Wheels, Tyres, Brakes

Knowledge and understanding

- **Different types of Wheels and their construction.**
- **Tyres and their construction. Identifying faults with tyres**
- **Basic braking system components and replacing brake discs and pads.**

Contents

Health and safety in the workshop

Health and safety in the work place is designed to reduce injury to employees at work. Measures are set in place to reduce the level on injury to the employees working on machinery or coming into contact with chemicals.

The 5 main parts of Personal protective equipment (PPE) are listed below. Be sure to be safe and adhere the safety mandatory signs within your work place when working.

If injury has occurred, document the injury in the accident book. Always ask your H&S supervisor if you're unsure.

Ear protection

- Protection to your hearing in the event of loud noises

Eye protection

- Protection to your eyes in the event of moving parts or swarf particles been ground away.

Safety boots

- Protection to toes and feet in the event of manual handling with heavy objects.

Safety Gloves

- Protection in the event of handling piercing, sharp objects or heat generated objects.

Respiratory mask

- Protection to your respiratory system in the event of working with harmful particles.

Wire wheels

Wire wheels have an amount of flexibility which is better than the previously used cast iron spoked wheels which were prone to cracking on uneven road surfaces. Wire wheels did have the advantages of being lighter and cheap to construct. Generally fitted to the older vehicle, but soon phased out by pressed steel wheels in the mid 1950's. It's fair to start talking about automobile wheels starting with Karl Benz's 1885 Benz Patent Motor wagon. The three-wheel vehicle used bicycle-like wire wheels, which were fitted with hard rubber.

Pressed steel

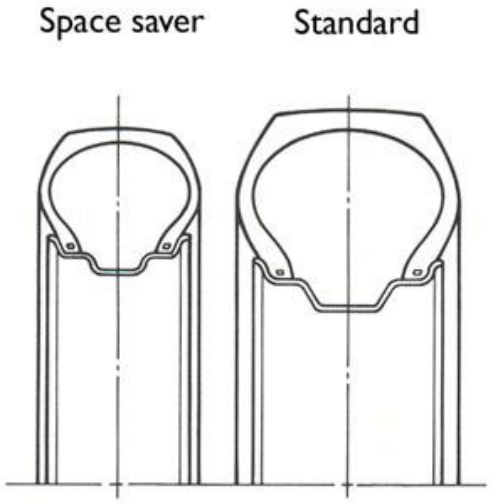
Pressed steel wheels were cheaper to construct than wire wheels. As in the name the wheel is made from steel and is pressed, then welded together. Having a lighter construction and cheaper manufacturing process, these wheels are still used on modern day vehicles today, often with the use of wheel trims.

Alloy wheels

Alloy wheels are lighter and better heat conductors. As a result, cars fitted with alloy wheels' improved steering and handling and prolong the life of the brakes. They are also more visually appealing. On the other hand, alloy wheels are considerably more expensive to make than steel ones, which raises the overall price of the car. Due to manufacturer's improving the weight and design of modern days' cars, the alloy wheel is the most preferred wheel used today on modern day vehicles. Alloy wheels are cast from an alloy of aluminium and sometimes magnesium. Magnesium alloy wheels (mags) are very lightweight and strong, but can suffer from corrosion if the surface is not treated correctly. Aluminium alloy wheels do not corrode.

Space saver wheel

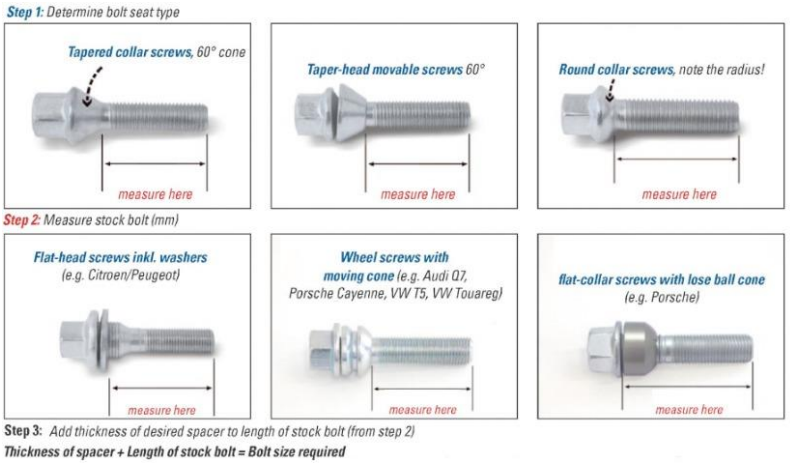
Space saver wheels are designed for emergency use, either to get you home or to get you to the nearest garage. Most manufacturer's state that space savers cannot be driven over 50 mph as marked on the sticker fitted to the wheel. The wheel is the same diameter but the section width is a lot thinner. The advantage of this is that you still have an emergency wheel to "get home" and takes up less space in the vehicles boot.

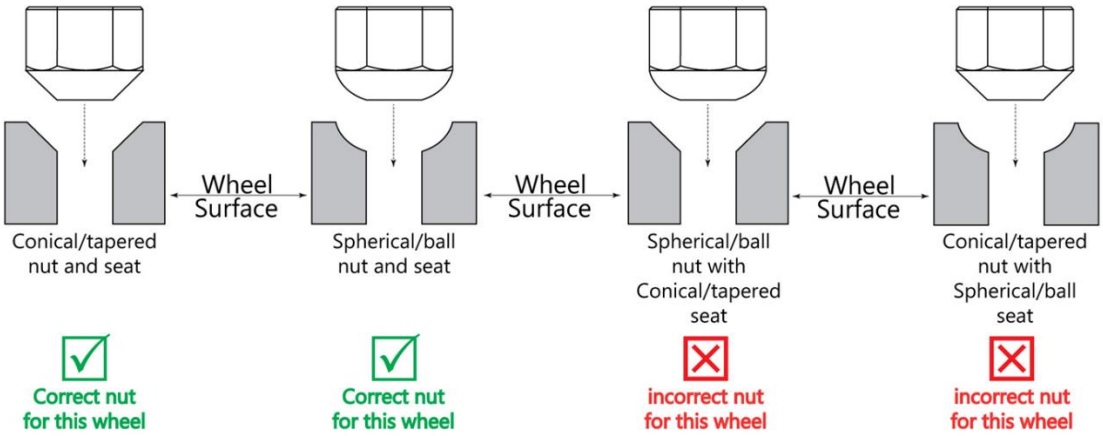


Wheel bolts and nuts

Wheel bolts and nuts have a machined taper or either flat head washer, furthermore the taper is relevant to the taper machined in to the wheel, failure to adhere to this has implications. The precisely machined taper provides a flush fit to the wheel.

Referring to manufacture's guide for installing the correct wheel nut or bolt is essential. There are different types of taper fit to suit different wheels manufactured. Aswel as the taper it is relevant to check the pitch and the length of thread.

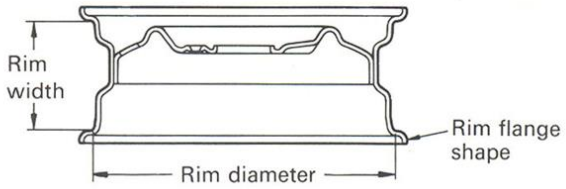




The rim width is from the inside of the rim to the opposite inner part of the rim. (see picture) it is mostly stamped on the inner part of the wheel.

It is measured in inches, in relevance to the picture, the rim width is denoted as 4.5 inches.

4 ½ = wheel rim width in inches
J = wheel rim flange shape
13 = wheel rim diameter in inches



The wheel rim flange shape is denoted as a J. There are other letters than denote the shapes but “J” is the most common one come across on today’s modern vehicles.

The rim diameter is measured in inches and can also be stamped upon the inside of the wheel.

Locking wheel bolts/nuts

Locking wheel bolts/nuts come in different shapes and sizes along with a master key for removal and fitting. The locking wheel bolts/nuts have a taper machined to them aswel and should be observed when fitting, always refer to manufacturer’s instruction when fitting to ensure they are the correct one for the vehicle.

Locking wheel nuts/bolts offer a form of security to your vehicle in the event of theft. As normal sockets, cannot be used because of the master key is the only tool to remove the bolt/nut. Locking wheel bolts/nuts have a spinning collar, this is to eliminate the bolt being removed with mole grips or any other type of tool.

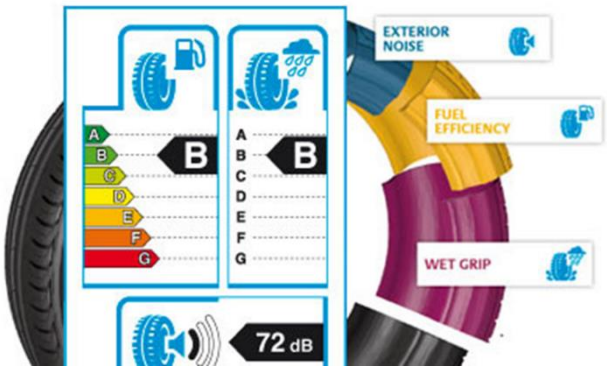
Ensure you do not use an air gun or any other power tools to remove or install the bolt as the vibrations between the bolt/nut and master key will cause damage.

If any damage is noted to the master key or locking wheel bolt/nut before removal, ensure the workshop controller is informed so the information is passed to the customer and then the relevant action can be taken.

Tyres

Different tyre manufacturers are working extensively to continue developments to tyres to cope with modern day vehicles. As of November, 1st 2012, new tyre label regulations are in force to help promote safer, more economical, and more environmental friendly transport in Europe. Tyre labels now indicate tyre performance in 3 key areas, They are.

- **Exterior noise**
- **Fuel efficiency**
- **Wet grip**

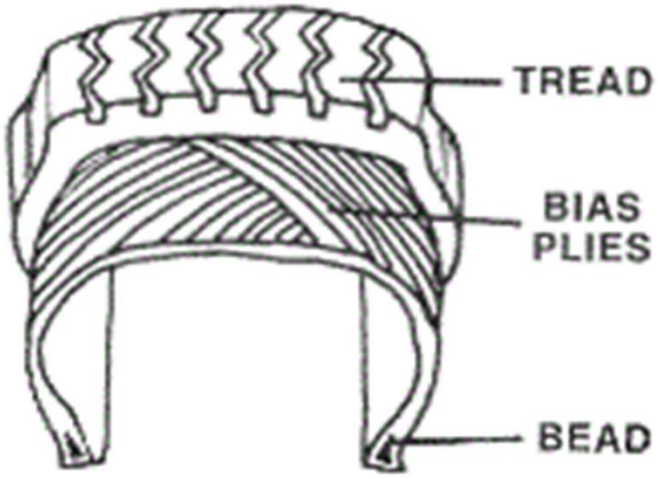


3 types of tyre construction

Cross-ply

Cross-ply tyres have been used instead of full rubber tyres since 1898. They were a standard feature in the car tyre industry before radial tyres were introduced.

Cross-ply tyres consist of carcase layers made from nylon cord. They are placed diagonally across each other in the tread and the side walls, at an angle of 55 degrees. Multiple rubber plies overlap each other and they form a thick layer, resulting in less flexibility which can make it more sensitive to overheating.



The cross-ply tyre has opposite qualities because it has a rigid sidewall. This rigid sidewall and the general design of the tyre don't allow heat to dissipate as effectively and the tyre wears out faster. Also, they don't have a very high speed rating. Generally, about 80 – 100 KPH. What this means is, if you drive in excess of this speed for over 4 hours you risk a blowout. Therefore, most vehicle manufacturers don't recommend fitting cross-ply tyres onto their vehicles.

How to Tell a Cross-ply Tyre from a Radial Tyre

Then the question of how to recognize whether the tyre is one or the other arose. This is very straight forward. A common size of tyre for a 4×4 is 750 16. If it is written on the tyre 750R16 it means it is one of the good guys. The R standing for radial. If it doesn't have the R, i.e. 750-16, then it's one of the cheaper type. If it's a profiled tyre such as 235/85R16 then it will be a radial.

Advantages of cross-ply tyres include:

- Improved vehicle stability
- Higher resistance against side wall damages

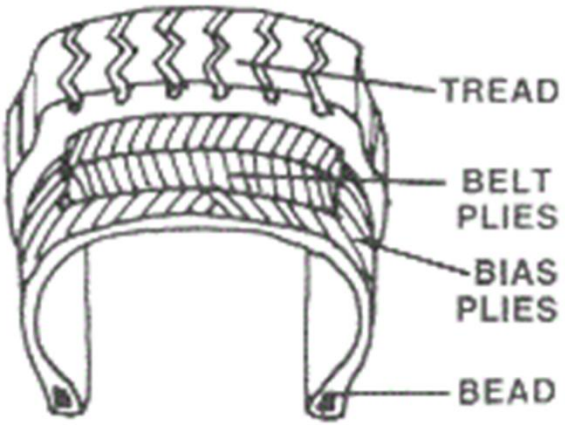
Disadvantages of cross-ply tyres include:

- High rolling resistance, which causes tyres to quickly heat up
- Reduced comfort due to the tyre's rigidity
- Increased fuel consumption

Bias belted

A bias belted tire starts with two or more bias-plies to which stabilizer belts are bonded directly beneath the tread. This construction provides smoother ride that is similar to the Cross-ply tire, while lessening rolling resistance because the belts increase tread stiffness.

The plies and belts are at different angles, which improves performance compared to non-belted bias tyres. The belts may be cord or steel.



Bias-belted tyres have phased out due to the popular demand and construction of the radial tyre. There is a very minimal chance of seeing a bias-belted tyre, but there may still be a few in circulation.

Always refer to the marking on the sidewall of the tyre for tyre construction.

Radial tyre

Radial tyres were developed in 1946 by Michelin. At the time, there was a need for more flexible tyres which were able to absorb shocks generated by road surfaces.

The sidewall of radial tyres and the tyre tread work as two independent features. The flexibility of a Radial tyre, together with its strength, are two combined factors which mean a radial tyre absorbs impact shock and bumps more effectively than a Cross-ply or Bias belted tyre.

Radial tyres lay all of the cord plies at 90 degrees to the direction of travel (that is, across the tyre from lip to lip). This design avoids having the plies rub against each other as the tyre flexes, reducing the tyre's rolling friction. This allows vehicles with radial tyres to achieve better fuel economy than with bias-ply tyres.

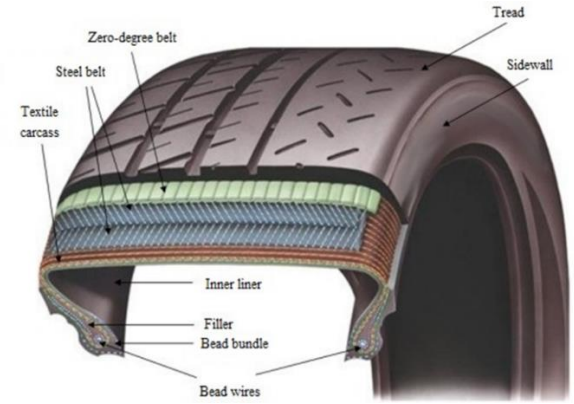
The advantages of radial tires over bias ply tires:

- Flexible sidewalls
- Reduced fuel consumption due to less rolling resistance
- A softer ride because of the layout of the tyre's plies and because of the flex of the sidewalls more stable contact with the road service.
- Steel Belted – Results in tougher overall construction
- Longer Tread Life
- Wider Footprint
- Less ground compaction and damage
- Reduction in tyre replacement due to less heat generated by the tyre.

- Reduced machine maintenance costs

Disadvantages of radial tyres include:

- The soft side walls are vulnerable when, for example, vehicles collide with curb stones
- Minor bumps in road are dealt with less effectively because radial tyres feature a steel belt



Tyres have not always been as we know them today. RW Thomson invented and patented the Pneumatic Tyre in 1845. His first design used several thin inflated tubes inside a leather cover as illustrated. This design had its advantages over later designs. It takes more than one puncture to deflate the whole tyre, and varying the pressures could alter the ride conditions.

It was not until the late nineteenth century, 1888, that John Boyd Dunlop invented the Rubber Pneumatic Tyre. Despite these technological breakthroughs, the solid rubber tyre continued to be the dominant tyre and it was not until 1889 that the pneumatic tyre caught on. Dunlop first advertised his tyres in December 1888. In May of the following year the Tyre had its first breakthrough. A Belfast Cycle Race was won on pneumatic rubber tyres, and by now the public were starting to take note.

Unfortunately, the original tyre had its drawbacks. The inner tube was difficult to get at because the tyre was stuck to the wheel. In 1890 CK Welsh patented the design of a wheel rim and outer cover with inextensible lip. By now we had the basics for today's tyre. Over the years, the tyre has developed into today's high technology offerings. Two of the most important technical developments include Michelin's creation of the radial tyre with its vastly superior grip in 1948, and when Dunlop did away with the inner tube on car tyres in 1972. Time has given the motor industry tyres capable of many different applications. This ranges from High Speed Racing such as Formula One to Heavy Plant Usage on vehicles as large as a house.

Performance tyres are designed for faster cars or people who drive harder than the average consumer. They typically put performance and grip ahead of longevity by using a softer rubber compound. Tread block design is normally biased towards outright grip rather than the ability to pump water out of the way on a wet road. The extreme example of performance tyres are "slicks" used in motor racing, so-called because they have no tread at all.

All season tyres

Are designed to be a compromise between grip, performance, longevity, noise and wet-weather safety. For increased tyre life, they are made with a harder rubber compound, which sacrifices outright grip and cornering performance.

The tread block design is normally a compromise between quiet running and water dispersion

Wet weather tyres use a softer compound than performance tyres. The rubber needs to heat up quicker in cold or wet conditions and needs to have as much mechanical grip as possible.

They'll normally also have a lot more siping to try to disperse water from the contact patch. Aqua channel tyres are a subset of winter or wet-weather tyres.

Winter tyres come at the other end of the spectrum to performance tyres. They're designed to work well in wintery conditions with snow and ice on the roads. Winter tyres typically have larger, (and nosier) tread block patterns. True snow tyres have tiny metal studs in the tread for biting into the snow and ice.

The downside of this is that they are incredibly noisy on dry roads and wear out both the tyre and the road surface extremely quickly if driven in the dry.

Mud & snow tyres typically either have 'M&S' stamped on the tyre sidewall. Snow & Ice tyres have a snowflake symbol

All-terrain tyres are typically used on SUVs and light trucks.

They are larger tyres with stiffer sidewalls and bigger tread block patterns.

The larger tread block means the tyres are very noisy on normal roads but grip loose sand and dirt very well when you take the car or truck off-road.

Mud tyres At the extreme end of the all-terrain tyre classification are mud tyres. These have massive, super-chunky tread blocks and really shouldn't ever be driven anywhere other than loose mud and dirt. The tread sometimes doesn't even come in blocks any more but looks more like paddles built in to the tyre carcass.

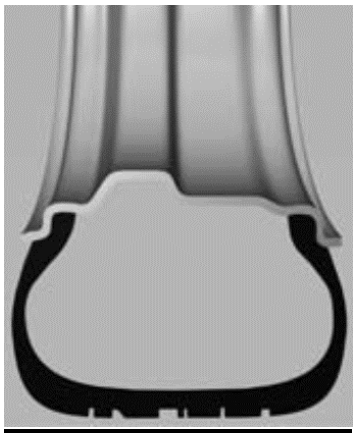
Conti-seal

For enhanced mobility and safety, even if a foreign object penetrates the tyre tread. Conti-Seal tyres contain an innovative technology which seals punctures in the tread area. Conti-Seal tyres have a sticky, viscous layer from shoulder to shoulder that instantly seals punctures caused by nails and other objects up to 5 mm in diameter. The layer temporarily seals the vast majority of tyre tread punctures. The material in the sealant layer prevents air loss even if the penetrating object becomes dislodged. Thus, there is no need to stop straight away or change the tyre immediately in the event of a puncture. Despite this, the tyre should be taken as soon as possible to a tyre specialist who can examine it to determine if it needs a permanent repair. Conti-Seal tyres are instantly recognisable by the nail symbol on the sidewall and are compatible with all commonly available wheel rims.

Conti-Seal tyres – the benefits at a glance:

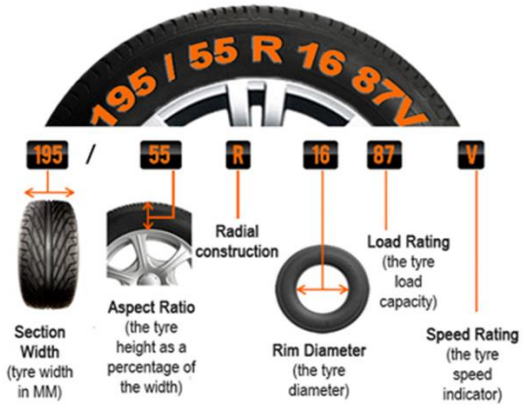
- punctures in the tread area caused by penetrating objects up to 5 mm in diameter are sealed
- holes are sealed even if the penetrating object becomes dislodged
- same high performance under normal driving conditions as no Conti-Seal tyres
- no need to stop straight away or change the tyre

Run flat tyre



The secret of SSR. Continental's SSR tyres use reinforced sidewalls to support the vehicle in the event of a loss of air pressure. SSR technology prevents the side of the flat tyre from being crushed between the road and wheel rim.

Increased safety thanks to reinforced sidewalls. SSR tyres allow for a controlled continuation of your journey at a reduced speed of up to 80 km at a maximum speed of 80 km/h depending on the condition of the roads, the condition of the tyre and the weight of the vehicle.



Size: Section width of the tyre

Aspect ratio/Profile: The tyres height as a percentage of the section width.

R This letter denotes that this tyre is a Radial construction tyre.

16 This represents the rim diameter.

87 The load capacity of the tyre.

V The speed rating that the tyre is capable of.

The section width of the tyre is measured from the edge of the shoulders on either side. If we took the tyre size **235/45 R18 94W**, the section width would be 235 and this is measured in millimetre. 235mm

There are different size section widths and they depend on what size is suitable for the vehicle.

The aspect ratio/profile represents the height of the sidewall as a percentage of the tyres section width. **235/45 R18 94W** so the height of the sidewall is 45% of 235mm.

R is the construction of the tyre which is Radial

18 represents the rim diameter in inches, which indicates the diameter is 18 inches

94 The load-rating is essentially the maximum weight the tyre can carry. The two-digit code is found just after rim diameter or before the speed rating. Different load index numbers represent a given weight in KG.

Load Index	Kilograms	Load Index	Kilograms	Load Index	Kilograms
65	290	80	450	95	690
66	300	81	462	96	710
67	307	82	475	97	730
68	315	83	487	98	750
69	325	84	500	99	775
70	335	85	515	100	800
71	345	86	530	101	825
72	355	87	545	102	850
73	365	88	560	103	875
74	375	89	580	104	900
75	387	90	600	105	925
76	400	91	615	106	950
77	412	92	630	107	975
78	425	93	650	108	1000
79	437	94	670		

235/45 R18 94W The load rating figure is 94 which indicates on the table the tyres maximum weight it can carry is 670KG.

W represents the speed rating of a tyre. 235/45/ R18 94W

W is the given letter that represents a given speed. W represents up to 168 mph (270 km/h)

Speed-Rated Symbol	Speed Category
M	Up to 81 mph (130 km/h)
N	Up to 87 mph (140 km/h)
P	Up to 93 mph (150 km/h)
Q	Up to 99 mph (160 km/h)
R	Up to 106 mph (170 km/h)
S	Up to 112 mph (180 km/h)
T	Up to 118 mph (190 km/h)
U	Up to 124 mph (200 km/h)
H	Up to 130 mph (210 km/h)
V	Up to 149 mph (240 km/h)
W	Up to 168 mph (270 km/h)***
Y	Up to 186 mph (300 km/h)***
Z R	Over 149 mph (240 km/h)**

Tyre inflation

Connect airline to tyre pressure gauge for accurate reading. Observe manufacturer's instruction to tyre pressure settings. Observe the operating window once connected to valve for pressure reading.

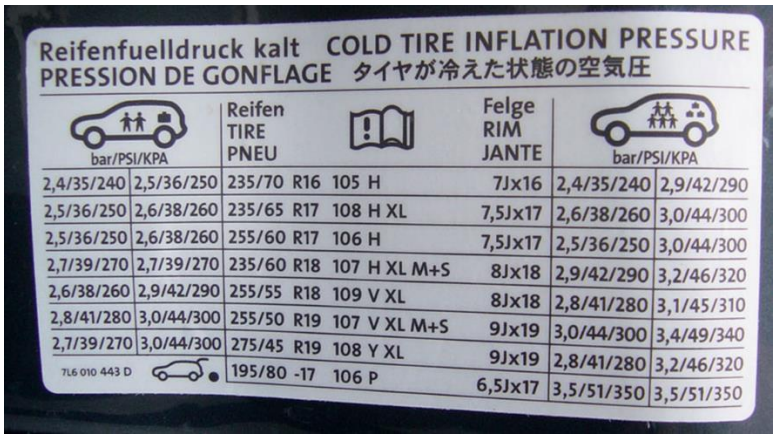
Press the lever down fully to inflate (increase pressure). Press the lever down half way to decrease pressure. Tyre pressures normally found in: Owners handbook Inside fuel filler flap, Inside the drivers or passenger door panel, Drivers door shut, Wall chart.

The unit of pressure is bar or psi (pounds per square inch)

The setting of tyre pressures is essential for the ride comfortability, vehicles handling and to eliminate any premature wear on the tyre.

If the tyres given specification is exceeded in pressure, this will allow the tyre to run on the central part of the tyre, increasing the wear on the central section. If the pressure is below the tyres given specification this allows the central part of the tyre to make less contact with the road and increased tyre wear becomes apparent on the inner and outer shoulders of the tyre, as this is the main contact patch.

Laden and unladen tyre pressures



Reifenfuelldruck kalt COLD TIRE INFLATION PRESSURE
PRESSION DE GONFLAGE タイヤが冷えた状態の空気圧

bar/PSI/KPA		Reifen TIRE PNEU	Felge RIM JANTE	bar/PSI/KPA	
2,4/35/240	2,5/36/250	235/70 R16 105 H	7Jx16	2,4/35/240	2,9/42/290
2,5/36/250	2,6/38/260	235/65 R17 108 H XL	7,5Jx17	2,6/38/260	3,0/44/300
2,5/36/250	2,6/38/260	255/60 R17 106 H	7,5Jx17	2,5/36/250	3,0/44/300
2,7/39/270	2,7/39/270	235/60 R18 107 H XL M+S	8Jx18	2,9/42/290	3,2/46/320
2,6/38/260	2,9/42/290	255/55 R18 109 V XL	8Jx18	2,8/41/280	3,1/45/310
2,8/41/280	3,0/44/300	255/50 R19 107 V XL M+S	9Jx19	3,0/44/300	3,4/49/340
2,7/39/270	3,0/44/300	275/45 R19 108 Y XL	9Jx19	2,8/41/280	3,2/46/320
7L6 010 443 D		195/80 -17 106 P	6,5Jx17	3,5/51/350	3,5/51/350

Unladen:

This is where there is no added weight to the vehicle, apart from driver and passenger.

Laden:

Extra weight added to the vehicle,

Extra passengers

Luggage/Shopping

Observe the data sheet and increase your tyre pressures if there is added weight to the vehicle dependant on tyre size. Data sheet issue's the unit of pressure in Bar and psi (pounds per square inch) and KPA. Ensure the tyre pressures are adjusted when the tyre is cold for a correct reading.

Any cuts to the tyres surface must not exceed 25mm in length and at no point should that cut be through to the cords. Any visible tyre deformation such as bulging sidewalls renders the tyre weak, dangerous and therefore illegal.

Tyres should be inspected for visible signs of damage and deformation and tread depth should be checked using a tyre tread depth gauge.
Great care should be taken when inspecting tyres. Do not run your hands around the tyre as any exposed steel bracing or glass may be exposed.

When checking tread depths, take your measurement over 75% of the tyres breadth. Minimum tread depth is 1.6mm. The 3 measurements should be taken from the inside. Central and outer part of the tread. Be sure to always note down your tread depths the correct order

Green: 5mm – 8mm

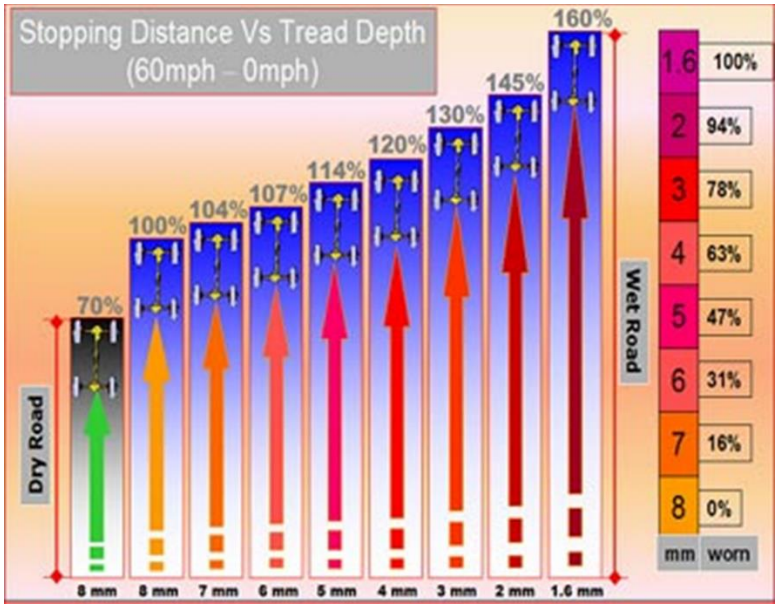
Tyre tread all ok

Amber: 2mm – 4.5mm

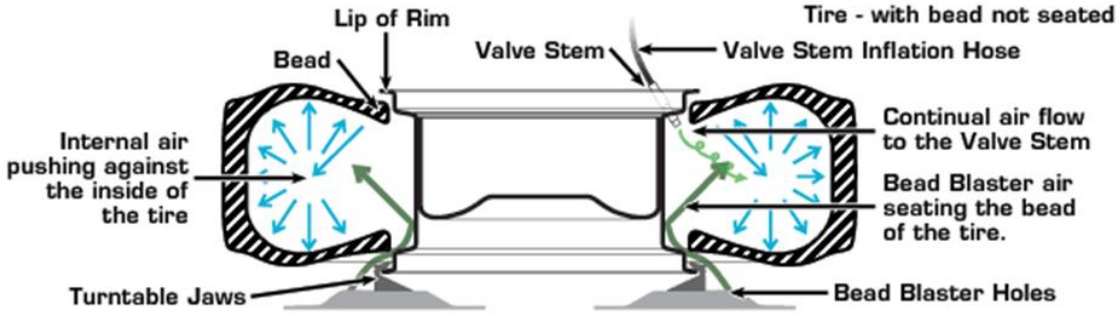
Advisory to the customer that the tyre tread is more than half worn and will require a monthly inspection.

Red: 1.6mm – 2mm

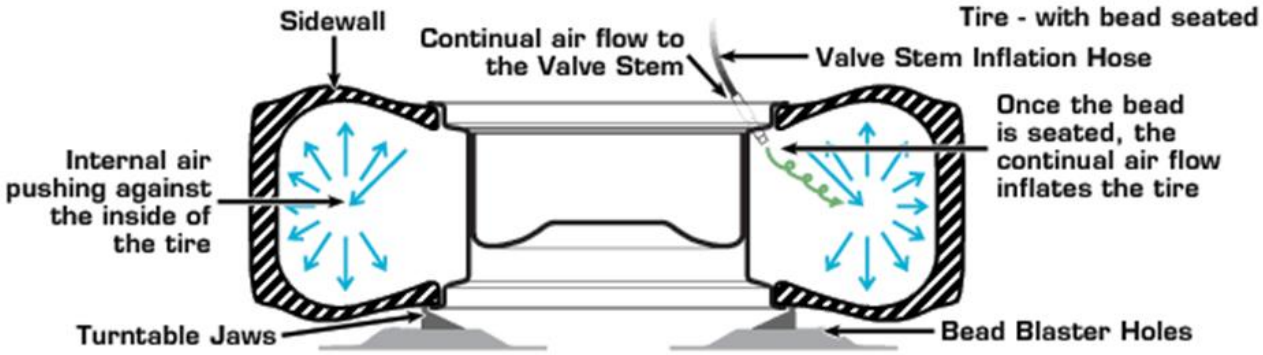
Urgent attention required.

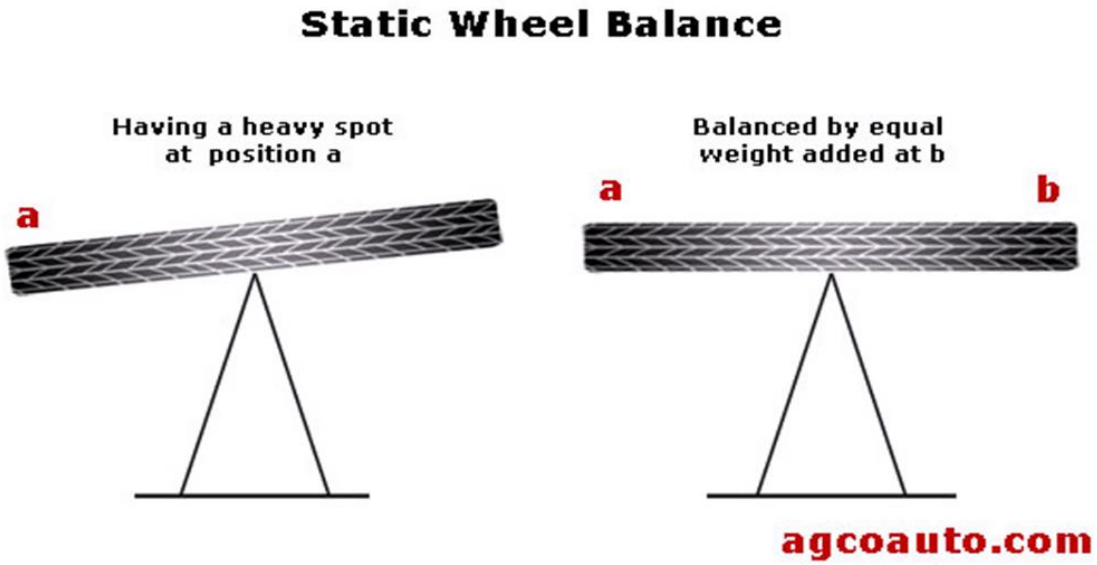


Bead blaster



A tyre changer's bead blaster system delivers a large volume of highly pressured air into the cavity of a tubeless tire to help "seat the beads" of the tyre to the wheel assembly. Many tubeless tyres have extremely stiff sidewalls and the beads of these tyres will not seat properly by just pumping air through the valve stem. (Even with the valve core removed) Compressed air is stored in the air chamber until that air is needed for the bead blaster. A large volume of compressed air is "blasted" into the cavity of the tyre. The combination of the valve stem air supply and the "bead blasted" air is usually enough to seat the beads of the most stubborn tyres. The "blast" of compressed air applies pressure to the top sidewall, temporarily seating the top bead of the tyre to the rim. The large volume of compressed air is then directed toward the bottom sidewall and the lower bead of the rim. This process takes less than one second in most car and light truck cars. The continual flow of the air through the valve stem maintains the pressure against both beads; forcing them to seat permanently and allowing the tyre to be inflated to the correct pressure. To understand how the bead blaster system works; picture yourself blowing up a balloon. Minimal constant air pressure will force the balloon to slowly inflate. That is how the inflation hose (attached to the valve stem) operates. If the balloon has been inflated recently or the balloon material is very pliable, not much air pressure is needed to fully inflate the balloon. However, if the balloon is new and has never been inflated, you must do one of two things to properly inflate the balloon. You can either “pull and stretch" the balloon to make the material more pliable (That's tough to do on a car tire); or you could just SNEEZE into the balloon (if you could fit it over your nose and mouth at the same time). The huge amount of air volume and pressure would inflate the balloon almost immediately.





Static balance can be measured by a static balancing machine where the tire is placed in its vertical axle on a non-rotating spindle tool. The spot on the tire with the greatest mass is acted upon by gravity to deflect the tooling downward. The amount of deflection indicates the magnitude of the unbalance. The angle of the deflection indicates the angular location of the unbalance. In tire manufacturing factories, static balancers operate by use of sensors mounted to the spindle assembly. In tire retail shops, static balancers are usually non-rotating bubble balancers, where the magnitude and angle of the unbalance is observed by looking at the centre bubble in an oil-filled glass sighting gauge.

Braking system

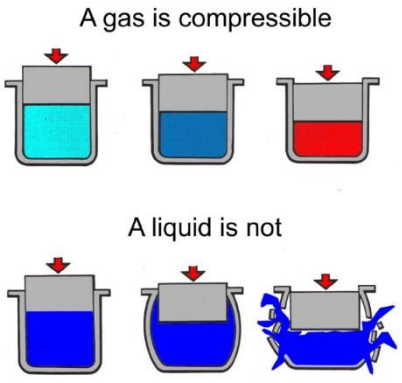
Brakes are considered as one of the most important areas of a motor vehicle, and with good reason. Without them the only means of deceleration would be pressing the clutch pedal in and waiting patiently, or not as the case may be, for the loud bang and the crunching noises. There are two main means of deceleration available to the drivers of small vehicles. The first is engine braking. This is the process of selecting a lower gear than is currently engaged and releasing the accelerator pedal. The drag and pumping effect of the engine reduces its revs quite quickly. As the engine is in gear (directly connected to the road wheels mechanically) when the engine speed decreases, so does the wheel speed, hence the car slows down. The second means of decelerating a vehicle is the braking system. The diagram on the right features a typical braking system. Just as a heat engine fitted to modern vehicles, transfers heat energy into kinetic energy, the brake system transfers kinetic energy into heat energy. Kinetic energy is the energy stored in a vehicle as it is moves along. When the vehicle is moving and neutral is selected, the vehicle continues to move. The sheer fact that the vehicle continues to move shows that kinetic energy is in the vehicle. As the vehicle slows down, the kinetic energy is dissipated (used up) overcoming the frictional forces acting against it such as tyre to road resistance and wind resistance.

The efficiency of a brake depends upon its ability to dissipate the heat that it creates. The faster the rate that the heat can be dissipated, the more efficient the brake is. Pressing a friction surface against a moving object, i.e. shoe to drum or pad to disc generates the heat. The amount or air governs the amount of heat dissipation able to flow over the heated surface and the material the disc is made of. It is important to remember that the heat can only be generated if the tyres remain in adhesion to the road. If the tyre loses traction with the road surface, the disc or drum fails to revolve, and so the shoe to drum or pad to disc contact, will generate no heat. Due to this it is very important for the road wheels to continue revolving during vehicle deceleration. There are valves located in the brake lines to prevent this happening; this will be explained in more detail later.

Brake fluid

In a hydraulic braking system, a special oil based fluid is used to transfer the force generated by the driver. This is possible because a liquid is not compressible and will act to transmit the braking force.

Brake fluid must be able to operate in harsh conditions without losing its properties.



Properties of brake fluid

Brake fluid must meet a wide variety of requirements such as:

Viscosity index – the fluid must be able to maintain a constant viscosity over a wide temperature range. (-40°C - 271°C DOT 5.1)

Low freezing point / high boiling point - the fluid must be able to cope with extreme low operating temperatures without freezing. The fluid must also be able to cope with the extreme temperatures generated during braking without boiling.

Lubricant - the fluid must be compatible with all the materials it meets in the braking system and act as a lubricant for the moving internal parts.

Brake fluid is a glycol based fluid. (The exception being DOT 5 which is silicon based fluid commonly used in motorsport applications). Unfortunately, it is hygroscopic which means that it continually absorbs water from the atmosphere. Therefore, many vehicle manufacturers recommend replacing your brake fluid every 2 years.

Maintenance

As part of routine maintenance, the brake fluids boiling point should be tested. This boiling point test requires the use of special equipment such as the 'Brake fluid safety meter' shown to the right.

Brake fluid is available with varying temperature ranges which is represented by its codes, DOT 3, 4 and 5.1.

Brake fluid has to meet various international standards such as FMVSS 16 DOT 3 140/254. DOT refers to Department of Transport (U.S. standard). 254 is a reference to the boiling point in Celsius of new uncontaminated fluid. The 140 refers to the wet boiling point. This is the boiling point in Celsius where the fluid has absorbed 3% water by volume of the system. This would be the minimum acceptable limit for DOT 3 brake fluid. The risks of having the minimum acceptable fluid in your system is that, if the temperatures generated by braking were high enough it could cause the water contained in the fluid to start to boil, this could cause a total loss of braking force as the vapour created is compressed by the drivers braking effort.

Replacement

When replacing brake fluid or fitting new hydraulic parts only use new brake fluid from a sealed container, fully flush the system with the fluid to ensure that the whole system is replenished. This guarantees all debris and moisture are removed from the braking system ensuring safety without compromise.

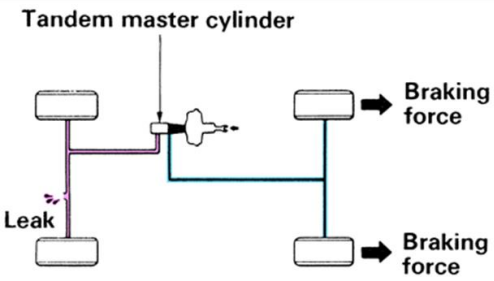
Always clean up any brake fluid spillages!

Brake lines single line

This is an unheard-of system in modern vehicles. The reason for this is the fact that if there is a leak in the system anywhere, none of the road wheels will be braked. This could obviously lead to catastrophic braking failure with dire results. The only means of braking that the driver would have would be the handbrake system and if you have ever tried to stop a vehicle using only the handbrake you will know what an ineffective method it is of stopping a car. A much more commonly used system now is the dual line braking system.

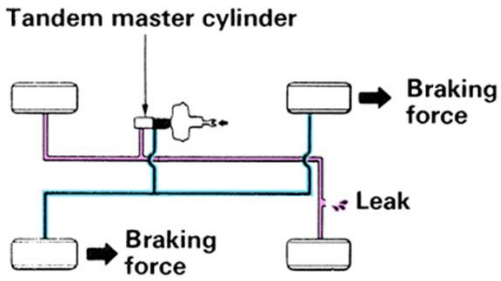
Brake lines dual line

Brake piping in FR type vehicles
Front / Rear Split



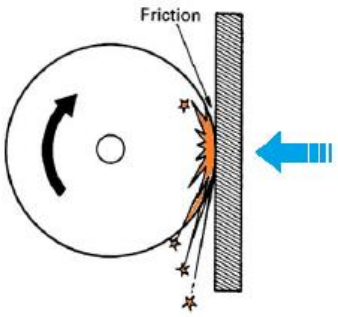
Dual line braking systems divide the hydraulic pressure in the braking system in two. This means two of the wheels are braked by hydraulic pressure in one brake line and the other two wheels are braked by hydraulic pressure in the other brake line. This makes the braking system far safer as even if there is a leak in one of the systems the other system will still be operable. For a dual line braking system to be possible, a dual line master cylinder must be fitted. There are two main splits. Front to rear, and diagonal split. The front to rear type tends to only be used on front engine rear wheel drive vehicles. This is because they have a more even front to rear weight distribution than front engine front wheel drive vehicles and so reduce the chance of a rear wheel lock up. Front engine front wheel drive vehicles are more likely to have a diagonal split so there is always one front wheel being braked.

Brake piping in FF type vehicles
Diagonal Piping



Disc brakes

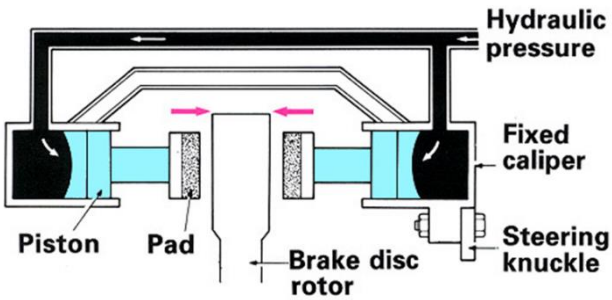
The engine of a vehicle converts thermal energy into kinetic energy (energy of motion) to move the vehicle. The brakes therefore have the job of converting kinetic energy back into thermal energy to stop the vehicle. Generally, vehicle braking systems involve a fixed object to be pressed against a rotating object. The braking effect is obtained from the friction that is generated between the two objects.



Disc brakes are in many ways a far superior form of brake for the road wheels for several reasons. Firstly, as the disc is largely exposed to the air, heat dissipation is much better than the drum brake. They are also easy to maintain as most of the components that are regularly replaced are easily inspected and easily replaced.

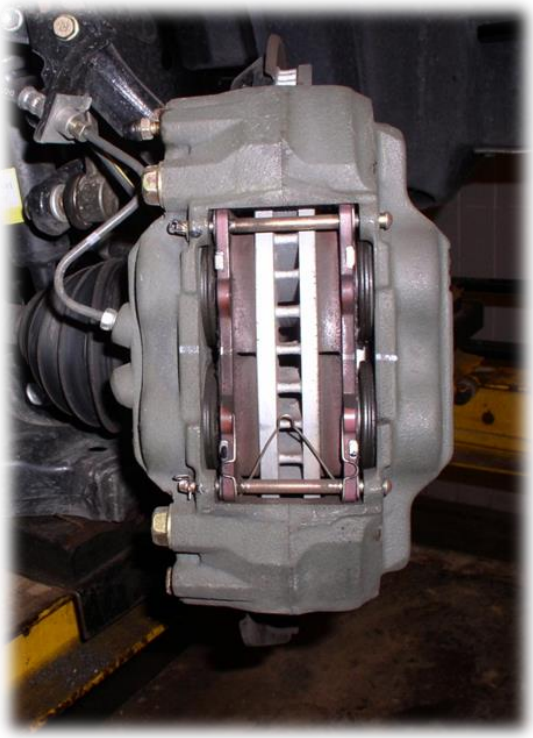
There is a viewing hole in the calliper that allows the brake pad thickness to be checked without any brake disassembly being required. The disc is also in view and so it can be inspected for width, grooving, and run out very simply.

Operation of the disc brake



The disc or rotor is bolted solidly to the stub axle. It is free to turn and the road wheel is bolted to it. Two friction surfaces known as brake pads are pushed towards the revolving disc by an equal clamping force created by hydraulic pressure inside the calliper forcing the piston out. As the pads come into contact with the revolving disc, friction creates heat and the revolving disc slows down.

As the pads wear, the cylinder does not retract into the calliper fully and so the pads stay very close to the disc always. As the piston, does not fully retract with each operation there is no need for manual adjustment. As the calliper is of a floating design itself centralises in relation to the disc and so the pads stay at an equal distance to the disc.

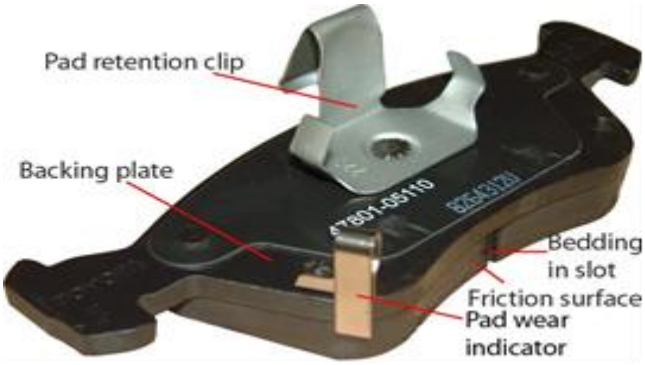


Some designs have a fixed calliper. This type of calliper will have one or more pistons pushing towards the disc on each side of it. Providing the pistons are of equal size they will push the pads towards the disc with equal force. Unlike the drum brake there is no self-servo affect with disc brakes and so the rate of retardation is proportional to the amount of force generated by the pressure put on the brake pedal.
As has been stated earlier, the more heat that can be dissipated from a brake the better the vehicle retardation will be (providing the wheel doesn't lose traction with the road). For this reason, vented and cross drilled discs are fitted to vehicles that need very good stopping power as they provide much better heat dissipation properties.

The diagram to the right shows a high-performance system would consist of a multi piston calliper. An advantage of a multi piston calliper is that several pistons have a larger surface area than one big one in the same size calliper and so more force can be exerted onto the pad. The leading edge of a brake pad is susceptible to wearing out first, with multi cylinder callipers the pistons on the leading edge of the pad are smaller and get progressively bigger as they go down the length of the calliper. This allows there to be less force exerted on the leading edge of the brake pad and so uniform pad wear should occur. Unlike a floating calliper a multi piston calliper is fixed in position and it is the opposing pistons that move. As the calliper is fixed it makes it more rigid, this assists the braking performance, pedal feel, and pad wear. In very high performance applications cross-drilled and grooved discs are commonly used.

There are several advantages of using cross-drilled discs; the first is better heat dissipation, caused by the additional ventilation created by the holes. The edges of the holes continuously clean the friction surface of the pad; this assists the bite of the pad. The holes or grooves in the disc will prevent any gas build up between the disc and the pad. The build-up can reduce the amount of heat generated between the pad and the disc. Finally, the disc is lighter; this means it has less inertia (a body's unwillingness to slow down). Less inertia means it will be more willing to slow down hence better braking. A lighter brake disc will also lead to a reduction in un-sprung weight. Un-sprung weight is any weight below the suspension springs on a vehicle. A vehicle with low un-sprung weight will handle better and provide better comfort, as the wheels will be more inclined to stay in contact with the road. The gyroscopic affect will also be reduced with a lighter disc, this helps the feel of the steering. Gyroscopic affect is best understood by holding a bicycle wheel with a hand on each side of the axle. Spin the wheel up and try to turn the wheel as if your arms are the forks of a bicycle. The resistance to turn will be very noticeable. The spinning wheels gyroscopic affect causes this. The lighter the wheel the less the gyroscopic affect will be. This is also the case with discs on a vehicle. Lighter discs assist the feel and operation of the steering.

Brake pad



Shown in the diagram to the right is an example of a brake pad. These vary in shape, size and friction material but they all do the same job. They are pushed against the disc and the friction between the friction surface and the rotating disc produces heat, and slows the rotation of the disc down. The friction surface is the part of the pad that comes directly into contact with the disc. It used to be made from asbestos but as asbestos is carcinogenic, other materials are now used. Care should still be taken to avoid inhalation of brake dust when maintaining the brakes. Brake cleaner should be sprayed onto any areas where brake dust may be, and a face mask should also be warn whenever carrying out any work on the discs or drums of a vehicles braking system. Most of the pad manufacturers produce the friction material out a combination of steel and mineral fibres, however some manufacturers have started working with composite materials such as Kevlar. The coefficient of friction in the latest pads are in the region of 0.43 whereas in the past it was more in the region of 0.3. Coefficient of friction is best described as a materials resistance to slide. The higher the figure, the more its resistance to slide. As the friction surface is comparatively rigid it can cause some bedding problems. For this reason, a bedding in slot is cut into the friction surface. The high coefficient of friction can cause squeal, to combat this the backing plate often has a rubberised coating or copper compound covering. The backing plate is the part of the pad that comes into contact with the calliper and the calliper carrier. The area that comes

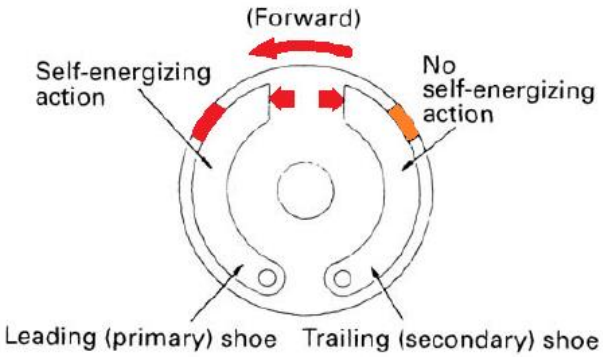
into contact with the piston, calliper and calliper carrier should be greased with the recommended grease; this will prevent any seizing and can reduce any squealing. Additionally, the pad retention clip and wear indicator is attached to this. The friction surface used to be attached by rivets but now it is attached by means of a special heat resistant glue.

Pad wear indication

It is recommended to replace pads when the friction surface has worn down by 70%. It is common now for brake pad warning indicators to be fitted to pads, usually on one side of each axle. The indicator tends to be of two types. The first type is shown in the photo. As the pad wears down the end of the indicator comes into contact with the disc. This produces and audible warning and so indicates to the driver of the vehicle that the pads need replacing.
The second is an electronic sensor. The sensor slots into a machined area on the backing plate or friction surface. As the pad wears down, the end of the sensor gets ground down by the rotating disc. Once the sensor has been worn down to a certain point either the wire is earthed or an open line is created, either way, a warning light will come on, on the dash and indicate excessive pad wear. Circled in the photo is the warning light that illuminates when the pads have worn down excessively.

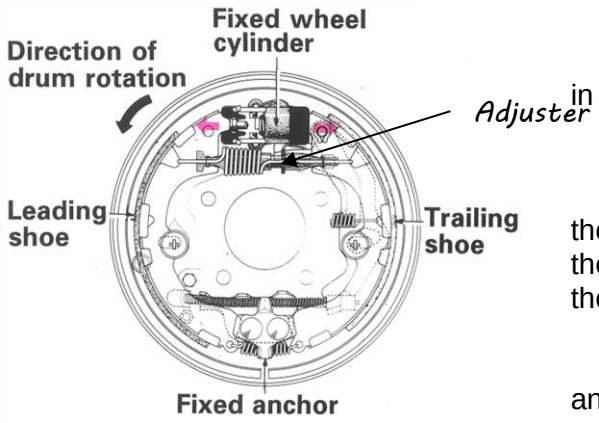
Drum brakes

In a drum brake type system, 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. This type of set up creates a ‘self-servo’ effect due to the rotating force of the drum and the expanding force of the shoe. This ‘self-servo’ action results in a large braking force generated from a relatively small pedal effort.



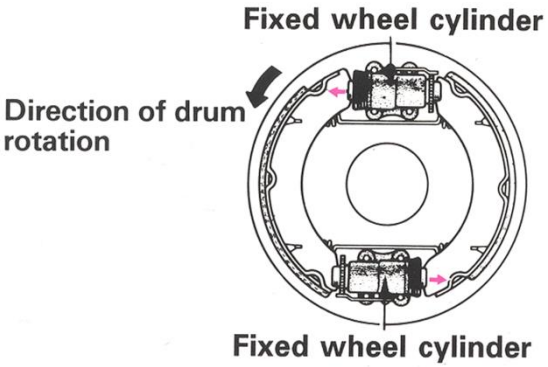
The main components comprising of a drum brake are the drum, brake shoes and the cylinder. The drum revolves around the fixed shoes and cylinder. As hydraulic pressure enters the wheel cylinder it pushes the piston/pistons out. The piston in turn pushes the shoes outwards about a fixed point that they pivot on. As the shoes move out they come into contact with the revolving drum. The contact creates friction between the friction surface on the shoe and the drum. And slows down the rate at which the drum is turning. As the drum is fixed to a road wheel, and the road wheel is in contact with the ground the vehicle decelerates.

There is just one cylinder located in this type of drum brake. The cylinder has a piston exiting on both sides. The shoes pivot about the fixed anchor point shown the diagram to the right.



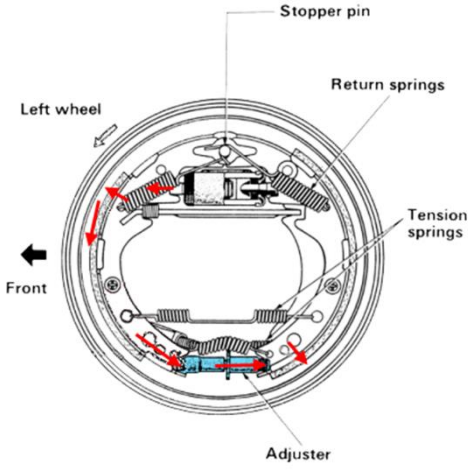
As the piston on the left-hand side of the cylinder travels over to the left it pushes top of the left-hand shoe into contact with drum first. It is not only the pressure of piston that holds the shoe against the drum. Due to the direction of the drums rotation it pulls the shoe tighter against it so increases the amount of friction between the drum and shoe. This action is known as a ‘self-servo’ effect. The top part of the shoe does by far the majority of the work and so wears down much quicker than the bottom of the shoe. At the same time as the left hand piston travels out so does the right-hand piston. This also presses the top of the shoe against the rotating drum. There is no ‘self-servo’ effect on this side due to the direction of the drums rotation and so the only force holding the shoe against the rotating drum is the hydraulic pressure from the cylinder. Please note, providing the brakes are adjusted correctly all of the friction area of the shoes come into contact with the drum when the cylinder pushes them outward, it is just at the top where the pressure is exerted on the shoe from the cylinder. This type of drum is particularly suited to the rear of vehicles as when the vehicle is reversed the right-hand shoe has the ‘self-servo’ action and so a good braking affect is created from this type of drum whether the vehicle is travelling forward of backwards.

Twin leading drum brake single action



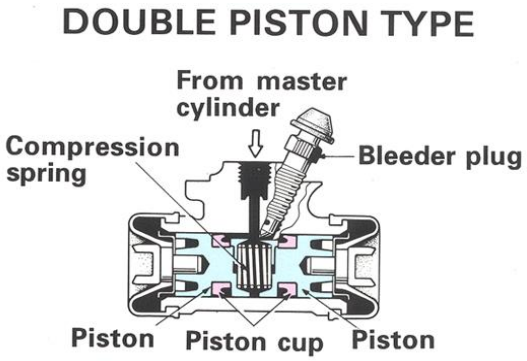
This type of drum is most suited to installation at the front of a vehicle. This type of brake has two cylinders and they both only have one piston in them. The top cylinder has a piston exiting out of the left-hand side. The left-hand shoe pivots at the back of the bottom cylinder and as the piston moves out it pushes the top of the shoe out to the left until it comes into contact with the drum. As soon as it comes into contact with the rotating drum the self-servo affect occurs and the braking affect is increased. The bottom cylinder has a piston exiting out of the right-hand side. The right-hand shoe pivots about a point at the back of the top cylinder. When the piston comes out of the bottom cylinder it pushes the bottom of the right shoe over to the left until it comes into contact with the drum. When it comes into contact with the drum the self-servo affect occurs again, hence increasing the braking affect further. This drum configuration is a very powerful brake when the vehicle is moving forward. When the vehicle is reversing, there is no self-servo affect and so the brake efficiency if very poor.

Duo servo drum brake



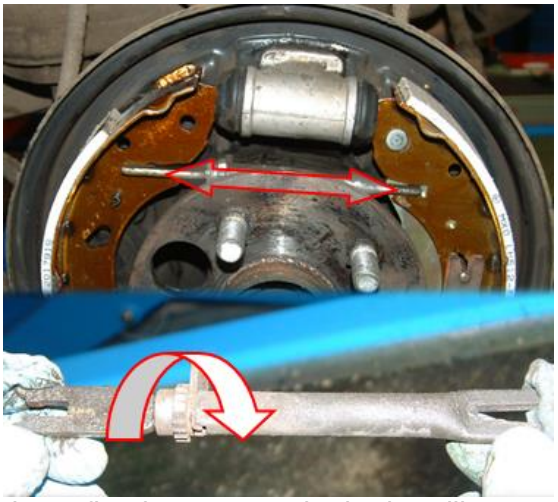
This drum brake system is also a very powerful drum brake. The diagram on the right shows a typical system. It has one cylinder that operates a piston out of its left-hand side. As hydraulic pressure enters the cylinder it forces the piston out. This in turn pushes the shoe until it comes into contact with the drum. As the shoe comes into contact with the drum the self-servo action occurs and tries to twist the shoe down. The shoe is free to travel round with the drum slightly as it does not have a solid fixing at the bottom. As the shoe moves down and round it pushes the adjuster over to the right, which in turn pushes the right hand shoe against the drum. As the right hand shoe comes into contact with the drum it in turn is pulled tighter against the drum by the self-servo action. The shoe on the right is not free to move round with the drum as it pivots about a fixed point at the back of the cylinder. One major point that should be noted about this drum is that its effectiveness goes down drastically with the reduction in friction value. This is particularly the case with this brake as if the leading shoe doesn't grip the drum at the top when it is pushed out by the piston it will reduce the self-servo affect. This will cause the trailing shoe to not be pushed as hard against the drum and so the amount of friction/heat generated will reduce. The more heat generated, the higher the stopping power of the brake.

Drum brake cylinders



The brake cylinder is the hydraulic part of the drum brake. It is fixed to the back plate rigidly with two bolts. As hydraulic pressure enters the cylinder the piston(s) is/are pushed outwards. It is this outwards movement that moves the shoes into contact with the drum. A bleeding plug is fitted to the highest point of the cylinder to allow any air in that part of the hydraulic system to escape. The seal that prevents any brake fluid escaping from the cylinder is designed in such a way that hydraulic pressure pushes it tighter against the piston. If it is installed the wrong way around the hydraulic pressure will be free to escape, and so care must be taken to fit the seal correctly. It tends to be usual practice to replace the whole wheel cylinder if any fault occurs rather than recondition it.

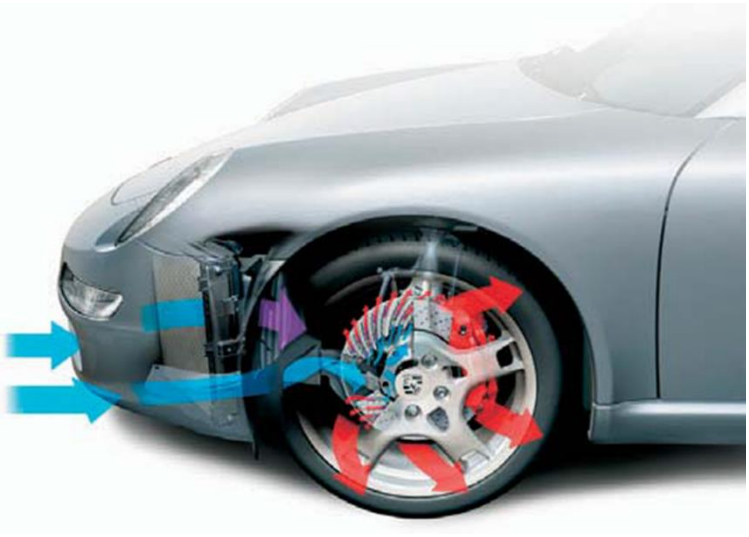
Drum brake adjustment



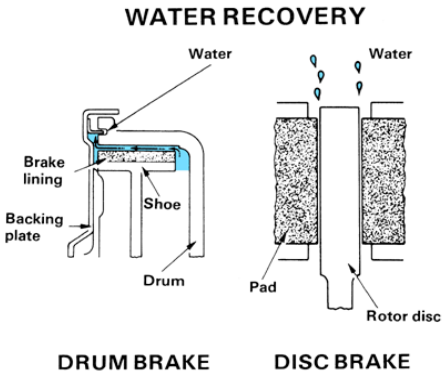
It is necessary to be able to adjust the shoes manually. As the drum wears, a shoe wide groove is created. This makes drum removal very difficult, and so there must be a way of adjusting the shoes manually with the drum in place. Adjustment is normally carried out by a ratchet on the shoe separating linkage. The ratchet is accessed through a hole in the drum. The ratchet can be turned by a screwdriver through a hole in the back plate or the drum. Once the ratchet is backed off sufficiently the shoes will have retracted sufficiently to be out of the groove worn in the drum and the drum can be removed. The ratchet must be re-adjusted once the drum has been fitted, to ensure the brake will operate correctly. Correct adjustment is to tighten the shoes up until the drum cannot be turned and then backed off until there is very slight/no “drag”.

Advantages of the disc brake over the drum brake

The heat dissipation qualities of the disc brake are far better than the drum brake; this is caused by the friction surface of the disc being exposed to the air directly. The drums friction surface is internal and so the cooling air doesn’t have direct contact with the friction surface. This makes fading due to reduction in the coefficient of friction less likely to occur with the disc.



The disc has much better water dissipation qualities, if any water gets onto the disc it is flung off by the centrifugal effect of the disc rotating. If water gets into the drum it struggles to escape. Water in the drum affects the friction between the shoe and the drum and so the braking characteristics are hampered considerable. The disc is considerably easier to maintain, as all the serviceable items are easy to access. Additionally, the components are all visible and so disc run out, disc width and pad wear are simple to check.



A disc is self-adjusting and so the amount of time maintaining them is considerably less than drums.
When a disc heats up and its width expands, the friction surface of the disc is expanding in the direction of the pad. This has no detrimental effect. Whereas with the drum brake, when heat expansion occurs, the diameter if the drum expands. This expansion is driving the friction surface away from the shoe. This can lead to a long pedal in heavy braking conditions.

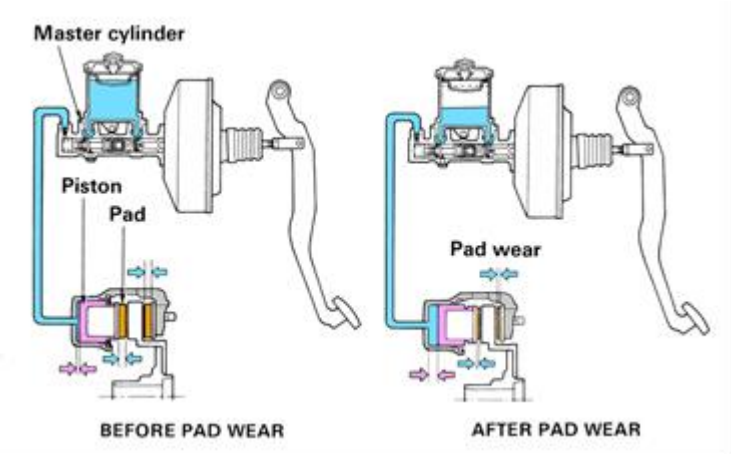
Disadvantages of the disc brake over the drum brake.

The surface area of the shoe is much larger than that of the brake pad. This means greater hydraulic force is needed to create the same amount of friction between the surfaces. Therefore, the pad must be able to resist higher quantities of friction and heat.

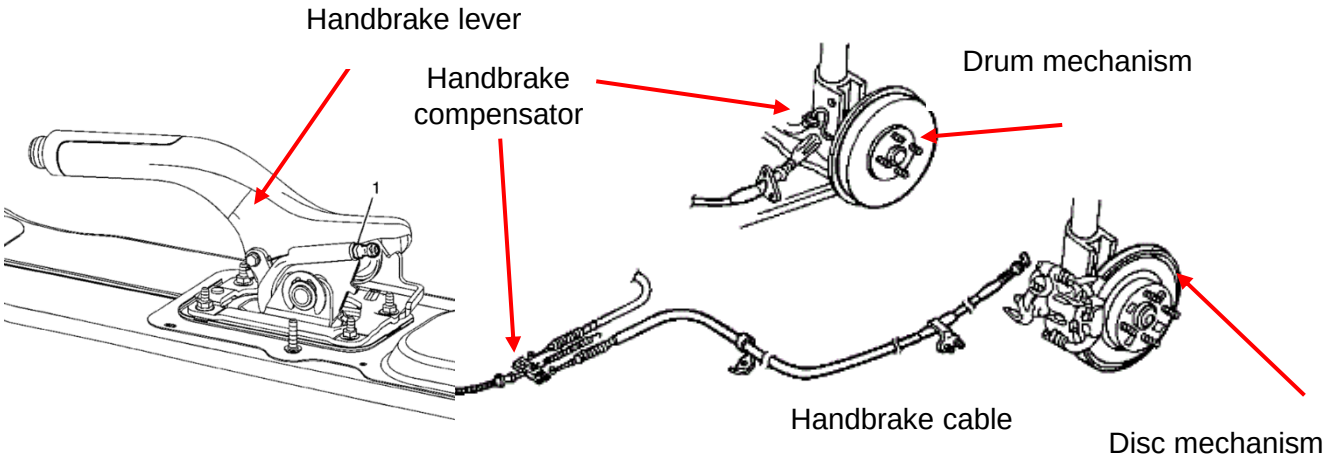
Disc brakes are more likely to squeal than a drum brake caused by the way the pad comes into contact with the disc.

The piston size needed to press the pad against the disc as a pose to the shoe against the drum needs to be of a considerable larger diameter in order to exert the sufficient force. Due to this factor a brake booster is needed in the system.

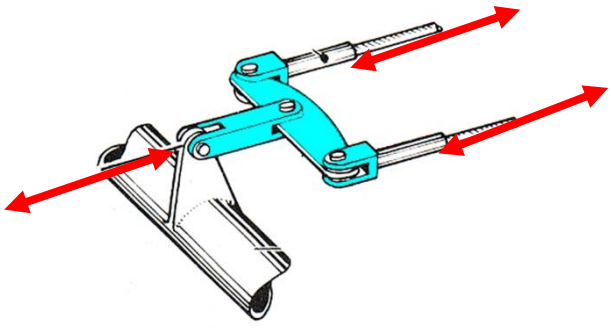
As the pad width reduces the piston sits further out of the calliper. This increases the volume of the hydraulic circuit and so the brake fluid level will go down in the reservoir. The reservoir must be monitored to make sure the level doesn't drop too low. If this occurs air will enter the system and complete brake failure could occur.



The diagram below shows a typical layout of a handbrake mechanism.



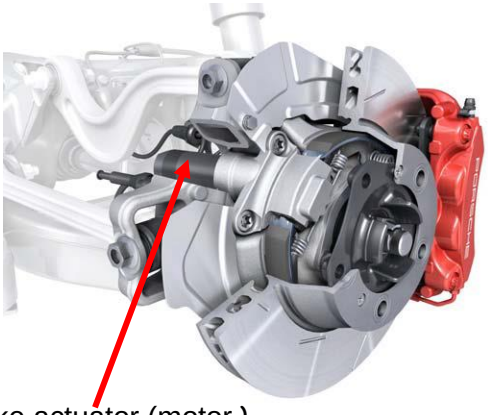
In between the handbrake and the cables is the handbrake cable equalising pivot (compensator), similar to the one shown below.



As the handbrake lever is pulled up the cables leading to the rear brakes are also pulled. It is the action of the handbrake compensator that ensures that the levers force is distributed evenly to each handbrake mechanism.

Electronic handbrake

In recent times the electromechanical handbrake has become a popular option favoured by vehicle manufacturers. The benefits are to be able to do away with the bulky levers and effort required to operate the handbrake. This was replaced with the action of a simple switch. Most of the electromechanical systems require the use of electric motors to mechanically apply the handbrake or release the mechanism.



Handbrake actuator (motor)