The Wheel Assembly

Structure of the wheel assembly

The wheel assembly comprises the following:

- the tyre
- the disk wheel
- and the valve

The steel disk wheel itself comprises the rim and the wheel nave, which are welded together.

Steel disk wheels usually have a wheel hub cap made of plastic or sheet metal. This protects the wheel studs/screws against corrosion and soiling. The hub cap is an important structural part which must not simply be done without (appearance, drag coefficient).

Disk-type light alloy wheels are for the most part cast or forged in one piece. In comparison with steel disk wheels they weigh less which is a factor that improves the suspension characteristics of the vehicle. Thanks to the production method, they enjoy superior dimensional accuracy and are consequently less susceptible to imbalance.

Disk-type light alloy wheels are not covered by a hub cap. They are mostly silver or painted with a transparent paint which preserves the typical appearance of the light alloy. The layer of paint must not be damaged when mounting the tyres. Re-painting of light alloy wheels is not allowed, only touching up is permissible; sand blasting or pickling is not recommended.

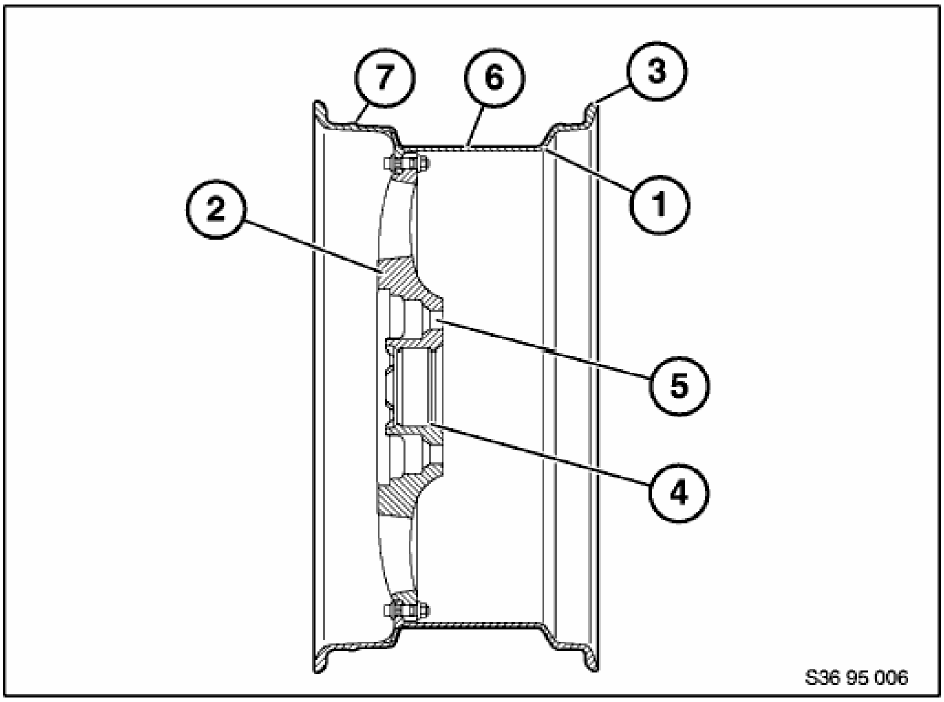


Figure 6: Wheel assembly with single parts

1. Rim
2. Wheel nave
3. Rim flange
4. Centre hole centering
5. Wheel stud hole
6. Drop centre
7. Hump

Dimensions of and terms used in connection with disk wheels

To enable tyres and disk wheels to be combined within the framework laid down, the most important of the dimensions are standardized.

The diameter (1) of the disk wheel is measured between the opposite facing contact surfaces of the tyre (outside diameter = bead seat and not rim flange) and given in inches.

The rim width (2) is measured between the rim flanges (that is, not the total width of the rim).

The rim offset (3) is the distance between the centre point of the rim and the wheel contact surface. The contact surface is offset from the centre of the rim towards the outer side of the wheel, in order to make room for the brake.

Only a wheel with a rim offset value (given in millimetres) within the specified range for a specific vehicle may be mounted. A smaller rim offset would result in an increase in the track, which in turn could lead to problems with the freedom of movement due to insufficient space.

The centre hole of the wheel serves to centre it on the wheel hub; for this reason, the diameter of the hole must match the hub of the wheel precisely. Before the wheel is mounted, the centre hole must be cleaned and slightly greased.

When centering the wheel while mounting it, always ensure that the centre hole is clean and without play. The wheel should be mounted with the valve at the bottom, so that the conditions are identical to those on the balancing machine.

The hole circle diameter (4) of the wheel and the number of holes in the wheel must match those in the wheel hub.

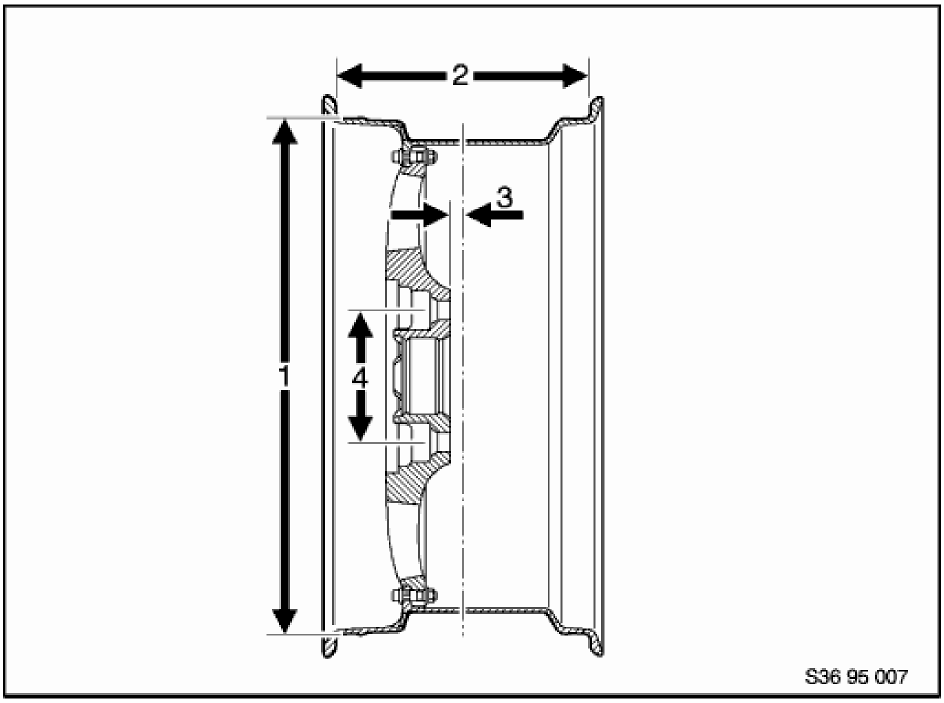


Figure 7: Diameter, rim width, rim offset and hole circle diameter of a disk wheel

1. Diameter
2. Rim width
3. Rim offset
4. Hole circle diameter

Rim design

Disk wheels made of steel generally comprise a rim and nave. The rim is that part of the wheel on which the tyre is mounted; the nave joins the rim to the wheel hub.

In the case of cast or forged disk wheels made of light alloy, the rim and nave are usually manufactured in one piece.

BMW AG currently only uses rims made in one piece. BMW M GmbH, however, does mount some 2-piece, bolted wheel assemblies.

The bead of the tyre sits on the rim bead seat. The sidewalls of the tyre are forced outwards by the pressure of the air which inflates the tyre and the tyre rests against the rim flange.

The rim flange is the collar around the circumference of the rim, against which the bead of the inflated tyre sits. The flange height and flange shape are specified in the wheel type designation by means of a code letter. The commonest type of flange has a height of 17.3 mm, code letter J.

When mounting the tyre, the bead of the tyre must be pulled over the rim flange. Since the bead is not elastic, this can only be done when it is able to plunge deep into the opposite side of the rim base. For this reason, rims are as a rule designed as drop centre rims. On the other hand, in order to leave sufficient space for the brake, the drop centre is of an asymmetric design.

The tyres predominantly in use today are tubeless. To prevent the tyres from plunging into the drop centre when subjected to strong lateral forces and thus to prevent them from losing air suddenly, the rims have a hump which runs around their circumference between the rim bead seat and the rim base. Typical nowadays is one hump on either side of the rim (inner and outer side); this is known as H2.

In the case of the asymmetric hump (AH2), the shape of the hump differs round the circumference of the rim, in order to provide even better protection against the tyre slipping into the drop centre.

Special wheels such as the TD (Dunlop) and AH2 (BMW M GmbH) allow a vehicle to be driven at limited speed in emergencies after a loss of air. After a tyre defect has arisen, the emergency running characteristics of the tyre allow you to drive out of hazardous zones, such as bottlenecks, heavy urban traffic, tunnels or road construction sites, without any difficulty with the flat tyre and then to change the tyre on a car park or on a filling station forecourt, if necessary.

The range with TD wheels when a tyre is flat is approx. 5 - 10 km at a maximum speed of 60 km/h.

TD tyres are only allowed to be mounted on TD wheels. These wheels have a special shape and are only allowed to be combined with matching tyres.

Markings on steel/light alloy wheels

Example:

7 J X 15 H2

7: rim width in inches (on TR and TD wheels in mm)

J: flange shape code letter

X: symbol for drop centre rim

15: rim diameter in inches

H2: hump on the 2 rim bead seats

Dimensions and designation of tyres

The sidewall of the tyre carries extensive designation markings. In addition to the manufacturer's name and trademark, the tyre designation is particularly important.

Example:

205 / 60 R 15 91 H

205: nominal width in mm

60: cross-section ratio in %

R: code letter for tyre (belt) design, in this case radial

15: rim diameter in inches (on TR and TD tyres in mm)

91: load-carrying capacity code number (not on ZR tyres)

H: speed code letter (on ZR tyres, before the R)

The first number is the tyre width given in millimetres. This describes the overall width of the tyre, but does not take markings, kerbing ribs and the like into account. The tyre width must match the rim width of the wheel.

This is followed by the cross-section ratio of the tyre width and the tyre height in percent. Over the years as the development of vehicle tyres has progressed, this ratio has become smaller and smaller. Whereas the first tyres made were higher than they were wide (cross-section ratio > 1), today's standard tyres have a cross-section ratio of 70 % (compact and mid-range passenger cars) to 60 % (luxury cars). Tyres with a cross-section ratio of 60 % or less are known as wide tyres.

The code letter that follows stands for the design of the belt. As a rule, this is an R, since today's vehicles are all fitted with radial tyres.

The next number is the necessary rim diameter given in inches. The value must match the corresponding specification on the disk wheel.

The next marking is the load index which specifies the load-carrying capacity of the tyre. Tyres of a particular size can have a different load-carrying capacity. The load-carrying capacity, given in kilogrammes, can be looked up in the tables compiled by the tyre manufacturers. The load index specified in the registration documents of a vehicle must not be fallen below.

The last code letter is the speed symbol. The tyre must be approved for a speed which is at least 10 km/h (6 mph) greater than the maximum speed of the vehicle. In the case of snow tyres (M + S), this is often not the case; a corresponding sticker indicating the maximum permissible speed for the tyres must then be affixed at a position in the driver's field of vision.

The date of manufacture and therefore the age of the tyre can be seen from the final three digits of the DOT number (approval number of the American Department of Transportation). The first two of these digits indicate the calendar week, the last digit the last digit of the year. Since 1990, a triangle has been appended in order to distinguish years belonging to this decade from those of the previous one.

Certain tyres have a design which means that they must be mounted with a specific direction of rotation; the direction of rotation is indicated by an arrow (and often the word ROTATION). Such tyres must be mounted accordingly in order to ensure optimum vehicle handling and noise levels.

On tyres with asymmetric tread, the sidewalls are marked, e.g. with "outside" and "inside".

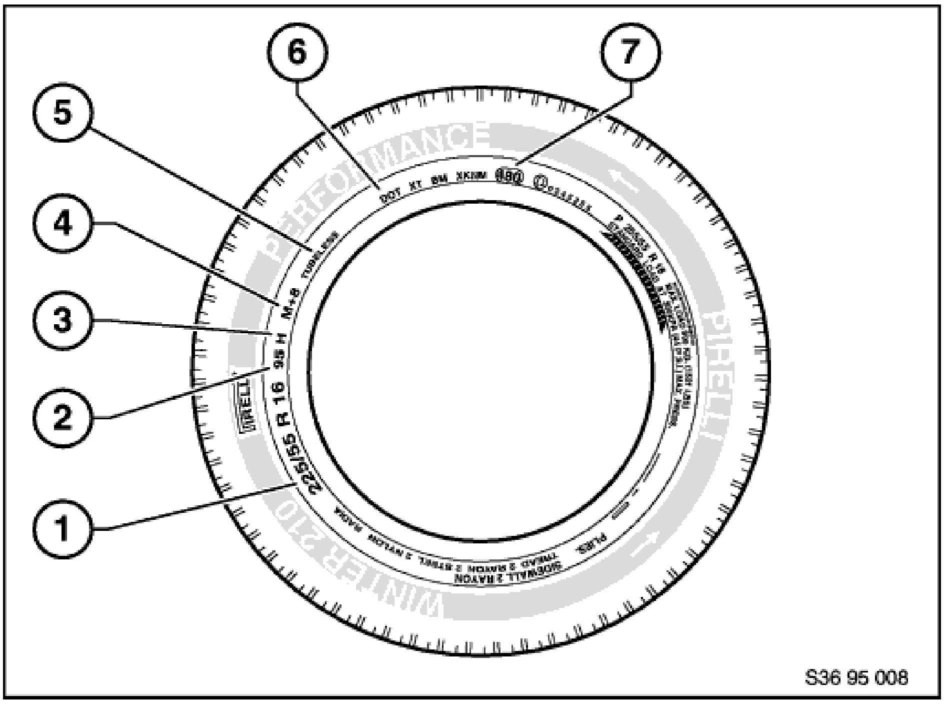


Figure 8: Markings on sidewall incl. DOT No.

1 Size

- 225 Tyre width in mm
- 55 Height : width ratio (55 %)
- R Radial design
- 16 Rim diameter in inches

2 95 Load-carrying capacity code (max. 690 kg/tyre)

3 H Speed symbol (max. 210 km/h)

4 M + S Mud and Snow tyre

5 Tubeless

6 Department of Transportation (USA)

7 480: Date of manufacture (48th production week 1990) with additional marking for identifying the decade in which the tyre was manufactured (1990 to 1999 since Jan. 1990, valid for all well-known European tyre manufacturers)

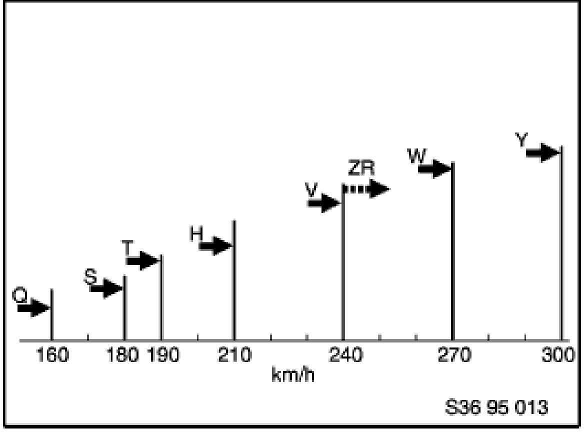


Figure 9: Tyre designations (speed classes)

Demands made on tyres

A wealth of demands are made on tyres. They should give the vehicle stability, precision and ease of steering, enable rapid deceleration during braking and also provide good grip when road conditions are poor. In addition, they should also have good suspension and damping characteristics, offer low rolling resistance, develop little noise and offer a long service life (mileage).

The demands made on tyres can be summarised in accordance with the following viewpoints:

Driving safety

- endurance strength
- resistance to ageing
- general road behaviour (dry, wet, ice, snow, etc.)
- handling

Ride comfort

- vibrations / oscillations
- uniformity
- impacts / joints
- interior noise

Economy

- price
- service life
- rolling resistance

Environmental compatibility

- noise emission
- material consumption
- recycling of used tyres

No tyre can be excellent in all disciplines. For this reason, different tyres are made for specific tasks, such as high-speed tyres and snow tyres.

A tyre must always fulfil the demands made on it with respect to driving safety. These demands include the following:

- A tyre must offer good tyre/road adhesion on dry and wet roads, e.g. when accelerating, braking and cornering. When cornering quickly, this adhesion must not break down abruptly; clear advance notice of the limit must be given to the driver.
- A tyre must remain tightly fitted on the rim even if the inflation pressure is incorrect and lateral forces are high. It must not lose contact with the rim, because this would result in an immediate loss of air and the vehicle breaking away (swerving).
- A tyre must withstand the maximum speed for which it is specified, under full load and permanently.
- A tyre must as far as possible prevent aquaplaning on deep films of water by displacing and expelling the water out of the footprint. This is only possible up to a certain speed.

All other criteria are subordinate to the safety criteria. A compromise must be found between the conflicting demands. Depending upon the form this compromise is to take, tyres can be designed with sportiness, comfort or economy and the respective driving conditions in mind.

Structure of tyres

The tyres are a high-quality structural element of the motor vehicle. They consist of up to 25 different components. The materials used for making tyres are: natural and synthetic rubber, steel cable, and steel and textile cords.

The steel and plastic cords give the tyre its stability. They enable the tyre to transfer the propulsive thrust and braking and lateral forces to the degree expected.

The rubber elements seal the tyre, give it the necessary elasticity and generate the grip on the surface of the road.

Tyre designs derive their names from the direction of the cord threads of the carcass plies. In older cross-ply tyres, several plies of cord were used, whose threads are placed on a bias (at an angle of 30 to 40 degrees) with respect to the contact surface in a criss-cross manner.

In radial tyres, the cord threads of the inner carcass ply are placed radially, that is, directly over the shortest distance from bead to bead. Below the contact surface are two steel cord plies, placed at an acute angle (15 - 30 degrees) to the direction of rotation and which act as a stabilising belt around the carcass. They prevent the diameter of the tyre from being enlarged by the effect of the centrifugal forces. It is these steel cord plies which enable the high speeds at which vehicles are driven today.

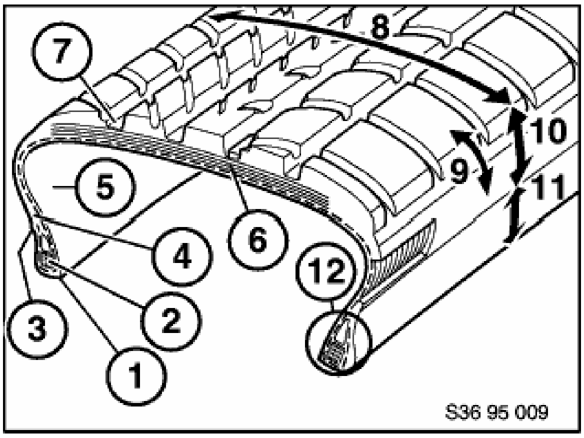
Due to their rigidity, they also ensure that the rolling resistance of the tyre is low and the service life long, all in all, then, an improvement in economy. The tyres used in the passenger-car sector nowadays are without exception radial tyres.

Let's describe the structure of a tyre following the production sequence:

- The **bead cables** , coppered or brassed steel cables sheathed with rubber, ensure tight seating of the tyre on the rim. The bead cable makes the tyre bead unelastic.
- The **bead heel** (which points towards the rim flange) and bead toe (which points towards the rim base) give the bead the shape that matches the rim exactly.
- The bead cable may also have a **bead filler** made of rubber. The design of this has an important influence on steering precision, driving stability and the ride provided by the suspension.
- The **carcass** , made of nylon, rayon or polyester, is wrapped round the bead and is therefore joined to it permanently; it holds the tyre inflation pressure.

  The carcass is made up of cords, which means that the warp threads are very distinctive and heavily twisted and the woof threads very thin. Sometimes the carcass does not have any woof threads and the cord is held together purely by the rubber film. Strong woof and warp threads, as are used for textiles, would saw through each other due to the flexing of the tyre.
  In the cross-ply tyres frequently used for motor cycles, the cord plies are placed in a criss-cross manner.
- The bead protection and bead reinforcement provide greater driving stability.
  The radial carcass alone would not be able to absorb the acceleration and braking forces. For this reason, there are two steel cord plies whose threads run at an angle of 15 - 30 degrees to the direction of rotation; these two plies form a belt round the carcass.
  In addition, the rigidity of this belt means that the tyre enjoys a low rolling resistance and a long service life. Altogether, it makes a considerable contribution towards improving the economy of the tyre. The tyre is frequently wrapped once more with a single- or two-ply bandage made of nylon. This makes the tyre particularly suitable for high-speed use and improves the precision of manufacture of the tyre.
- The liner, a soft layer of rubber, is positioned on the inner side of the carcass and replaces the tube in a tubeless tyre; that is, it seals the tyre.
- The sidewall is the visible part on either side of the tyre. It is subjected to all environmental influences and possible even damage by kerbstones. This necessitates a high degree of robustness and resistance to light. In addition, it must be extremely flexible, because it is subjected to constant flexing when out on the road. The sidewall carries the designation of the tyre, the centering rings and sometimes a projecting rib which serves to protect the rim.
- The contact surface makes contact with the roadway. It is its tread pattern and the compound of the rubber which determine the application of the tyre.
- The transition between the contact surface and the sidewall is termed the shoulder of the tyre. It supports the

lateral control of the tyre when cornering.



1. Bead toe
2. Bead cable
3. Centering ring
4. Carcass ply
5. Liner
6. Belt plies
7. Tread pattern
8. Contact surface
9. Shoulder area
10. Sidewall
11. Bead area
12. Bead