

# Dry handling – a laboratory method for prediction and an approach for optimisation

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## Introduction

Dry handling is a complex ensemble of tyre properties like breaking, stable turning behaviour, round lap times and the stability at line change. In principle the aspects driving safety and driving dynamics are in the foreground for the practical life.

This short and incomplete list of tyre properties shows already that a fully characterisation of a tyre's quality implies a full set of different tyre test procedures. These test are time consuming and costly. Notably is also that beside objective values like breaking distance or lap times there are also subjective assessments e.g. driving stability and line swerving.

Up to now there are no physical rubber properties available which predict properly the results of tyre test in practice. Very often noted indicators like  $E^*$  and  $\tan\delta/E^*$  are most of the time insufficient.

Attempts were made with the LAT 100 machine to gain insights into the dry handling properties of tyre treads in the laboratory.

## Background

In principle two aspects of the side force coefficient are physically playing a role for the rating of dry handling. This is at the one hand the dynamic side stiffness and on the other hand the dynamic friction coefficient. The first is primarily responsible for the lateral stability and the latter for the grip of the tyre.

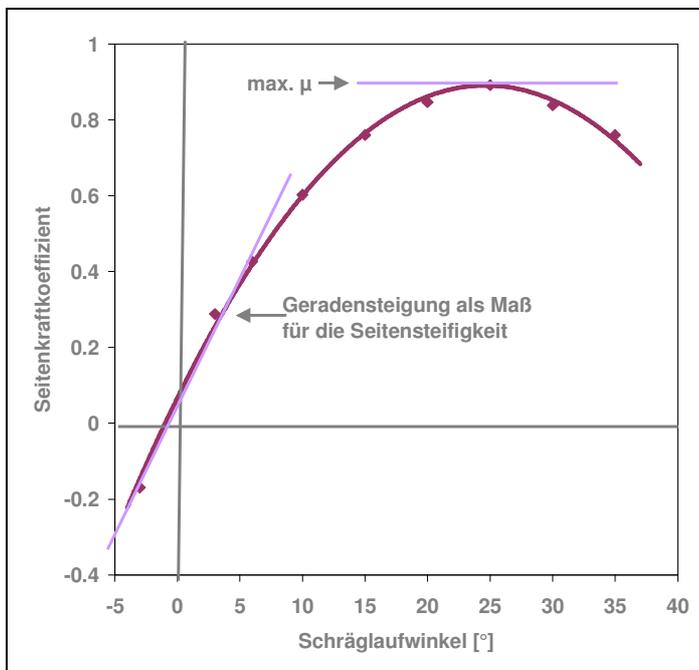


Abb. 1 Side force coefficient as a function of slip

Looking at the side force coefficient over the slip angle it becomes visible that the side stability is characterised by the gradient at low slip. The dynamic friction coefficient is characterised by the maximum of the  $\mu$ -curve.

Both properties are quite differently affected by the different steering manoeuvres of the dry handling tests. Table 1 gives an overview about the most important relations.

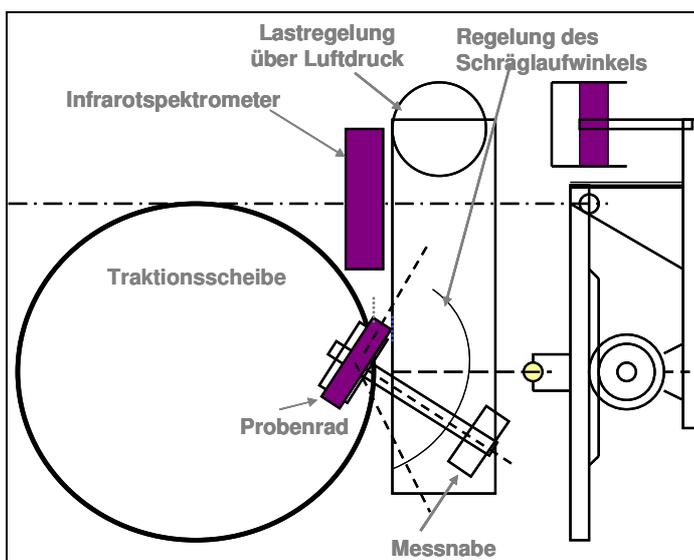
Eigenschaft	Seitensteifigkeit	max. $\mu$
<b>Einschwingverhalten</b> - Pendelbewegung eines Fahrzeugs, meist verursacht durch Scherkräfte und Feder-Dämpfereigenschaften des Reifens bei geringem Lateralschlupf	+	-
<b>Konstantes Kurvenfahren</b>	+	+
<b>Stabilität beim Kurvenfahren</b> – Fahrzeugausweichen bei größeren Lenkwinkeln => Sprungantwortverhalten bei hohem Schlupf	o	+
<b>Überrollen</b> – Wankbewegung des Fahrzeuges; Aufschaukeln bis zum Überschlagen des Fahrzeuges möglich	o	+
<b>Rundenzeiten auf Kreisbahn</b>	o	+
<b>Trockenbremsen</b>	-	+

+ – sehr bedeutend  
o – weniger bedeutend  
- – unbedeutend

Tab. 1 steering manoeuvres for dry handling tests

### Instrument and experiment

It is important that the equipment is able to vary velocity and applied load in order to be able to characterise the different aspects of handling properties. It is essential that slip angle, side forces, loads and contact temperatures of the sample wheels have to be recorded with a considerable accuracy. A further important and essential feature is to be able to change the texture of the traction surface.



## Abb. 2 traction measuring unit

The LAT 100 includes these features. Its based on control cabinet, computer, the friction test assembly, containing traction disk, sample wheel, measuring hub/collar and infrared detector (pic 2).

The sample wheel (solid rubber) has an outer diameter of 84 mm, an inner diameter of 35 mm and a thickness of 18 mm. This means that the influence of carcass and tyre profile is not taken into account into the evaluation of the dry handling. Only the compound itself will be rated.

The tests are performed at 75 N load – correlating to 45 N/cm<sup>2</sup> - and velocities of 0,2 km/h, 2.1 km/h and 20 km/h. This is equivalent to angular velocities of 1.5 km/h, 16 km/h and 150 km/h at the tyre. The slip angle is mainly varied from -3° to 35°. The traction discs are made of corundum and have a roughness of 60 and 180.

## Analysis

The basic analysis follows the equation 1

$$\mu = \frac{F}{L} \quad (\text{Gl. 1})$$

with  $F$  = side force,  $L$  = load,

to calculate the side force coefficients. Additionally the surface temperatures of the sample wheels are measured during the whole procedure.

Beyond that the gradient of the best fit straight line of the  $\mu$ -values between -3° and 6° slip is calculated. The maximum side force coefficient is achieved by fitting all  $\mu$ -values over the whole slip angle range with a 2<sup>nd</sup> order polynomial. As typical practice in the tyre industry a relative rating to a reference is calculated.

In order to describe the dry handling with one parameter [3] a rating  $R$  is calculated according to equation 2. This rating  $R$  encloses the component of side stiffness and maximum side force coefficient.

$$R = \frac{\text{rel. Rating(Seitensteifigkeit)} * \text{rel. Rating(max. } \mu)}{100} \quad (\text{Gl. 2})$$

## Evaluation and results

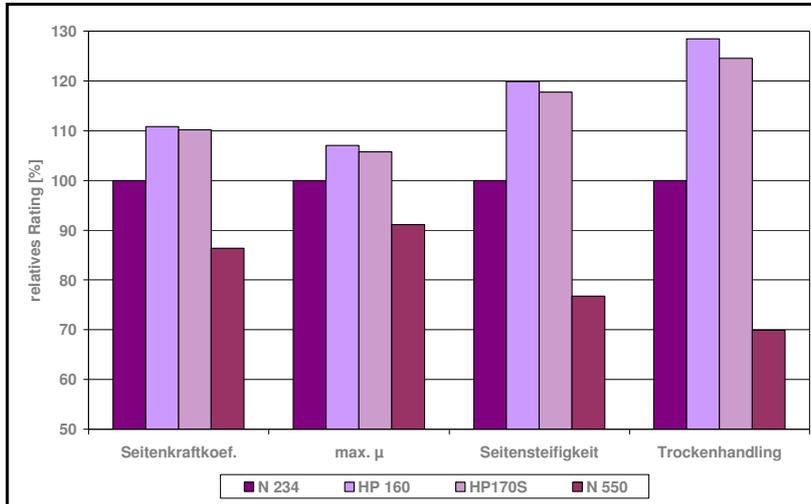
For a first evaluation and optimisation of the test procedure different compounds were repeatedly tested and the statistical parameters like standard deviation calculated. These are different for the investigated traction discs as well as for the measured parameters. Nevertheless the accuracy is satisfying because they are in the low single digit range. This means that the method fulfils the requirements for a capable rubber test procedure [4,5].

Different in-use compounds were tested in co-operation with customers to develop a feeling for the relevance of calculated rankings and to test how strong the compounds can be differentiated. It could be shown that there is a good accordance between the tyre test ratings and our test results over a relatively wide range of rating.

The basic correlation between filler dispersion and dry handling properties in the practical live could also be confirmed with our method. Furthermore the dry handling properties of different carbon blacks (tab 2) were tested in the green tyre formulation. It could be shown that high surface area blacks like HP 160 and HP 170 are superior over a standard tread black like N234 (pic 3). As expected the soft black N550 shows the lowest rating.

Carbon Black	CTAB [m <sup>2</sup> /g]	COAN [ml/100g]
N 234	119.1	98.9
HP 160	158.1	96.9
HP170S	170.3	120.7
N 550	40.4	87

**Tab. 2** tested blacks



**Abb. 3** Mean values of the characteristic dry handling properties

A dramatic increase of heat generation can be recorded for the increasing velocities and slip angles, which also differentiates the compounds.

## Summary

The presented lab method is capable of describing the relative rating of tyre tread compounds regarding the different properties on dry road surface. In practical use tailor-made high surface area blacks make a significant improvement of the dry handling possible.

## Literatur

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- [4] Leitfaden zur Angabe der Unsicherheit beim Messen; Deutsche Fassung; DIN V ENV 13005
- [5] Rubber and rubber products - Determination of precision for test method standards; ISO/TC 45; TR 9272