“BMW Group Tyre Development Process”

- General Tire Development and Homologation Process
- The New Runflat Tire Technology
- BMW Tire Marking

Presentation for ‘Round Table Reifentechnik’

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BMW Group

CARS

MOTORCYCLES
BMW Product Portfolio (Cars)
MINI Product Portfolio

MINI ONE

MINI COOPER

MINI COOPER S
What is included in Chassis and Suspension?
Responsibilities, Chassis without Control Systems

Frontaxle
Rearaxle
Steering System
Tyres & Wheels
Springs & Shockabsorbers
Brake System
Requirements on Tires

- Handling
- Economy
- Comfort
- Legal Compliance
- Safety

Quality
The Ultimate Driving Machine!

Top Level Suspension

Top Level Tires
Wheel / Tire Concept

In the development phase the complete range of wheels and tires is determined in cooperation with the tire manufacturers and all internal departments involved in vehicle development.

The next steps are to analyze the results of initial simulations of the vehicle and the driving characteristics anticipated, to focus on the design of the future vehicle and to examine specific package concepts in the virtual area of the future wheel arch.

In the virtual development process so-called 'tire mountains', that is specifications comprising the entire range of tires planned, with and without snow chains and considering the actual axle elasticity on the axles involved define the space available for the tires and wheels.

In the subsequent vehicle testing process the virtually planned free spaces within the vehicle are examined and verified up to the extreme.

Tire forces and momentum in both a lateral and longitudinal direction as well as their interaction are determined by BMW. With the help of prototype tires running on a dynamic 2-meter drum tester, the so-called tire map tester. The results obtained go into simulation models and are thus verified in an ongoing loop.

Since it is still impossible to simulate tires in their overall behavior and with all their interdependent factors – there are no simulation models which cover all of these criteria – the development and use of tires on a specific vehicle still requires a lot of testing. Suitable reference vehicles and reference tires form the basis for tire specifications.
Defining the targets and parameters of future tires on the vehicle under development.

The development of all tires to be fitted on a new model

- as standard tires
- as optional equipment
- or as dealer option
- (special equipment)

then consistently follows the same process:

Iterative examination and assessment of all relevant features versus the specifications, with vehicle prototypes becoming increasingly concrete and specific, that is coming closer and closer to their final stage.

Once the target criteria have been achieved and all requirements in the specifications are fulfilled, a tire can be recommended for approval.

Now let's take a closer look at the criteria and requirements involved:
Safety

Safety criteria come first in the development of high-performance tires not only for a manufacturer of premium cars.

The high-speed safety of a new test tire and a test tire already driven to its wear limit in a real-life vehicle test is checked in the laboratory.

The tire must fulfill demanding test requirements (up to $4^0$ negative camber on the rear drive wheels) beyond the top speed of the vehicle.

The behavior of new and worn tires in the wet is checked on the wet handling track and in aquaplaning tests in bends. BMW attaches particular significance to this point due to its great relevance to the BMW customer: Safe driving behavior in the wet is even more important to the customer than the car's behavior on dry roads.

Applying the brakes under dry conditions.

Applying the brakes under dry conditions from a speed of 100 km/h has become a popular test with the motoring press in Germany in recent years and must therefore be considered appropriately in the design and configuration of a new tire. Although experts do not all agree on the value of such a test – since other important tire properties are influenced negatively at least in part – BMW takes this requirement very seriously.
Rim roll-off

The rim roll-off test is no problem these days for modern tires. On a 50-meter circular skid pad modern high-performance steel radial-ply tires roll off the rim when entering the skid pad at 60 km/h or 40 mph, equal to about 1.1 g lateral acceleration, with a tire pressure usually between 1.0 and 1.2 bar.

Run-flat tires are not allowed to roll off the rim in a comparable test with lateral acceleration up to 0.5 g, even with 0 bar tire pressure. This is also because such tires run on Extended Hump (EH2) rims with a somewhat greater hump diameter. But the fact remains that this test is very tough for run-flat tires, too.

Nürburgring

The structural strength of tires has been tested on BMW cars for many years on the world-famous Nürburgring Race Track, that is the "old", extremely demanding 21-kilometer Northern Circuit in the Eifel Region of Germany. For many years the Nürburgring test was the benchmark for BMW tires, feared by all tire manufacturers and carefully avoided by nearly all other car makers, who did not want to face these demanding test requirements.

Today, nearly all tires made by virtually all tire manufacturers are able to cover 20 laps on the Northern Circuit at racing speed without tread breakage and with hardly any deficiencies. Indeed, the tire industry has told us time and again that this test in particular and its consistent application by BMW is one of the main factors for the superior performance modern steel radial-ply tires are able to offer. BMW therefore remains committed to this test and demands that summer tires are able to cover 20 laps without any deficiencies, all-season tires 10 laps. Winter tires, in turn, are tested at Nürburgring only for special purposes. Run-flat tires are subject to the same test requirements as normal steel radial-ply tires.
Dynamic axle / wheel tester

Complete axles together with the wheels and tires are tested under dynamic load conditions on the dynamic wheel tester, allowing to simulate driving and load profiles recorded on the Nürburgring Race Track under realistic conditions in the laboratory. This tester is used primarily for testing wheels.

Run-flat behavior / run-flat tests

Right now there are no standards (e.g. ISO) or statutory requirements regarding

- the run-flat distance to be covered by a tire under 0 bar pressure.

With quite a few years of experience (about 7 years in the case of BMW) on all kinds of run-flat tire systems (SST, PAX, CSR or CWS), we have arrived at a compromise between

- the run-flat distance, on the one hand, which is only required in the rare case of severe tire damage and

- the comfort required by the car’s occupants under normal tire pressure in the vast majority of cases.

This compromise is presented in the following chart for the second generation of run-flat tires.
**RFT-Tire-System Features, 2. Generation, „soft“**

<table>
<thead>
<tr>
<th>p = 0 bar, (worst case)</th>
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<tr>
<td>➢ Speed: max. 80 km/h</td>
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**Runflat mileage:**
- ➢ One person: > 250 km
- ➢ **Medium load:** > 150 km  
  (roadster: 2 persons, 4-5 seater: 3-4 persons)
- ➢ Full load: > 50 km  
  (saloon):

At **p > 0 bar**, (85% of all tire defects) the runflat distance is **up to 2000 km** (starting at RPA warning)
BMW has **two test circuits for testing run-flat tires with zero pressure in public traffic**, both of which are near our Test Centers in Munich and the south of France.

The circuit we take in France - a combination of long and straight roads with very bumpy, narrow, winding and mountainous country road segments – currently represents our benchmark.

Comparisons of the two circuits show that the quality of the road surface has a great influence on the remaining lifecycle of a run-flat tire running under zero pressure.

It is not yet possible to **state once and for all** what remaining mileage is required with **absolutely no pressure**, since the number of cars driven by customers worldwide with pressure control systems and run-flat tires is still inadequate to provide an overall answer.

**Economy**

*Tire wear test (tire endurance test)*

Every tire to be approved by BMW is tested for wear in a **vehicle endurance test**, carrying a specific load on identical test circuits and preferably fitted on the car to be equipped with such tires at a later point in time. In the process we check the mileage of the tires on all wheels as well as their wear patterns. The objective is that tire wear should be the same all round.

Summer tires are required to fulfil conditions different from all-season tires: High-performance summer tires are driven primarily in Germany under European or German driving conditions and are tested for wear usually in the USA under typical US conditions.
Tires worn down on the car are then subjected to other, final tests, for example for noise, function/handling, aquaplaning and high speed.

Rolling resistance

The roll resistance of a tire is becoming increasingly significant, also on premium cars, since its effect on fuel consumption is approximately 1:7 (meaning that a 7 percent reduction in roll resistance corresponds to a reduction of fuel consumption under test conditions by approximately 1 percent). This is obviously an important point, with increasingly strict consumption standards imposed by lawmakers in the USA and, as of the year 2008, also in Europe (by means of CO₂ limits applied to each fleet of cars) in the interest of the environment require a consistent reduction in fuel consumption for homologation purposes alone.

While the introduction of silica technology in the early '90s was a big step towards reducing roll resistance also on high-performance car tires in Europe (with roll resistance decreasing by up to 30 percent), further potentials must still be achieved in future.

In the laboratory BMW checks roll resistance on 2-meter drum testers and conducts coast-down tests on the vehicle itself in order to verify fuel consumption programs.

Different tires for

- standard equipment
- optional equipment
- special equipment (= dealer option)
While the **standard tires** on a car must offer the **best compromise** of all relevant criteria with a particular view to

**motoring economy**

- BMW's optional tires (ex factory) and
- dealer options ranking even higher
- together with attractive, specially styled aluminum wheels in **+1" all the way to +3" format**, that is in some cases **wheels up to 20 inches in size**, focus in particular in
  - individual style
  - sporting performance
  - optimum handling.

Clearly, roll comfort, noise and aquaplaning are not given quite the same significance in this case.

**Handling**

The **main point** in BMW development has always been the **handling** of BMW cars: Best in segment handling is **absolutely essential** for BMW as a premium manufacturer in all of our models. Here we make no compromises!

We define the handling of a car in terms of its

- steering properties
- directional stability and
- handling in bends.
Applying this to the tires of a car, we ensure driving properties remaining as consistent as possible throughout the tire's entire running life. This is why we analyze the handling of tires on BMW cars also when worn, before they receive approval.

1. Steering properties

We define the essential criteria for good steering in terms of

- steering response from the zero, i.e. central position,

- the build-up and development of lateral stability as a function of the steering angle, which is to be as consistent and harmonious as possible,

- steering forces both in absolute terms and in their overall distribution,

- and last but not least any unwanted effects in the steering commonly referred to as steering bumpiness.

The tester checking tires under his subjective impression will very quickly understand the effects of different tires in terms of both their dimensions and makes or models. Within just a few hours, you can distinguish between very good and good tires, on the one hand, and unacceptable tires, on the other. The video will show you what we mean.

2. Straight-ahead stability

Stable, undisturbed straight-ahead directional stability on all kinds of roads is perhaps the most important criterion for the customer covering long distances in his car.

Particularly the 7, 5 and, to an increasing extent, the 3 Series must meet this requirement without the slightest criticism.
This is why we focus particularly on the tires of a car in the development of our suspension and chassis systems.

We therefore check all tires to be approved for this purpose on

- flat and bumpy roads,
- roads with worn lanes, and
- each individual tire for its response to overrun and engine power (gas change).

The objective, obviously, is to keep tire distortion to a minimum.

Our film shows how directional stability is judged in the process.

3. Behavior in bends

The precise, predictable and safe behavior of BMW Group cars in bends is one of the specific features we literally design and build into our automobiles.

We therefore judge our cars, their chassis and suspension systems in terms of their behavior in bends in combination with all tires to be approved, focusing in particular on

- behavior in bends when driven to the limit,
- load change behavior (gas change in bends),
- behavior when changing lanes at speed,
- brake behavior in bends.

In addition, we grade every tire for its general behavior in bends. You might say, statistically speaking, that this is the typical grade of the average BMW driver.
Run-flat tires are also checked and assessed under zero pressure for their stability in bends.

Naturally, we do this under conditions typical of an emergency.

In physical terms, run-flat tires become more stable with a lower height (lower aspect ratio).

Legal Compliance

Legal compliance in the case of tires means in the global production and sale of cars that all statutory requirements the world over must be properly fulfilled.

Again looking at each tire, this means that tire manufacturers must fulfill all FMVSS, DOT, ECE, JATMA, ADR,... standards and requirements with their tires.

To fulfill the statutory requirements made of tires, BMW focuses in particular on

- blow-out tests when driving straight ahead and

- pass-by noise tests under the EU Directive.

For years blow-out tests focusing primarily on directional stability under a sudden loss of air when driving straight ahead at a speed of more than 100 km/h have no longer been a problem for modern vehicles and tires.
In the last 20 years the pass-by noise of passenger car tires and the vehicle as a whole has been reduced significantly.
Comfort

Dampening, roll noise, flat-spotting and uniformity behavior are the most important, tire-related comfort parameters.

We examine tire dampening in its effect on vehicle dampening on

- bad asphalt and
- cross-seams on the road.

Roll noise is measured on new and worn tires
- in bends
- in terms of humming and
- on smooth as well as rough asphalt.

Flat-spot behavior, particularly the gradual reduction of the flat-spot effect and uniformity forces, are measured and assessed on test stands.

Comfort remains a significant criterion today in the case of run-flat tires.

The comfort of run-flat tires is assessed both subjectively and objectively in comparison with normal tires.

Subjective blind tests and objective comparisons based on scientific criteria round off the range of tests conducted.
Quality

BMW's quality policy is based on plant audits, process series, internal quality circles, supplier training and very selective, careful choice of suppliers.

**Plant audits** conducted by BMW's Development Departments reveal weak points sometimes remaining undetected in DIN/ISO audits. Such plant audits therefore give us the confidence and good faith we need for a reliable supply of production tires by the respective manufacturer.

Internal **quality circles** consistently compare target and actual values.

We consistently train our suppliers, which is absolutely essential, given the large number of projects running parallel to one another.

Very selective choice of tire suppliers focusing on the Big Six manufacturers also supports our commitment to quality. Here we expect an even clearer focus in future on just a small number of suppliers.

**Best possible harmonization and orientation of all BMW Group O.E. tire specifications to our chassis and suspension systems** as well as an appropriate chassis set-up are essential prerequisites for the premium driving and comfort qualities we need. This is why all BMW tire specifications (summer, winter and all-season tires) are marked additionally with the ‘BMW tire mark’ (an asterisk - *) over and above the designation already used by the tire manufacturer. And we will do this even more consistently in future.

A further point is that our customers are also able in after-sales to fit their car with BMW specific tires, bearing the ‘BMW tire mark’, in order to maintain the desired driving characteristics as long as possible.
BMW Group Tire Suppliers

BMW is cooperating with its tire suppliers:

- Bridgestone
- Continental
- Dunlop
- Goodyear
- Michelin
- Pirelli
Finally:

„Run Flat Tyre Systems“

+ NEW 5 series + NEW 6 series + ....
BMW Run Flat Tire System with 'RPA'

**BMW RSC run flat tires with 'RPA'**
(Reifen-Pannen-Anzeige / Run-Flat-Indicator)

=  
**A wheel/tire system with runflat properties**

consisting of

**High performance self-supporting tires, called**
*RSC* (Runflat-System-Component)

+  
**Extended hump rims (EH2)**

+  
**Run Flat Indicator/RPA** (indirect TPMS)
## Tire Evaluation, 2. Generation RFT Tire

<table>
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<tr>
<th>Criterion</th>
<th>Evaluation</th>
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<td>Dry Handling, Lateral Dynamics</td>
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<tr>
<td>Straight Ahead, Grooves</td>
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<tr>
<td>Wet Handling</td>
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<td>Aquaplaning</td>
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<td>Comfort, in terms of Single Obstacles</td>
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<td>Rolling Noise</td>
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<td>Mileage</td>
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<td>Heel and Toe Wear</td>
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<td>Rim-Roll-Off</td>
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<td>Uniformity, Flatspot</td>
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<td>Rolling Resistance</td>
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<td>Tire Weight</td>
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<td>Car Weight (without spare tire)</td>
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### Runflat Tire Technology
2. Generation compared to Conventional Standard Tire on BMW 3 series (E46)

Tire
225/45 R 17 W Summer Runflat

Reference:
225/45 R 17 W Summer Standard
What do we and our customers expect of a run-flat tire?

In the medium term the run-flat tire should replace the fifth wheel on a car, that is the spare wheel. This is why we already have a clear message today:

“Good to know that the spare tire is already built into your new tires. - The Run-Flat Tire System (RSC)”

Applying this philosophy to each wheel on the car, it means that a car today no longer has one spare wheel, but rather four spare wheels built in right from the start!
Your car will remain on the move even if it suffers not just one, but several punctures.

You can reach your destination - or, in the worst case, the nearest service station - comfortably and without any hassle worth mentioning, without running any risks, and without having to work on the car.
The car carries less (unnecessary) weight and offers more space for new, important components or extra capacity in the luggage compartment. Alternatively, it can be built with more compact dimensions while maintaining the same space and roominess inside.

Run-flat tires are less sensitive to damage at the side (when hitting kerbs) and offer significantly greater safety reserves under a sudden loss of pressure and at higher speeds, particularly in bends. This enables the driver to keep the car firmly and safely on the road.
Message

This means much greater safety under the usual driving conditions. RSC tires are a significant contribution to the avoidance of economic damage, since every traffic fatality costs the economy several million dollars.

Ladies and Gentlemen,
All this makes RSC a very significant contribution to Active Safety in the event of a tire defect.

And, in our opinion, RSC tires should be fitted on every new modern road vehicle, wherever it is possible.

Hans-Rudolf Hein
BMW Group
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General Manager
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