |
| Nominal Duration | **hours** |
| Summary of the Learning Outcomes: | |
| Upon completion of this module the student must be able to: | |
| LO1. Prepare to diagnose and repair steering system | |
| LO2. Diagnose steeringsystem | |
| LO3. Repair steering system | |
| LO4. Complete work processes | |

**LEARNING EXPERIENCES**

**LEARNING OUTCOMES NO. 4**

**COMPLETE WORK**

| **Learning Activities** | **Special Instructions** |
| --- | --- |
| Read Information Sheet 3.1-1 Complete work processes | If you have some problem with the content of the information sheet don’t hesitate to approach your Trainer.  If you feel that you are now knowledgeable on the content of the information sheet, you can now answer the self-check provided in the module. |
| Answer Self-Check 3.1-1 on Complete work processes | Try to answer the Self-check without looking at the Answer Key  Compare your answer to Answer Key 3.1-1 |
| Observe Trainer’s demonstration on Task Sheet 3.1-1 on Complete work processes | Listen carefully and attentively so that you may be able to perform a task correctly  Ask questions if are in doubt for clarification |
| Perform the Task Sheet 3.1-1 on Complete work processes | Remember the step-by-step procedure the Complete work processes |
| Evaluate the performance using the Performance Criteria Checklist 3.1-1 | Repeat the task in case fail to meet the criteria |

**INFORMATION SHEET 1.1-1**

**COMPLETE WORK**

**Learning Objectives:**

After reading this **Information Sheet**, you must be able to:

1. Made final inspection.
2. Turned-over vehicle.
3. Restored work area.
4. Managed wastes.
5. Checked and stored tools and equipment.
6. Accomplished workplace documents.

**STEERING SYSTEM**

**Perform wheel balancing**

Tire and wheel assemblies provide the only connection between the road and the vehicle. The tire design has improved dramatically during the past few years. Modern tires require increased attention to achieve their full potential of extended service and correct ride control. Tire wear that is uneven o premature is usually a good indication of steering and suspension system problems. Tires, therefore, become not only a good diagnostic aid to a technician, but also be clear evidence to the customer that there is a need for service.

**WHEELS**

Wheels are made of either stamped or pressed steel discs riveted or welded together. They are also available in the form of aluminum or magnesium rims that are die-cast or forged **(Figure 42-1).** Magnesium wheels are commonly referred to as mag wheels, although they are usually made of an aluminum alloy. Aluminum wheels are lighter in weight compared with the stamped steel type. This weight savings is important because the wheels and tires on a vehicle are unsprung weight. This means of weight is not supported by the vehicle’s springs.

**Figure 42-1** An alloy wheel on a late-model car.

Near the end of the wheel are mounting holes that are tapered to fit mounting nuts **(lug nuts)** that center the wheel over the hub. The rim has a hole for the tire’s **valve stem** and a **drop center** are designed to allow for easy tire removal and installation. **Wheel offset** is the vertical distance between the centerline of the rim and the mounting face of the wheel. The offset is considered positive if the centerline of the rim is inboard of the mounting face and negative if outboard of the mounting face. The amount and type of offset is critical because changing the wheel offset changes the front suspension loading as well as the scrub radius.

The wheel is bolted to a hub, either by lug bolts that pass through the wheel and thread into the hub, or by studs that protrude from the hub. In the case of studs, special lug nuts are required. A few vehicles have left-hand threads (which turn counterclockwise to tighten) on the driver’s side and right-hand threads (which turn clockwise to tighten) on the passenger’s side. All other vehicles use right-hand threads on both sides.

Wheel sides are designated by rim width and rim diameter **(Figure 42-2).** Rim width is determined by measuring across the flanges. Rim diameter is measured across the bead seating areas form the top to the bottom of the wheel. Some rims have safety ridges near the lips. In the event of a tire from moving into the dropped center and from coming the wheel.

**Figure 42-2** Wheel dimensions are important when replacing tires.

Replacement wheels must be equal to the original equipment in the load capacity, diameter, width, offset, and mounting configuration. An incorrect wheel can affect wheel and bearing life., ground and tire clearance, or speedometer and odometer calibrations. A wrong size wheel can also affect the anticlock brake system.

**TIRES**

The primary purpose of tires is to provide traction. Tires also help the suspension absorb road shocks, but this is a side benefit. They must perform under a variety of conditions. The road might be wet or dry or paved with asphalt, concrete, or gravel, or there might be no road at all. The car might be travelling slowly on a straight road, or moving quickly through curves or over hills. All of these conditions call for special requirements that must be present, at least to some degree, in all tires.

In addition to providing good traction, tires are also designed to carry the wight of the vehicle, to withstand side thrust over varying speeds and conditions, and to transfer braking and driving torque to the road. As a tire rolls to the road, friction is created between the tires and the road. This friction gives the tire its traction. Although good traction is desirable, it must be limited. Too much means there is much friction. Too much friction means there is a lit of rolling resistance. Rolling resistance wastes engine power and fuel; therefore, it must be kept to a minimal level. This delimma is a major concern in the design of today’s tires.

**Tube and Tubeless Tires**

Early vehicle tires were solid rubber. These were replaced with the pneumatic tire, which are filled with air.

There are two basic types of pneumatic tires; those that use inner tubes and those that do not. The latter are passenger cars today. A tubeless tire has a soft inner linking that keeps air from leaking between the tire and rim. On some tires, this inner can form a seal around a nail or other object that punctures the tread. A self-sealing tire holds in air even after the object is removed. The key to this sealing is a lining of sticky rubber compound on the inside of the tread area that will seal a hole up to 3/16 inch (4.77 mm).

A tubeless tire valve has a central core that is spring-loaded to allow air pass inward only, unless the pin is depressed. If the core becomes defective, it can be unscrewed and replaced. The airtight cap on the end of the valve provides extra protection against valve leakage. A tubeless tire is mounted on a special rim that retains air between the rim and the tire casing when the tire is inflated.

**Figure 42-3** shows a cutaway view of a typical tubeless tire. The basic parts are shown. The cord body or casing consist of layers of rubber-impregnated body or called **pliers** that are bonded into a solid unit. Typical tires are made of 2, 4, 8 pliers; thus, the reference to 2-a-and 8-ply tires. The pliers determine a tire’s strength, handling, ride, amount of road noise, traction, and resistance to fatigue, heat, and bruises. The **bead** is the portion of the tire that helps keep it in contact with the rim of the wheel. It also provides the air seal on the tubeless tires. The bead is constructed of a heavy band of steel wire wrapped into the inner circumference of the tire’s ply structure. The **tread,** or crown, is the portion of the tire that comes in contact with the road surface. It is a pattern of grooves and ribs that provides traction. The grooves are designed to drain off water, while the ribs road surface. Tread thickness varies with tire quality. On some tires, small, cuts, called **sipes,** are molded into the ribs of the tread. These sipes as the tire flexes on the road, offering additional gripping action, especially on wet road surfaces. The **sidewalls** are the sides of the tire’s body. They are constructed of thinner material than the tread to offer greater flexibility.

**Figure 42-3**  A typical tubeless tire.

The tire body and belt material can be made of rayon, nylon, polyester fiberglass, steel, amarid, or Kevlar. Each has its advantages. For instance, rayon and cord tires are low in cost and give a good ride, but do not have the inherent strength needed to cope with along high-speed runs or extended periods of abusive use on tough roads. Nylon-cord tires generally give a slightly harder ride that rayon - especially for the first few miles after the car has been parked – but offer greater toughness and resistance to road damage. Polyester and fiberglass tires offer many of the best qualities of rayon and nylon, but have no disadvantages. They run a almost as tough as nylon, but give much smoother ride, steel is tougher than fiberglass or polyester, but it gives a tightly rougher ride because the steel cord does not give under impact, as do fabric pliers. Amarid and Kevlar cord are lighter than steel cords, pound for pound, stronger than steel.

**Types of Tire Construction**

There are three basic type of tire construction in use today **(Figure 42-4).** The oldest design currently in use is the **bias ply**. It has a body of fabric pliers that run alternately at opposite angles to form a crisscross design. The angle varies from 30 to 38 degrees with the centerline of the tire and has been an effect on high-speed stability, ride harshness, and handling. Generally speaking, the lower the cord angle, the better the high-speed stability, but also the harsher the ride. Bias ply tires usually are available in 2- 4-ply.

**Figure 43-4** The construction of the three basic types of tires.

**Belted bias ply** tires are similar to bias ply tires, except that two or more belts runs the circumference of the tire under the tread. This construction gives strength to the sidewall and greater stability to the tread. The belts reduce tread motion during contact with the road, thus improving the tread life. Pliers and belts of various combinations or rayon, nylon, polyester, fiberglass, and steel are used with belted bias construction. Belted bias tires usually cost more than conventional bias ply tires, but last to 40% longer.

**Radial ply** tires have body cords that extend from the bead to bead at an angle of about 90 degrees - “radial” to the circumferential centerline of the tire – plus two or more layers of relatively inflexible belts under the tread. The construction of various combinations of rayon, nylon, fiberglass, and steel gives greater strength to the tread area and flexibility to the sidewall. The belts restrict tread motion during contact with the road, thus improving tread life and traction. Radial ply tire also offer greater fuel economy, increased skid resistance, and more positive braking.

One of the newer tire designs has steel reinforced sidewalls that allow the tire to maintain shape with no air pressure. The so-called run-flat tire has been punctured. Since they were designed to be filled with air, their ride and handling characteristics are much better when they have air than when they do not. However, the tire will not leave the driver stranded or forced to put on a spare tire when the tire is punctured.

**Specialty Tires**

Specialty tire reflect the advances made in the conventional tire field. Special snow and mud tire are available on all three construction types. Studded tires provide superior traction on ice, but are slowly disappearing from the market because their performance on dry surfaces is poor. In addition, many states have outlawed their use because they damage the road and can be a safety hazard to the road during cornering and stopping. The studs offer less friction than the rubber tire tread.

Most tire manufacturers offer all season or all-weather tires. These tires are designed to perform well on all types of road conditions, but they will not be excellent performers over the surface. Tires can be designed to great on dry surfaces or wet surfaces. However, it is near impossible to have a tire that performs extremely well on both. Tire designed for dry and smooth roads do not really need a tread pattern. They can be “slicks” the smooth, dry surface. However when a slicks hits a wet spot, there is no traction. The tire simply slide on the water.

Tire designed for wet surfaces have tread designs that move the road’s water behind to the side of the tire. Moving the water is the only way the tire can grip the road. Needless to say, when a tire has many directed and open channels for water in its tread, less rubber meets the road.

**Tread Designs**

The real tire is one that wears little, holds the road well to provide sure handling and braking, and provides a cushion from the road shock. The ideal tire should provide maximum grip on dry roads, wet roads, and snow, and operate quietly at any speed. This is a tall order, to tire manufacturers, compromise on one or two these qualities for the sake of excelling at another. A tire’s thread dictates what the tire will excel at.

There are basically three categories of tread patterns: directional, nondirectional, and symmetric and symmetric

A directional tire is mounted so that it revolves in a particular direction. These tires have an arrow on the sidewalls that show the designed direction of travel. A directional tire offers good performance only when it is rotating in the direction in which it was designed to rotate **(Figure 42-5).** A nondirectional tire has the same handling qualities in either direction or rotation. A symmetric tire has the same tread pattern on both sides of the pattern. An asymmetrical tire has a tread design that is different from one side to the other. Asymmetrical tires are typically designed to provide good grip when travelling straight (the inside half) and good grip in turns (the outside half of the tread). Most asymmetric tires are also directional tires.

**Figure 42-5** There are many different tread designs available for today’s tires.

The number and size of the blocks, sipes, and grooves on a tire’s tread not only determine how much rubber contacts the road and how much water can be displaced, they also determine how quiet will be during travel. The more statement is especially true if the noise it will make is made of a hard compound. Softer tires typically make less noise but wear more quickly. Soft tires also adhere to the road better.

Channels are cut into a tire’s tread to allow water to move away from the tire’s direction of travel. Obviously the deeper the channel, the more water the tire can move. The disadvantage if this channel is decreased road contact.

| **S H O P T A L K**  Whenever the customer wants a better handling tire, make sure he or she knows a better gripping tire may make more noise and not wear as long as other tires. Knowing what design of tire will meet a customer’s need is a science. Always consult with a tire specialist before recommending one tie or another, |
| --- |

**Spare Tires**

Nearly all vehicles are equipped with a spare tire to be used in case on of the vehicle’s tire loses air and goes flat. A spare tire can be a tire that matches the tires on the vehicle or can be a compact spare. Compact spares are use to designed to reduce weight and storage space but still

provide the driver with a tire in the case of an emergency. Compact tires are typically on of the types: high-pressure mini space, spare-saver spare, and lightweight skin spare.

A high-pressure mini spare tire is a temporary tire. It should not be used for extended mileage or for speeds above 50 mph. A space-saver spare must be blown up with a compressor that operates from the cigarette lighter or a built-in-air compressor. A skin spare is a normal bias ply tire with a reduced tread depth.

| **S H O P T A L K**  Make sure you warn your customer that a mini space-saver, or similar type compact spare should be used only as temporary tire. Any continous load use of temporary spare will result in tire failure, loss of vehicle control, and possible injury to the vehicle’s occupants. |
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**High-Performance (Speed-Rated) Tires**

The so-called high-performance tire has made an increasing appearance on many new cars. Most drivers do not care if they actually use the speed capabilities of the tire, just as long as the performance is there. In fact, many of their cars are not capable of the speeds the tires are rated at. The speed rating of a tire is really nothing more than an expression of how the tire will withstand the temperatures of high speed. This does not necessary mean a high-speed rated tire will perform better at low speeds than a lower rated tire.

**Table 42-1** list the various letters used to designate the speed rating of a tire and the maximum speed the tire was designed to safely operate at. Driving a vehicle at the speeds greater than the speed rating of the tires is risky. The heat generated can cause the tire to come apart. If this happens at high speed, it will be close to impossible for the driver to maintain control of the vehicle.

Although high-performance tires withstand heat between than normal tires, they still wear and must be replaced. In some European countries, the replacement tire must have, by law, the same speed rating as the OE tire. Although it is not a law in the United States, preventing the practice of trading down the speed ratings probably would not be a bad idea.

| | **TABLE 42-1 SPEE RATINGS** | | --- |   **Symbol** | **Maximum Speed** |
| --- | --- | --- |
| F  G  J  K  L  M  N  P  Q  R  S  T  U  H  V  Z | 50 mph  56 mph  62 mph  68 mph  75 mph  81 mph  87 mph  93 mph  100 mph  106 mph  112 mph  118 mph  124 mph  130 mph  149 mph  +149 mph |

**Tire Rating and Designation**

Tires are also rated by their profile (aspect) ratio, size, and load range. A **tire’s profile** is the relation of its cross-sectional height (from sidewall to sidewall). Today, this ratio is also known as **series.**

For many years, the accepted profile ratio standard bias ply passenger car tires was approximately 83. This meant the tire was 83% as high as it was wide. Since the introduction, lower profile tires and ratios or 78, 70, 60, 50, and even 40 have become popular **(Figure 42-6).** The lower the number, the wider the tire. As an example, a 50-series tire appears to be low and flat because its height is 50% of its width.

**Figure 42-6** The aspect ratio (profile) of attire it is cross-sectional height compared to its cross-sectional width expressed in percentage.

In the designation P195/75R14, P indentifies passenger car tire. The width in millimeters is 195. The height-to-width ratio is 75. R identifies radial construction. The rim diameter is 14. If this designation if followed by M, S, or MS, the tire is rated for use in mud, snow, or both.

All-metric system measurements are now being given along with a standard translation. A typical metric tire shoes its width in millimeters, its inflation pressure in kilopascals equals .895 psi. A typical all-metric tire radial size is 190/65R-390. It fits a 390-mm diameter wheel.

Also on the sidewall of a tire are rating for maximum load, road wear, traction, temperature, maximum inflation, tread pliers, and side plies. These ratings are normally listed separately from the side of the tire **(Figure 42-7).**

**Figure 42-7** There is a lot of information about a tire on its sidewall.

The maximum load ratings lists the maximum amount of weight the tire can carry at the recommended tire pressure. Tread wear is listed as a number that ranges from 100 to 500. A rating of 100 means the tire will wear easily and quickly, whereas a rating of 500 means the tire is hard and will resist wear. The traction rating is given as an A, B, or C. A tire rated as C will provide less traction than one rated with an A. Also given as A, B, or C is the tire temperature ratings. A tire with an A temperature ratings will be able to withstand high temperature better than those rated B or C.

It is important to remember that the maximum inflation number on the tire is the maximum inflation and not the recommended inflation. Tires should never be inflated beyond this maximum rating.

Typically, the load rating and the number of tread and sidewall plies are proportional. In most cases, the more plies has, the more weight it can support.

**Tire Placard**

The placard, or safety compliance certification label, is generally found on the driver’s door jam. It includes recommended maximum vehicle load, tire size (including spare), and the *correct* cold tire inflation to reach tire for each vehicle **(Figure 42-8).** Never use this information for other cars.

**Figure 42-8**  A tire placard on a doorjamb.

As a general rule, tires should be replaced with the same size designation or an optional size as recommended by the auto or tire manufacturer. Also, always follow the manufacturer’s recommendation for tire type, inflation pressures, and rotation patterns.

| **S H O P T A L K**  Whenever the customer wants a better handling tire, make sure he or she knows a better gripping tire may make more noise and not wear as long as other tires. Knowing what design of tire will meet a customer’s need is a science. Always consult with a tire specialist before recommending one tie or another, |
| --- |

**Tire Care**

To maximize the performance, inspect for signs of improper inflation and uneven wear, which can indicate a need for balancing, rotation, or wheel alignment. Tire should also be checked frequently for cuts, stone bruises, abrasions, and blisters, and for objects that might become imbedded in the tread. More frequent inspections are recommended when rapid or extreme temperature changes occur, or where road surfaces are rough or occasionally littered with debris.

To clean tires, use a mild soap and water solution only. Rinse thoroughly with the clear water. Do not use any caustic solutions or abrasive materials. Never use steel wool or wire brushes. avoid gasoline, paint thinner, and similar materials having a mineral oil base. These materials will cause premature drying of the tire’s rubber. As the rubber dries, it gets harder and the tire will loose some of its performance characteristics.

**Inflation Pressure** A properly inflated tire gives the best tire life, riding comfort, handling stability, and fuel economy for normal driving conditions. Too little air pressure can result in tire squeal, hard steeling, excessive tire heat, abnormal tire wear, and increased fuel consumption by as much as 10%. An underinflated tire shows maximum wear on the outside of the tread. There is little or no wear in the car.

Conversely, an overinflated tire shows its wear in the center of the tread and little wear on the outside edges. A tire inflated higher than recommended can cause a hard ride, tire bruising, and rapid wear at the center of the tire **(Figure 42-9).**

**Figure 42-9** Effects of inflation on tread contact

Many inflation pressures listed for imported vehicles are given in kilopascals (kPa) rather than psi. **Table 42-2** converts kPa to psi.

| **TABLE 42-2 INFLATION PRESSURE CONVERSION**  **(KILOPASCALS psi)** |
| --- |

| kPa | psi | kPa | psi |
| --- | --- | --- | --- |
| 140  145  155  160  165  170  180  185  190  200  205 | 20  21  22  23  24  25  26  27  28  29  30 | 215  220  230  235  240  250  275  310  345  380  415 | 31  32  33  34  35  36  40  45  50  55  60 |

Conversion 6.9 kPa = 1 psi

A few vehicles are fit with the tire inflation monitoring systems. These systems have air pressure sensors strapped around the drop center of each wheel. When the pressure is below or above a specified range, the vehicle’s computer causes a warning light on the dash to illuminate. This alerts the drive to the problem.

**Tire Rotation** To equalize tire wear, most car tire manufacturers recommend that the tires be rotated. Remember that front and rear tires perform different jobs and jobs and cat wear differently, depending on driving habits and the type of vehicle. In a RWD vehicle, for instance, the front tires usually wear along the outer edges, primarily because of the scuffing and slipping in cornering. The rear tires wear in the center because the acceleration thrusts. To equalize encountered wear, it is recommended that tires be rotated as illustrated in **Figure** **42-10**. Bias-ply and bias-belted rotated tires should about every 6,000 miles (10,000 km). Radial tires should be initially rotated at 7,500 miles (12,000 km) and then at least every 15,000 miles (24,000 km) thereafter. It is important that directional tires are kept rotating in the correct direction after rotating them. This means the tires may need to be dismounted from the wheel, flipped, and reinstalled on the rim before being put on the other side of the car. Many auto shops keep a record of tire rotation periods so they can notify their customers when it should be done next.

**Figure 42-10** Rotation for radial tires.

| **S H O P T A L K**  Although the rotation patterns shown in **Figure 42-10** can serve as the general rule, always refer to a service manual. Some vehicles equipped with radial tires should have their tires rotated in a crisscross pattern. The correct rotation method depends on the design of the vehicle’s suspension and steering systems. |
| --- |

When snow tires are installed, the gear tread tires on the rear should be moved to the front and the front tires stored. When snow tires are removed, install the stored tires on the rear. Do not rotate studded tires. Always remount them in their original position.

When storing tires, lay them flat on a clean, dry, oil-free floor. Keep them away from ozone, which comes from the electrical sparking frequently produced by electrical sparking frequently produced by electric motors. Store them in the dark. Direct sunlight is hard on tires.

**Tread Wear** Most tires used today have built-in tread wear indicators to show when they need replacement. These indicators appear as 1/2 –inch (12 mm) wide bands when the tire tread depth wears to 1/6 inch (1.5 mm). When the indicators appear in two or more adjacent grooves at three locations around the tire, or when cord or fabric is exposed, tire replacement.

If the tires do not have tread wear indicators, a tread depth indicators, a tread depth indicator **(Figure 42-11)** quickly shows in 32nds of an inch how much tire tread is left. When only 2/32 inch (1.5 mm) is left, it is time to replace a tire.

**Figure 42-11**  Checking tread depth.

**Tire Pressure Monitor (TPM)**

The tire pressure monitor (TPM) checks the inflation pressures in all four tires at frequent periodic intervals. The TPM’s sensors keep track of the tire pressures both when the vehicle is moving and when it is stationary. When the TPM detects changes in any tire’s inflation pressure, tire responds by triggering a warning lamp on the instrument panel.

Each wheel is equipped with an electronic sensor assembly located just behind the valve stem **(Figure 42-12).** This assembly is made up of a pressure sensor, a transmitter, and a battery. The pressure sensor measures the tire inflation pressure and relays this information to the vehicle via radio waves. These signals are picked up be separate body-mounted antennas for each wheel. A central electronic control unit processes the signals from the four wheels and reports any vibrations to the system.

**Figure 42-12** A tire pressure monitor with its valve stem.

**Run-Flat Tires**

A run-flat tire consist of a self-supporting tire, a specially designed wheel, and a flat-tire monitor that displays a warning when a tire is detected. Depending on the load of the vehicle and the type of the tire, run-flat tires can typically be driven for about 100 miles (1 60 km) at up to 50 mph (80 km/h) even with the tire completely deflated.

The sidewalls of these tires feature supplementary reinforcement belts manufactured in a special, heat-resistant rubber compound. This design allows the deflated tire to cover the specified distance without compressing against the wheel’s rim flange. The contribution provided by the specially shaped safety rim ensures the tire remains securely seated **(Figure 42-13).** Together these two features allow the driver to continue travelling without installing the same tire.

| **WARNING!** |
| --- |

| Special rim clamps must be used for mounting run-flat tires. |
| --- |

The flat tires monitor uses the rotation rate on each tire as its index for detecting pressure loss; the reduction in rolling radius that accompanies pressure loss produces a change in the tire’s rotation speed. The ABS wheel speed sensors monitor rotation rates of each wheel. If there is a pressure loss, the system turns on a warning lamp. On some vehicles, a graphic will display which tire is flat.

**Figure 42-13** Features of a run-flat tire.

Safety tires are labeled on the tire sidewall with a circular symbol containing the letters “RSC”. Safety tires consist of self-supporting tires and special rims **(Figure 42-14).** The tire reinforcement ensures that the tire retains residual safety in the event of pressure drop and that driving remains possible to a restricted degree. Vehicles with a TPM system or flat-tire monitor use the tires.

**Figure 42-14** A cutaway of run-flat tire with an insert for support in case the tire goes very flat.

**TIRE REPAIR**

The most common tire problem beside wear is a puncture. When properly repaired, the tire can be put back in service without the fear of an air leak recurring. Punctures in the tread area are the only ones that should be repaired or even attempted to be repaired. Never attempt to service punctures in the tire’s shoulders or sidewalls. In addition, do not service any tire that has sustained the following damage;

Bulges or blisters

Ply separation

Broken or cracked beads

Fabric cracks or cuts

Wear to the fabric or visible wear indicators

Punctures larger than 1/4 –inch (6mm) diameter

Some car owners attempt to seal punctures with the tire sealants. These are injected into the tire through the valve system. Sometimes the criminals in the sealant do great job sealing the hole, other times they fail. The sealants should never be used and will not work on the side wall punctures. Some of the sealant are very flammable and carry a warning that the tie should be marked so that the next technician knows the sealant has been used.

| **WARNING!** |
| --- |

| Tire sealant injected through the valve stem can produce wheel rust and tire imbalance. |
| --- |

To locate a puncture in a tire, inflate it to the maximum inflation pressure indicated on its sidewall. Them submerged the tire/wheel assembly in a tank of water or sponge it soapy water solution. Bubbles will identify the location of any air leakage.

Make the location of the leak with a crayon so it can be easily found once the tire is removed form the wheel. Also use the crayon to mark the location of the valve stem so that original tire and wheel balance can be maintained after the tire is put back on the wheel.

The proper procedure for dismounting and remounting a tire is illustrated in Photo Sequence 45. Do not use hand tools or tire irons alone the change a tire because they might damage the beads or wheel rim. When mounting or dismounting tires on vehicles using aluminum or wire spokes wheels, it is recommended that the tire changer manufacturer be contacted about thee accessories that are requires to protect the wheel’s finish.

**Repair Methods**

Once the tire is off the wheel and the cause of the puncture is removed, the tire can be permanently serviced from the inside using a combination service plug and vulcanized patch. While the service kit’s instructions should always be followed, there are some general guideline that that help make a good, permanent patch of the methods used to repair a tire.

**Plug Repair** The head-type plug **(Figure 42-15)** is commonly used. A plug that is slightly larger than the size of the puncture is inserted into the hole from the inside of the tire with an insertion tool. Before doing this, insert the plug into the eye of the tool and coat the hole, plug, and tool with vulcanizing fluid.

While holding and stretching the long end of the plug, insert it into the hole. The plug must extend above both the tread and inner liner surface. If the plug pops through, throw it away and insert a new plug. Once the plug is in place, remove the tool and trim off the plug 1/32 in (0.7) above the inner surface. Be careful not to pull on the plug while cutting it.

**Figure 42-15** A plug for a radial tire.

**Cold Patch Panel** When using a cold patch, carefully remove the backing from the patch. Spread vulcanizing fluid on the puncture area. Let it dry, then center the patch base over the puncture area. Run a stitching tool over the patch to help bind it to the area.

| **WARNING!** |
| --- |

| When replacing radial tires, use only a patch specially approved for that application. These special patches have arrows that must be lined up parallel to the radial plies |
| --- |

**Hot Patch Repair** A hot tire patch application is similar to a cold patch. The difference is that the hot patch is clamped over the puncture and heat is applied to the patch to make it adhere.

**Installation of Tire/Wheel Assembly on the Vehicle**

A wheel should be carefully inspected each time a tire is to be mounted on it. The major causes of wheel failure are improper maintenance, overloading, age, and accidents, including pothole damage. Wheels must be replaced when they are bent, dented, heavily rusted; have leaks or elongated bolt holes; have excessive **lateral** or **radial runout.** Wheels with lateral or radial runout greater than specifications can cause high-speed vibrations. Wobble or shimmy caused by a damaged wheel bearings. Stones wedged between the and disc brake rotor or drum can unbalance the wheel. Also, check the lug nuts to be sure that they are set according to the torque given in the vehicle’s service manual. Loose lug nuts can cause shimmy and vibration and can also distort the stud holes caused by improperly positioning the wheel on the wheel hub or by improperly tightening the lug nuts.

| **S H O P T A L K**  When mounting new ties, always install new valve stems. The life of tire rubber is close to the life of the valve stem rubber. Most stems are the snap-in type. These are installed from inside the wheel with a pulling tool. Make sure that the stem is properly seated. Another style of stem has a retaining nut that must be removed when the pulling off the old stem. Be sure to completely tighten the new nut. |
| --- |

Before reinstalling a tie/wheel assembly on a vehicle, inspect the wheel bearings as describe as describe later in this chapter, then clean the axle/rotor flange and wheel bore with a wire brush or steel wool. Coat the axle pilot flange with disc brake caliper slide grease or an equivalent. Place the wheel on the hub. Install the locking wheel-cover pedestal (if used) and lug nuts, and tighten them alternately to draw the wheel evenly against the hub. They should be tightened to a specified torque and sequence **(Figure 42-16)** to avoid distortion. Many tire technicians snug up the lug nuts. Then when the car is lowered to the floor, they use a torque wrench for the final tightening.

**Figure 42-16** The lug nut tightening sequence for a four-lug wheel (A) and a five-lug wheel (

| **WARNING!** |
| --- |

| Over torquing of the lug nuts is the most common cause of disc brake rotor distortion. Also an overtorque lug distort the treads of the lug and could lead to premature failure. |
| --- |

Be sure the wheels and hub are clean. To clean the aluminum wheels, use a mild soap and water solution and rinse thoroughly with a clear water. Do not use a steel wool abrasive cleaner or strong detergent containing high alkaline or caustic agents because the might damage the protective coating and cause discoloration. Once the vehicle is on the ground, check and adjust the air pressure in all tires.

**TIRE/WHEEL RUNOUT**

A tire that is off center is said to run out; that is, it has radial runout or eccentricity. One that wobbles side to side is said to have lateral runout. If a tire with some built-in runout is mismatched with a wheel’s runout, the resulting total runout can exceed the ability of the balance weights to correct the problem. For this reason, part of a wheel balance check for excessive runout. Sometimes tires or wheels can be remounted to lessen or correct runout problems.

To avoid false readings caused by temporary flat spots in the tires, check runout only after the vehicle has been driven. Visually inspect the tire for abnormal bulges or distortions. The extent of runout should be made with a dial indicator. All measurements should be made on the vehicle with the tires inflated to recommended load information pressures and with the wheel bearing adjusted to specification.

Measure the radial at the center and outside ribs of the tread face. Measure tire lateral runout must above the buffing rib on the sidewall **(Figure 42-17).** Mark the high points of the lateral and radial runout for future references. On bias or belted bias tires, radial runout must not exceed 0.104 inch (2.64 mm) and lateral runout must not exceed 0.099 inch (2.5 mm). On radial ply tires, radial runout must not exceed 0.999 inch (2.5 mm).

**Figure 42-17** Checking wheel runout.

If total radial or lateral runout of the tire exceeds specified limits, it is necessary to check wheel runout to determine whether the wheel or tire is at fault. Wheel radial runout is measured at the wheel rim just inside the wheelcover retaining nibs. Wheel lateral runout is measured at the wheel rim bead flange just inside the curved lip of the flange. Wheel radial runout should not exceed 0.35 inch (.88 mm) and wheel lateral runout should not exceed 0.40 inch (1.0 mm). Mark the high points of radial and lateral runout for future reference.

If total tire runout, either lateral or radial, exceeds the specified limit but wheel runout is within the specified limit, it might be possible to reduce runout to an acceptable level. This is done the wheel so that the previously marked high points are 180 degrees apart.

**INFORMATION SHEET NO. 2**

**Perform wheel balancing**

**TIRE/WHEEL ASSEMBLY SERVICE**

For most tire/wheel service, the assembly must be first be removed form the vehicle. The wheel and the tire must be removed from the vehicle. The wheel and the tire must be separated whenever tires are placed or repaired. The rear-wheel drum or disc brake rotor is usually attached to studs on the rear axle shaft’s hub flange. The wheel and tire mount on the same studs and are held against the hub and drum or rotor by the wheel nuts.

**Tire/Wheel Balance**

Proper wheel alignment allows the tires to roll straight without excessive tread wear. The wheels can go out of alignment from striking raised objects or potholes. Misalignment subjects the tires to uneven and/or irregular wear.

Should an inspection show uneven or irregular tire wear, wheel alignment and balance service is a must. Wheel balancing distributes weight along the wheel rim, which counteract heavy spots in the wheels and tires and allow them to roll smoothly without vibration. The wheel weight adhered to the wheel or are clipped over the edge of the wheel’s rim. There are two types of wheel imbalance: static and dynamic.

**Static Balance Static Balance** is the equal distribution of weight around the wheel. Wheels that are statically unbalanced cause a bouncing action called **wheel tramp.** This condition eventually causes uneven tire wear. As the name implies, static balance means balancing a wheel at rest. This is done by adding a compensating weight. A statically unbalanced wheel tends to rotate by itself until the heavy potion is down. A bubble balancer is used to statically balance a tire and wheel. When it is placed in the balancer, any imbalance moves the bubble off center.

Many equipment manufacturers recommend static balancing a wheel at equal distance from the center of the light area. Balance weight are usually hammered on with their holding tabs between the tire bead and rim **(Figure 42-18).** Wheel weight are not normally hammered onto alloy or mag wheels, rather special tape weight are adhere to the wheels to balance them.

**Figure 42-18** A typical wheel weight attached to a wheel.

**Dynamic Balance Dynamic balance**  is the equal distribution of weight on each side of the centerline. When the balanced tire spins, there is no tendency for the assembly to move from the side to side. Wheels that are dynamically unbalanced can cause **wheel shimmy** and a wear pattern **(Figure 42-19).** Dynamic balance, simply stated, means balancing a wheel in motion. Once a wheel in motion, the static weights try to reach the true plane of rotation when there is imbalance, the static weights force the spindle to one side.

At 180 degrees of wheel rotation, static weights kick the spindle in the opposite direction. The resultant side thrust cause the wheel assembly to wobble or wiggle. When the imbalance is severe enough, as already mentioned, it causes vibration and front-wheel shimmy.

To correct dynamic unbalance, equal weights are place 180 degrees opposite each other, one on the inside of the wheel and one on the outside, at the point of unbalance. This corrects the couple action or wiggle of the wheel assembly. Also, note that dynamic balance is obtained, while static balance remains unaffected.

The most commonly used dynamic wheel balancer requires that the tire/wheel assembly be taken off and mounted on the balancer’s spindle **(Figure 42-20).** The machine spins the entire assembly to indicatae the heavy spot with a strobe light or other device. Two tests must be done, one for the static and one for the dynamic imbalance.

**Figure 42-20** A computerized tire balancer.

There are several electronic dynamic/static balancer units that will permit when the wheel and tire are on the car. A switch on the console sets the machine for either static or dynamic balancing. When the balancing assembly is mounted for static balancing, it rotates until the heavy spots falls to the bottom. Weight are added to balance the assembly.

In the dynamic balance mode, the wheel assembly is rotated at high-speed. Observing the balance scale, the operator reads out the amount of weight that has to be added and the location where the weights should be placed.

**INFORMATION SHEET NO. 3**

**Conduct wheel alignment**

Swift and sure steering responses are needed at today’s driving speeds. To accomplish this, the wheels must be in alignment. Wheel alignment allows the wheels to roll without scuffing, dragging, or slipping on different types or road conditions. Proper alignment of both the front and the rear wheels ensures greater safety in driving, easier steering, longer tire life, reduction in fuel consumption, and less strain on the parts that make up the steering and suspension systems of the vehicle (**Figure 45 – 1)**.

**Figure 45-1** Technicians who specialize in wheel alignment.

There are a multitude of angles and specification that the automotive manufacturers must consider when designing a car. The multiple functions of the suspension system complicate things a great deal for design engineers. They must take into account more then basic geometry. Durably, maintenance, tire wear, available space, and production cost are all critical elements. Most elements contain a degree of compromise in order to satisfy the minimum requirements of each.

Most technicians do not need to be concerned with such requirements. All they need to do is restore the vehicle to the condition the design engineer specified. To do this, however, the technician must be totally familiar with the purpose of basic alignment angles.

The alignment angles are designed in the vehicle to properly locate the vehicle’s weight on moving parts and to facilitate steering. If these angles are not correct, the vehicle is misaligned. The effects of misalignment are given in **Table 45 – 1.**  It is important to remember that alignment angles, when specified in the text, are those specific angles that should exist when the system is being measured under a given set of conditions. During regular performance, these angles change as the traveling surface and vehicle driving forces change.

An important thing to remember when doing wheel alignment and diagnosis is that roads are not designed to be flat. They are designed to allow rain to flow off the surface rather than to accumulate. To accomplish this drainage, the rod’s surface is paved at a slight angle.

| **TABLE 45 – 1 EFFECTS OF INCORRECT**  **WHEEL ALIGNMENT** | |
| --- | --- |
| **Problem** | **Effect** |
| Incorrect camber setting | Tire wear  Ball point / wheel bearing wear  Pull to side of most positive /  least negative camber |
| Too much positive caster | Hard steering  Excessive road shock  Wheel shimmy |
| Too much negative caster | Wander  Weave  Instability at high speeds |
| Unequal caster | Pull to side most negative /  least positive caster |
| Incorrect SAI | Instability  Poor return  Pull to side of lesser inclination  Hard steering |
| Incorrect toe setting | Tire wear |
| Incorrect turning radius | Tire wear  Squeal in turns |

This angle is called road crown. Road crown also can cause a vehicle to pull toward the right. Therefore, alignment angles must compensate for it. Slightly more positive camber on one of the front tires will correct for road crown.

**ALIGNMENT GEOMETRY**

The proper alignment of a suspension / steering system centers on the accuracy of the following angles.

**Caster**

**Caster** is the angle of the steering axis of a wheel from the vertical, as viewed from the side of the vehicle. The forward or rearward tilt from the vertical line **(** **Figure 45 – 2)** is caster. Caster is the first angle adjusted during an alignment. Tilting backward is positive caster.

**Figure 45-2** Three types of caster are (A) zero, (B) positive, and (C) negative.

Caster is designed to provide steering stability. The caster angle for each wheel on an axle should be equal. Unequal caster angles cause the vehicle to steer toward the side with less caster. Too much negative caster can cause the vehicle to have sensitive steering at high speeds. The vehicle might wander as a result of negative caster. Caster is not related to tire wear.

Caster is affected by worn or loose strut rod and control arm bushings. Caster adjustments are not possible on some strut suspension systems. Where they are provided, they can be made at the top or bottom mount of the strut assembly.

**Camber**

**Camber** is the angle represented by the tilt of either the front or rear wheels inward or outward from the vertical as viewed from the front of the car **(Figure 45 – 3).** Camber is designed into the vehicle to compensate for road crown, passenger weight, and vehicle weight. Camber is usually set equally for each wheel. Equal camber means each wheel is tilted outward or inward the same amount. Unequal camber causes tire wear and causes the vehicle to steer toward the side that is more positive.

**Figure 45-3** (A) Positive and (B) negative chamber.

Camber angle changes, through the travel of the suspension system, are controlled by pivots. Camber is affected by worn or loose ball joints, control arm bushings, and wheel bearings. Anything that changes chassis height also affects camber. Camber is adjustable on most vehicles. Some manufactures prefer to include a camber adjustment at the spindle assembly. Camber adjustments are also provided on some strut suspension system at the top mounting of the strut. Very little adjustment of camber (or caster) is required on strut suspensions if the tower and lower control arm positions are in their proper place. If serious camber error has occurred and the suspension mounting positions have not been damaged, it is an indication of bent suspension parts. In this case, diagnostic angle and dimensional checks should be made on the suspension parts. Damaged parts should be replaced.

**Toe**

**Toe** is the distance comparison between the leading edge and trailing edge of the front tires. If the leading edge distance is less, then there is toe – in. If it is greater, there is toe – out **(Figure 45 – 4).**  Actually, toe is critical as a tire wearing angle. Wheels that do not track straight ahead have to drag as they travel forward. Excessive toe – in will cause tire wear on the outside edge of the tire. Toe – out causes wear on the inside edge.

**Figure 45-4** The position of the wheels during toe-in and toe0out.

Toe adjustments are made at the tie rod. They must be made evenly on both sides of the car. If the toe settings are not equal, the car may tend to pull due to the steering wheel being off – center. An off – center steering wheel and steering pull should be corrected by making the toe adjustments equal on both sides of the car with the steering wheel centered. Toe is the last adjustment made in an alignment.

**Thrust Line Alignment**

A main consideration in any alignment is to make sure the vehicle runs straight down the road, with the rear tires tracking directly behind the front tires when the steering wheel is in the straight – ahead position. The geometric centerline of the vehicle should parallel the road direction. This is the case when rear toe is parallel to the vehicle’s geometric centerline in the straight – ahead position. If rear toe does not parallel the vehicle centerline, a thrust direction to the left or right is created **(Figure 45 – 5).** This difference of rear toe from the geometric centerline is called the **thrust angle**. The vehicle tends to travel in the direction of the thrust line, rather than straight ahead.

**Figure 45-5** The thrust line or driving direction of the rear wheels.

To correct this problem, begin by setting individual rear – wheel toe equally in reference to the geometric centerline. Four – wheel – alignment machines check individual to on each wheel. Once the rear wheels are in alignment with the geometric centerline, set the individual front toe in reference to the thrust angle. Following this procedure assures that the steering wheel is straight – ahead travel. If you set the front toe to the vehicle geometric centerline, ignoring the rear toe angle, a cocked steering wheel results.

**Steering Axis Inclination (SAI)**

**Steering axis inclination (SAI)** locates the vehicle weight to the inside or outside of the vertical centerline of the tire. The SAI is the angle between true vertical and a line drawn between the steering pivots as viewed from the front of the vehicle **(Figure 45 – 6)**. It is an engineering angle designed to project the weight of the vehicle to the road surface for stability. The SAI helps the vehicle’s steering system return to straight ahead after a turn.

**Figure 45-6** The effects of steering axis inclination changes.

If the vehicle has 0 (zero) SAI, the upper and lower ball joints (or strut pivot points) would be located directly over one another. Problems associated with this simple relationship include tire scrub in turns, lack of control, and increased effort during turn recovery. If the SAI is titled, a triangle is formed between ball joints and spindle. An arc is then formed when turning. There is a high point at straight – ahead position and a drop downward turning to each side. This motion travels through the control arms to the springs and, finally, to the weight of the vehicle. The forces generated in a turn are actually trying to lift the vehicle. The tilting and loading effect of SAI offsets the lifting forces and helps to pull the tires back to straight ahead when the turn is finished.

Front – wheel – drive vehicles with strut suspensions typically have a higher SAI angle (12 to 18 degrees) than a short – long arm rear – wheel – drive suspension (6 to 8 degrees). This is because the extra leverage provided by a larger angle helps directional stability.

If the SAI angles are unequal side – to – side, torque steer, brake pull, and pump steer (jerking from side to side). Can occur even if static camber angles are within specifications.

Checking the SAI angle can help locate various problems that affect wheel alignment. For example, an SAI angle that varies from side to side may indicate an out – of – position upper strut tower, a bowed lower control arm, or a shifted center crossmember.

On a short – long arm suspension, SAI is the angle between true vertical and a line drawn from the upper ball joint through the lower ball joint. In a strut – equipped vehicle this line is drawn through the center of the strut’s upper mount down through the center of the lower ball joint.

When the camber angle is added to the SAI angle, the sum of the two is called the **included angle.** Comparing SAI, included, and camber angles can also help identify damaged or worn components. For example, if the SAI reading is correct, but the camber and included angles are less than specifications, the steering knuckle or strut tower may be sent. **Table 45 – 2** summarizes the various angle combinations used to troubleshoot short – long arm, strut, and twin I – beam suspension system alignment problems.

**Turning Radius**

Turning radius is the amount of toe – out present in turns **(Figure 45 – 7)**. Turning radius is also called “toe – out on turns” or “turning angle”. As a car goes around a corner, the inside tire must travel in a smaller radius circle than the outside tire. This is accomplished by designing the steering geometry to turn the inside wheel sharper than the outside wheel. The result can be seen as toe – out in turns. This eliminates tire scrubbing on the road surface by keeping the tires pointed in the direction they have to move.

**Figure 45-7** Turning radius is affected by toe-out in turns.

When a car has a steering problem, the first diagnostic check should be a visual inspection of the entire vehicle for anything obvious: bent wheels, misalignment of cradle, and so on. If there is nothing obviously wrong with the car, make a series of diagnostic checks without disassembling the vehicle. One of the most useful checks that can be made with a minimum of equipment is a jounce – rebound check.

This jounce – rebound check determines if there is misalignment in the rack and pinion gear. For a quick check, unlock the steering wheel and see if it moves during the jounce or rebound. For a more careful check, use a pointer and a piece of chalk. Use the chalk to make a reference mark on the tire tread and place the pointer on the same line as the chalk mark. Jounce and rebound the suspension system a few times while someone watches the chalk mark and the pointer. If the mark on the wheel moves unequally in and out on both sides of the car, the steering arm and gear are probably all right. Each wheel or side should be checked.

| **TABLE 45 – 2 ALIGNMENT ANGLE DIAGNOSTIC CHART** | | | | |
| --- | --- | --- | --- | --- |
| **Suspension**  **Systems** | **SAI** | **Camber** | **Included**  **Angle** | **Probable Cause** |
| Short Arm /  Long Arm  Suspension | Correct  Less  Greater  Less | Less  Greater  Less  Greater | Less  Correct  Correct  Greater | Bent knuckle  Bent lower control arm  Bent upper control arm  Bent knuckle |
| MacPherson  Strut  Suspension | Correct  Correct  Less  Greater  Greater  Less    Less | Less  Greater  Greater  Less  Greater  Greater    Less | Less  Greater  Correct  Correct  Greater  Greater    Less | Bent knuckle and/or bent strut  Bent knuckle and/or bent strut  Bent control arm or strut tower (out at top)  Strut tower (in at top)  Strut tower (in at top) and spindle and/or bent strut  Bent control arm or strut tower (out at top) plus  bent knuckle and/or bent strut  Strut tower (out at top) and knuckle and/or strut  bent or bent control arm |
| Twin I – Beam  Suspension | Correct  Greater  Less  Less | Greater  Less  Greater  Greater | Greater  Correct  Correct  Greater | Bent knuckle  Bent I beam  Bent I beam  Bent knuckle |

Turning radius is not an adjustable angle. If the angle is not correct, steering or suspension parts are damaged and will need to be replaced.

**Tracking**

All vehicles are built around a geometric centerline that runs through the center of the chassis from the back to the front. The thrust line is the direction the rear axle would travel if unaffected by the front wheels. This condition is also called **tracking**. An ideal alignment has all four wheels parallel to the centerline, making the thrust line parallel to the centerline. However, the rear – wheel thrust line of a vehicle might not always be parallel to the actual centerline of the vehicle, so the angle of the thrust line must be checked first.

Rear – wheel – drive vehicle rarely need thrust line adjustment unless they have been in an accident or experienced severe usage. Independent rear suspension can have offset thrust angles from unequal rear toe adjustments. An offset thrust angle effects handling by pulling in the direction away from the thrust line, and it can cause tire wear similar in pattern to that of incorrect toe setting. As a general rule, minor variations between the thrust line and centerline are not noticeable and do not cause handling problems as long as the front wheels are aligned parallel to the thrust line.

Correct tracking refers to a situation with all suspension and wheels in their correct location and condition and aligned so that the rear wheels follow directly behind the front wheels while moving in a straight line **(Figure 45 – 8)**. For this to occur, all wheels must be parallel to one another, and axle and spindle lines must be at 90-degress angles to the vehicle centerline. Simply stated, all four wheels should form a perfect rectangle.

**Figure 45-8** When a car is tracking correctly, its rear wheels are the same distance from the front wheels on both sides.

**Load Distribution**

Load distribution refers to the load placed on each wheel. Every vehicle is engineered to operate at a designed curb height (also called **trim height**). At this height, each wheel must carry the correct amount of weight. Excessive loading to the front, rear, or one side of the vehicle changes the curb height, upsetting vehicle balance and steering geometry.

In correct alignment, sagging springs and bent suspension parts can also change this condition, upsetting geometry and placing excessive load on only one or two wheels.

All of these element, springs, shocks, suspension, and geometry – are engineered to work together as a balance team to provide safe and comfortable riding and handling. Quite naturally, if one wheel is running under a different condition of weight load and steering geometry, the vehicle does not ride and handle as it is capable of doing.

**PREALIGNMENT INSPECTION**

An extreme important part of a wheel alignment is the preliminary inspection. During this inspection if any parts are found to be defective, they should be replaced before proceeding with the alignment. The following are guidelines for the inspection:

* Begin the alignment with a road test. While driving the car, check to see that the steering wheel is straight. Feel the vibration in the steering wheel as well as in the floor or seats. Notice any pulling or abnormal handling problems, such as hard steering, tire squeal, while cornering, or mechanical pops or clunks. The road test helps find problems that must be corrected before proceeding with the alignment.
* Carefully inspect the tire wear patterns and mismatched tire sizes or types. Check the tires’ inflation and correct if necessary. Also, look for the results of collision damage and towing damage.
* Check the tires and wheels for the radial runout.
* Check the wheel bearings.
* Remove heavy items from the trunk and passenger compartment. However, if these items, such as toolboxes, are normally carried in the vehicle, leave them in.
* Check the vehicle’s ride height **(Figure 45 – 9)**. Every vehicle is designed to ride at a specific curb height. Curb height specifications and the specific measuring points are given in service manuals. Proper alignment is impossible if the ride height is incorrect. If the height is slightly off, the problem can be corrected with spring spacers.
* Check the play of the steering wheel.
* Jounce the vehicle raised, inspect all steering components such as control arm bushing, upper strut mounts, pitman arm, idler arm, center link, tie – rod ends, ball joints, and shock absorbers. Check the CV joints (if equipped) for looseness, popping sounds, binding, and broken boots. Damaged components must be repaired before adjusting alignment angles.

**Figure 45-9** Typical measuring points for idle height.

**WHEEL ALIGNMENT EQUIPMENT**

There are many different ways to measure the alignment angles on a vehicle. The most common way is the use of an alignment machine or rack. The equipment used of an alignment machine angles has evolved from string and measuring tapes to computerized machines. Today, computerized machines are the most commonly used **(Figured 45 – 10).** A typicalcomputerized system gives information on a CRT screen to guide the technician step – by – step through the alignment process.

**Figure 45- 10** A computerized wheel alignment machine.

After vehicle information is keyed into the machine and the wheel units are installed, the machine must be compensated for wheel runout. When compensation is complete, alignment measurements are instantly displayed. Also displayed are the specifications for that vehicle. In addition to the normal alignment specifications, the CRT may display asymmetric tolerances, different left – and right – side specifications, and cross specifications (difference allowed between left and right side). Graphics and text on the screen show the technician where and how to make adjustments **(Figure 45 – 11)**. As the adjustments are made on the vehicle, the technicians can observe the center block slide toward the target. When the block aligns with the target, adjustment is within half the specified tolerance.

**Figure 45-11** Examples of the screens available on the latest alignment machines.

Other alignment equipment often use are turning radius gauges, caster – camber gauges, optical toe gauges, and trammel bar gauges (also known as tram gauges).

**Turning Radius Gauges**

Turning radius gauges measure how many degrees the front wheels are turned. They are commonly used to measure the camber, caster, and toe – out on turns. Turning radius gauges (sometimes called turn table) may be portable but are commonly found as part of an alignment rack. To use these gauges, the front wheels are centered on the gauge plates. Then the locking pins are removed to allow the plate to turn with the tires. As the tires are turned, a pointer will indicate how many degrees the tires have turned. To check toe – out on turns, turn one of the tires to 20 degrees. Then look at the gauge on the other tire.

**Caster – Camber Gauge**

A caster – camber gauge is used with the turning radius plate to check caster and camber. This gauge is often referred to as a bubble gauge. The gauge is normally attached to the wheel hub with a magnet. Make sure the vehicle is on a level surface, and then jounce the front bumper several times to stabilize the suspension. Now look at the bubble gauges to read camber and compare yours with the specifications. Do both front wheels. Apply the brakes and hold the brake pedal down with a brake pedal lock. Turn one front tire 20 degrees out and adjust the bubble gauge to read zero. Now turn the wheel 20 degrees in and take the reading from the bubble gauge. This is the caster reading for that wheel. Compare it to specification. Now measure caster on the other front tire. If any reading is outside the specifications, the angles need to be adjusted.

**Optical Toe Gauges**

Checking wheel toe is also with the tires sitting on the turning radius plates. Make sure the tires are straight ahead and the plates are at zero degrees before removing the locking pins on the plate. Then install a steering wheel clamp to prevent the steering wheel from moving. Then install the brake pedal lock. Remove the hubcaps and grease caps from the front wheel. Jounce the front suspension several times to allow it to stabilize. Note the location of the steering gear. If the steering linkage is at the rear of the front wheels, push outwardly on the rear of the tires. If the linkage is to the front, push on the front of the tires. Mount the optical toe gauges onto the front wheel hubs. Use the level indicators on the gauges to make sure the gauges are level. Then read wheel toe on the gauges and compare then to specifications.

**Trammel Bar Gauges.**

A trammel bar gauge is a purely mechanical way to check toe. It is used to measure the distances between the center of the two front tires. First a distance measurement is taken at the car of the tires (centerline to centerline), then the same measurement is taken at the front of the tires. The difference in the measurements is the amount of toe. Compare this reading with specification.

**Miscellaneous Tools**

**Figure 45 – 12** shows an assorted of the special tools required for wheel alignment and other and suspension system work.

**Figure 45-12** An assortment of steering and suspension tools.

**ALIGNMENT MACHINES**

Most shops use an alignment machine to check all of the alignment angles. Normally an alignment rack is part of the alignment machine’s package. The rack is best described as a limited vehicle hoist (lift) equipped with turning radius plates. There are many varieties of alignment machines that have been used through the years. Some are equipped to measure alignment angles at all four wheels of the vehicle, and others measure the angles at only two wheels. Some alignment machines simply display the angles readings, whereas others display the reading plus give advice on how to correct the angles.

**Four – wheel alignment** (or **total wheel alignment**), whether front or rear drive, solid axle or independent rear suspension, sets the alignment angles on all four wheels so they are positioned straight ahead with the steering wheel centered. The wheels must also be parallel to one another and perpendicular to a common centerline. More than 85% of all new vehicles require that all four wheels are aligned.

To accomplish this, the total for all four wheels must be determined and rear toe adjusted where possible to bring the rear axle or wheels into square with the chassis. The front toe setting can then be adjusted to compensate for any rear alignment deviation that might persist.

Four – wheel also includes checking and adjusting rear – wheel camber as well as toe, and doing all the traditional checks of front cambers, toe, caster, toe – out on turns, and steering axis inclination. The most important thing a four – wheel alignment job tells the technician is whether or not the rear axle or rear wheels are square with respect to the front wheels and chassis.

With two – wheel alignment equipment that aligns the front wheels to the geometric centerline, the assumption is made that the rear wheels are square with respect to the centerline. If that is true, the alignment job produces satisfactory results. If not, steering and tracking might be a problem.

Rear – wheel alignment can be checked on a two – wheel machine by simply backing the vehicle onto the rack.

The rear wheels can also be checked for square by measuring the wheelbase on both sides with a track bar to make sure it is equal. The obvious drawback to this approach is that four – wheel alignment involves several extra steps. There is also the question of aligning the wheels to the centerline or thrust line.

The best approach in terms of both accuracy and completeness for wheel alignment is to reference the front wheels to the rear wheels. With this approach, individual rear toe is measured so the thrust line can be determined and the front wheels adjusted to the centerline. It also eliminates the need to back the vehicle onto the alignment machine because heads are provided for the rear wheels.

The actual procedure for total four – wheel alignment, as with two – wheel alignment, begins with a thorough inspection of the wire and suspension. Do not forget to check the ride height based on the normal vehicle load.

Once the alignment heads are installed and compensated for wheel runout, read front and rear camber and front and rear toe. The thrust angle created by near wheels can then be determined. A typical procedure for checking the alignment of all four wheels with a computerized alignment machine is shown In Photo Sequence 49.

Most alignment machines compensate for wheel setback. Some show how much setback is present and where. Nearly all machines will also show SAI. Steering axis inclination, an angle frequently neglected on quick alignment jobs, is important to include because it can help pinpoint damaged parts. If the SAI does not match specifications, compare both sides. Problems can be caused by bent struts, control arms spindle, or steering knuckles. A mislocated strut tower or control arm anchor can also throw off the reading.

**ADJUSTING WHEEL ALIGNMENT**

All wheel alignment angles are interrelated. Regardless of the make of a car or the type of suspension, the same adjustment order – caster, camber, toe – should be followed, as far as the car permits such adjustments to be made. Some MacPherson suspensions do not provide for caster or camber adjustments. Additionally, adjustment methods vary from model to model and, occasionally, even in different model years.

**Caster / Camber Adjustments**

Caster affects steering stability and steering wheel returnability. Zero (0) caster is present when the upper ball joint are in the same plane as viewed from the side of the vehicle. Positive caster exists when the upper ball joint or top strut bearing is toward the rear of the vehicle in relationship to the lower ball joint. When the upper ball joint or top strut bearing is toward the front of the vehicle in relationship to the lower ball joint, negative caster is present. If the caster at both wheels is not equal, the vehicle will tend to drift toward the side with the lowest caster.

Camber is the inward or outward tilt of the top of the wheel. Adjusting camber centers the vehicle’s weight on the tire. Proper camber adjustment minimizes tire wear Zero (0) camber is present when the wheel is at a perfectly vertical position. The tires have positive camber when the top of the tire is tilted out, or away from the engine. When the top of the tire is tilted in, there is negative camber. Incorrect camber will cause excessive stress and wear on suspension parts. Too much negative camber will cause wear on the inside tread of the tire, whereas too much positive camber will cause tire wear on the outside tread. If camber is not the same on the both wheels, the vehicle will pull toward the side with the most positive camber.

To compensate for road crown, most alignment specifications allow for slightly more negative caster or slightly more positive camber on the left side of the vehicle.

Several methods are used to adjust caster and camber.

**Shims** Many cars use shims for adjusting caster and camber **(Figure 45 – 13)**. The shims can be located between the control arm pivot shaft and the inside of the frame. Both caster and camber can be adjusted in one operation requiring the loosening of the shim bolts just once. Caster is changed by adding or subtracting shims from one end of the pivot shaft only. Then, camber is adjusted by adding or subtracting an equal amount of shims from the front and rear bolts. This procedure allows camber to change without affecting the caster setting.

**Figure 45-13** Adding and subtracting shims between the control arm and the frame will change caster and camber.

Some cars use shims located between the control arm pivot shaft and the outside of the frame. The adjustment procedure is the same as just described. Always look at the shim arrangements to determine the desired direction of change loosening the bolts.

**Eccentrics and Shims** Eccentrics and shims are used on some vehicles to adjust caster and camber. In some designs, an eccentric bolt and cam on the upper control arm adjust both caster and camber. To adjust, the nuts on the upper control arm are loosened first. Then, one eccentric bolt at a time is turned to set caster. Both bolts are turned equally to set camber.

The **eccentric bolt and cam** assembly **(Figure 45 – 14)** can be located on the inner lower or upper control arm. Unlike other designs, camber is adjusted first. Some car models have a cambers eccentric between the steering knuckle and the upper control arm. The camber eccentric is rotated to set camber **(Figure 45 – 15)**. Caster is set with an adjustable strut rod.

**Figure 45-14** Eccentric bolt and cam, shown on an upper control arm.

**Figure 45-15** Graduated cam for adjusting camber.

**Slotted Frame** The slotted frame adjustments has slotted holes under the control arm inner shaft the allow the shaft to be repositioned to the correct caster and camber settings. Caster and camber adjusting tools help in making adjustments. One end of the shaft is moved for caster adjustments. Both ends of the shaft are moved for camber adjustment. Turning a nut on one end of the rod changes its length and adjusts caster. Camber is set by an eccentric at the inner end of the lower control arm, or by a camber eccentric in the steering knuckle of the upper support arm, as described earlier.

**Rotating Ball Joint Washers** In this design, camber is increased by disconnecting the upper ball joint, rotating it 180 degrees, and reconnecting. This positions the flat of the ball joint flange inboard and increases camber approximately 1 degree. Caster angle is changed with a kit containing two washers, one 0.12-inch (3-mm) thick and one 0.36-inch (9-mm) thick. The washers are placed at opposite ends of the locating tube between the legs of the upper control arm. Placement of the large washer the rear leg of the control arm increases caster by 1 degree. Placement of the large washer at the front leg of the control arm decrease caster by 1 degree.

**MacPherson Suspension Adjustments**

Caster / camber adjustments are made only on certain models with MacPherson suspensions. There are two general OEM procedures for doing this, although aftermarket kit adapters are available for some models. Service information must be consulted for an accurate listing of models on which adjustments can be made.

In one version, a cam bolt at the base of the strut assembly is used to adjust camber **(Figure 45 - 16)**. On different models, this bolt can be either the upper or the lower of the bolts connecting the strut assembly to the steering knuckle. Both bolts must be loosened to make the adjustment, and the wheel assembly must be centered. Turn the cam bolt to reach the correct alignment, then retighten the bolts to the appropriate torque specifications. There is no caster adjustment on this version.

**Figure 45-16** Some MacPherson suspensions use cam bolts at the connection to the steering knuckle for camber adjustments.

In the other form of kit adapter, both caster and camber are adjustable at the strut upper mount. Slots in the mounting plate permit the strut assembly to be shifted to reach the alignment specifications. To adjust caster, loosen the three locknuts on the mounting studs and relocate the plate. Do not remove the nuts **(Figure 45 – 17).** Loosen the center locknut and slide it toward or away from the engine as needed to adjust camber correctly.

**Figure 45-17** Caster and camber adjustment of locknuts.

While caster cannot be adjusted on many MacPherson strut front suspensions, camber can be adjusted. The camber is such that, although it is locked in place with a pivot rivet, it can be adjusted by removing the rivet from the camber plate and loosening the three nuts that hold the plate to the body apron **(Figure 45 – 18)**. Camber is changed by moving the top of the shock strut to the position in which the desired camber setting is achieved. The nuts are then tightened to specifications. (It is not necessary to install a new pop rivet).

**Figure 45-18** An upper strut mount with a camber plate. Note the location of the ricet and the attaching bolts.

**Rear – Wheel Camber Adjustments**

Like front camber, rear camber affects both tire wear and handling. The ideal situation is to have zero running camber on all four wheels to keep the in full contact with the road for optimum traction and handling.

Camber is not a static angle. It changes as the suspension moves up and down. Camber also changes as the vehicle is loaded and the suspension sags under the weight.

To compensate for loading, most vehicles with independent rear suspension often call for a slight amount of positive camber. A collapsed or mislocated strut tower, bent strut, collapsed upper control arm bushing, bent upper control arm, sagging spring, or an overloaded suspension can cause the rear wheels to have negative camber. A bent spindle or strut bowed lower control arm can cause too much positive camber. Even rigid rear axle housings in rear – wheel – drive vehicle can become bowed by excessive torque, severe overloading, or road damage.

| ***C A U T I O N !*** |
| --- |
| Never jack up or lift a FWD vehicle on its rear axle.  The weight of the vehicle may cause the axle to  bend and result an misalignment of the rear wheels.  Always lift the vehicle at the recommended lifting  points. |

Besides wearing the tires unevenly across the tread, uneven side – to – side camber (as when one leans in and the other does not) creates a steering pull just like it does when the camber reading on the front wheels do not match. It is like leaning on a bicycle. A vehicle always pulls toward a wheel with the most positive camber. If the mismatch is at the rear wheels, the rear axle pulls toward the side with the greatest amount of positive camber. If the rear axle pulls to the right, the front of the car drifts to the left, and the result is a steering pull even though the front wheels may be perfectly aligned.

The methods used to adjust rear suspensions vary. On some semi – independent suspensions, camber and toe are adjusted by inserting different sizes of shims between the rear spindle and the spindle mounting **(Figure 45 – 19)**. The shim thickness is changed between the top or bottom of the spindle to adjust camber. Many shims are now available that are round but have different thicknesses through their diameters.

On others, a camber adjustment can be made by installing a wedge spacer between the top of the knuckle and the strut. Still others have eccentric bolts and cams at the mounting points for the and/or trailing arms **(Figure 45 – 20)**.

**Figure 45-19** A computer screen showing what shim to install in the rear to bring the vehicle into alignment.

**Figure 45-20** An independent rear suspension may have eccentric cams at all of its control arms.

**Toe Adjustment**

Toe is the last alignment angle to be set. The same procedure is followed on all vehicles, except those with bonded ball stud sockets. Connect toe will minimize tire wear and rolling friction.

To adjust toe, start by being sure the steering wheel is centered **(Figure 45 – 21)** when the front wheels point straight ahead. Then loosen the retaining bolts on the tie – rod adjusting sleeves. Turn the sleeves to move the tie – rod ends **(Figure 45 – 22)**.

**Figure 45-21** A typical acceptable steering wheel position—measured from a normal spoke angle.

**Figure 45-22** Turn the adjusting sleeves to adjust toe.

On many rack and pinion systems, the tie – rod locknut must be loosened and the tie rod rotated to adjust toe at each wheel **(Figure 45 – 23).** Before rotating the tie rod, the small outer bellows clamp must be loosened.

**Figure 45-23** Rotating the tie rod to adjust the toe on a rack and pinion steering gear.

Other rack and pinion tie – rod ends have internal threads and a threaded adjuster. One end of the adjuster has right – hand threads, the other has left – hand threads. As the adjuster is turned, it changes the overall length of the tie rod, thereby changing toe.

And ideal toe condition is both wheels exactly straight ahead, which would minimize tire, wear. This, however, is not possible because of the many factors affecting alignment. As a result of these numerous conditions dealing with both tire wear and handling, all suspensions are designed with a slight toe – i8n or toe – out.

Any misalignment of the steering linkage pivot point or control arm pivot or control arm pivot point (such as the center link or rack and pinion out of place) causes the condition known as **toe – change.** Toe –changed involves turning the wheels from their straight – ahead position as the suspension moves up and down.

The change might be only one wheel, both wheels in the same direction, or both wheels in the opposite direction. Regardless of the condition, any change of one or more wheels is a toe – change condition. The results are tire wear wheels is a toe – change condition. The results are tire wear and a hard – to – handle vehicle. The poor handling effects can get to the point that the vehicle is dangerous to drive.

Toe change is not a specification, it is a condition in which the toe setting constantly varies. It must be determined by equipment or a method that measures individual wheel toe at all suspension heights. There must be a change in suspension heights for any changes to occur.

Lightweight front – wheel – drive vehicles can be affected greatly by toe – change. With these vehicles, the front wheels are no longer being pushed. They actually pull the vehicle forward and as a result, if the wheels are not maintaining a straight - ahead position, they affect directional control. Adverse road condition, such as wet or icy condition, can also increase the handling effects created by toe – change in the front- wheel – drive car.

**Rear Toe** Rear toe, like front toe, is a critical tire wear angle. It toed – out, the rear tires scuff just like the front ones. Either condition can also contribute to steering instability as well as reduced braking effectiveness. Keep this in my mind with antilock brake systems.

Like camber, rear toe is not a static alignment angle. It changes as the suspension goes through jounce and rebound. It also changes in response to rolling resistance and the application of the engine torque. With FWD vehicles, the front wheels tend to toe – in under power while the rear wheels toe-out in response to rolling resistance and suspension compliance. With RWD vehicles, the opposite happens: the front wheels toe –out while the rear wheels on an independent suspension try to toe – in as they push the vehicle ahead.

If the toe is not within specifications, it affects tire wear and steering stability just as much as front toe. A total toe reading that is within specifications does not necessarily mean the wheels are properly aligned – especially when it comes to rear toe measurements. If one rear wheel is toe – in while the other is toe – out by an equal amount, total toe would be within specifications. However, the vehicle would have a steering pull because the rear wheels would not be parallel to center.

Remember, the ideal situation is to have all four wheels at zero running toe when the car is traveling down the road. This is especially true with antilock brakes where improper toe can effect can affect brakes; such a condition can affect brake balance when braking on slick or wet surfaces, causing the antilock brakes to cycle on and off to prevent a skid. Without antilock brakes, this condition may upset traction enough to cause an uncontrollable skid.

**Thrust Line** If both rear wheels are square to one another and the rest of the vehicle, the thrust line is perpendicular to the rear axle and coincides with the vehicle’s centerline. But if one or both rear wheels are toed – in or toed – out, or one is set back slightly with respect to the other, the thrust line is thrown off – center. This creates a thrust angle that causes a steering pull in the opposite direction. For example, a thrust line that is off – center to the right makes the car pull left.

The presence of a thrust angle can cause poor directional stability on ice, snow, or wet pavement. It can sometimes make a vehicle pull during braking or hard acceleration. It can also increase tire wear as the front wheels fight the rear ones for steering control.

The only way to eliminate the problem is to eliminate the thrust angle. The thrust line can be reentered by realigning rear toe. On most FWD applications that can be easily be done by using the factory – provided toe adjustments, by placing toe / camber shims between the rear spindles and axle, or by using eccentric bushing kits. With RWD vehicles that have a solid rear axle, changing rear toe is not easy. Sometimes the floorpan or frames rails are misaligned from the factory or from collision damage. Short of pulling the chassis on a collision bench to restore the correct control arm or spring – mount geometry, the only other options are to try some type of offset trailing arm bushing with the coil springs or to reposition the spring shackles or U – bolts with leaf springs.

If rear toe cannot be easily changed, the next best alternative is to align the front wheels to the rear axle thrust line rather than the vehicle centerline. Doing this puts the steering wheel back on center and eliminates the steering pull – but it does eliminate dog tracking. Dog tracking occurs when the rear wheels do not follow directly behind the front wheels when the vehicle is moving forward.

**FOUR – WHEEL – DRIVE VEHICLE ALIGNMENT**

With front – wheel – drive and full – time 4WD vehicles, the front wheels are also driving wheels. As the front wheels pull the vehicle, the wheels tend to toe – in when torque is applied. To offset this tendency, the front wheels usually need less static toe – in to produce zero running toe. In fact, the preferred toe alignment specifications in this instance can be zero to slightly toe – out (1/16-inch [1.5-mm] toe – out).

It is important to note that when the front wheels of a part – time 4WD system are freewheeling, they behave the same as the front wheels in a rear – wheel – drive vehicle. That is, they roll rather than pull. The wheels tend to toe – out, so the static toe setting would have to toe – in to achieve zero running toe when driving in the two – wheel mode.

The tires suffer in proportion to toe misalignment. For a tire that is only 1/8 inch (3 mm) off (1/4 degree), the tire is scrubbed sideways 12 feet (3.6 meters) for every mile traveled. That may not sound like much, but 12 feet (3.6 meters) of sideways scrub every mile can cut a tire’s life in half.

If rapid tire wear seems to be the problem, look for the telltale feathered wear pattern. If the wheels are running toe –in, the feathered wear pattern leaves sharp edges on the inside edges of the tread. If the wheels are running toe – out, sharp the edges are toward the outside of the tread. It is usually easier to feel the feathered wear pattern that to see it. To tell which way the wear pattern runs, rub your fingers sideways across the tread.

On most 4Wd vehicles, caster is not adjustable. Aftermarket companies do provide caster adjustment kits for some pickups. These kits may contain shims or eccentric cam and bolt. For some pickups, the aftermarket cam kit will also provide for camber adjustments.

On other 4WD vehicles, camber is adjusted by installing adjustments shims between the spindle and the steering knuckle or by installing and/or adjusting an eccentric bushing at the upper ball joint. Most aftermarket parts manufacturers have camber adjustment shims available in various thicknesses and diameters. Never stack the shims. Only one shin per side should be used.