+++ Constructive innovation +++ Brand name quality +++ Safety +++ Driving pleasure +++

Product Information 2006

Made in Germany

Brake discs for cars and commercial vehicles · Brake drums for cars · Cross-drilled brake discs · Compound brake disc "Formula Z"

Zimmermann
Bremsscheiben · Bremstrommeln
Brake Discs · Brake Drums

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Brake Discs · Brake Drums

Made in Germany

Publisher:
This product information is published by

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Press date: December 2005

Note on foreign language versions:
The German version is authoritative!

TÜV CERT

ZERTIFIKAT

Die TÜV CERT-Zertifizierungsstelle der TÜV Management Service GmbH

bescheinigt gemäß
TÜV CERT-Verfahren, dass das Unternehmen

Otto Zimmermann GmbH
Maschinen- und Apparatebau
Am Leitzelbach 8
D-74889 Sinsheim-Dühren

für den Geltungsbereich

Herstellung von Bremsscheiben und Bremstrommeln für PKW und LKW

ein Qualitätsmanagementsystem
eingeführt hat und anwendet.

Durch ein Audit, Bericht-Nr. **70019493**
wurde der Nachweis erbracht, dass die Forderungen der

ISO 9001: 2000
und des internationalen und deutschen
Straßenverkehrsrechtes erfüllt sind

(Fertigungsstätten und Geltungsbereiche siehe Anlage, bestehend aus 1 Blatt).

Dieses Zertifikat ist gültig bis **2006-12-31**

Zertifikat-Registrier-Nr. **12 102 21426**

Mannheim, 2004-02-06

KBA-ZM-A 22001-05

TÜV MANAGEMENT SERVICE

TÜV CERT-Zertifizierungsstelle
der TÜV Management Service GmbH
Unternehmensgruppe TÜV Süddeutschland
Ridlerstraße 65
D-80339 München

Contents

Introducing ZIMMERMANN

For more than five decades German limited company Otto Zimmermann GmbH has been developing, producing and selling sophisticated motor vehicle components for automotive manufacturers and the free spare parts market. Since its landmark relocation from Eppingen to Sinsheim in 1990 Otto Zimmermann GmbH has been systematically expanding its administrative premises, production facilities and warehousing space to over 17,000 square metres.

Our aim is to supply our business partners and customers with high-quality products at all times with a reliable delivery service.
As a manufacturer of safety parts we are acutely aware of our responsibilities and always give precedence to product quality.
Since we give top priority to product quality right back at the stage of selecting our suppliers, we are able to guarantee the consistently high quality of our products thanks to our production facilities in Sinsheim.
Our company is managed on the basis of a quality management system conforming to the requirements specified by DIN EN ISO 9001:2000 and with due regard for, and compliance with, the terms stipulated in contractually applicable rules and regulations.

By continually maintaining and expanding our range and by constantly extending our storage capacity we can offer our customers a top-level supply and delivery service.

In developing new products such as the *Formula Z* compound brake disk, we demonstrate our expertise in the brake component business.

Original Zimmermann products

- **Brake disks for cars**
- **Brake discs for commercial vehicles**
- **Brake drums for cars**
- **Sports brake disks**
- ***Formula Z* compound brake disk**

This product information is intended to provide our customers with detailed technical insights and bakkground information to allow an appreciation of differences in the quality of brake disks and brake drums.

This product information is also intended to facilitate the evaluation and processing of complaints by presenting the most frequent symptoms of damage.

Further information about our company and products
and our news can be found on our website at

WWW.OTTO-ZIMMERMANN.DE and **WWW.OTTO-ZIMMERMANN-TRUCK.DE**

1. Original Zimmermann products

Essentially original Zimmermann products are equivalent-quality spare parts, as defined by motor vehicle block exemption regulation KFZ-GVO 1400/2002, which are on a par with the respective original parts first fitted. The dimensioning and the materials used meet the respective specifications of the motor vehicle manufacturers.

Process tolerances, particularly in respect of the running characteristics of the products (shape and positional tolerances), are often set smaller than specified by the motor vehicle manufacturers.

In order to be able to guarantee their identification and traceability all Zimmermann products are labelled accordingly.

Original Zimmermann products can be identified by the following marking on the external diameter of the brake surface or on the external diameter of the hub:

Article number	➜ 4-digit centre section of the article number
Manufacturer's logo	➜ OZ logo ("Z" in circle)
Batch number	➜ Numerical code allowing deduction of manufacturing data
Operator number	➜ Machine operator in charge at time of manufacture

2. Manufacture

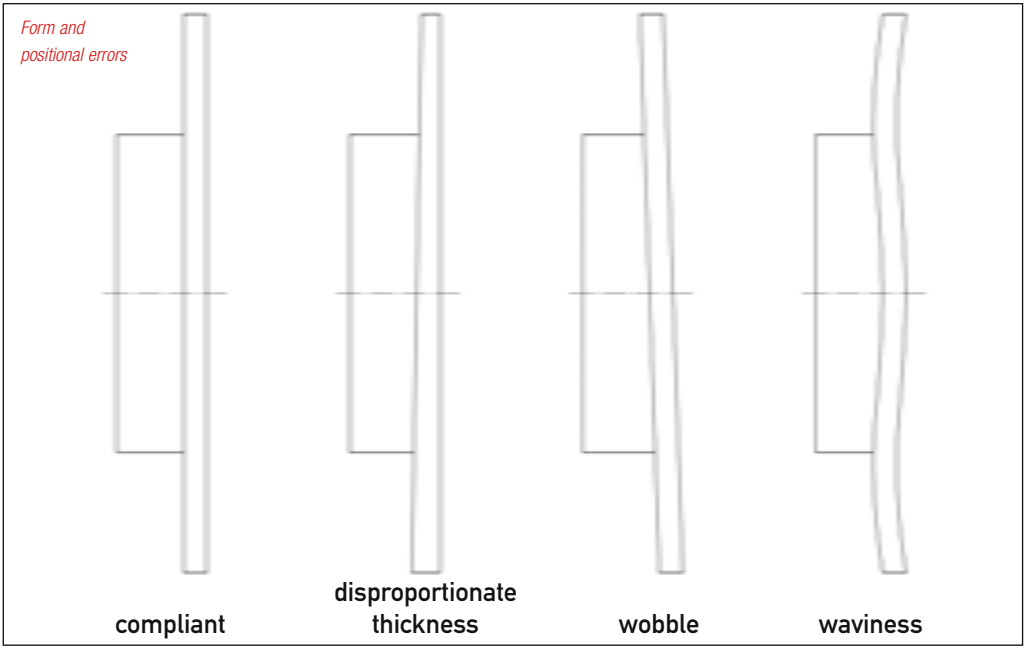
Brake disks and brake drums are made with unmachined castings containing flake graphite (grey cast iron) which are made on state-of-the-art CNC units operated under a quality management system satisfying the requirements of DIN EN ISO 9001:2000.

This guarantees high process reliability, which in turn guarantees consistent product quality, maintained at the highest level from the first to the last part of any given batch.

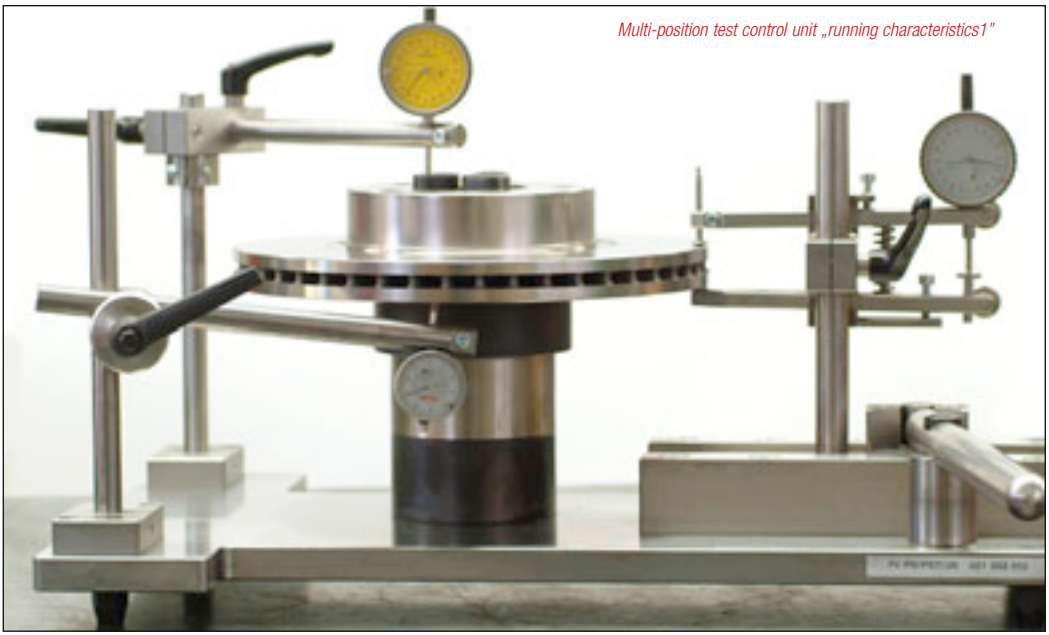
The manufacturing process principally involves the following machining steps, although steps III to VI are optional depending on the model.

I.	**Turning**	➜ Geometry in line with specification (running characteristics in one take-up!)
II.	**Boring**	➜ Drilling pattern in hub base (mounting holes, centre holes)
III.	**Perforating**	➜ Drilling pattern in braking area
IV.	**Grinding**	➜ Braking area on sports brake disks, optional on "standard" brake disks
V.	**Mounting**	➜ Where necessary, centering pins and wheel bolts, bearings / bearing shells, sensor (ABS) and retaining rings, etc.
VI.	**Balancing**	➜ Ventilated brake disks and steel-backed brake drums
VII.	**Preserving**	➜ Protection from corrosion during transportation and storage
VIII.	**Packaging**	➜ Placing in storage

When machining the raw parts special attention is paid not only to the functional properties, which are relevant to ease of assembly, but also to the so-called running characteristics, such as unequal thickness / DTV (disk thickness variation), axial run-out, concentricity and evenness of the reference and functional surfaces / function elements.



The use of multi-position test control units developed by ZIMMERMANN offers a rapid, effective and workshop-compatible method for in-process monitoring of the running characteristics.



Multi-position test control unit „running characteristics1"

Multi-position test control unit „running characteristics 2"

3. Quality assurance

A total quality assurance system conforming to the latest standards guarantees consistent product quality at the highest level.

First sampling, receiving inspections, specimen acceptances, in-process inspections and final inspections are carried out although these are kept to an absolute minimum in deference to the operator self-inspection programme (OSI) and are only used where necessary to supplement the OSI in case of special requirements.

Damage and surface defects in the cast material are detected by visual inspections at all stages of production, allowing the affected units to be sifted out of the manufacturing process and withdrawn from further use. Damage includes scratch marks, blemishes or material fractures, for example, which can occur through handling during manufacture and internal transportation.

Surface defects in the cast material, such as areas of porosity, shrink holes, cavities (hollows) and material shortage caused by insufficient mould filling or moulding, can occur during the casting and cooling process. The amount of damage and surface defects permitted in the products is very low.

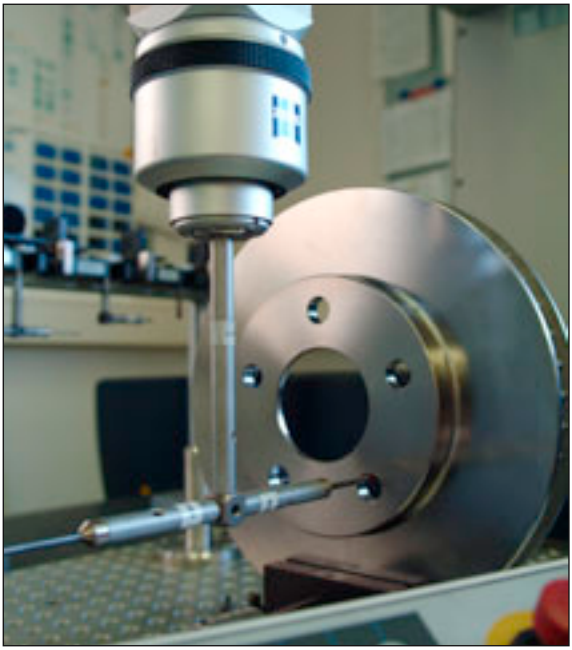
In addition to the customary analogue and digital (digital transfer of measured values ➜ SPC) testing and measuring equipment in standard use, Quality Assurance has access to other devices and facilities used to carry out the following further inspections, to name but some:

● **SPECTROCAST spectral analysis instrument**

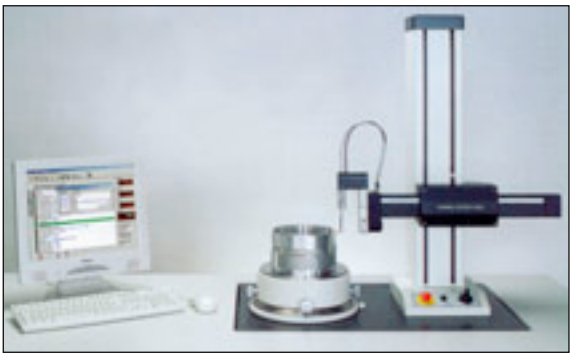
➜ Chemical composition
of the individual material qualities

● **BRIRO BEH 1 hardness tester**

➜ Mechanical properties of the individual material qualities (HB 5/750)

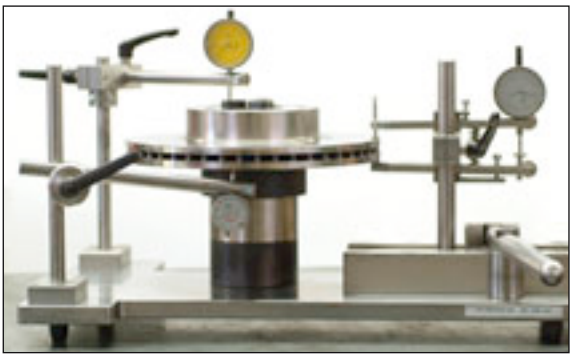


- **ZEISS ECLIPSE 775 CNC 3D coordinate measuring machine**



- **HOMMEL F2004 form measuring system**

- **Multi-position test control units (analogue and / or digital)**



Multi-position test control unit "running characteristics 1"

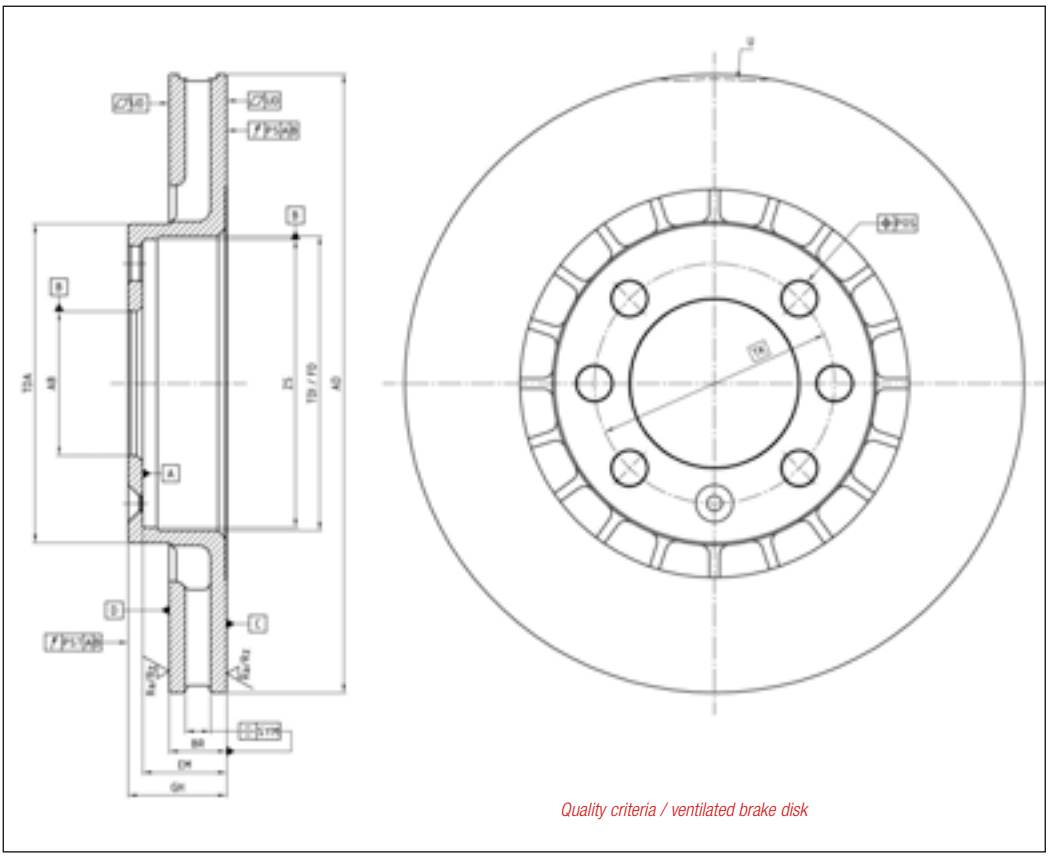
Multi-position test control unit "running characteristics 2"

4. Quality criteria

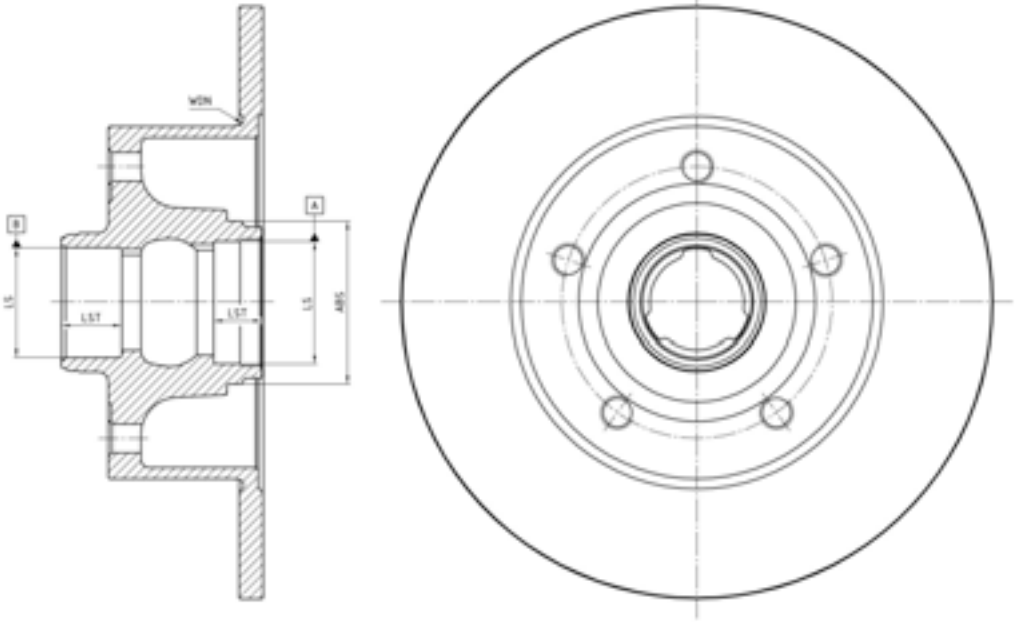
Uncompromising quality in terms of the operational reliability and safety of ZIMMERMANN products means that the tolerance limits of the function-related quality criteria are narrowly defined and guaranteed.

Legend:

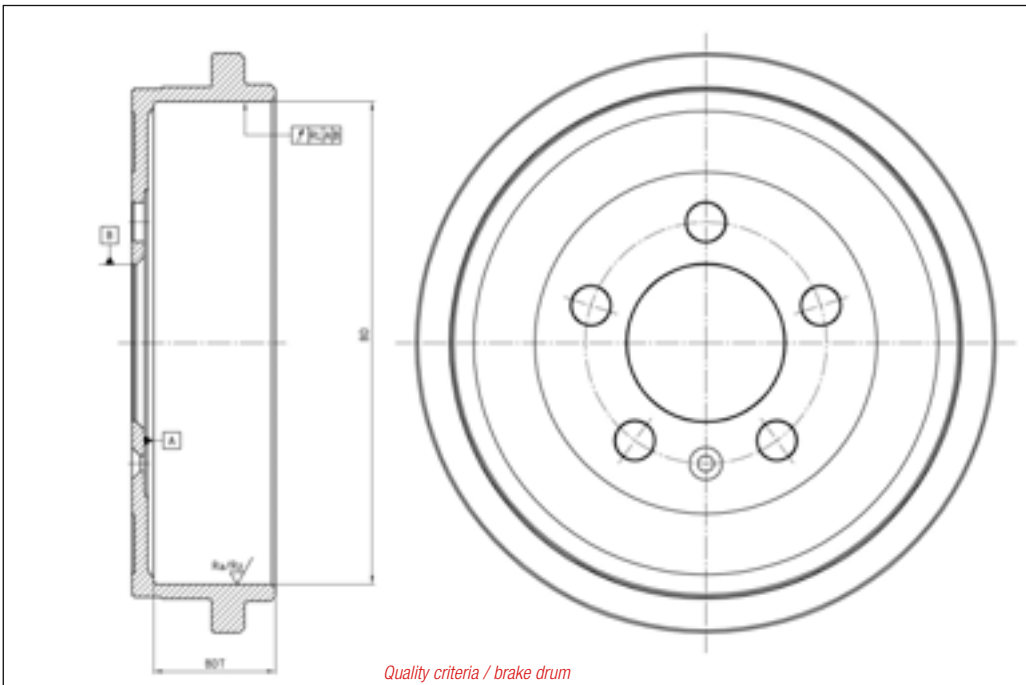
AB	-Locating hole	PS	-Axial run-out / friction surface
ABS	-ABS hub	PST	-Axial run-out / hub
AD	-External diameter	Ra / Rz	-Surface roughness
BR	-Friction surface thickness	RL	-Concentricity
BD	-Friction surface diameter	SYM	-Position of ventilation channel / friction surface
BDT	-Friction surface depth	TDA	-Hub diameter, external
EM	-Installation dimension	TDI	-Hub diameter, internal
FD	-Diameter of parking brake area	TK	-Pitch circle diameter
GH	-Total height	U	-Unbalance
LS	-Bearing seat	UD	-Disk thickness variation (DTV)
LST	-Bearing seat depth	WDN	-Thermal insulation channel
POS	-Position of holes / locating holes	ZS	-Centering seat



Quality criteria / ventilated brake disk



Quality criteria / hub disk



Quality criteria / brake drum

Having highlighted the quality criteria (see graphics) which are important for a product's ease of assembly, the following section gives a somewhat more detailed explanation of the quality criteria relevant to operating safety and driving / braking feel:

Locating hole	**Tolerance class H8**
Increased values entail	➜ increased radial run-out ➜ increased wear on wheel bearings and wheel

Surface roughness	**R_a 3 / R_z 12 … 16/ R_a 10 / R_z 25 … 40 (parking brake area Ø)**
Erhöhte Werte verursachen	➜ intensification of rippling effect ➜ poor running-in influences

Plane parallelism, radial / ripple	**max. 50 µm**
Increased values entail	➜ increased wear of brake disk and / or pads ➜ fading of braking effect

Axial run-out / friction surface	**max. 30 µm**
Increased values entail	➜ steering wheel wobble ➜ brake pedal vibration

Axial run-out / hub	**max. 50 µm**
Increased values entail	➜ steering wheel wobble ➜ partly equalised by the tyres

Concentricity	**max. 50 µm / max. 100 µm (steel-backed brake drum)**
Increased values entail	➜ increased radial run-out ➜ increased wear on wheel bearings and wheel suspension

Symmetry of ventilation channel / friction surface **Constant cross section all round brake friction areas**	**max. 1,0** **max. ±0,5**
Increased values entail	➜ brake pedal vibration ➜ steering wheel wobble ➜ so-called hot judder ➜ strong shielding at normal running temperature ➜brake fade

Unequal thickness / DTV (plane parallelism, tangential)	**max. 15 µm**
Increased values entail	➜ brake pedal vibration ➜ so-called cold judder ➜ increased wear of brake disk and / or pads

Unbalance / uneven mass distribution	**max. 30 cmg**
Increased values entail	➜ increased radial run-out ➜ increased wear of wheel bearings and wheel suspension

Thermal insulation channel (diameter, cross section, angle, curves)	**generally OE-compliant**
Different dimensions entail	➜ brake pedal vibration ➜ steering wheel wobble ➜ so-called hot judder ➜ strong shielding at normal running temperature ➜ brake fade

Centering seat	**Toleranzklasse H9**
Increased values entail	➜ increased radial run-out ➜ increased wear on wheel bearings and wheel suspension

The following summary shows the differences in the quality of ZIMMERMANN products as compared to the quality of other manufacturers' products.

Quality Criterion	Original ZIMMERMANN	Other Manufacturers
Locating hole	Tolerance class H8	+0,15
Evenness / reference & functional surfaces	max. 50 µm	150 µm
Geometry, general	Generally OE-compliant	simplified machining: unmachined (raw) areas, edges not chamfered, holes not deburred ➜ low tooling requirement ➜ shorter machining time
Marking	OZ-specific (article no., OZ logo, batch no.)	not clear, sometimes no marking
Surface roughness / friction surface (high-precision turned, optionally ground)	R_a 1…3 / R_z 12…16	R_a 10 / R_z 25…40
Axial run-out / friction surface	max. 30 µm	50 µm
Axial run-out / hub	max. 50 µm	100 µm
Positioning accuracy/drilling pattern	max. 0,3	0,5
Cross section / brake friction areas (constant all round)	max. ±0,5	±1,0
Concentricity	max. 50 µm max. 100 µm (steel-backed brake drum)	100 µm 200 µm (steel-backed brake drum)
Symm. pos. of vent. channel / friction surface	max. 1,0	2,0
Ventilation channel	generally OE-compliant	different geometry ➜ sometimes fewer fins ➜ sometimes fins instead of pillars
Unequal thickness (DTV)	max. 15 µm	30 µm
Unbalance	max. 30 cmg	100 cmg, sometimes unbalanced
Heat insulation groove	generally OE-compliant (diameter, cross section, angle, curves)	simplified design differing from OE ➜ low tooling requirement, ➜ shorter machining time
Material	generally OE-compliant, approx. 45 different qualities	standard GG-20 / GG-25, or a mixture of both qualities
Centering seat	Toleranzklasse H9	±0,3

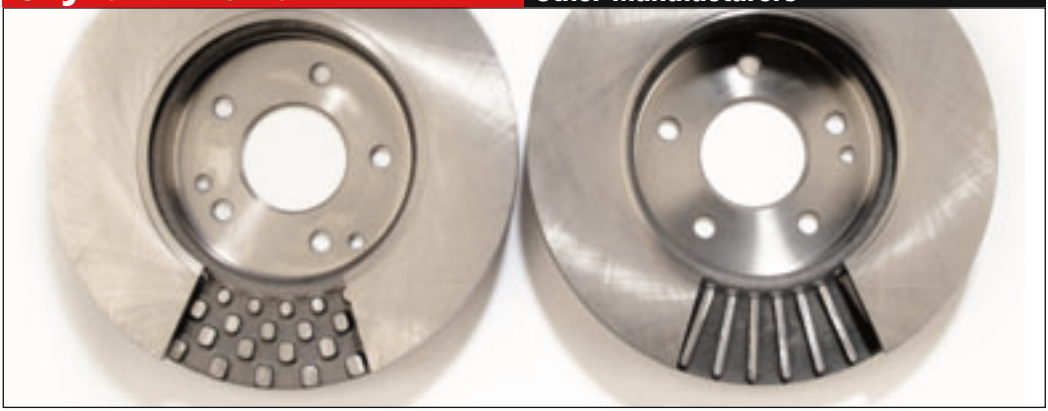
This should become clear with the help of some photographs for visual comparison:

Original Zimmermann	Other Manufacturers

- 3 recesses for hub pullers (OE-compliant)
  ➜ Prescribed special tool can be used
- Sensor ring for ABS included (OE-compliant)
  ➜ Fast and simple assembly; product is complete
  ➜ No further outlay for purchase
- Cast quality: neat blasted finish inside hub
  ➜ Less unbalance, less unsprung mass

- Only 2 recesses
  ➜ Prescribed special tool does not fit
- Sensor ring not included
  ➜ Additional outlay on purchase
  ➜ Purchase may even be impossible in some cases
- Considerable sand inclusion
  ➜ Greater unbalance, more unsprung mass

Original Zimmermann	Other Manufacturers



- Ventilation channel design: pillars (OE-compliant)
- Drilling pattern in hub base: 5 + 2 (OE-compliant)
  ➜ Latest standard agreeable to car manufacturers
- Cast quality: neat blasted ventilation channel
  ➜ Less unbalance, less unsprung mass

- Ventilation channel design: fins
- One centre / mounting hole missing
  ➜ Old design, not up-to-date
- Considerable sand inclusion
  ➜ Greater unbalance, more unsprung mass

Original Zimmermann

- External hub diameter machined (OE-compliant)
  ➜ Sophisticated manufacture
- Unbalance corrected by milling
  ➜ Reduction of unsprung mass
  ➜ Reduction of run-out (radial)

Other Manufacturers

- Unmachined (raw)
  ➜ Simplified manufacture, lower production costs
- Unbalance not corrected
  ➜ More unsprung mass
  ➜ Large unbalance, increased run-out (radial)
  ➜ Erhöhter Höhenschlag (radial)

Original Zimmermann

- Width of ventilation channel (OE-compliant)
  ➜ Resistance to shielding and thermal crack formation
- Large transition radii on fins / brake friction areas an Rippen / Bremsflächenseiten
  ➜ Resistance to mechanical crack formation
  ➜ No notch effect

Other Manufacturers

- Ventilation channel approx. 1 mm wider
  ➜ Lower material costs
  ➜ Cross section of brake friction areas is weakened
  ➜ Increased shielding
  ➜ Danger of thermal crack formation
- Sharp-edged transition with small radii
  ➜ Increased danger of mechanical crack formation
  ➜ Increased fatigue notch factor

Original Zimmermann

- Cross section of brake friction faces constant all round
  - ➜ Even rise in temperature in brake friction faces
  - ➜ Less shielding
  - ➜ No thermal crack formation

Other Manufacturers

- Thickness variations all round brake friction faces
  - ➜ Partial thermal overload
  - ➜ Increased shielding
  - ➜ Increased danger of thermal crack formation

Original Zimmermann

Other Manufacturers

- Unbalance corrected by milling
  - ➜ Elimination of mass
  - ➜ Precise balancing (accurate up to 0.5 gram)
  - ➜ Reduction of unsprung mass
  - ➜ Reduction of run-out (radial)

- Unbalance partly corrected by clips (wire clamps)
  - ➜ Addition of mass
  - ➜ Imprecisely balanced as operation only possible with integral multiples of the mass of a clip
  - ➜ More unsprung mass
  - ➜ Increased run-out (radial)

Original Zimmermann

Other Manufacturers

- Fins are at right angles on brake friction faces
- Constant cross section of fins
  - ➜ Optimum strength
  - ➜ Even heat transfer
  - ➜ Reduced shielding
  - ➜ No mechanical or thermal crack formation

- Fins misformed due to fault on casting pattern
- Fins weakened due to misalignment in cross section
  - ➜ Reduced strength due to sectional weakening
  - ➜ Uneven heat transfer
  - ➜ Increased shieldingIncreased risk of mechanical
  - ➜ and thermal crack formation

5. Models

5.1 Brake disks

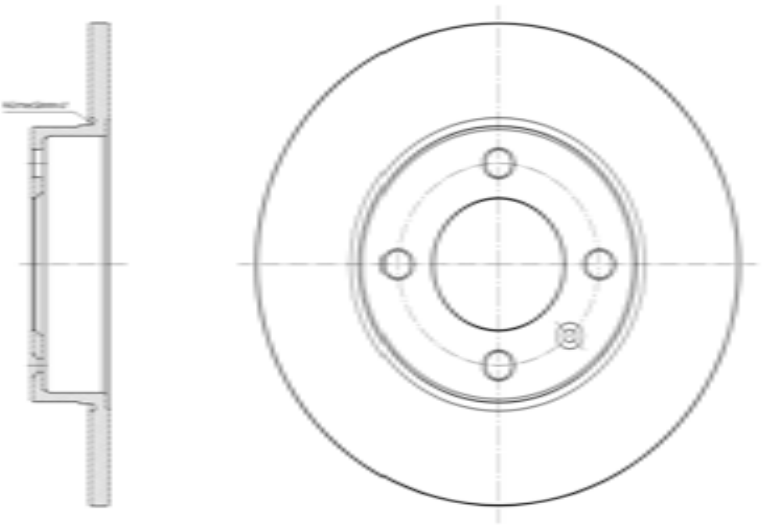
The brake disks consist of a friction ring and hub which are firmly connected to each other via the so-called heat insulation groove. The design and construction of the heat insulation groove is important for the dissipation of the heat energy generated when braking.

Different brake disk models

5.1.1 Non-ventilated brake disks

On non-ventilated brake disks the friction surface comprises a solid disk.

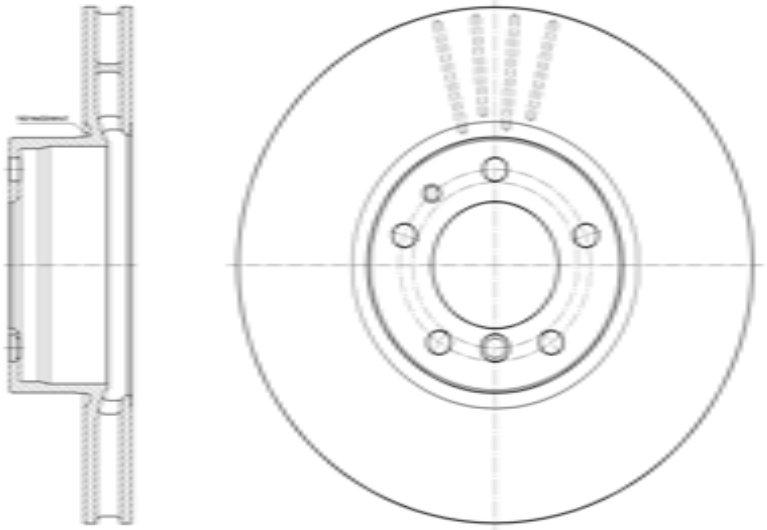
Unventilated brake disk



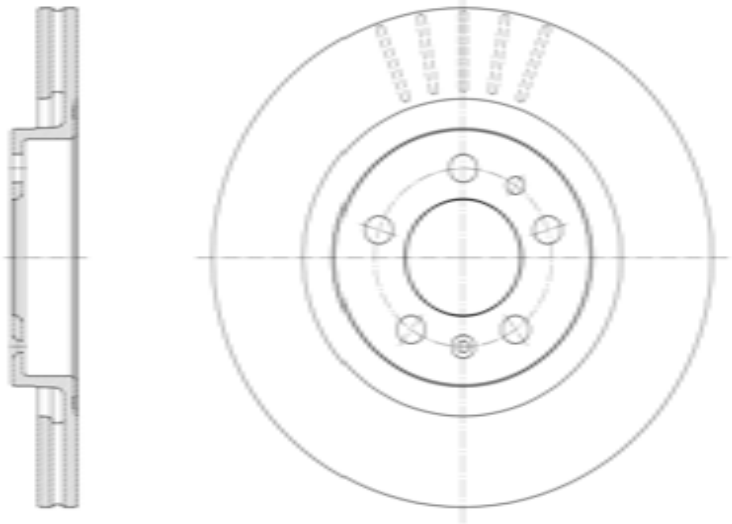
5.1.2 Ventilated brake disks

On ventilated brake disks the friction surface comprises two brake friction faces which are separated by the ventilation channel and connected by fins or pillars.
We differentiate between external and internal ventilation depending on the routing of the air flow. With the externally ventilated type the air is drawn in from the outside of the hub, routed through the ventilation channel and carried off outside on the external diameter of the friction surface, whereas with the internally ventilated type the air intake is from inside on the hub.
The fins come in various shapes and can be aligned differently. The pillars can also have different profiles (even inside a brake disk).

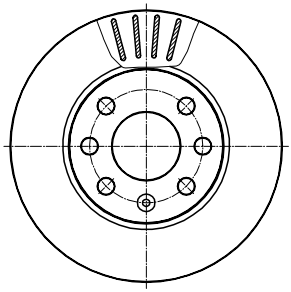
Internally ventilated brake disk



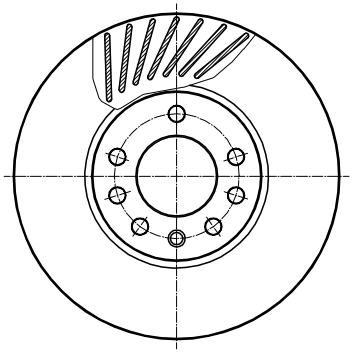
Externally ventilated brake disk



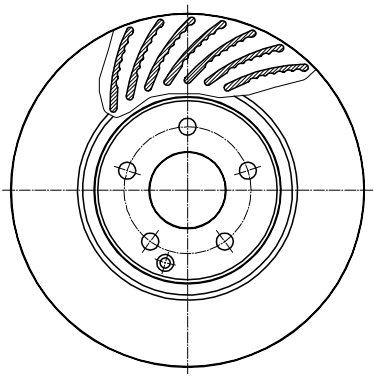
Variations in design of ventilation channel



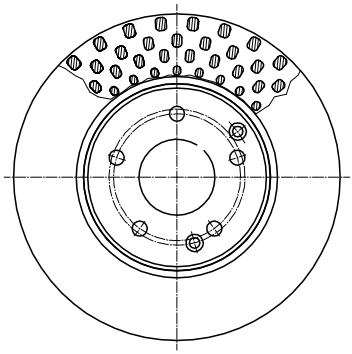
radial ribs



angular ribs



bended ribs



pillars

5.2 Hub disks

Hub disks have integrated structural elements for holding or mounting wheel bearings, rotary shaft seals, retaining rings, sensor rings for ABS and cover / sealing caps.
A distinction is also drawn in this case between non-ventilated and ventilated and between externally and internally ventilated designs.

5.3 Sports brake disks

The only external difference between ZIMMERMANN sports brake disks and "standard" brake disks are the holes drilled through the braking area.
The distinctive feature of the perforation is the special layout of the holes. The even distribution of the holes on / over the braking area brings about an even distribution of heat on the entire braking area, therefore helping to prevent crack formation due to thermal stress. The depth of the chamfer on the perforations is designed and dimensioned such that the chamfer is no longer visible when the wear limit has been reached.

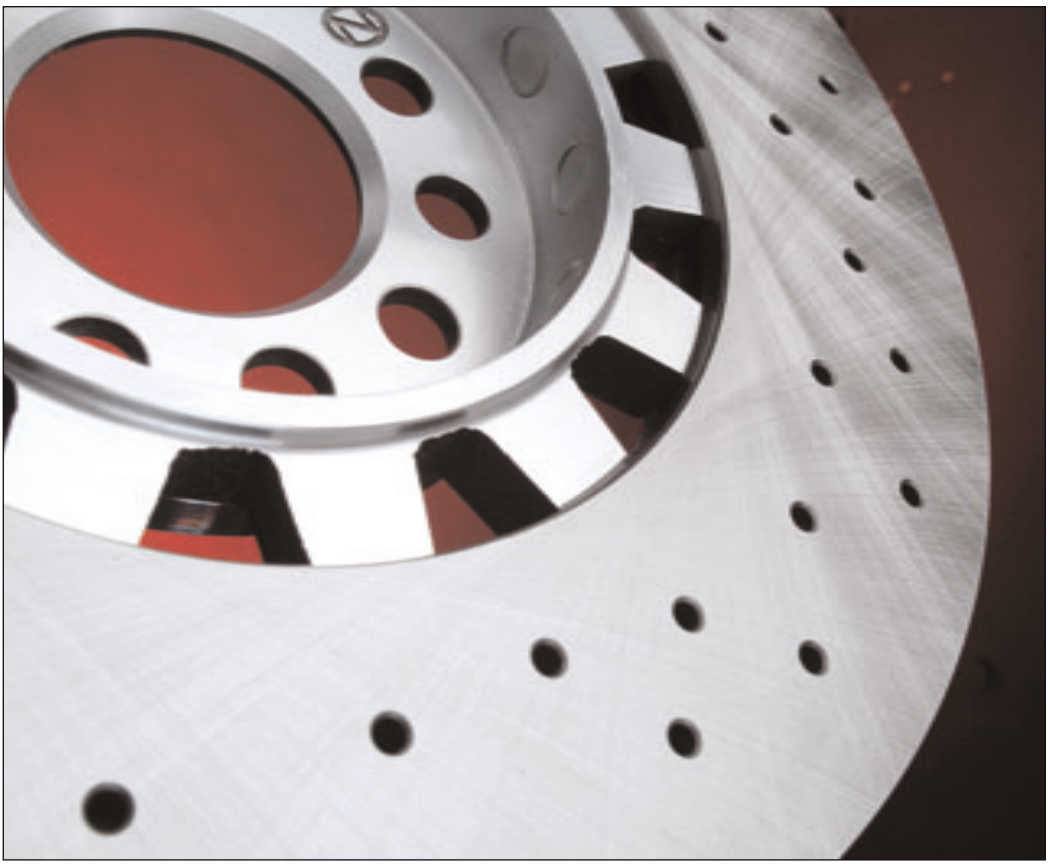
ZIMMERMANN sports brake disks have been tested by the *RWTÜV [Rhineland German Technical Inspection Authority]* in respect of their efficiency, operating safety and wear properties, and have been approved by the *KBA [Federal Office for Motor Traffic]* for conventional use in **series-production vehicles**, i.e. the products meet the requirements normally associated with their **designated use** in terms of mechanical load and thermal stress.

5.4 Compound brake disks

Unlike the "standard" brake disks, ZIMMERMANN **Formula Z** compound brake disks consist of several components. Whereas a "standard" brake disk is cast in a single piece, with the **Formula Z** compound brake disk the friction ring and hub are connected to each other by means of fasteners. This design allows a floating mounting of the friction ring, thus guaranteeing unimpeded thermal expansion of the friction ring and, in conjunction with the symmetrical connection of the friction ring to the hub, prevention of the shielding of the friction ring.

The ZIMMERMANN **Formula Z** compound brake disk can simply be exchanged with the original brake disk because it shares every function-related characteristic of the original brake disk. No additional adaptive elements, parts or components are required.

ZIMMERMANN compound brake disks have been tested by the TÜV NORD [North German Technical Inspection Authority] in respect of their efficiency, operating safety and wear properties and have been approved by the KBA [Federal Office for Motor Traffic] for conventional use in **series-production vehicles**, i.e. the products meet the requirements normally associated with their **designated use** in terms of mechanical load and thermal stress.



6. Brake drums

With brake drums we differentiate between full-cast, hub and steel-backed brake drums.

Different brake drum models

6.1 Full-cast brake drum

The full-cast brake drum comprises the actual drum and the drum base which are homogeneously joined to each other (in one cast).

6.2 Hub drums

Drum brakes hubs have integrated structural elements for holding or mounting wheel bearings, rotary shaft seals, retaining rings, sensor rings for ABS and cover / sealing caps.

6.3 Steel-backed brake drums

In steel-backed brake drums the drum base is made of sheet steel which is integrally cast into the drum, forming not a homogeneous metal joint, as with the full-cast brake drum, but a positive locking connection.

7. Damage symptoms

The following section is intended to explore the causes and effects of the most frequently occurring symptoms of damage. The various symptoms of damage can basically be subdivided into three groups.

7.1 Incorrect assembly

7.1.1 Contaminated contact surface

Symptom: Contact surface is contaminated / smeared with grease and / or paste

Cause:
- Failure to observe recommendations in ZIMMERMANN mounting instructions
  - ➜ Brake disks / brake drums should be assembled dry, cleanly, and metallically bright

Effect:
- Grease / paste bind foreign particles which get trapped between disk / drum and hub
- Coplanar assembly not possible or only possible to a limited degree
  - ➜ Brake disk / brake drum is assembled "lopsidedly" and runs increasingly untrue with increased mileage
  - ➜ Axial run-out caused by assembly can be checked on the vehicle itself, without the need for a test drive, by using a dial gauge / micrometer gauge and magnetic stand!
- Steering wheel wobble / judder after approx. 1,500 – 5,000 km

7.1.1 Contaminated contact surface

Contact surface with paint / lacquer

Symptom: Contact surface is sprayed or daubed with paint / lacquer

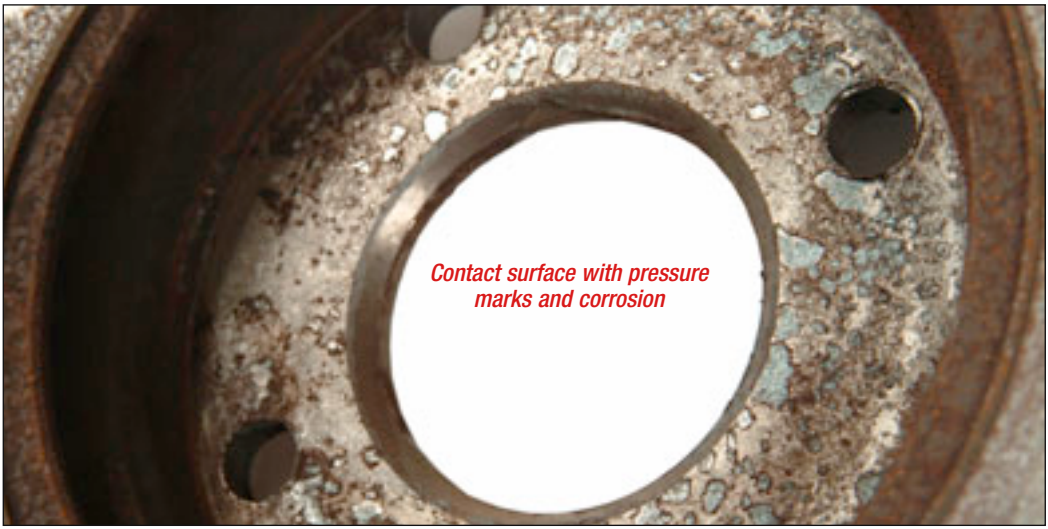
Cause:

- Failure to observe recommendations in ZIMMERMANN mounting instructions
  ➜ Brake disks / brake drums should be assembled dry, cleanly, and metallically bright

Effect::

- Paint / lacquer has oozed out at holes and excess paint has become trapped between brake disk / brake drum and hub
- Coplanar assembly not possible or only possible to a limited degree
  ➜ Brake disk / brake drum is assembled "lopsidedly" and runs increasingly untrue with increased mileage
  ➜ Axial run-out caused by assembly can be checked on the vehicle itself, without the need for a test drive, by using a dial gauge / micrometer gauge and magnetic stand!
- Steering wheel wobble / judder after approx. 1,500 – 5,000 km

7.1.2 Pressure marks and corrosion



Symptom: Contact surface shows pressure marks and is corroded in parts

Cause:
- Contact surface of wheel hub has not been cleaned at all or only insufficiently
- Failure to observe recommendations in ZIMMERMANN mounting instructions
  - ➜ Brake disks / brake drums should be assembled dry, cleanly, and metallically bright

Effect::
- Dirt and / or rust particles have become trapped between brake disk / brake drum and hub
- Planparallele Montage nicht oder nur eingeschränkt möglich
  - ➜ Brake disk / brake drum is assembled "lopsidedly" and runs increasingly untrue with increased mileage
  - ➜ Axial run-out caused by assembly can be checked on the vehicle itself, without the need for a test drive, by using a dial gauge / micrometer gauge and magnetic stand!
- Steering wheel wobble / judder after approx. 1,500 – 5,000 km

7.1.3 Torque and tightening sequence

Contact surface is cracked in the vicinity of a hole

Symptom: The contact surface is cracked in the vicinity of the hole(s)

Cause:
- The wheel bolts / wheel nuts have been tightened with excessive torque and / or in the incorrect order
- Failure to observe vehicle manufacturer's instructions
- Failure to observe recommendations in ZIMMERMANN mounting instructions

Effect:
- Coplanar assembly not possible or only possible to a limited degree
  - ➜ Brake disk / brake drum is assembled "lopsidedly" and runs untrue immediately after assembly
  - ➜ Axial run-out caused by assembly can be checked on the vehicle itself, without the need for a test drive, by using a dial gauge / micrometer gauge and magnetic stand!
- Deformation of contact surface (even if no cracks are visible!)

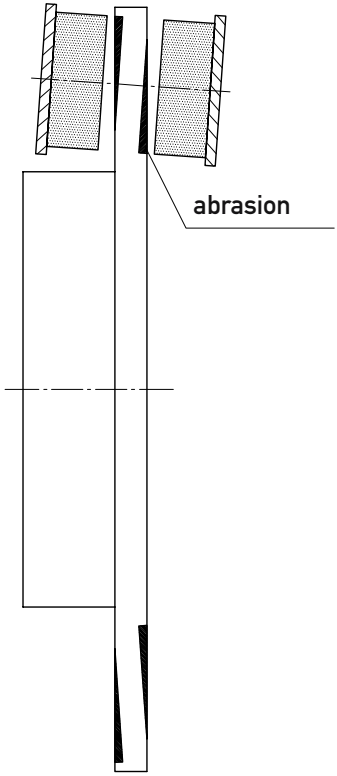
7.1.4 Incorrect brake disk

Symptom: The face diameter / centering seat of the brake disk is too small for the wheel hub of the vehicle concerned

Cause:
- Selected product is not suitable for vehicle

Effect:
- Coplanar assembly not possible or only possible to a limited degree
  - ➜ Brake disk / brake drum is assembled "lopsidedly" and runs untrue immediately after assembly
  - ➜ Axial run-out caused by assembly can be checked on the vehicle itself, without the need for a test drive, by using a dial gauge / micrometer gauge and magnetic stand!
- Contact surface and / or hub can crack if force is applied

7.1.5 Position of calliper / brake disk



Asymmetrical wear, caused by calliper

Symptom: Asymmetrical wear on brake friction faces

Cause:
- Functional axes of brake disk and calliper are out of alignment
- Calliper is mounted off straight in relation to the brake disk / wheel hub

Effect:
- Brake pedal vibration / judder
- Steering wheel wobble
- Brake fade
- Wear limit reached prematurely

7.1.6 Hub run-out

Asymmetrical wear, caused by wheel hub

Symptom:
- Asymmetrical wear of brake friction faces
- Blue-black hot spots

Cause:
- Functional axes of brake disk and calliper are out of alignment
- Wheel hub is mounted off straight in relation to the calliper
  - ➜ Axial run-out caused by assembly can be checked on the vehicle itself, without the need for a test drive, by using a dial gauge / micrometer gauge and magnetic stand!

Effect:
- Brake pedal vibration / judder
- Steering wheel wobble
- Brake fade
- Wear limit reached prematurely
- Partial thermal overload due to constant grinding of friction ring on pad

7.2. Use and road performance

7.2.1 Running-in phase

Annealed brake disk

Symptom: Friction surface and / or hub showing the so-called annealing colours (off-white to grey)

Cause:
- Running-in phase too short
- Violent braking / panic stops carried out during running-in phase
- Use of incorrect pads (friction factor, composition, quality)

Effect:
- Brake pedal vibration
- Steering wheel wobble
- Brake fade
- Due to thermal overload
  - ➜ Brake disk anneals
  - ➜ Structural transformation, alteration of the mechanical properties of the cast material

7.2.2 Intensive use

Symptom: The brake friction faces are showing blue-black so-called hot spots. Net-like hairline cracks have developed into larger radial heat cracks mainly in the centre of the friction ring.

Cause:

- Running-in phase too short
- Violent braking / panic stops carried out during running-in phase
- Use of incorrect pads (friction factor, composition, quality)
- Individual vehicle handling

Effect:

- Brake pedal vibration
- Steering wheel wobble
- Brake fade
- Due to thermal and / or mechanical overload:
  - ➜ Brake disk anneals
  - ➜ Structural transformation, alteration of the mechanical properties of the cast material
  - ➜ Friction surface / brake friction faces can crack through

7.2.3 Wear limit

Heavily worn, shortfall on wear limit

Symptom: The brake friction faces are unduly worn; there is a clear difference in thickness between the contact area of the pads and the original thickness of the friction surface

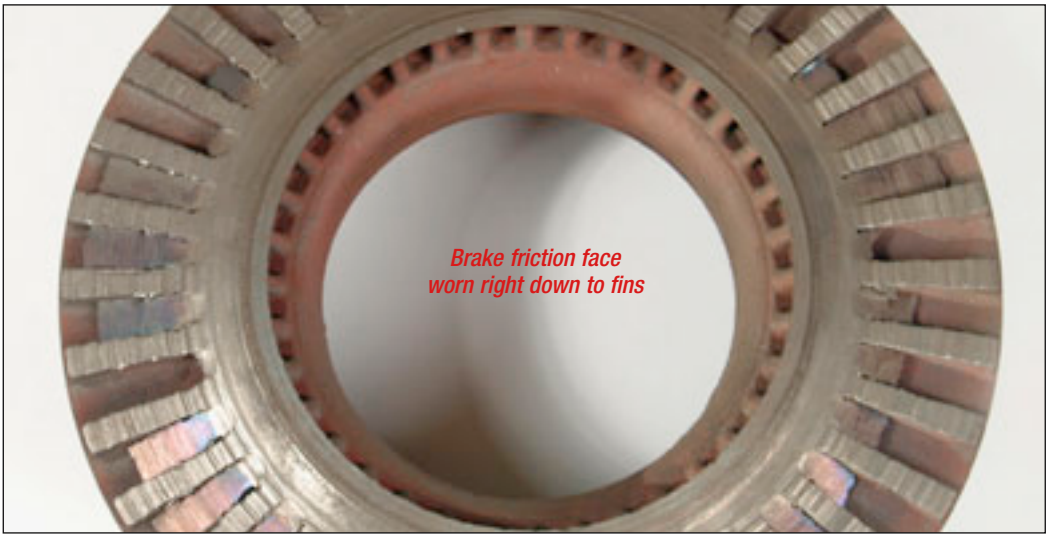
Cause:

- There is a substantial shortfall below the prescribed wear limit
- Failure to observe recommendations in ZIMMERMANN mounting instructions
  ➜ Verschleißgrenze ist am Außendurchmesser der Bremsfläche oder am Topfaußendurchmesser eingeprägt

Effect:

- Steering wheel wobble
- Brake fade
  ➜ „Long" brake pedal travel
- Due to thermal and / or mechanical overload:
  ➜Brake disk anneals
  ➜Structural transformation, alteration of the mechanical properties of the cast material
  ➜Friction ring can break away from hub

7.2.4 Uneven wear / worn pads



Symptom: The external brake friction face is completely worn, right into the V-shaped channel, whereas the internal brake friction face has virtually no trace of contact

Ursache:

- Calliper seized on one side
  ➜ Unilateral pressure on the brake disk
- Pad completely worn out; braking was effected by pad backing
  ➜ Metal on metal

Auswirkung:

- Uneven wear
- Brake fade
  ➜ „Long" brake pedal travel
- Noise generation (humming, droning, grating)
- Steering wheel wobble
- Friction ring can break away from hub (if the internal brake friction face only was under load)

7.2.5 Thermal overload

Hot spots

Symptom:

The brake friction faces are showing blue-black so-called hot spots.
Net-like hairline cracks have developed into larger radial heat cracks.

Cause:

- Thermal overload
- Individual vehicle handling

Effect:

- Brake pedal vibration
- Steering wheel wobble
- Brake fade
- Noise generation (humming, droning, grating)
- Due to thermal and / or mechanical overload:

  ➜ Brake disk anneals
  ➜ Structural transformation, alteration of the mechanical properties of the cast material
  ➜ Friction surface / brake friction faces can crack through

7.2.6 Periods of non-use

Layers of corrosion detaching from friction ring

Symptom:

On the braking area there are layers of corrosion, some of them thick, peeling off the friction ring.

Ursache:

- The vehicle concerned was not in use for a relatively long period
  ➜ Garaged vehicle / stored vehicle
- The vehicle concerned was not used for relatively long periods after being driven in damp / wet conditions
  ➜ Water damage

Effect:

- Brake pedal vibration / judder
- Steering wheel wobble / shimmy
- Brake fade
  ➜ Brake pedal becomes „hard"
- Noise generation (humming, droning, grating)
- When started up again the friction ring and pads are badly damaged by the extremely hard scale particles becoming detached
  ➜ Fragments of disk and pad material are torn out

7.2.7 Scaling

Severe corrosion,
layers of rust flaking off

Symptom: In the areas in which the pads were not in contact the brake disk is showing extremely heavy corrosion which is flaking off in thick layers.

Cause:

- The brake disk was applied when hot and then cooled / "quenched" extremely quickly (possibly several times consecutively)
  - ➜ e.g. when driving through a puddle or in relevant weather conditions (rain, snow, slush)

Effect:

- Due to sudden temperature changes
  - ➜ Structural transformation, alteration of the mechanical properties of the cast material
- Formation of a thick layer of corrosion which flakes off gradually after several cycles
- Gradual weakening of the brake disk
  - ➜ Reduction of wall thickness / cross section (thickness of brake friction faces, thickness of fins / pillars, thickness of hub casing, friction ring width)
  - ➜ Mechanical / thermal overload
- Brake pedal vibration / judder
- Steering wheel wobble / shimmy

7.2.8 Applied parking brake

Symptom:

- The brake disk has radial cracks in the area of the parking brake diameter (hand brake), some of which continue across the thermal insulation channel into the braking area.
- The parking brake area diameter (hand brake), thermal insulation channel and braking area are exhibiting the so-called annealing colours.

Cause:

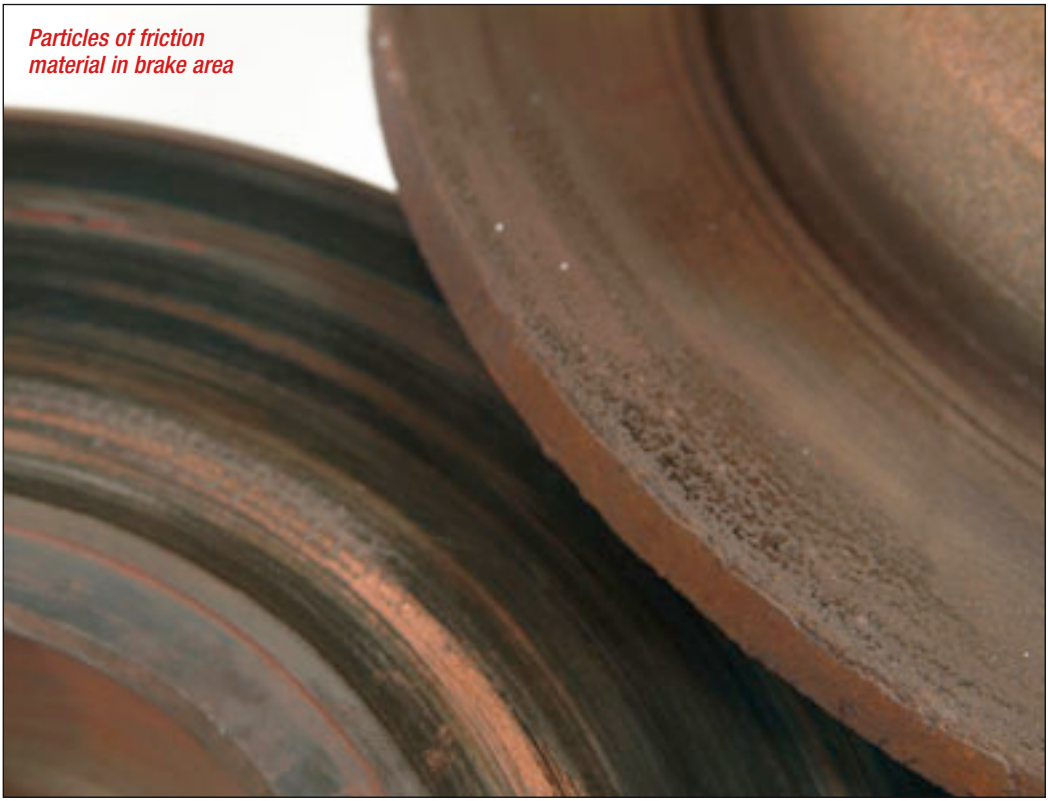
- The vehicle was driven with the parking brake on (applied) for a relatively long period and then also stopped with the parking brake applied.
  The mechanics of the parking brake and / or the cables are sluggish or not serviceable.

Effect:

- Due to thermal and / or mechanical overload:
  ➜ Brake disk anneals
  ➜ Structural transformation, alteration of the mechanical properties of the cast material
  ➜ Friction surface / brake friction faces and hub can crack through
- Acute noise generation (humming, droning, knocking) when braking
- Acute noise generation (grinding, rubbing, rattling) when applying the parking brake

7.3 Other brake system components

7.3.1 Glazed brake pads / friction surface



Particles of friction material in brake area

Symptom:

Particles of the friction material have worked / "burnt" into the braking area
➜ Shiny surface on brake friction faces

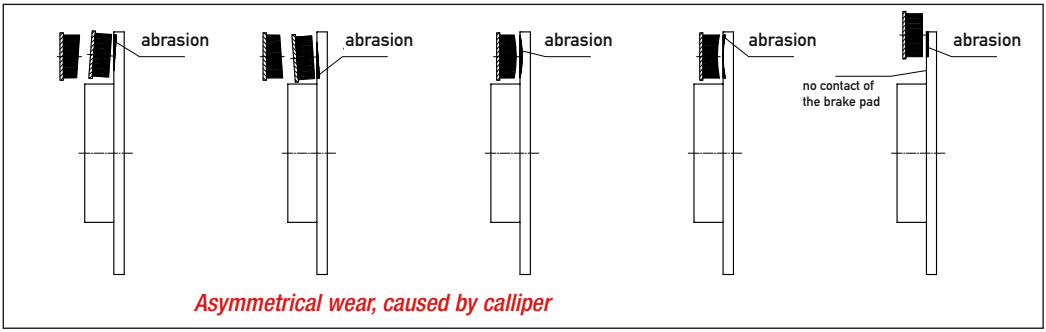
Cause:

- Inferior pad quality
  ➜ Consistency of binding agent, lubricant and filler
  ➜ Non-homogeneity of friction material (uneven distribution of abrading medium)
- Sudden quenching of hot brake disk
  ➜ Flaking of particles from the friction ring
  ➜ Occurs frequently with relatively new brake disks which are still insufficiently run in

Effect:

- Brake fade
  ➜ Brake pedal becomes „hard"
- Excessive wear of brake disk and pad
- Noise generation (humming, droning, grating)

7.3.2 Position of calliper / pad surface



Asymmetrical wear, caused by calliper

Symptom:

The brake friction faces are showing signs of uneven pad contact, not reaching across the entire width of the friction ring

- ➜ Some corroded areas on the brake friction faces
- ➜ Pads not making contact in this area

Cause:

- Inferior pad quality
  - ➜ Evenness / plane parallelism not guaranteed
- Functional axes of brake disk and calliper are out of alignment
- Calliper is mounted off straight in relation to the brake disk / wheel hub
- Partial loss of friction material

Effect:

- Brake fade
  - ➜ Brake pedal becomes "hard"
  - ➜ Reduction of friction surface actually available
- Partial excessive wear of brake disk and pad
- Thermal and / or mechanical overload
- Steering wheel wobble / shimmy

7.3.3 Flutes and grooves

Flutes and grooves on friction surface

Symptom: The brake friction faces have deep grooves / flutes in comparison to the overall wear situation.

Cause:

- Foreign body trapped between pad and brake disk
- Inadequate pad quality
  - ➜ Protruding parts of pad / foreign body
  - ➜ Consistency of binding agent, lubricant and filler
  - ➜ Non-homogeneity of friction material (uneven distribution of abrading medium)
- Calliper is mounted off straight in relation to the brake disk / wheel hub
- Partial loss of friction material

Effect:

- Brake fade
- Noise generation (squeaking, grinding, chafing)

7.3.4 Poor pad quality

Symptom:

- The perforations are clogged with friction material
- The brake friction faces have grooves / flutes (outer area of friction ring width)

Cause:

- Inferior pad quality
  - ➜ Consistency of binding agent, lubricant and filler
  - ➜ Non-homogeneity of friction material (uneven distribution of abrading medium)

Effect:

- Insufficient cooling of friction ring
  - ➜Thermal overload
  - ➜Brake disk anneals
  - ➜Structural transformation, alteration of the mechanical properties of the cast material
- Brake fade
- Noise generation (squeaking, grinding, chafing)

7.3.5 Incorrect pads

Symptom:

Areas are apparent on the brake friction faces in which the pads have not been in contact.

➜ Corroded area (width of ring area approx. 12 mm)

Cause:

- Incorrect pads (too narrow), not intended for the vehicle concerned
- Calliper is mounted off straight in relation to the brake disk / wheel hub

Effect:

- Brake fade
  - ➜ Reduction of friction surface
- Due to thermal and / or mechanical overload:
  - ➜ Brake disk anneals
  - ➜ Structural transformation, alteration of the mechanical properties of the cast material
- Steering wheel wobble / shimmy

7.3.6 Displaced pad backing

Symptom:

Clear reductions of area apparent on hub casing

- ➜ Wall thickness of hub casing is greatly reduced
- ➜ „Turned" groove

Cause:

- Friction material is entirely depleted / worn out
- Pad backing not fixed / positioned
  - ➜ Radially displaced
  - ➜ Cuts hub off from friction ring

Effect:

- Brake fade
  - ➜ „Long" brake pedal travel
- Noise generation (grating, grinding, chafing)
- Loss of braking effect
  - ➜ Detachment of friction ring from hub