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CHASSIS

OUTLINE OF THE CHASSIS

Chassis systems include the suspension that supports the axles, the steering that steers the vehicle, wheels, tires, brakes that stop the vehicle, etc. These systems have direct impacts on riding comfort, the vehicle stability, steering feeling,
etc., and vary widely in mechanisms and devices. The braking system is used to decelerate or stop the running vehicle and maintain it in a parked condition.

SUSPENSION

1.) DESCRIPTION

A suspension system is located between the vehicle body of frame and the wheels and is designed to ease the shocks of road surface irregularities and thus improve riding comfort and stability as well as the tire's road-holding characteristics.

It combines springs, shock absorbers, stabilizers, and so forth. Suspension systems may be generally grouped into the rigid axle suspension type and the independent suspension type by the way they are made up.

The suspension connects the body of the vehicle with the wheels, and carries out the following functions:

- During running, it acts, together with the tires, to absorb and damp the various vibrations, oscillations, and shocks received by the vehicle due to irregularities in the surface of the road, in order to protect the passengers and cargo, and improve driving stability.
- It transmits driving and braking forces, which are generated due to friction between the road surface and the wheels, to the body.
- It supports the body on the axles and maintains the proper geometrical relationship between body and wheels.

2.) PRINCIPAL SUSPENSION COMPONENTS

Suspension mainly consists of the following components. Of these components, springs and shock absorbers are used in all suspension systems while others are found in only some.

- Springs
- Shock absorbers
- Suspension arms
- Ball joints
- Rubber bushings
- Strut bars
- Stabilizer bar
- Lateral control rod

- Control arms
- Bumpers

SPRINGS

Springs are designed to prevent shocks from the road surface and vibration of the wheels from reaching the vehicle body directly. They also help
Enhance the tires’ road-holding ability. There are three main types of springs.

1.) Coil Springs

Coil springs are made of special steel rods formed into spirals.

2.) Leaf Springs

Leaf springs are bent blades of spring steel that can flex freely.

3.) Torsion Bar Springs

Torsion bar springs are made of spring steel bars having torsional elasticity.

SHOCK ABSORBERS

1.) Description

A problem with the simple spring is that it tends to oscillate up and down when it is subjected to a road jolt. Riding comfort will be poor unless some means is provided to stop this oscillation. A shock absorber is designed to damp oscillation quickly to improve riding comfort. It also gives the tires better road-holding characteristics.

2.) Theory of Operation

In automobiles, telescopic shock absorbers are used employing a special fluid, called shock absorber fluid, as the working medium. In this type of shock absorber, a damping force is generated by the flow resistance caused by the fluid being forced through an orifice (small hole) by the movement of a piston.

3.) Types

Shock absorbers classified according to their operation, construction, and by their working medium as follows:

1) Classification by Operation

(1) Single-action Shock Absorber

Damping occurs only when the shock absorber is extended. No damping force is generated when it is compressed.

(2) Multiple-action Shock Absorber

Damping occurs both when the shock absorber is extended and when it is compressed. Currently, most shock absorbers used on cars are of this type.

2) Classification by Construction

(1) Twin-tube Shock Absorber

The cylinder is divided by the pressure tube and the outer tube into a working chamber (inner cylinder) and a reservoir chamber (outer cylinder).

(2) Mono-tube Shock Absorber

Fhis is a shock absorber with only a single ~ylinder (i.e., without a reservoir).

3) Classification by Working Medium

(1) Hydraulic Shock Absorber

This is an ordinary shock absorber which uses only a fluid (shock absorber fluid) as a working medium.

(2) Gas-filled Shock Absorber

This is a hydraulic absorber which is charged with gas. The principal gas used is nitrogen, which is kept under either low pressure 10 – 15 kg/cm^2 (142—213 psi, 981 —1,471 kPa) or high pressure 20 – 30 kg/cm^2 (284 – 427 psi, 1,961 – 2,942 kPa).

BALL JOINTS

1 Description

Ball joints bear vertical as well as lateral loads and also act as pivots for the steering knuckles when the wheels are turned.

2) Lubrication of Ball Joints

The inside of the ball joint is packed with grease to lubricate sliding surfaces. The grease in the ball joint should be replaced at the recommended interval using molybdenum disulfide lithium based grease.

REFERENCE

To add grease, remove the screw plug, then install the grease fitting.

IMPORTANT!

Be sure to replace the grease fitting with the screw plug after greasing is completed.

There is another type of ball joint that uses resin seats. In this type, replacement of the grease is unnecessary.

STABILIZER BAR

1 **Description**

The stabilizer is designed to reduce the inclination of the vehicle due to the centrifugal force that is generated when the vehicle rolls* on turns. It also improves the traction of the tires.

On the front suspension, the stabilizer bar is normally fitted at both ends to the lower suspension arms via rubber cushions and linkages.
The center section is fitted to the vehicle frame or body at two points via rubber bushings. (*See P5-il)

2) **Operation**

If the right and left wheels go up and down at the same time, in the same direction and by equal amounts, the stabilizer bar will be free of torsion.

Normally, however, the outer spring is compressed while the inner spring expands when the vehicle is turning. For this reason, one end of the stabilizer bar is twisted up while the other end is twisted down, and the stabilizer bar is twisted as a result. However, the bar tends to resist the torsion, and it is this resistance that reduces this vehicle roll and maintains the body as level as possible.

STRUT BARS

As illustrated below, the strut bars are fitted at one end to the lower suspension arm by a bolt or nut, and at the other end to the strut bar bracket which is fixed to the body or cross member, via rubber cushions.

When the front wheels are subjected to shocks due to road irregularities, obstacles, braking, etc., the strut bars prevent the lower suspension arms from moving back and forth.

LATERAL CONTROL ROD

In order to bear forces in the lateral direction and to help position the axle so that it is not displaced in the lateral direction, a lateral control rod is used, mainly on the rear suspension. The lateral rod is mounted transversely between the axle and a structural member.

BUMPERS

The springs sometimes contract and expand more than permitted and can cause damage to other components when the wheels goes over a large bump or hole. The bounding and rebounding bumpers protect the frame, axles, shock absorber, etc., when the springs compresses and expand more than permitted.

REFERENCE

BOTTOMING:

Bottoming refers to a large upward shock felt by the occupants of the vehicle caused by a major rolling or pitching of the vehicle when the wheel goes over a large hole or bump. Bottoming is caused by the bounding bumpers as they hit the frame, etc., when the suspension spring compresses more than permitted.

OSCILLATION OF THE BODY

Several types of oscillation can occur to the body as shown below.

Pitching

Pitching is the up-and-down oscillation, in relation to the car's center of gravity, of the front and back of the car. This happens especially when the car goes over large ruts or bumps in the road or when driving over an unpaved road which is rough and full of potholes. Also, pitching occurs more easily in vehicles with softer (easily compressed)springs than in those with harder springs.

- RoIling
  When turning or when running on a bumpy road, the springs on one side of the vehicle expand, while those on the other side contract. This results in body rolling in the lateral (side-to-side) direction.

- Bouncing
  Bouncing is the up-and-down movement of the auto body as a whole. When a car is running at high speeds on an undulating surface, bouncing is likely to occur. Also, it occurs easily when the springs are soft.

- Yawing
  Yawing is the movement of the car's longitudinal centerline to the right and left, in relation to the car's center of gravity. On roads where pitching occurs, yawing is also likely to occur.

3. SUSPENSION TYPES AND CHARACTERISTICS

Suspensions can be broadly divided into two types according to their construction.

- Rigid axle suspension in which the right and left wheels are connected by a single axle.
- Independent suspension in which the left and right wheels move independently of each other.

RIGID AXLE SUSPENSION

In vehicles having a rigid axle suspension system, the right and left wheels are connected by a single axle which itself is fitted to the body and the frame via springs (leaf springs or coil springs). Due to its great strength and simple construction, the rigid axle suspension system is widely used with the front and rear wheels of buses and trucks and with the rear wheels of passenger cars.

INDEPENDENT SUSPENSION

In vehicles having an independent suspension system, the right and left wheels are not connected directly by an axle. The suspension is fitted to the body and the frame in such a way that both wheels can move independently without affecting each other. The independent suspension system is commonly used with the front wheels of passenger cars and small trucks and more recently, with the rear wheels of passenger cars as well.

4. FRONT SUSPENSION SYSTEMS

A big difference between the front and rear suspensions is that the front wheels have to be steered.

When a car corners or goes over bumps, it is subjected, via the wheels, to a variety of forces. The suspension must be able to prevent these forces from deflecting the car from the course selected by the driver. Also, it must not allow the wheels to wobble, move forward, backward, or
sideways any significant distance, or alter their angle of tilt to any serious degree, as this would interfere with the handling of the car. Therefore, independent suspension is often used for the front wheels. Two representative types of independent suspension are the Macpherson strut type suspension and the double wishbone type suspension.

MACPH ERSON STRUT TYPE

This is the most widely used independent suspension system for the front suspension of small and medium sized cars.

Construction

The strut type suspension is composed of the lower arms, strut bars, stabilizer bar and strut assemblies.

- One end of the lower arm is attached to the suspension member via a rubber bushing, and can move freely up and down. The other end is mounted on the steering knuckle arm by means of a ball joint.

- The strut bars withstand the force being exerted from the wheels in the longitudinal direction. One end is fastened to the lower arm and the other end is mounted via a rubber cushion to a strut bar bracket welded to the front cross member.

- The stabilizer bar helps maintain the vehicle level on corners and give the tires better road holding characteristics. It is fitted at both ends to the lower supension arm via rubber bushings and links, and at two center points to the body via rubber bushings.

- The coil springs are mounted on the strut assembly, and the shock absorber is built into the strut assembly.

Since the shock absorber acts as a part of the suspension linkage, besides being able to stand up to and absorb road shock and oscillation, it must also be strong enough to bear the vertical load that is placed upon it. Its top end is mounted on the fender apron via the upper support, which is composed of a rubber cushion and a bearing. It can turn freely on its axis. The bottom end of the strut assembly is fastened to the steering knuckle arm with bolts.

MACPHERSON STRUT TYPE WITH L-SHAPED LOWER ARM

Construction

There are several lower-arm configurations being used to support the wheels and car body. Some front-engine, front-wheel-drive vehicles employ L-shaped lower arms. The L-shaped lower arms are mounted to the body at two points, via bush-
ings, and at one more point to the steering knuckle via the ball joint.

This type of arm can withstand both lateral and longitudinal forces, thus making it possible to eliminate the strut bar.

DOUBLE WISHBONE TYPE WITH COIL SPRINGS

This type of independent suspension system is used widely as the front suspension of passenger cars and small trucks.

Construction

The wheel is fitted to the body via a pair of suspension arms (upper and lower arms).

The shock absorber and coil springs are mounted inside the quadrilateral formed by these two arms, the steering knuckle and the frame.
One end of each suspension arm is fitted to the body or frame via bushings, and the other end to the steering knuckle via a ball joint. The top of the shock absorber is fitted to the body or frame, and the bottom to the lower arm. The coil spring is fastened between the lower arm and the body or frame.

DOUBLE WISHBONE TYPE WITH TORSION BARS

This type of suspension is used on many small trucks in place of a suspension system with coil springs.
The torsion bar is fastened to the upper or lower arm.

Construction

Shown below is the torsion bar fitted to the upper arm. The lower arm is connected to the suspension member by a rubber bushing.

The upper arm is joined to the upper arm shaft by rubber bushings. The torque arm is attached to the rear of the upper arm by two bolts and the torsion bar is splined to it.

The front of each torsion bar is splined to the torque arm of the upper arm, and the rear of the bar fits into the anchor arm, which is attached to the cross member by the anchor arm adjusting bolt. It is therefore easy to adjust the height of the vehicle using this bolt. The front and rear splines are each provided with a dust cover to keep out muddy water, etc.

IMPORTANT!
In some vehicle models, "R" or "L" has been stamped on the end of the torsion bar so that it will not be installed incorrectly.

PARALLEL LEAF SPRING TYPE

This type of suspension is used for the front suspension of trucks, buses, etc.
The illustration below shows the front suspension of a four-wheel-drive truck.
The center of each leaf spring is fastened to the front axle housing with U-bolts.

The suspension shown in the figure below is ordinarily used as the front suspension of rear-wheel-drive trucks.
The leaf springs are fastened to the front axle (which is an I beam) with U-bolts.

5. REAR SUSPENSION SYSTEMS

In most cars, the rear suspension must carry most of the extra weight of the passengers and luggage. This leads to a difficult problem: if the suspension springs are made hard or stiff enough to handle this extra load, they will be too hard for when there is only the driver; on the other hand, if they are made soft enough for when there is only the driver, they will be too soft for when the car is fully loaded. The same also applies to theshock absorbers. This problem can be solved by using leaf springs or other types of springs having a variable spring rate, gas-filled shock absorbers, different types of independent suspension, etc.

The rear suspension is designed so that it will keep the axle properly positioned, while allowing the wheels to bounce without affecting the steering characteristics of the front wheels.

PARALLEL LEAF SPRING TYPE

This is the rigid axle suspension which is most generally used for the rear suspension of commercial vehicles.

The type of axle generally used with a parallel leaf spring type suspension is the so-called live axle, in which the differential, axle shafts, and wheel-
hub mountings are combined into one rigid unit. The live axle is connected to the propeller shaft and is attached to the frame in such a way as to allow it (the axle) to move up and down on its springs, and to cope with the loads and the braking and driving forces imposed upon it.

Construction

Generally, the front end of each leaf spring is mounted to a spring bracket on a structural member or the frame via a rubber bushing with a hanger pin. The rear end of the spring is mounted to a spring bracket on a structural member or the frame via a rubber bushing with a shackle. As shown below, when the spring is flexed due to changes in the load, even if the length of the spring changes, the shackle can compensate for the change.

The rubber bushings serve two purposes:

They absorb vibration and thus prevent it from reaching the body; they also allow the spring eyes to twist back and forth as the leaf springs bend.

The center of each leaf spring is connected to the axle housing by a pair of U-bolts.

Illustrated below is an example of a rear suspension system for front-wheel-drive vehicles.
The leaf spring of this system, found in the Corolla Wagon (EE97), is fitted at its center to the rear axle tube.

4-LINK TYPE

Of the various types of rigid axle suspensions, this suspension provides superior riding comfort, since it handles axle positioning and load
suspension separately. Ordinarily, coil springs are used as suspension springs.

Construction

Axle positioning is carried out by two lower control arms, two upper control arms and one lateral control rod. For load suspension and absorption of road shock, only the springs are used.

Reactive forces to the wheels' driving and braking torques (which act in the vehicle's longitudinal direction) are handled by the lower and upper control arms, and lateral forces by the lateral control rod.
One end of each control arm, or one end of the lateral rod, is fastened to the body or the frame and the other ends are attached to the rear axle housing via rubber bushings.

Coil springs are mounted between the lower control arms or rear axle housing and the body.

SEMI-TRAILING ARM TYPE

This is an independent suspension system designed with the objectives of increasing rigidity with respect to lateral loads and minimizing changes in alignment (toe-in, tread, and cam-
ber) that occur due to the up-and-down motions of the wheels.
Generally, the construction is simple and the components take up little space, so it often used as the rear suspension on passenger cars.

Construction

The swing axis of the suspension arms are located forward of the wheels, and the arms are installed via bushings to the suspension members so that their axis are at an angle with respect to the vehicle's longitudinal centerline.

The differential is carried by a differential support member mounted on the body via bushings. Also, CV (constant velocity) joints are normally used as joints in the drive shaft.

DOUBLE WISHBONE TYPE

This type of independent suspension system is used as the rear suspension of rear-wheel-drive passenger cars.

Construction

Each wheel is supported by three suspension arms (one upper and two lower suspension arms) positioned nearly perpendicular to the longitudinal centerline of the vehicle and a strut rod extending along the centerline. One end of the upper suspension arm is fitted to the suspension member via bushings and the other end to the axle carrier via a ball joint.

One end of each of the lower suspension arms is fitted to the suspension member via bushings. Of the two other ends, arms No. 1 and No. 2 are fitted to the axle carrier via a ball joint and via bushing respectively.

The strut rod bears the longitudinal force of the vehicle. One end is fitted to the suspension member via a bushing and the other to the axle carrier via a bushing.

The coil spring and shock absorber are joined integrally at the bottom to the axle carrier via bushing while their upper ends are fitted to the car structure via a upper support. The stabilizer bar is fitted at both ends to lower arm No. 2 on each side via a link and ball joint. It is fitted to the suspension member at two points in the middle via rubber bushings.

DUAL-LINK STRUT TYPE

This type of suspension is used in the rear of the front-engine front-wheel-drive cars and is one type of strut suspension.

Construction

The wheels are supported by two suspension arms which are nearly perpendicular to the vehicle's longitudinal centerline, and by strut rods running parallel to this centerline. The longitudinal, lateral and vertical loads from the wheels' up-down motions are each borne by different components. Therefore, since it is possible for each of the components to have the most appropriate design for the vehicle, superior handling stability and riding comfort can be realized with this suspension.

Forces and loads from various directions are applied to the following components:

Vertical = Coil springs Shock absorbers
Upper support rubber cushions

Longitudinal = Strut rods and bushings

*Lateral = Suspension arms and bushings

TRAILING ARM TYPE WITH TWISTING BEAM

This is a rigid axle suspension which is used for the rear suspension of small front-wheel drive cars.

Construction

The rear ends of the suspension arms are welded to the axle beam, which houses the stabilizer. Both ends of the stabilizer are also welded to the same axle beam. Loads applied from the tires are therefore broken down into their directional components for distribution as shown in the chart below.

Vertical * Coil springs

Shock absorbers and
lower bushings
Upper support rubber
cushion

Longitudinal * Suspension arms and front bushings

Lateral * Lateral rod and bushings

When the wheels bound and rebound in opposite directions, the twisting movement of the ends of the suspension arms is translated into a twisting of the rear axle beam, built-in stabilizer and rear suspension arms. The twisting of the rear axle beam and stabilizer generates a reactive force which opposes the twisting of the suspension arms, aiding the coil springs in providing roll rigidity* to minimize body rolling, thus yielding greater steering stability.

* Roll rigidity is the sum of the increases in front and rear suspension recovery moments that are produced when the vehicle rolls from side to side, and which are transmitted from the front and rear suspensions to the body.

STEERING

1. DESCRIPTION

The purpose of the steering system is to allow the driver to control the direction of the vehicle by turning the front wheels.

This is done by means of a steering wheel, a steering column which transmits the rotation of the steering wheel to the steering gears, the steering gears which increase the rotational force of the steering wheel in order to transmit greater torque to the steering linkage, and the steering linkage which transmits the steering gear movement to the front wheels.
The steering system configuration depends on the car design (the drive train and suspension systems used, whether it is a passenger car or a commercial vehicle, etc.). At present, the recirculating-ball type and the rack-and-pinion types are in use, most often in passenger cars especially. These are shown below and in the following page.

2. PRINCIPAL STEERING COMPONENTS

The steering system generally consists of three main sections:

Steering column

Steering gear

Steering linkage

STEERING COLUMN

The steering column consists of the main steering shaft which transmits the steering wheel rotation to the steering gear, and the column tube which fixes the main steering shaft to the body. The top end of the main steering shaft is tapered and serrated, and the steering wheel is fitted to it by a nut.
The steering column incorporates a energy-absorbing mechanism that absorbs the thrust force that would otherwise be applied to the driver at the time of a collision. The steering column is fitted to the body via a breakaway type column bracket so that the steering column can easily collapse in a crash.

IMPORTANT!
When removing the steering wheel, never attempt to hammer the main steering shaft as the impact may break the plastic pin in the energy-absorbing mechanism. Always use an SST designed for removing the steering wheel safely.

The bottom end of the main steering shaft is connected to the steering gear, generally by way of a flexible joint or universal joint to minimize the transmission of road shock from the steering gear to the steering wheel.

In addition to the energy-absorbing mechanism, the main steering shaft on some vehicles may also contain a number of steering control systems: for example, the steering lock mechanism which locks the main shaft completely; the tilt steering mechanism, which allows the driver to adjust the vertical position of the steering wheel; the V telescopic steering system, which lets the driver change the length of the steering shaft freely to obtain an optimal driving position; etc.

STEERING GEAR

The gears in the steering gear assembly not only steer the front wheels but, at the same time, they act as reduction gears, reducing steering wheel turning effort by increasing the output torque. The reduction ratio is called the steering gear ratio and is normally between 1 8 and 20:1. A larger ratio reduces the steering effort but makes it necessary to turn the steering wheel more when going around a curve.

There are various types of steering gear systems, but the recirculating-ball type and the rack-and-pinion type are most commonly used on current vehicles.

The former type is generally equipped on medium-sized to large passenger cars and commercial vehicles, and the latter on small to medium-sized passenger cars.

REFERENCE

STEERING GEAR RATIO

In the case of the recirculating-ball type, the steering gear ratio is found by dividing the amount of steering wheel rotation by the amount of pitman arm movement:

Amount of steering wheel rotation
(in degrees)

Pitman arm movement (in degrees)

For the rack-and-pinion type, the steering gear ratio is found by dividing the amount of steering wheel rotation by the front wheel steering angle:

Amount of steering wheel rotation

(in degrees)

Front wheel steering angle (in degrees)

STEERING LINKAGE

A steering linkage consists of rods and arms that transmit the movement of the steering gear to the front wheels. It is crucial that the steering wheel movement be transmitted very accurately to the front wheels at all times despite up-and-down movements of the car.

There are various types of steering linkage and joint constructions designed for this purpose. The appropriateness of the design greatly affects driving stability.

Types of Linkage

1) Steering Linkage for Rigid-axle Suspension Systems.

This type of steering linkage consists of a pitman arm, drag link, knuckle arms, tie rod and tie rod ends. The tie rod has a tube for adjusting the rod length.

2) Steering Linkage for Independent Suspension Systems

This type of steering linkage has a pair of tie rods that are connected by a relay rod (the rack of a rack-and-pinion type steering system acts as the relay rod). A tube is fitted between the tie rod and a tie rod end for adjusting the rod length.

POWER STEERING

1) **Description**

A power-assisted steering system has a hydraulic booster in the middle of the steering mechanism to reduce the steering effort (the effort required by the driver to operate the steering wheel).

The steering effort is normally 2 -4 kg (4.4—8.8 lb, 20—39 N). Apowersteering system is designed to reduce the steering effort when the vehicle is moving at a low speed and to adjust it to an appropriate level when the car is moving at medium to high speeds.

2) **Types of Power Steering Systems**

1) Integral Type

This type of power-assisted steering system has a control valve and a power piston contained inside the gear box (as the name “integral” implies). The gear itself is of a recirculating-ball type.

Shown here is the mechanism of an integral type power steering system. It is mainly comprised of a reservoir tank (filled with fluid), vane pump that generates hydraulic force, a gear box containing ~ a control valve, power piston and steering gear, tubes that transmit the fluid, and flexible hoses.

2) Rack-and-pinion Type

In this type of power steering, the control valve is contained in the gear housing and the power piston inside the power cylinder separately. Otherwise, the rack-and-pinion type is similar in mechanism to that of the integral type.

3) Vane Pump

Shown below is the vane pump that generates hydraulic pressure. The reservoir, located above the pump, is always filled with a specific amount of fluid, and the fluid level must be checked regularly. For this purpose, it is important that the person checking the fluid level be fully familiar with checking conditions including the fluid temperature, lack of bubble or cloudiness in the fluid.

REFERENCE

The amount of fluid in the power steering system does not change unless there is a leak.

REMOVAL AND INSTALLATION OF STEERING WHEEL

OBJECTIVE : • To learn how to remove and install the steering wheel and position it correctly in the straight-ahead direction.

PREPARATION :
- SST 09609-20011 Steering Wheel Puller
- Torque wrench (350 kg-cm, 25 ft-lb. 34 N. m)

REMOVING STEERING WHEEL

1. DISCONNECT THE BATTERY CABLE

Disconnect the ground (negative) cable from the battery.

- The cable is removed cable so that the horn will not sound when the steering wheel pad is removed.

2. **REMOVE STEERING WHEEL PAD**

Lifting the steering wheel pad from the bottom, remove it off the four hooks.

REFERENCE

The pad removing method varies by the model. Refer to the appropriate repair manual for details.

3. REMOVE STEERING WHEEL

(a) Remove the steering wheel set nut.

(b) Place the steering wheel in the straight-ahead position.

(c) Put matchmarks on the steering wheel hub and the main shaft.

IMPORTANT!

Do not turn the main shaft or move the front wheels until the steering wheel is reinstalled on the main shaft.

(d) Remove the left-side horn button contact plate.

(e) Using an SST, remove the steering wheel. SST 09609-20011

IMPORTANT!

Always use the proper SST to remove the steering wheel. Pulling **it** or hammering the main shaft may damage or break the energy-absorbing mechanism.

INSTALLING STEERING WHEEL

1. INSTALL STEERING WHEEL

(a) Install the left-side horn contact plate to the steering wheel.
(b) Install the steering wheel onto the main shaft.
- Install the steering wheel according to the matchmarks on the main shaft and the steering wheel hub.

IMPORTANT!
If the steering wheel is misaligned in relation to the main shaft by one serration, it will change the wheel position by approximately 11 degrees.

2. CHECK AUTOMATIC TURN SIGNAL CANCEL OPERATION

(a) Put the turn signal lever in the left turn position.
(b) While pressing the steering wheel down onto the main shaft, turn the steering wheel one full turn to the left. Then, returning the steering wheel one full turn to the right, check whether the turn signal lever returns to its neutral position.
(c) Do the same for the other side.

3. INSTALL AND TIGHTEN STEERING WHEEL SET NUT

Install and tighten the steering wheel set nut to the specified torque.
Torque: 350 kg-cm (25 ft-lb. 34 N m)

4. CHECK INSTALLED POSITION OF STEERING WHEEL

(a) With the vehicle running straight ahead on a flat surface, the steering wheel must be in a straight-ahead position.
(b) If incorrect, reinstall the steering wheel in the correct position.

5. INSTALL STEERING WHEEL PAD

6. CONNECT BATTERY CABLE

7. CHECK HORN OPERATION

TIRES

1. DESCRIPTION

Automobiles ride on pneumatic tires filled with pressurized air. Tires are the only automobile constituents that come into direct contact with the road surface. They roll along the road and the engine power is transmitted through them. They also act as dampers to smooth out minor shocks from the road and increase riding comfort.

TIRE FUNTIONS

- The tires support the overall weight of the vehicle.
- The tires directly contact the road surface and transmit the vehicle's driving and braking forces to the road, thus controlling starting, acceleration, deceleration, stopping, and turning.
- The tires attenuate shock caused by irregularities in the road surface.

2. TIRE CONSTRUCTION

The following illustrates the basic construction of a tire.

REFERENCE

TIRE TREAD WEAR INDICATORS:

Tire tread wear indicators are patterned ridges 1.6 mm (0.0630 in.) to 1.8 mm (0.0709 in.) higher than the rest of the tread surface, and are molded into the tread at four to six points along the circumference of the tire. As the tire tread wears in time, the depth of the ridges becomes less until they become flush with the surface of the tread.

Tire tread wear indicators indicate the allowable limit of tire wear, showing when it is time to replace the tire.

3. TIRE TYPES

BIAS-PLY TIRES AND RADIAL-PLY TIRES

Tires are classified, according to the construction of the carcass, into bias-ply and radial-ply tires.

1) **Bias-ply Tires**

The bias-ply tire carcass is made up of alternating layers of ply cords bonded together, and lying at an angle of 30 — 4Q0 relative to the tire's circumferencial centerline.

This arrangement supports loads applied both along the tire circumference and across the diameter.

However, when the tire is subjected to a vertical load from the road surface, the ply cords tend to "squirm", or deform as shown in the illustration below.

Bias-ply tire tread tends to "squirm" as it meets the road, while belted-radial-ply tire tread tends to remain apart.

Bias-ply tires give a softer ride, but are inferior to the radial-ply tires in terms of cornering performance and wear resistance.

2) Radial-ply Tires

The radial-ply tire carcass consists of layers of cords bonded together with rubber perpendicular to the tire circumference. This construction gives the tire great flexibility in the radial direction. Nevertheless, such a carcass alone cannot withstand the full load applied along the tire circumference. The radial-ply tire, therefore, is provided with belts (sometimes called rigid breakers) made of strong textile cords or steel wires bonded together with rubber which bind the carcass in a manner similar to the hoops binding a barrel. This arrangement also increases the tread rigidity.

Radial-ply tires have a high belt rigidity, which means their cornering performance and highspeed performance are good and rolling resistance is low.

Their wear resistance is high also, but they are inferior to bias-ply tires in terms of riding comfort when the car goes over small bumps at a low speed.

TUBED TIRES AND TUBELESS TIRES

1) Tubed Tires

A tubed tire has a separate rubber inner tube to retain pressurized air inside the tire. The tire valve or air valve, which protrudes through a hole in the wheel rim, is bonded to the inner tube. If punctured, a tubed tire deflates quickly.

The softer, more flexible sidewalls on a radial-ply tire are subjected to greater deformation. To compensate for this, the inner tubes of tubed radial-ply tires are more durable than those of bias-ply tires.

2) Tubeless Tires

The tubeless tire, as the name indicates, has no inner tube. The pressurized air is held in by an inner liner, a specially-formulated thick rubber lining with high sealing effectiveness. Since the tubeless tire does away with the inner tube, the air valve is secured directly to the wheel rim.

REFERENCE

FEATURES OF TUBELESS TIRES
If a nail or other sharp object penetrates the tire, the tubeless tire leaks air more slowly because of the self-sealing effect of the inner liner. Even if it punctures while the vehicle is in motion, there is usually no pressure drop sudden enough to cause the driver to lose control of the vehicle.

This does not mean that the tubeless tire is puncture-proof, but only that the air leaks from it much more slowly than from a tubed tire. Since the nail or other sharp object that is stuck into the tubeless tire does not cause an immediate loss of a significant amount of air (though this depends upon the size of the object and how deeply it is imbedded), the driver is sometimes unaware that the tire is underinflated.

Driving a vehicle with a punctured tubeless tire could be hazardous or costly – the rapidly spinning tire may eject the nail at a high speed from the tire, or the temperature of the tire may rise unusually high (due to the stress caused by underinflation), causing the tire to be damaged beyond repair.

It is therefore recommended that tubeless tires be given regular pre-start checks – check inflation pressure, and examine closely for imbedded nails and other foreign objects-if the vehicle is frequently driven at high speeds.

COMPACT SPARE TIRES

1) Temporary-use Tire (T Type Tire)

The compact spare tire, designed to save space in the luggage compartment, is only intended for temporary use when a standard tire has punctured.

The T type tire is a tubeless spare with a bias-ply carcass. The outside diameter is almost identical to that of the standard tire. But the overall and tread widths are smaller, and the tread and carcass are thinner. To make up for the disadvantages in load and driving performance due to its compactness, the T type tire is inflated to a higher pressure (4.2 kg/cm^2, 60 psi, 412 kpa).

IMPORTANT!

The outside wheel rim of the T type tire is painted orange or yellow to distinguish it from a standard wheel rim.

2) Tire and Rim Specification Coding System (Example)

- **Tire**

T 135 /70 D 16
1) 2) 3) 4) 5)

1 Temporary use
2 Section width (in millimeters)
3 Aspect ratio (in percent)
4 Bias-ply (diagonal) tire
5 Wheel rim diameter (in inches)

- **Wheel Rim**

4 T x 16
1) 2) 3)

1 Rim width (in inches)
2 Rim flange shape (for temporary-use tire)
3 Rim diameter (in inches)

3) Precautions

For all practical purposes, compact spare tires approach the performance of normal tires except for cornering performance and performance under rough driving conditions. When using a compact spare tire, observe the following precautions:

(a) The compact spare tire is designed for *temporary use only.* The standard tire should be repaired or replaced as soon as possible.

(b) Do not use the compact spare tire with any other rim. Nor should standard tires, wheel covers or trim rings be used on the compact spare tire rim as this may cause damage to these items or other vehicle components.

(c) Check the inflation pressure of the T type tire at least once a month, and maintain a cold tire pressure of 4.2 kg/cm^2 (60 psi, 412 kpa). When adding air to the T type tire, be very careful because it inflates quickly due to its smaller size. Add compressed air in small quantities and check the pressure often until 4.2 kg/cm^2 (60 psi, 41 2 kpa) (when cold) is reached.

(d) Do not attempt to use a tire chain on the compact spare tire, as this may result in damage to the vehicle as well as to the tire.

(e) Do not rotate a compact spare tire.

(f) A punctured T type tire should be repaired with a patch rather than with plugs or insert wires.

(g) When driving with a T type tire, keep the following in mind.

- Continuous speeds over 80 km/h should be avoided.
- Because the T type tire is smaller than the standard tire, vehicle ground clearance will be reduced. Therefore, avoid driving over obstacles, and do not put the vehicle through an automatic car wash as the vehicle may get caught in the machinery, resulting in vehicle and property damage.

4. TIRE SPECIFICATION CODING SYSTEM (Example)

The tire sidewall usually bears the codes representing the tire width, the inside diameter (rim diameter) and the ply rating. A high-speed tire usually bears an additional code such as H, S, etc.; a radial-ply tire, an R. Some coding systems include the aspect ratio.

- **Bias-ply Tire**

  6.45 S 14 4PR
  1 2 3 4

- **Radial-ply Tire**

195 / 70 H R 14
1 5 2 6 3

- **International Standardization Organization (ISO) Tire Coding System**

195 / 70 R 14 86 H
1 5 6 3 7 2

1 Tire width in inches (bias tires)or millimeters (radial tires)
2 Maximum permissible speed
3 Wheel rim diameter in inches
4 Maximum load-carrying capacity in ply rating.
(A 4PR tire has a strength equivalent to a tire with 4 layers of cotton cord).
5 Aspect ratio (Tire Height / Tire Width) in percentage
6 Radial-ply tire
7 Load-carrying capacity (load index)

REFERENCE
MAXIMUM PERMISSIBLE SPEED CODES
AND SPEEDS:

Code	Speed (km/h)	Code	Speed (km\ h)
K	110	R	170
L	120	S	180
M	130	T	190
N	140	U	200
P	150	H	210
Q	160	V	210 or more

5. TIRE SERVICE

DESCRIPTION

Tires are the only automobile components that come into direct contact with the road. Therefore, they must be handled and maintained properly so that they provide optimal driving safety, comfort and economy while performing their designed functions.

INFLATION PRESSURE

The inflation pressure of tires plays a vital role in terms of total vehicle performance and safety. Although tires are made up of more or less airtight materials, they still allow minute quantities of air to gradually leak away over time.

Therefore, the tire inflation pressure must be checked regularly and adjusted as necessary whenever it differs from the specified pressure.

1) Overinflation

An inflation pressure above the specified level can lead to the following problems:

(a) The narrower tread width reduces driving stability and braking performance.
(b) Driving comfort suffers.
(c) The middle part of the tread wears more quickly.
(d) The tire's ply cord layers are extremely tense and prone to damage due to external impacts.
(e) Tread rubber layers are more likely to separate due to frictional heat concentrating in the center part of the tread.

2) Underinflation

Insufficient inflation can lead to its own special problems:

(a) Increased friction between the tread and the road wastes energy and consumes more fuel.
(b) Front tires become harder to steer.
(c) The tread shoulders wear more quickly.
(d) When in motion, the tire is subjected to greater flexure which sharply increases the tire's internal temperature. When the inflation pressure is extremely low and the vehicle is running at high speeds, the tire may burst, which can be very dangerous.
(e) At high speeds, the tire is more likely to generate a standing wave and experience hydroplaning.

IMPORTANT!

Tires should be inflated to a pressure of 0.2—0.3 kg/cm^2 (2.8—4.3 psi, 20—29 kpa) higher than usual for expressway travel in order to increase their rigidity. This will minimize tread flexure, and thus the occurrence of the problems described in (d) and (e) above.

3) Checking Inflation Pressure

(a) The tire must be cooled down before checking and adjusting the inflation pressure.
(b) Always use a tire pressure gauge to check the inflation pressure. Never rely on a visual check.
(c) Refer to appropriate repair manuals, service data sheets, or owner's manuals for proper tire inflation pressure for varying loads.

IMPORTANT!

- **If the inflation pressure rises due to heat, do not release the "excess" air from the tire – the pressure will return to normal once the tire has cooled down. If air is released when the tire is hot, the pressure will drop below normal after the tire cools off.**
- **Make sure that the air valve is not leaking air after the inflation pressure inspection.**

TIRE ROTATION

Ideally, all four tires (five, if the spare is included) should exhibit the same wear patterns. A tire used over a long period in the same position (for example, left front, right rear, etc.), however, will develop wear that is peculiar to that wheel.
Generally, the tires installed on the front wheels of rear-wheel-drive vehicles wear 10—20% faster than the rear tires, with the outside shoulders wearing fastest of all. The reasons for such faster wear are:

(a) In most vehicles, greater loads are applied to the front wheels than to the rear.
(b) Cornering places the greatest load on the front outside wheel.
(c) The front wheels are given camber and toe-in.

Tires should be rotated (that is, changed from one position to another) regularly so that they will wear uniformly. This will help lengthen the tire's service life.

1) **Bias-ply Tires**

Bias-ply tires can be switched from one side of the car to the other.

2) Radial-ply Tires

If a radial-ply tire is switched to the opposite side of the car, tire noise and yawing after lanechanging will become temporarily worse, because the tire is turning in the opposite direction than previously. Therefore, it is recommended that radial-ply tires be kept on the same side of the car when rotated, as shown in the next illustration.

IMPORTANT!

- When rotating tires, always take advantage of the opportunity to check the tire surfaces visually for cracks, unusual wear, etc.
- Some models use different inflation pressures for the front and rear tires. Adjust the inflation pressures to the specified levels after rotating the tires.
- Do not rotate the compact spare tire. It is intended for temporary use only.
- When rotating a tire whose rotational direction is marked on the sidewall, be sure that the tire will not turn in the opposite direction in its new position.

DISC WHEELS

1. DESCRIPTION

Tires are, of course, not installed directly onto the automobile but are mounted on wheels, usually disc wheels. Because the wheel is a component that is vital to safe driving, it must be strong enough to withstand the vertical and lateral loads, driving and braking forces and various other forces imposed upon it. At the same time, it must be as light as possible. In addition, it must be well-balanced so that it will rotate smoothly at high speeds, and the rims must be manufactured accurately enough to keep the tire securely in place.

2. DISC WHEEL TYPES

Disc wheels are classified according to the method of their manufacture and the materials out of which they are made. Two types are in commom use at present: pressed steel and cast light alloy.

PRESSED-STEEL DISC WHEEL

This type consists of a rim welded to a disc stamped from sheet steel, a construction well suited for mass production. Most automobiles now use the pressed-steel disc type because of its higher durability and uniform quality levels.

CAST LIGHT-ALLOY DISC WHEEL

This type, cast from a light alloy consisting mainly of aluminum or magnesium, is widely used not only for vehicle models requiring lighter weight, but also to add an accent to the vehicle's appearance.

– IMPORTANT!

ALUMINUM WHEEL PRECAUTIONS

- If a car's aluminum wheels are temporarily removed for tire rotation, repairs, etc., or if new wheels are installed on the car, the wheel nuts should be checked for tightness after the first 1500 km.
- When using tire chains, be careful to install them so that they will not damage the aluminum wheels.
- Use only wheel nuts designed for the aluminum wheels.
- When balancing the wheels, use only balance weights designed for the aluminum wheels (or equivalent), and install them with a plastic or rubber (never metal) hammer.
- As with any wheel, periodically check aluminum wheels for damage. If damaged, replace immediately.

3. DISC WHEEL SPECIFICATION CODING SYSTEM (Example)

The disc wheel size is indicated on the surface of the disc wheel itself. It generally includes the rim width, rim flange shape and rim diameter.

4 ^{1}/s— J x 13

1 2 3

5.50 F x 15 SDC

1 2 3 4

1 Rim width (in inches)

2 Rim flange shape

3 Rim diameter (in inches)
4 Rim type

REFERENCE
"J" AND "JJ" IN THE RIM FLANGE SHAPE SYMBOLS
Disc wheels code-marked "J" and "JJ" are identical in shape but the flange rise size (distance) from the tire bead fitting differs slightly. The flange rise size is 1 7.5 mm (0.689 in.) on "J" rim flanges and 18mm (0709 in) on "JJ" rim flanges.
Generally speaking, the rim flange shape is „J" on wheel rims up to about 5 inches in diameter while wheels rims having larger diameters tend to have "JJ" rim flanges. The "JJ" design is said to be more preferable for wider tires because a higher flange edge makes it harder for the tire to come off the wheel. For this reason, the "JJ" design is used commonly with wide rims for wide tires.

WHEEL ALIGNMENT

1. DESCRIPTION

The steering system, in combination with the suspension system, must ensure handling, good steering stability and good steering wheel recovery after turns.

However, for the steering and suspension systems to do their jobs properly, the front wheels must be kept correctly aligned. In addition to ensuring that the vehicle handles properly, this also reduces the dynamic stress and wear of each component part by properly setting the geometry of the suspension and steering mechanisms, which move in a very complicated manner.

Front wheel alignment consists of the adjustment of the geometrical angles and dimensions of the front wheels, suspension components and steering components after their installation to the body (or chassis) structure. It is generally categorized into the following elements:

- **Camber**
- **Steering axis (kingpin) inclination**
- **Caster**
- **Toe angle**
- **Turning radius**

The setting angles and dimensions of these elements depend on the suspension system, wheel drive system and steering system. They are set to optimize driving performance, steering stability, and the durability of the component parts.

On vehicles having independent rear suspension, rear wheels are aligned (camber and toe angle) the same way as the front wheels in order to reduce dynamic stress and wear of component parts.

Since these specifications depend on the load on the car and the levelness of the car while stationary, the front wheels must be aligned with the car stationary and level and with the car body at the specified height from the ground.

2. CAMBER

The front wheels of the car are installed with their tops tilted outward or inward (this can best be seen by looking at the wheels from directly in front).
This is called camber and is measured in degrees of tilt from the vertical. When the top is tilted outward, it is called positive camber. Conversely, inward inclination is called negative camber

On vehicles having a positive camber, the load acting upon the steering knuckle is positioned close to the spindle base to reduce the burden on the steering knuckle.

In addition, the wheels are pushed inward in this design to prevent them from coming off.

Negative cambering is aimed at emphasizing the straight-ahead stability of the vehicle. A negative camber reduces the ground camber of the vehicle during rolling (tilting of the vehicle during turning) to improve the vehicle's cornering performance. Negative camber is found in some front-engine front-wheel-drive vehicles.

3. STEERING AXIS INCLINATION

The axis around which the wheel rotates as it turns to the right or left is called the steering axis. This axis is found by drawing an imaginary line between the top of the shock absorber's upper support bearing and the lower suspension arm ball joint.

This line is tilted inward as viewed from the front of the car and is called the steering axis inclination or kingpin angle.

Furthermore, the distance "I" from the intersection of the steering axis with the ground to the intersection of the wheel centerline with the ground is called the offset.

A smaller offset reduces the steering effort and minimizes driving and braking shocks. The steering axis inclination also tends to return the steering wheel to a neutral position as the vehicle weight is in part converted by the inclination into a force that tends to return the front wheels to the straight-ahead position.

4. CASTER

The steering axis centerline as viewed from the side is normally tilted from the vertical. The angle formed by this line and a line drawn vertical to the ground is called caster.

Backward tilt from the vertical line is called positive caster, while forward tilt is called negative caster. Positive caster is generally used because it is most effective in ensuring both straight-ahead driving stability and wheel recovery after turning.

The distance from the intersection of the steering axis centerline with the ground, to the center of the tire-to-road contact area, is called trail.

A large positive caster increases the trail as well as the force that returns the steering wheel to a neutral position, but increases the steering effort at the same time. It also tends to cause shimmy, flutter, etc.

Negative caster leads to a lighter steering resistance but also affects the straight-ahead stability of the vehicle. Steering also becomes less easily controllable.

5. TOE ANGLE (Toe—in and Toe—out)

When the front of the wheels are closer together than the rear of the wheels (as viewed from above), this is called toe-in. The opposite arrangement is called toe-out.

Toe angle is usually expressed by a distance
(B —A).

When the front wheels are given positive camber, they tilt outward at the top. This causes them to attempt to roll outward as the car moves forward, and therefore to side-slip. This subjects the tires to wear.
Therefore, toe-in is provided for the front wheels to prevent this by cancelling outward rolling due to camber

6. TURNING RADIUS

If the right and left front wheels were both to turn by exactly the same amount (that is, if the right and left steering angles were the same), they would have the same turning radius (r_1 rj, but each wheel would turn around a different center (O~ and 02). Smooth turning would therefore be impossible due to side-slipping of the tires.
To prevent this, the knuckle arms and tie rods are so arranged as to cause the wheels to toe out slightly when turned. This causes the inner wheel to turn with a slightly greater angle than the outer wheel so that the centers around which they turn will coincide but the turning radii will be different (r_1 > rj. (This is called Ackerman’s principle.)

In the type of suspension having the tie rod behind the spindles, the wheels can be given toe-out by angling the right and left steering knuckles slightly toward the center of the car (0).

7. SIDE-SLIP

Side-slip is the total distance that the right and left tires slip to the side while the vehicle is in motion.

Side-slip is measured with a side-slip tester during straight-ahead driving at a very low speed.

Side-slip is generally expressed as the amount of sideway slippage, in mm, per 1 m of forward motion. The general guideline is 0 . 3 mm (0—0.118 in.).

The purpose of measuring side-slip is to be able to make an overall judgment of wheel alignment with the vehicle running straight ahead.

The cause of side-slip is mainly incorrect camber or toe-in, but it is also important to pay attention to caster and steering axis inclination.

BRAKE SYSTEM

1. DESCRIPTION

Brakes are designed to decelerate (slow down) and stop the car or allow it to be parked on a slope. They are therefore extremely essential equipment on an automobile to ensure safe driving.
In today's motorized society, brakes are expected to be highly reliable as well as durable so that the car can be stopped both safely and promptly in any place and under any conditions.

2. PRINCIPLE OF BRAKES

A moving car cannot stop immediately when the engine is disconnected from the power train, due to inertia (the tendency of a moving object to continue moving). This inertia must be reduced in order to bring the car to a halt.

The engine converts thermal energy into kinetic energy (energy of motion) to move the vehicle. In contrast, the brakes change this kinetic energy back into thermal energy to stop the vehicle.
Generally, car brakes work by causing a fixed object to be pressed against a rotating object. The braking effect is obtained from the friction that is generated between the two objects.

3. TYPES OF BRAKES

Brakes that are used on motor vehicles can be grouped into several types depending on their purpose.

- Service or foot brakes are used to control vehicle speed and stop the vehicle.
- Parking brakes are used mainly when the car is parked.
- Auxiliary brakes are used in combination with the ordinary service brakes by diesel trucks and other heavy-duty vehicles.

Hydra u Ii c -

Service brakes

-(foot) K- Wheel brakes

brakes Pneumatic

-J

I brakes

Center brakes

Brakes Parking __Mechanical

brakes brakes

Rear-wheel

brakes

Auxiliary brakes Exhaust brake

Furthermore, “engine braking” is sometimes used to reduce vehicle speed. However, as this is a braking effect created by the resistance to rotation of the engine itself, no special equipment is needed for it. For this reason, “engine braking” is not discussed in this TRAINING MANUAL.

4. SERVICE BRAKES (Foot Brakes) DESCRIPTION

Service brakes are grouped into two types:
hydraulic and pneumatic brakes.

The hydraulic brakes can respond much faster than other types and are simpler in design. Hydraulic brakes also have a superior design flexibility. Due to these advantages, hydraulic brakes are most commonly used with passenger cars and light-duty trucks today.

The pneumatic brake system includes a compressor or the like, which produces compressed air which is used to apply the brakes. This type of brake system is commonly found on heavy-duty trucks and buses.

Hydraulic service brakes comprise the following operating mechanisms that transmit the brake applying force, and the braking mechanisms that generate the braking force.

Master cylinder

- Brake system
  - Operating mechanism
    - Brake booster
    - Proportioning valve
  - Braking mechanism
    - Drum type
    - Disc type

OPERATING MECHANISMS 1 Master Cylinder

The master cylinder converts the motion of the brake pedal into hydraulic pressure.
It consists of the reservoir tank, which contains the brake fluid, as well as the piston and cylinder, which generate the hydraulic pressure.

There are two types of cylinder: the single type and tandem type.

The tandem type master cylinder is used more commonly than the single type.

- Single type
  - Plunger type (Girling type)
  - Conventional type (Lockheed type)
  - Portless type
- Tandem type
  - Double conventional type
  - Conventional! portless type

The tandem master cylinder has separate hydraulic systems for front and rear wheels so that if one of these systems becomes inoperative, the other system can still function properly

On front-engine rear-wheel-drive (FR) vehicles, one of the hydraulic systems brakes the front wheels while the other brakes the rear wheels. On front-engine front-wheel-drive (FF) vehicles, however, an extra load is applied to the front brakes. To cope with this problem, a diagonal split hydraulic systems are used (consisting of one set of brake lines for the right front and left rear wheels, and one for the left front and right rear wheels), so braking efficiency remains equal on both sides (but with only half the normal braking power) even if one of the two systems should happen to become defective.

2 Brake Booster

The force with which the driver steps on the brake pedal would not be enough to cause the brakes to operate to stop the vehicle quickly.
The brake booster therefore multiplies the driver’s pedal effort so that a large braking force is created.

The brake booster may be an integral part of the master cylinder or fitted separately from it. The integrated type is used with passenger cars and light-duty trucks.

The brake booster has a diaphragm that is operated by the difference in pressure between atmospheric pressure and the vacuum that is generated inside the engine's intake manifold. The master cylinder is activated jointly by the pedal and the diaphragm to create a large braking force from a minimum of pedal effort.

It the brake booster should start to malfunction for one reason or another, but it is designed in such a way that only the boosting power applied to the brakes is lost. The brakes will require additional pedal effort in such a case, but the vehicle can be braked normally without the booster.

On vehicles powered by a diesel engine, a vacuum pump is used to generate a strong vacuum for the brake booster because the intake manifold vacuum of a diesel engine is not sufficiently strong for this.

The brake booster consists mainly of the booster body, booster piston, diaphragm, reaction mechanism and control valve mechanism.

The booster body is divided into the front (constant pressure chamber) and rear (variable pressure chamber) sections, separated from each other by a diaphragm and booster piston.

The control valve mechanism regulates the pressure inside the variable pressure chamber. It includes an air valve, vacuum valve, control valve, etc. and is connected to the brake pedal via the valve operating rod.

3 Proportioning Valve (P Valve)

The vehicle is braked by friction between the tire and the road. The friction increases in proportion to the load.

Since the engine is usually in the front of the vehicle, the front is heavier than the rear. When the vehicle is braked, the center of gravity of the vehicle shifts forward due to inertia, and even a greater load is applied to the front.

If an equal braking force were applied to all four tires, the rear wheels would lock up (causing slipping between the tire and the road surface) because the braking force would be too large. Locking of the rear wheels would cause a sharp drop in friction, and the rear of the vehicle could "fishtail" (move from side to side out of control). This could be very dangerous.

For this reason, a device is needed that causes more braking force to be applied to the front wheels than to the rear wheels.

Such a device is called a “proportioning valve” or simply a P valve. It automatically reduces the hydraulic pressure to the rear wheel cylinders so that it is less than that to the front, so less braking force is applied to the rear wheels.

The following diagram shows the ideal hydraulic pressure to the rear wheel cylinders.
Besides the P valve, a similar effect can be obtained from a load sensing and proportioning valve (ES PV) which changes the initial pressure split point of the rear wheels according to the load, a proportioning and bypass valve (P & BV) which transmits master cylinder pressure directly to the wheel cylinders without allowing it to pass through the P valve if the front brake system becomes defective, a deceleration-sensing and proportioning valve (DSPV) which varies the initial pressure split point according to the rate of deceleration during braking, and other devices.

4 Anti- lock Brake System (ABS.)

An anti-lock brake system is designed not only to prevent the rear wheels from locking up during panic braking but also to control the front wheels as well to prevent the vehicle from spinning out of control and thus maintain the vehicle in good steering control.

Features:

- When the vehicle starts to skid, it can be corrected by steering wheel operation to evade obstacles more easily.
- When brakes are applied during turning, the vehicle can be brought to a halt more safely without changing direction.

Function of Components

Component	Function
Front Speed Sensors	
Rear Speed Sensors	
Stop Light Switch	
ANTI-LOCK Warning Light	

ABS. Actuator

ABS. Computer

Detects wheel speed of each of the front wheels.

Detects wheel speed of each of the rear wheels.

Detects the braking signal and sends it to the ABS. computer.

Lights up to alert the driver when a malfunction has occurred in the Anti-lock Brake System.

Controls the brake fluid pressure to each disc brake cylinder by signals from the ABS. computer.

By the signals from each speed sensor, it calculates acceleration and deceleration and sends signals to the actuator to control brake fluid pressure.

CHECK AND ADJUSTMENT OF BRAKE PEDAL

OBJECTIVE • To learn correct methods of adjusting the brake pedal height.
- To learn the appropriate brake pedal effort for inspecting the pedal freeplay.
- To le.~rn the appropriate brake pedal effort for inspecting the pedal reserve distance.

CHECK AND ADJUSTMENT OF PEDAL HEIGHT

1. CHECK PEDAL HEIGHT

Turn back the floor carpet under the brake pedal and, with a ruler, measure the distance between the top surface of the brake pedal and the toe board (asphalt sheet).

2. **IF NECESSARY, ADJUST PEDAL HEIGHT**

(a) Disconnect the wiring connector 1 for the stop light switch 2)

(b) Loosen the lock nut 3 of the stop light switch and screw out the stop light switch a few turns.

(c) Loosen the lock nut (4~ of the push rod (5 and adjust the pedal height by turning the push rod.

(d) Screw in the stop light switch until its pedal stopper lightly contacts the cushion, and then tighten the lock nut.

IMPORTANT!

Be careful that the pedal stopper of the switch is not touching the pedal cushion too strongly or the pedal height may be insufficient.

(e) Connect the wiring connector for the stop light switch.

3. ADJUST PEDAL FREEPLAY

After adjusting the pedal height, check and adjust the pedal freeplay on the next page.

CHECK AND ADJUSTMENT OF BRAKE PEDAL FREEPLAY

1. CHECK BRAKE PEDAL FREEPLAY

(a) After stopping the engine, release the vacuum stored in the brake booster by pumping the brake pedal until the pedal reserve distance does not change even with the same pedal pressure.

IMPORTANT!

If vacuum remains in the booster, the correct freeplay cannot be checked.

(b) Lightly push the brake pedal with your finger until it meets resistance and measure the pedal stroke.

2. **IF NECESSARY, ADJUST PEDAL FR EEP LAY**

(a) If freeplay is not within specification, loosen the lock nut 4 of the master cylinder push rod <5 . Adjust by turning the push rod.

(b) Tighten the lock nut and measure the freeplay again.

(c) After adjusting the pedal freeplay, check the pedal heigh and stop light operation.

CHECK OF PEDAL RESERVE DISTANCE

1. CHECK PEDAL RESERVE DISTANCE

(a) Place chocks under the front and rear wheels, release the parking brake and start the engine.

(b) Press down on the brake pedal with 50 kg (110.2 lb. 490 N) of force and measure the distance between the top surface of the brake pedal and the asphalt sheet.

(c) If the reserve distance is less than specification, it may be caUsed by excessive shoe clearance between the brake shoe and brake drum.

(d) Adjust the shoe clearance.

REFERENCE

The shoe clearance is adjusted differently depending on the vehicle model arid brake type. Refer to appropriate repair manual.

5. DRUM BRAKES DESCRIPTION

In the drum type brake, braking power is obtained by causing non-rotating shoes to be pushed against the inner surface of a drum that rotates together with the wheel.

Because of the self-energizing action* created by the rotating force of the drum and the expanding force of the shoe, a large braking force results from a relatively small pedal effort.

REFERENCE

- Self-energizing action

There are two types of brake shoe, as shown in the illustration to the left: the leading (or primary) shoe and the trailing (or secondary) shoe. When the upper end (or toe) of the forward brake shoe is forced outward against the brake drum (by the wheel cylinder) as the drum rotates in the direction shown by the arrow, the shoe tends to "stick" tO the drum and revolve with it ... this shoe is called the "leading shoe". On the other hand, the upper end of the rear shoe is pushed inward by the drum as it attempts to expand outward ... this is called the "trailing shoe".
The action of the drum, in which it tries to force the leading shoe to rotate with it, is called "self-energizing" or "self-servo" action. Self-energizing action creates a greater braking force. On the other hand, the repulsive force to which the trailing shoe is subjected reduces the braking power of that shoe. The ratio of the braking power provided by the leading and trailing shoes is about 3 to 1. Although leading shoes provide more braking power, there is a disadvantage to this in that they wear faster than trailing shoe.

COMPONENTS

The drum brake consists mainly of the following components:

	Backing plate
Components	**Wheel cylinder**
	Brake shoe and lining

Brake drum

1 Backing Plate

The backing plate is a pressed steel plate, bolted to the rear axle housing or rear axle carrier. Since the brake shoes are fitted to the backing plate, all of the braking force acts on the backing plate.

~---IMPORTANT!-

If the friction surface of the brake shoe wears excessively, the brakes will drag. Brake shoes must be checked carefully every time the brakes are disassembled to prevent this problem.

Wheel Cylinder

The w heel cylinder consists of a number of components as illustrated on the right. One or two wheel cylinders are used for each wheel. Some systems have two pistons to operate the both shoes, one at each side of the wheel cylinder, while other systems have only one piston to operates only one shoe.

When the hydraulic pressure generated in the master cylinder acts upon the piston cup, the pistons are pushed toward the shoes, forcing them against the drum.

When the brakes are not being applied, the pistons are returned to their original positions by the force of the brake shoe return springs, and the compression spring is contracted.

A bleeder plug is provided in the wheel cylinder for removing air from the brake fluid.

3 Brake Shoe & Brake Lining

The brake shoe, like the drum, is semi-circular in shape.

Brake shoes are usually made of steel plates. The brake lining is attached to the friction surface of the shoe by rivets (on large vehicles) or by adhesives (on small vehicles).

Linings must be resistant against heat and wear and have a high friction coefficient. This coefficient must be as unaffected as possible by fluctuations in temperature and humidity. Generally, brake linings are made from fiber metallic mixed with brass, lead, plastics, etc. and formed under heat.

4 Brake Drum

The brake drum is generally made of gray cast iron and has a cross-section such as shown below. It is positioned very close to the brake shoe without actually touching it and rotates with the wheel.

As the lining is pushed against the inner surface of the drum when the brake is applied, friction heat can reach as high as 200^0C (3920 F) to 300^0C (5720 F).

TYPES OF DRUM BRAKE

Drum brakes use various combinations of leading and trailing shoes:

1 Leading-and-trailing Type

As illustrated, the upper end of each brake shoe is pushed open by the wheel cylinder, while the lower end either pivots or floats. This type has only a single wheel cylinder.

When the drum rotates forward, in the direction of the arrow, and the brake pedal is depressed, the upper end of each shoe is pushed open around the lower end by the wheel cylinder and exerts braking force against the drum. The left-hand shoe is called the leading shoe, and the right-hand shoe is called the trailing shoe.

Drum brakes

- Leading-and-trailing type
- Two-leading type
- U ni-servo type
- Duo-servo type

When the drum rotates in the opposite direction (backward), the leading shoe becomes the trailing shoe and the trailing shoe becomes the leading shoe. But both shoes still exert the same braking force as in forward rotation.

The leading shoe wears faster than the trailing shoe when the brake is used more frequently in the forward direction.

This type is used in rear brakes of passenger cars and small commercial vehicles

2 Two-leading Type

Two-leading type shoes are further divided into the single-action and double-action types.

The single-action two-leading shoe type has two wheel cylinders, each having a piston at one end only, as shown. When the brake is applied when the vehicle is moving forward, both shoes function as leading shoes.

When the drum is rotating in the direction of the arrow (forward), this type exerts a high braking force. However, a disadvantage of this type is that, when the drum rotates in the opposite direction (backward), both shoes work as trailing shoes exerting only a small braking force.

This type is used in front brakes of passenger cars and commercial vehicles.

The double-action two-leading shoe type has two wheel cylinders, each having pistons at both ends. While the single-action type exerts self-energizing force in one direction only, the double-action type works efficiently in both forward and backward directions.

This type is used in rear brakes of commercial vehicles.

3 Uni-servo Type

The uni-servo type has a single wheel cylinder with a piston at one end only and an adjusting cylinder that connects both shoes.

When the piston in the wheel cylinder pushes the upper end of the left-hand shoe against the drum, both shoes function as leading shoes and exert a high braking force. Again, there is a disadvantage to this type in that, when the drum rotates in the opposite direction, both shoes function as trailing shoes and exert only a small braking force.

4 Duo-servo Type

The duo-servo type is an improved version of the uni-servo shoe type and has two pistons per wheel cylinder. Since the wheel cylinder pushes both shoes when the brake is applied, this type exerts a high braking force regardless of the direction of drum rotation.

This type is used in rear brakes of commercial vehicles.

BRAKE DRUM AND BRAKE LINING CONTACT

Friction between the brake drum and brake lining is affected by the temperature of the brake lining itself. Normally, both friction decreases and braking force decrease as the drum and lining become hot.

Braking force is also affected by the position of contact between the drum and lining although the contact area may be the same. This is because self-energizing action acts differently depending on the contact position.

IMPORTANT!
One wheel may brake more than the other if the wheel lining contact is not the same for both wheels. They must be adjusted so that the lining and drum are contacting equally (see page 5 – 86).

BRAKE SHOE CLEARANCE

An excessively large clearance between the brake drum and lining will causes a delay in braking. If the drum-to-lining clearance is too small, the brakes will drag and seizure between the drum and brake lining may occur. Furthermore, if the clearance is not equal for all four wheels, the vehicle may pull to one side or the rear end of the vehicle may fishtail (oscillate from side to side).

To prevent these troubles, it is very important that the specified drum-to-lining clearance be accurately maintained at all times.

In some types of brake, this is done automatically. In others, however, this clearance must be periodically adjusted.

Automatic Brake Shoe Clearance Adj ustment

Automatic brake shoe clearance adjustment refers to the automatic adjustment of the drum-to-lining clearance and includes the following types of adjustments:

- Adjustment effected by braking during reverse travel
- Adjustment effected by braking during forward travel
- Adjustment effected by the parking brake

1) Construction and Operation

(1) Adjustment Effected by Braking During Reverse Travel

This adjustment method is used with duo-servo shoe type brakes and uses an adjusting cable, adjusting lever, shoe adjusting screw and other parts.

The adjusting cable is fixed at one end to the anchor pin, while the other end is hooked to the adjusting lever via a spring.

The adjusting lever is fitted to the lower end of No. 2 shoe and engages with the shoe adjusting screw.

The shoe adjusting screw consists of a bolt and nut as shown.

- Operation

When the brake pedal is depressed while the vehicle is moving backward, the brake shoes expand and contact the drum. The shoes are forced by the drum to begin rotating, until the upper end of shoe No. 1 contacts the anchor pin. Since shoe No. 2 is moving away from the anchor pin at the same time, it pulls the adjusting wire. This causes the adjusting lever to turn the shoe adjusting screw and adjust the clearance.

The shoe adjusting screw consists of a bolt and nut as shown.

Since each end of the screw is in contact with a brake shoe, the brake shoe clearance increases and decreases as the screw turns.

(2) Adjustment Effected by Braking During Forward Travel

One end of the link on the wheel cylinder is engaged with the wheel cylinder piston and moves with the piston as a unit. The other end of the link is connected to the automatic adjusting lever via a spring and transmits the movement of the piston to the automatic adjusting lever.

The automatic adjusting lever is fitted to the wheel cylinder body by a pin. One end of the automatic adjusting lever is connected to a spring, while the other end engages with the teeth of the adjusting wheel. The adjusting lever pivots around the pin in accordance with the movements of the link and thus turns the adjusting wheel. This adjusts the shoe clearance.

- Operation

When the brake pedal is depressed, the piston and link move upwards as a unit. This causes the automatic adjusting lever to pivot around the pin in a counterclockwise direction.

(a) Shoe Clearance Within Standard

Since the amount of piston movement is small, ~ the amount of automatic adjusting lever movement is also small. Therefore, the adjusting ~ lever only moves back and forth between the same two teeth of the adjusting wheel, so the adjusting wheel does not rotate.

(b) Shoe Clearance Greater than Standard

When the brake pedal is depressed, the amount of piston movement is greater than that of the standard shoe clearance. Therefore, the amount of adjusting lever rotation is also greater, causing the adjusting wheel to turn a little.
When the brake pedal is released, the piston, link and adjusting lever return to their original positions, but since the adjusting wheel has turned from its original position, the adjusting lever engages with the next toot.h of the adjusting wheel.

When the brake pedal is depressed the second time, the adjusting wheel rotates, the adjusting bolt moves in such a direction that the brake shoes expand, and shoe clearance is adjusted accordingly.

(3) Adjustment Effected by Parking Brake

The adjusting lever is fitted, together with the parking brake lever, to the shoes. One end of the adjusting lever is fitted to a brake shoe via a spring, and the other end of the lever engages with the adjusting screw, which is built into the parking brake shoe strut.

• Operation

When the parking brake is applied, the parking brake lever is pulled to the left. At the same time, ~ the adjusting lever rotates clockwise around the pin to which the shoe is fitted, turning the adjusting screw.

(a) Brake Shoe Clearance Greater than Standard

When the parking brake lever is pulled, the adjusting lever moves an extra distance over to the next tooth of the adjusting screw.

When the parking brake lever is released, the adjusting lever also goes down. This causes the adjusting screw to rotate, adjusting the brake shoe clearance.

(b) Brake Shoe Clearance Normal

When the parking brake lever is pulled, the adjusting lever moves only a small distance and the adjusting lever does not move to the next tooth of the adjusting screw. Brake shoe clearance remains unchanged as a result.

REFERENCE

The adjusting lever is arranged in such a way as to engage with one adjusting screw tooth. Therefore, one operation of the parking brake lever only advances the adjusting screw by one tooth, reducing brake shoe clearance by approximately 0.03 mm, even if brake shoe clearance is large.

BRAKE SHOE REPLACEMENT

OBJECTIVE To learn correct methods to replace and inspect rear brake shoes.

PREPARATION • SST 09703-30010 Brake Shoe Return Spring Tool
09718-00010 Shoe Hold-down Spring Driver

- Torque wrench (1050 kg-cm, 76 ft-lb, 103 Nm)
- Vernier caliper (201 mm, 7.91 in.)
- High-temperature type grease

REMOVAL OF REAR BRAKE SHOE

1. REMOVE REAR WHEELS

(a) Using a wheel nut wrench, loosen the wheel nuts 1 /4 to 1 /2 turn in crisscross sequence, before raising the vehicle.

(b) Raise the vehicle and remove the rear wheels.

IMPORTANT!
Be careful not to mix the tires up-leave each one by the hub from which it was removed.

(c) Release the parking brake.

2. REMOVE REAR BRAKE DRUMS

REFERENCE
If the brake drum cannot be removed easily, do the following:
(a) Insert a screwdriver through the hole in the backing plate and hold the automatic adjusting lever away from the adjusting bolt.
(b) Using another screwdriver, shorten the brake shoe strut by turning the adjusting bolt.

3. REMOVE FRONT SHOE

(a) Using the SST, disconnect the return spring. SST 09703-30010

IMPORTANT!
Do not damage wheel cylinder boots.

(b) Remove the hold-down spring, retainers and pin.
- Using the SST, turn the hold-down spring pin 9Q0 while holding the pin end with your finger. SST 09718-00010

(c) Disconnect the anchor spring from the front shoe and remove it.

4. REMOVE ANCHOR SPRING

5. REMOVE REAR SHOE

(a) Remove the hold-down spring, retainers and pin.
- Using the SST, turn the hold-down spring pin 9Q0 while holding the pin end with your finger. SST 0971 8-00010

(b) Using a screwdriver, disconnect the parking brake cable from the anchor plate.

3. REMOVE FRONT SHOE

(a) Using the SST, disconnect the return spring. SST 09703-30010

IMPORTANT!
Do not damage wheel cylinder boots.

(b) Remove the hold-down spring, retainers and pin.
- Using the SST, turn the hold-down spring pin 9Q0 while holding the pin end with your finger. SST 09718-00010

(c) Disconnect the anchor spring from the front shoe and remove it.

4. REMOVE ANCHOR SPRING

5. REMOVE REAR SHOE

(a) Remove the hold-down spring, retainers and pin.
- Using the SST, turn the hold-down spring pin 9Q0 while holding the pin end with your finger. SST 0971 8-00010

(b) Using a screwdriver, disconnect the parking brake cable from the anchor plate.

8. REMOVE PARKING BRAKE LEVER
Using a screwdriver, pull the C-washer upward and remove the parking brake lever from the rear brake shoe.

INSPECTION OF REAR BRAKE COMPONENTS

1. MEASURE BRAKE DRUM INSIDE DIAM ETER
Standard inside diameter:
Maximum inside diameter:

If the diameter is greater than
replace the brake drums.
200.0 mm (7.874 in.)
201.0 mm (7.913 in.)
the specification,

2. INSPECT BRAKE DRUM
Check the brake drum for abnormal wear or scoring.

If the drum is scored or worn, the brake drum may be lathed to the maximum inside diameter.

REFERENCE
The maximum inside diameter of the brake drum is indicated inside the drum.

3. MEASURE BRAKE SHOE LINING THICKNESS

Standard thickness: 4.0 mm (0.157 in.) Minimum thickness: 1 .0 mm (0.039 in.)
If the thinnest area of the shoe lining is less than the minimum or is close to it, or the lining shows signs of uneven wear, replace the brake shoes.

IMPORTANT!
If any of the brake shoes has to be replaced₁ replace all of the rear brake shoes in order to maintain even braking.

4. INSPECT BRAKE LINING AND DRUM FOR PROPER CONTACT
Apply chalk along the inside of the brake drum and fit it against the brake shoe.

IMPORTANT!
Wipe off the chalk after inspection.

If the contact between the brake lining and drum is improper, repair the lining with a brake shoe grinder or replace the brake shoe assembly.

INSTALLATION OF REAR BRAKE SHOE

Assemble the parts in the correct direction as shown.

1. APPLY HIGH-TEMPERATURE GREASE TO FOLLOWING PARTS:
(a) Backing plate and brake shoe contact points.
(b) Anchor plate and brake shoe contact points.

(c) Adjusting bolt.
(d) Adjuster and brake shoe contact points.

2. INSTALL PARKING BRAKE SHOE LEVER

(a) Using a new C-washer, temporarily fit the parking brake shoe lever to the rear shoe.
(b) Using a feeler gauge, measure the clearance between the brake shoe and lever.

Standard clearance:

Less than 0.35 mm (0.01 38 in.)

If the clearance is not within specification, replace the shim with one of the correct size.

Shim thickness			mm (in.)
0.2	**(0.008)**	**0.5**	(0.020)
0.3	(0.012)	0.6	(0.024)
0.4	**(0.016)**	**0.9**	(0.035)

(c) Install the C-washer using pliers.

3. INSTALL AUTOMATIC ADJUSTING LEVER

(a) Install the automatic adjusting lever to the rear shoe.
(b) Using pliers, install a new C-washer.
(c) Check that both levers move freely.

IMPORTANT!

If the lever movement does not move easily, the automatic adjuster will not work properly or the parking brake will not release.

4. INSTALL STRUT TO REAR SHOE

(a) Install the strut to the automatic adjusting lever.
(b) Install the return spring to the rear shoe.

(c) Using needle-nose pliers, install the adjusting lever spring to the automatic adjusting lever.

5. INSTALL REAR SHOE

IMPORTANT!

Do not allow oil or grease to get on the rubbing face of the wheel cylinder boot.

(a) Using needle-nose pliers, connect the parking brake cable to the parking brake shoe lever.

(b) Using a screwdriver, install the parking brake cable to the anchor.

(c) Set the rear shoe in place with the end of the shoe inserted in the wheel cylinder and the other end in the anchor plate.

(d) Using the SST, install the shoe hold-down spring, two cups and pin.
SST 09718-00010

6. INSTALL FRONT SHOE

(a) Install the anchor spring between the front and rear shoes.

(b) Set the front shoe in place with the end of the shoe inserted in the wheel cylinder and the adjuster in place.

IMPORTANT !

Do not allow oil or grease to get on the rubbing face of the wheel cylinder boot.

(c) Using the SST, install the shoe hold-down spring, two cups and pin.
SST 09718-00010

(d) Using the SST, connect the return spring. SST 09703-30010

IMPORTANT!

- **Do not damage wheel cylinder boots.**
- **Make sure that the brake shoes and automatic adjuster assembly are properly installed.**)

7. CLEAN BRAKE SHOE LININGS

(a) Clean the brake shoe linings with sandpaper to remove oil stains.

(b) Clean the inside surface of the brake drum

8. **CHECK OPERATION OF AUTOMATIC ADJUSTING MECHANISM**

(a) Move the parking brake lever of the rear shoe back and forth as shown.
Check that the adjusting bolt turns.

If the adjusting bolt does not turn, check for incorrect installation of the rear brakes.

(b) Adjust the adjuster length to the shortest possible amount.

(c) Install the brake drum and temporarily fit the hub nuts to the hub bolts.

d) Pull the parking brake lever all the way up until a clicking sound can no longer be heard.

9. CHECK CLEARANCE BETWEEN BRAKE SHOES AND DRUM

(a) Remove the drum.

(b) Measure the brake drum inside diameter.

(c) Measure the diameter of the brake shoes.

(d) Check that the difference between the diameters is the correct shoe clearance.

Shoe clearance 0.6 mm (0.024 in.)

If incorrect, check the parking brake system.

10. INSTALL BRAKE DRUM

11. CHECK FOR BRAKE OPERATION

Depress the brake pedal a few times and ch
the following:

- Check that the drums on both sides turn fr without excessive drag.

IMPORTANT!

Although the drums may cause the bral shoes to drag slightly, this will not cau~ significant wear of the linings unless tl drag is excessive.

- Make sure that the brake pedal reserve dista is more than the specified amount.

12. CHECK FOR BRAKE FLUID LEAKA~

13. INSTALL REAR WHEEL

Install the wheels and tighten the hub nuts curely after lowering the vehicle.

Torque: 1,050 kg-cm (76 ft-lb. 103 Nri

6. DISC BRAKES DESCRIPTION

A disc brake basically consists of a cast-iron disc (disc rotor) that rotates with the wheel and fixed friction materials (disc pads) that are pushed against the disc rotor. Braking force is generated by friction between the disc and the disc pads.

Since the disc brake characteristically has only a minimum of self-energizing action, its braking force is little affected by fluctuations in the friction coefficient, resulting in high stability. Furthermore, because the friction surface is constantly exposed to the air, good heat radiation is ensured; this minimizes fading and ensures good water recovery*

However, the disc brake has a design restriction:
The size of the disc pads is somewhat limited and this, coupled with the limited self-energizing action, makes it necessary to apply greater hydraulic pressure to obtain sufficient braking force. Also, pads wear faster than drum brake shoes for this reason. Nevertheless, the simpler design facilitates easy maintenance and pad replacement

– REFERENCE
• WATER RECOVERY

When the vehicle travels on a wet road and the friction surfaces of shoes and pads become wet from water splashing onto them, their friction coefficient decreases due to the lubricating action of water. This phenomenon is called “water fading”. The opposite phenomenon, in which the friction surface is restored to its original condition and friction coefficient, is called “water recovery.”

Naturally, all brakes are required to have good water recovery. However, the drum brake is less advanced in this respect than the disc brake, because in the case of disc brakes, water that splashes onto the discs can be removed by centrifugal force. This helps to minimize the undesirable effects of water upon braking efficiency and ensure better water recovery.

COMPONENTS

Main components –
- Disc rotor
- Caliper*
- Brake pad

• Caliper is explained under “Types of Disc Brake

Caliper".

1 Disc Rotor

Generally, the disc rotor is made of gray cast iron, and is either solid or ventilated.

The solid type disc rotor consists of a pair of hollow discs to ensure good cooling, both to prevent fading and to ensure longer pad life.

The disc rotor sometimes doubles as a parking brake drum.

2) Brake Pad

A disc pad is usually a baked mixture of metallic fibers and resin containing a small amount of metal power. This type is called the semi-metallic disc pad.

A slit is provided on the rotor side of the pad to indicate the pad thickness (allowable limit) so that the pad wear can be checked easily.

On some disc pads, a metallic plate (called an anti-squeal shim) is fitted in the piston side of the. pad to prevent the brakes from squeaking.

TYPES OF DISC BRAKE CALIPER

The caliper, also called the cylinder body, holds the pistons and is provided with channels through which the brake fluid is supplied to the cylinders.

Calipers are grouped into the following types by the way in which they are installed:

- Fixed caliper type (double pistons)
- Floating caliper type (single piston)

1~ Fixed Caliper Type (Double Pistons)

The caliper is fixed to the axle or strut. As illustrated below, the fixed caliper is provided with a pair of pistons. Braking force is obtained when the pads are pushed hydraulically by the piston against both ends of the disc rotor.

The fixed caliper is the most basic design and ensures accurate operation. However, its heat radiating effect is limited since the outer brake cylinder is located between disc rotor and wheel disc, making it difficult for air to reach and cool it. In addition, it requires a large number of components. For these reasons, the fixed caliper type disc brakes are seldom used today.

2 Floating Caliper Type (Single Piston)

As illustrated, the piston is located in one side of the caliper only. Hydraulic pressure from the master cylinder pushes the piston (A) and thus presses the pads against the disc rotor. At the same time, an equal hydraulic pressure (reaction force B) acts on the bottom of the cylinder. This causes the caliper to move to the right and presses the pad located opposite the piston against the disc rotor to exert braking force.

The floating type calipers are further grouped into the following kinds:

Semi-floating type	PS type
	F type
Full-floating type	FS type
	AD type
	PD type

The semi-floating type caliper receives braking force that is generated by the outer pad.

In the full-floating type calipers, the braking force being generated by the two pads is received by the torque plate.

Floating calipers are used in the great majority of modern passenger cars.

1) Semi-floating Type (PS Type)

The caliper is fixed to the torque plate by two pins. When brakes are applied, the body is moved inward by the piston. The braking pressure of the outer pad is received by the caliper to transmit torque to the pin in the direction of rotation. Reaction force of the inner pad is received directly by the torque plate.

Because of its simple mechanism, this type of caliper is little prone to malfunction and excels in terms of ease of servicing and braking performance. This type is often used in rear disc brakes having a built-in parking brake.

2) Full-floating Types

(1) FType

As shown below, the F type has a caliper that is supported by the torque plate in such a way that allows it to slide. An arm extends from the caliper to transmit the piston force to the outer pad.

This type requires less space but is more prone t han other types to drag because the sliding surface of the caliper and torque plate is exposed. It is used in the rear disc brakes in some vehicles only.

(2) FS Type

The caliper in this type is fitted by two pins (main and sub pins) to the torque plate which is bolted itself, as shown below. The caliper and the two pins are moved as a unit by the piston. Reaction forces of both the inner and outer pads are received by the torque plate so that torque is not transmitted to the pins. Moreover, the sliding section of the caliper (main and sub pins) is concealed completely. This is a design that increases reliability of this area.
Therefore, the FS type is less prone to drag than the F type and is often used in the front brakes of luxury vehicles.

(3) AD Type

As shown below, the main pin of the AD type is press-fitted into the torque plate while the sub pin is bolted to it. A stainless steep plate (antisqueal shim) is fitted in the pad and torque plate contact area to prevent unpleasant squeaking sounds and seizure of the pad due to rust.

This type is used in the front brakes of mediumsized passenger cars.

4) PD Type

The PD type is basically the same as the AD type except that the main and sub pins are bolted to the torque plate. This is used in the front brakes of small passenger cars.

AUTOMATIC ADJUSTMENT OF ROTOR-TO-PAD CLEARANCE

1 Description

As pads wear thin, the rotor-to-pad clearance increases requiring a greater pedal stroke. Therefore, disc brakes always require an automatic clearance adjusting mechanism by a piston seal type adjusting mechanism.

2 Operation

1) Normal Clearance (No Pad Wear)

The automatic clearance adjuster includes a piston seal (rubber) which is built into the cylinder. This has two functions: it seals off the piston to prevent brake fluid from leaking out from the inside of the cylinder; and when the brake is applied and the piston is moved by hydraulic pressure, the piston seal deforms elastically as shown in the illustration. When the brake pedal is released and hydraulic pressure is reduced, the piston seal returns to its original shape, pulling the piston back. The original disc rotor-to-pad clearance is maintained as a result.

2) Clearance Too Large (Pad Worn)

As pads become thin from wear, clearance increases so the piston has to travel a greater distance when the brake is applied. This causes the piston to begin slipping in relationship to the piston seal once the seal has reached the limit of its deformation.

This slipping stops when the pad contacts the rotor and the piston stops moving. When the brake pedal is released, the piston returns by a distance equal to the amount of the piston seal deformation, and normal clearance is restored

DISC BRAKE PAD REPLACEMENT

Refer to “Brake Pad Inspection” in “Pre-delivery Service and Periodic Maintenance” in the TEAM Training Manual, Step 1, Vol. 3 (Pub. No. TTM 103).

7. PARKING BRAKES DES CR1 PTI ON

Parking brakes are mainly used for parking the vehicle. Passenger cars and small commercial vehicles have rear wheel type parking brakes that share the brake drums of the service brakes (foot brakes), or exclusive parking brakes that are connected to the rear wheels.

Large commercial vehicles use the center brake type parking brakes that are fitted between the propeller shaft and the transmission.

A parking brake system consists of a parking lever, stick or pedal, cable or rod type operating mechanism and the brake drums and shoe that generate the braking force.

OPERATING MECHANISM

The operating mechanism is basically the same in both the rear wheel type parking brake and the center brake type parking brake. The parking brake lever is located near the driver’s seat. Pulling the parking brake lever operates the brakes via a cable connected to the lever.

There are a number of different types of parking brake levers, as shown below, which are used depending upon the design of the driver’s seat and the desired operating effort.

The parking brake lever is provided with ratchets to maintain the lever at the position to which it was set. Some parking levers have an adjusting screw near the brake lever so the amount of brake lever travel can be easily adjusted.

The parking brake cable transmits the lever movement to the brake drum sub-assembly. In the case of the rear wheel parking brake, there is an equalizer in the middle of the cable to equally ~ divide the lever operating force to both wheels.

The intermediate lever is provided to increase the operating force.

PARKING BRAKE BODY

1 Rear Wheel Type Parking Brakes

Parking brake bodies are grouped into the two structural types depending on whether they share the braking drum or disc assembly of the service (foot) brakes or have their own braking components.

Structural classification	Service (foot) brake sharing type
	Devoted parking brake type

1) Service (Foot) Brake Sharing Type

This type of parking brakes share the braking mechanism of the foot brakes. They are mechanically connected to the brake shoe on vehicles having drum brakes or to the piston on vehicles having disc brakes.

(1) Vehicles Having Drum Brakes

In this type of parking brake, the brake shoe is expanded by the brake shoe lever and the shoe strut (shown below). The parking brake cable is fitted to brake shoe lever, and the operating force of the parking brake lever is transmitted via the parking brake cable to the brake shoe lever.

(2) Vehicles Having Disc Brakes

In this type of parking brakes, the parking brake mechanism is built into the caliper of the disc brake. As shown below, the movement of the lever causes the lever shaft to rotate which in turn causes the spindle to move the piston. The pad is pressed against the disc rotor as a result.

The pad wears out in time and the parking brake stroke increases accordingly. For this reason, an automatic adjusting mechanism is fitted in the parking brake mechanism to keep a constant spindle stroke at all times.

2) Devoted Parking Brake Type

In this type of parking brakes, a separate parking brake drum assembly is assembled to the center of the rear disc brake, as shown below. They operate the same way as the foot brake sharing type parking brakes on vehicles having drum brakes.

2 Center Brake Type

This type is used primarily in large commercial vehicles. It is a type of drum brake but is fitted between the rear end of the transmission and the front end of the propeller shaft.

In the center brake type parking brakes, braking force is acquired as a stationary brake shoe is pushed from inside against a drum that rotates in unison with the output shaft of the transmission and the propeller shaft.

This type of parking brakes operates the same way as the foot brake sharing type parking brakes on vehicles having drum brakes.