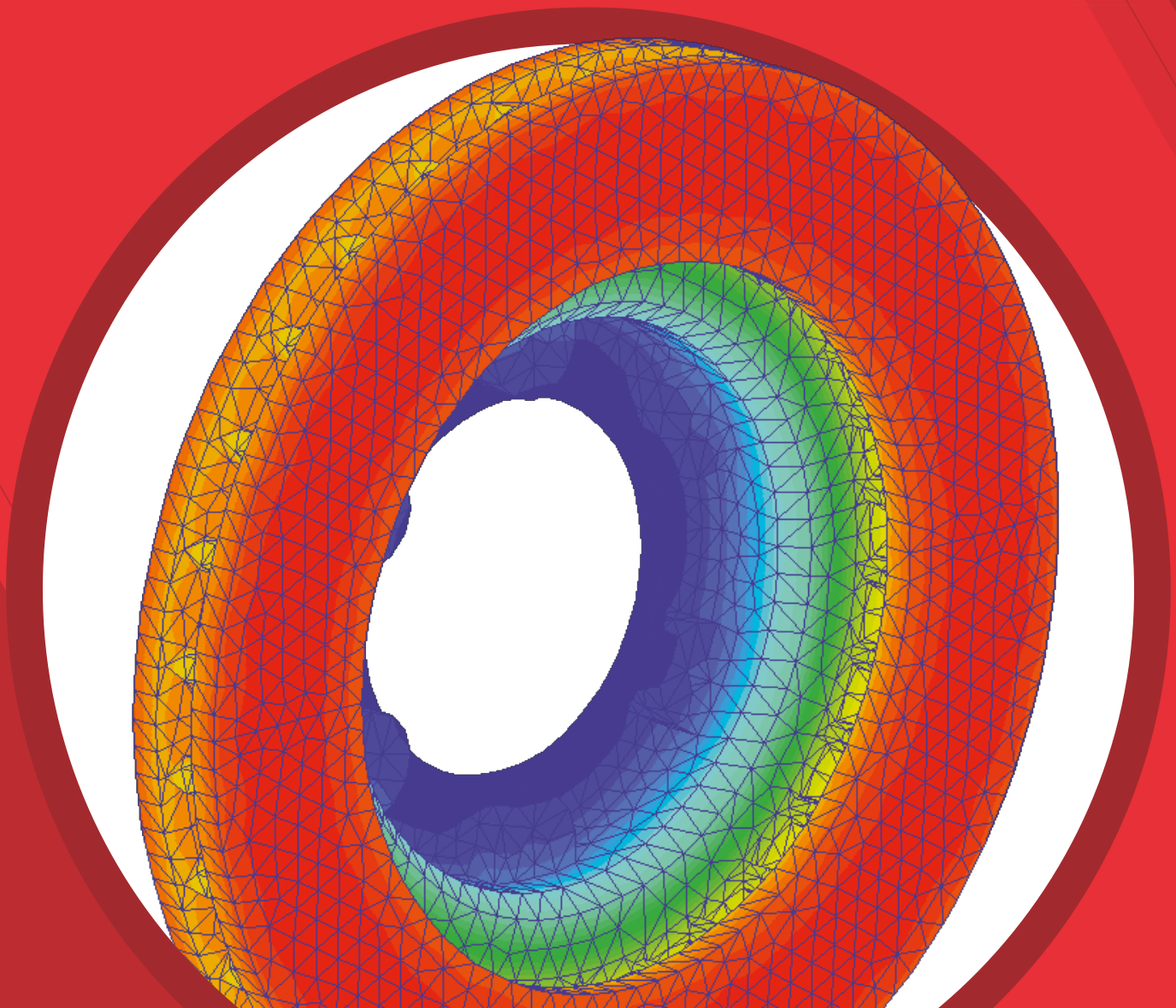
THE **BREMBO** GUIDE TO **BRAKE** DISC **ASSEMBLY** AND **MAINTENANCE**



PREFACE

Curno, September 15, 1997

Brembo published its first Brake Disc Manual in June 1985.
This was a twenty page volume that highlighted the disc's role in "disc" braking systems (quite often misunderstood) and gave indications on necessary checks and maintenance of the disc, whilst emphasising the skills required to manufacture a component capable of offering guarantees of efficiency, safety and durability.
Today it is even more true to say that the brake disc remains a little-known, although vital, component. The rules of the game have changed. Asbestos has been eliminated from brake pad composition and vehicles are now heavier.
For instance, an unladen 1974 Golf 1.5 weighed 780 kg whereas the Golf 3, 1.4 weighs 1030 kg. Even so it is still equipped with the same 239 x 12 mm Brembo brake disc, code 08.4177.10. This fact in itself has proved to be non-critical as far as this vehicle is concerned. Similar developments for other cars, however, have led to the exceeding of a brake discs limits. It is important to understand why.
This is one of the aspects that this Manual aims to clarify.
Today, cars are faster and make less noise. Users are now much more demanding and less willing to tolerate noises and vibrations that, in the past, were lost in the background noise but which today can often be heard and are rarely accepted.
I felt that Brembo should update the earlier volume and make the new manual a tool that explains the principles and developments of disc brake systems in general and the brake disc in particular: how does it function, why and how does wear occur, how can correct vehicle maintenance be ensured?
It is a fact that competently fitted Brembo brake discs give all cars the assurance of high performance, safety and comfort for a long time to come.

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President

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CHAPTER 1

BRAKE DISC MAINTENANCE

1.1 PROCEDURE TO REPLACE A DISC

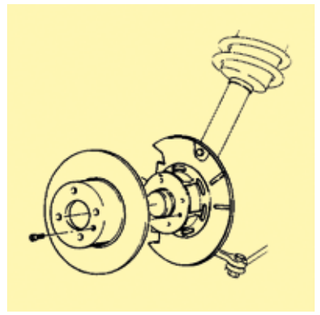
1.1.1 DISMANTLING AND REFITTING

1. Remove the wheel.

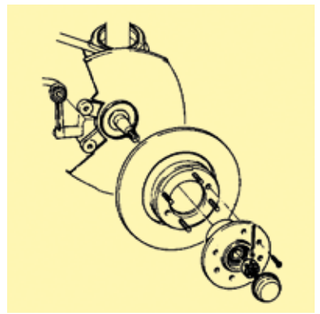
2. Remove the pads and push back the pistons using the pro-per tool for this operation.

3. Dismantle the complete caliper from its support, without disconnecting the brake fluid ducts. Do not leave the caliper hanging from the flexible ducts. Suspend the caliper in some way (for instance, on a hook).

4a. Dismantle only the used disc, if this has a mounting flange inside the carrier.



4b. If the mounting flange is external to the carrier then it will be necessary to first dismantle the hub and then the worn disc.



5. Clean the new disc with an appropriate solvent (for example, petrol or spirit). The anticorrosion layer must be completely removed. The disc must not be contaminated by oil or grease as these substances could be passed on to the pads and so reduce their performance. Carefully clean the surface of the disc that will come into contact with the hub.

6. Carefully clean the surface of the wheel hub on which the disc will be installed. Eliminate rust and other deposits. Check that the support surface is neither distorted nor damaged.

1.1.1

7. Check that play in the bearings does not exceed the tolerance and that the ball bearings rotate freely within their crown. If possible, adjust the bearing.

8. Fit the brake disc on the hub.

9. For discs with a mounting surface that is external to the carrier, fit the wheel hub and adjust the wheel bea-ring.

1.1.1

10. Once the disc has been fitted, use a DTI Gauge (fi xed to the suspension bracket) to measure disc run out on a braking surface at the point of its external diameter. At the end of one complete rotation, run out should not exceed 0.10 mm.
If it is greater, change the position of the disc on the hub (provided that the mounting aperture allows this), or fit the second disc from the pack.
If the disc is held in place by one bolt only, secure it to the wheel hub by two other bolts (using wheel studs plus washers to compensate for the thickness of the wheel) in order to simulate rotation conditions once the wheel has been fi tted.
Measurement of disc run out is a vitally important operation: if there should be too much run out then in time, after a few thousand kilometres, the disc may be subject to abnormal wear when travelling - and outside of occasions when the brakes are applied (due to slight rubbing against the pads) - and braking vibrations may occur. The recommended maximum tolerance for disc run out has been established on the basis of our experience. Other sources may indicate slightly different values - in such cases the original value should be observed.

11. When the maximum recommended run out for the disc is exceeded then check run out for the bare hub. It should be borne in mind that the value recorded for the hub will double when measured at the outer diameter of the disc.

12. Fit the caliper to its support. A floating caliper must move smoothly and regularly along its guides. The pistons must move freely. Dust shields must be integral.

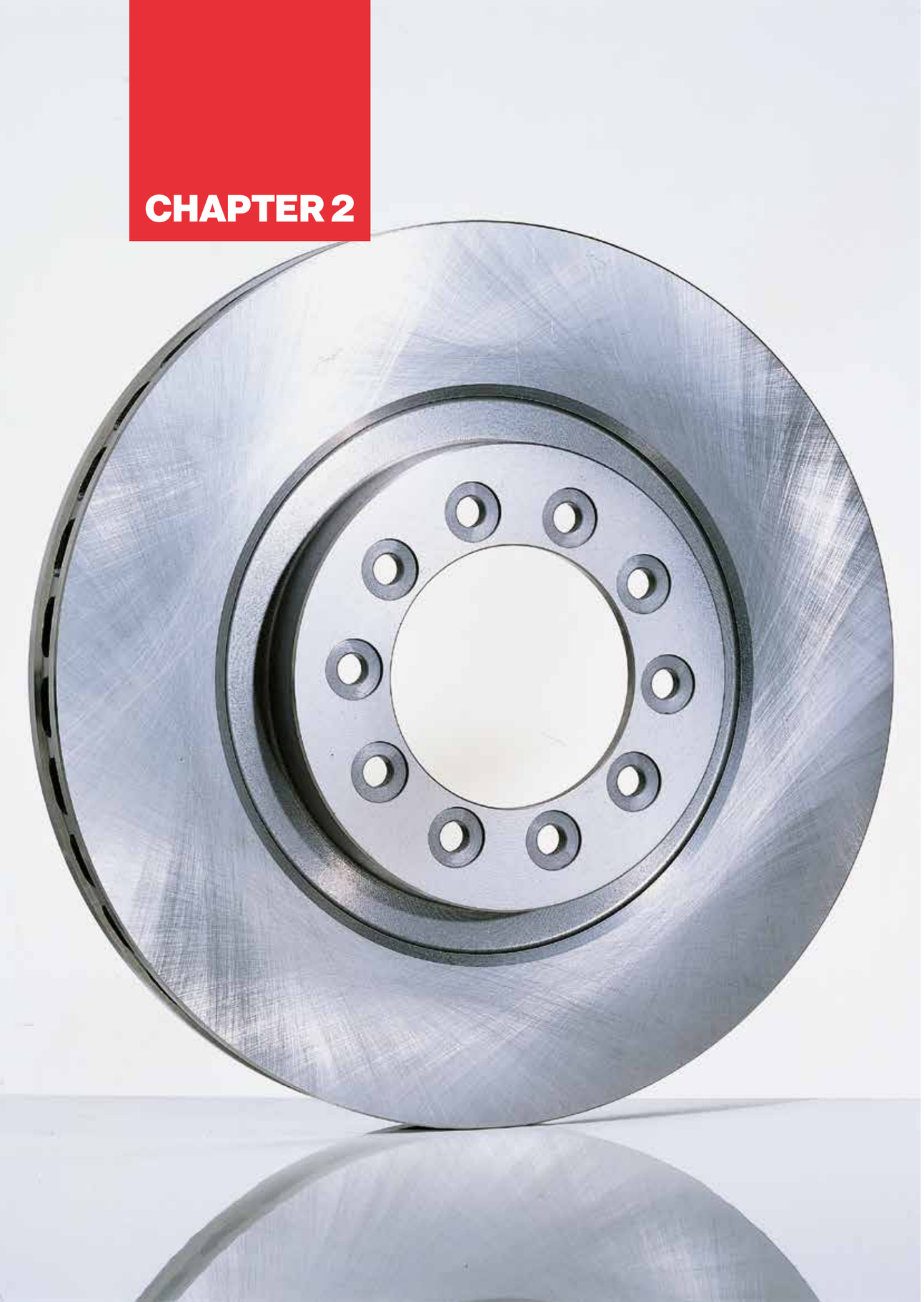
13. Fit the new pads - they must be free within their seats. Fit the springs and any other parts included in the kit.

14. Before fitting the wheel make sure that the rims are not distorted. Balance the wheel/tyre unit correctly. Tighten bolts in the correct sequence and observe the recommended torque.

15. Check that the elements comprising the suspension are integral. Check that the shock absorbers function properly. The suspension adjustment must correspond to the manufacturer's recom-mended values.

1.1.2 TESTING AND RUNNING IN

Once the discs and pads have been replaced, the mechanic should then carry out a road test. He must ascertain that there are no brake vibra¬tions or noises, either while travelling or during braking. He must also check that the braking action is both correct and efficient, even though the brakes are not yet run in. It is the braking distance that is important. Never brake sharply during these tests. The car user should be advised to observe an approximately 200 km run-ning-in period. During this period a short, smooth braking action should be adopted so that the pads can align correctly to the disc surface. Too sharp or heavy braking may not only cause the pads' friction material to overheat, but also the disc itself. This would end up by compromising brake integrity and performance. In particular, do not attempt to activa¬te the ABS.



CHAPTER 2

CAUSES AND **CONSEQUENCES** OF **DISC DETERIORATION**: PRACTICAL EXAMPLES

In the previous chapters we have examined, albeit sometimes from a theoretical standpoint, the various types of alteration and deterioration that can affect a disc. These can be summarised by classifying them in four groups:

- **Geometrical modifications** that can be measured quite easily using a sliding caliper, a micrometer caliper or a DTI Gauge.
- **Structural modifi cations** that can be observed by examining the disc's braking surface. Simple, unaided observation will be suffi cient in cases involving a change in colour whereas in other instances a microscope will have to be used.
- **Wear**, or rather types of wear, since the causes and effects can be many.
- **Cracks** that may lead to **breakage**.

We have also described - without going into too much detail - the main deterioration **mechanisms** that involve stresses of both a thermal and mechanical origin. When describing disc **production** we reviewed the various defects that might arise were the production process not properly controlled: run out, DTV, incorrect planarity, equilibrium defect, but also an inappropriate or irregular composition of the cast iron. In this chapter we will avoid re-examining the consequences of these imperfections since current quality controls ensure that braking problems due to defective manufacture are extremely rare, in the order of a few tenths of one percent.

On the contrary, we will conduct a review using a very practical approach as regards the various defects and deterioration caused by **use**. The word *use* is intended in a broad sense since it also includes disc **installation**, braking in **extreme conditions**, **excessive wear** and the involvement of **other components** in the braking system. Examination of the different cases of disc deterioration shows that the

majority of these could have been avoided if greater care had been taken during the installation stage. This not only concerns certain checks that can be quantified by means of measurement but also, in a more simple manner, by a close visual examination of the components concerned. By way of example, and before attempting to classify the various causes of deterioration, here are two pertinent cases. As these are extreme and rather infrequent cases they have been excluded from the more recurrent situations in the list. In the first case the **hub is distorted** or presents a **conspicuous run out**, probably as a result of a collision.

The disc has been fitted without fi rst repairing this damage. Such an assembly will progressively cause an increase in braking vibrations. If the run out is particularly pronounced then these vibrations may well be felt right from the very fi rst braking action. The illustrations show the disc, in an oblique position, with an uneven wear first on one side and then, half a turn later, on the other. Visual examination or the use of a DTI Gauge highlights possible anomalies during fi tting. This examination, suggested here in order to establish poor functioning, is even more useful during fitting as a means to ensure that the braking system is operative.

The second case is exceptional, rather extreme. Careful examination of the state of the disc and pads reveals visible defects and is always a valuable source of information as to the overall functioning of the system. It can be seen in the photo that a foreign body (a screw) is lodged between the disc and pad, it probably happened during refi tting. The illustration shows the damage that this piece of steel can provoke, damaging the disc and causing unusual wear, a source of vibrations and noise when braking.

2.1 DETERIORATION DUE TO FITTING THE DISC

2.1.1 INCORRECT TIGHTENING

Description of defect: Formation of cracks on the carrier surface in contact with the hub. This is due to incorrect tightening during fitting. The tightening sequence has not been followed and torque is insufficient. Failure to follow the recommended sequence and tightening torque can cause distortion of the carrier mounting surface even when there are no visible cracks.
Consequences: Distortion of the carrier mounting surface causes vibrations that can be felt immediately after fitting when the brake pedal is pressed.
Advice: Fit another disc, following the recommended sequence and tightening torque.

2.1.2 FAILURE TO OBSERVE THE RECOMMENDED TIGHTENING TORQUE

Description of the defect: The carrier mounting surface breaks away from the rest of the disc. There are clear signs of excessive tightening, above all in the area of the two fi xing holes. This is evidence of a failure to observe the recommended torque and sequence during tightening.
Consequences: Pronounced rasping noises and absence of braking torque.
Advice: Fit another disc, following the recommended sequence and tightening torque.

2.1.3 EXCESSIVE TIGHTENING OF THE POSITIONING BOLT

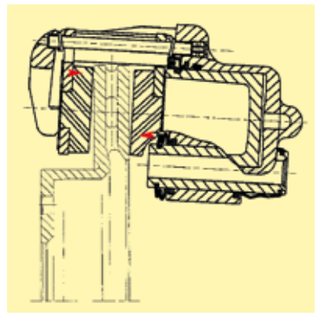
Description of the defect: The carrier mounting surface can easily distort when the disc positioning bolt is tightened too much. This excessive tightening can cause the mounting surface to break as can be seen in the photo.
Consequences: Run outing cannot be kept within an acceptable tolerance. Heavy vibrations occur during the very fi rst kilometres following installation.
Advice: Tightening bolts are only intended to ensure that discs are positioned correctly. Do not tighten them excessively.

2.1.4 FITTING A DISC THAT DOES NOT CORRESPOND TO THE CAR

Description of the defect: Formation of cracks on the carrier mounting surface. Signs of a poor match between the diameter of the disc centring and that of the hub.
Consequences: Disc contact with the wheel hub is incorrect. This defective installation will immediately cause vibrations due to excessive run outing.
Advice: Check catalogues to determine the correct disc reference: model, year of manufacture. Never force discs when fitting.

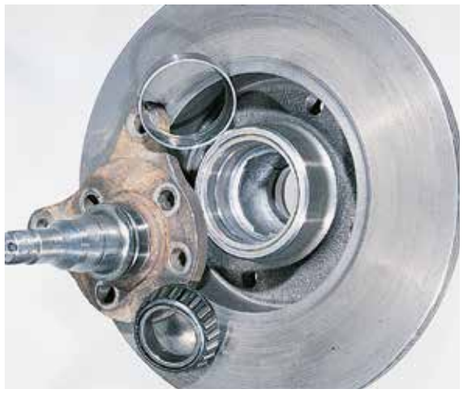
2.1.5 INCORRECT ASSEMBLY OF THE CALIPER BODY ON THE AXLE

Description of defect: The braking surfaces have broken away from the hub. Asymmetrical braking surface wear can be noted: the central area of the external surface in respect of the vehicle and the outer edge of the internal surface. In this case mechanical stress has caused the disc to break and the braking surfaces have come away. **Consequences:** The impact of this breakage can be felt when braking. Very loud rasping noises. Safety is compromised.
Advice: Before fitting new discs check the alignment and assembly of the caliper body on the axle.



2.1.6 NCORRECT TIGHTENING OF THE DISC AND HUBBEARINGS

Description of defect: An exaggerated tightening torque knocks the bottom out of the bearing seat.
Consequences: Braking system functioning is compromised because of disc instability relative to the bearings. Strong vibrations are felt right from the fi rst braking action.
Advice: Replace the hub, bearings and disc. Apply correct tightening torque when installing.



2.1.7 DIRTY HUB

Description of defect: The hub surface was not cleaned when the disc was fitted: presence of rust or dirt. Tightening against this unsuitable surface causes the new disc to run out excessively.
Consequences: This error during installation causes the onset of vibrations after a few hundred or thousand braking actions, vibrations that increase with the distance travelled. Uneven disc wear as a result of the pads causes DTV to increase - this is the origin of the vibrations - and noise (see section 3.3.3).
Advice: Clean contact surfaces very carefully. Check disc run out after installation.

2.1.8 PRONOUNCED WHEEL HUB RUN OUT

Description of defect: Excessive hub run out causes the braking surfaces to wear as they are not parallel to the plane of the disc. Evidence of localised overheating is indicated by the darker colour of the worn areas. This is due to an alternating rubbing action of the disc and pads as a result of pronounced wheel hub run out.
Consequences: Vibrations can be felt right from the start and progressively increase. Onset of loud noises.
Advice: Check the wheel hub run out and ensure that this falls within the tolerance specifi ed in the disc installation instructions.

2.2 DETERIORATION DUE TO USE

2.2.1 NO RUNNING IN

Description of defect: Disc shows colouring of varying intensity and shades (blue, violet, golden), mainly visible in the cooling areas (groove and carrier interior).
Consequences: Initial slight vibrations that progressively increase Overheating of this type alters the mechanical characteristics of the cast iron in as much as there is a change in structure due to the formation of cementite (Fe3C).

Advice: Always advise users to observe a running in period. Brake only moderately and briefly during the first 200-300 kilometres over a mixed itinerary. Avoid prolonged pad to disc contact.

2.2.2 INTENSIVE USE

Description of defect: Disc thickness is considerably less than the recom-mended minimum thickness (4 mm less in total). Cracks are evident. Heat spots are visible in areas corresponding to the ventilation blades. This is advance warning that other cracks will form. **Consequences:** Noises, vibra-tions.
Advice: This situation is typical of that found on certain sports vehicles which are subjected to an intensive and excessive use on the road.

2.3 EXCESSIVE WEAR

2.3.1 EXCEEDING THE LIMIT

Description of defect: The thickness of the braking surfaces measured using a micrometer is less than the recommended minimum thickness etched on the outer disc rim or on the carrier.
Consequences: Performance and comfort decreases.
Advice: Check state of disc wear periodically. The disc should be replaced after every two or three pad changes. Pads must be changed every time discs are replaced.

2.3.2 EXCESSIVE WEAR WITH CRACKS

Description of defect:
a) disc
The minimum thickness indicated on the outer rim of the disc has been exceeded by more than 1 mm. Furthermore, the disc has been subjected to excessive operating temperatures as a result of the reduced braking surface thickness. This causes cracks of a thermal origin.
b) pads
More marked wear can be noted in the central area of the disc whereas the area in correspondence with the pads is less worn. This can be attributed to the presence of hard points in the friction material, an indication that the production mixture was not homogeneous. It can also indicate poor functioning of the caliper.
Consequences: Distortion caused by vibrations during braking. In the long run cracks may form that can lead to disc breakage.

2.3.3 APPEARANCE OF CRACKS

Description of defect: The disc has been subjected to excessive operating temperatures: in the outer area of the braking surface there are evident signs of overheating. High operating temperatures lead to the appearance of cracks.
Consequences: Distortion and pad “bouncing”when hot that causes vibrations during braking. With time, cracks form and the disc may break.
Advice: The worn disc must be replaced. Check the state of wear periodically**.**

2.3.4 EXCESSIVE WEAR AND PADS COMPLETELY WORN DOWN

Description of defect: The disc is extremely worn and has been damaged by the metal pad support, the friction material of which has completely disappeared. The thickness of this disc when new was 7 mm, measured now it is 3.5 mm compared to a recommended minimum thickness of 5 mm.
Consequences: Very loud noises, very long braking distances, caliper functioning is critical.
Advice: Replace pads when they reach wear limits. Check out the pad wear warning indicator circuit.

2.3.5 BREAKAGE DUE TO EXCESSIVE WEAR

Description of defect: Braking surfaces show evident signs of overheating due to the considerably reduced mass of the worn disc. This situation has caused the braking surfaces to break away from the hub.
Consequences: Violent impact during braking. A very strong rasping noise when braking. Possible safety problem**.**
Advice: Always check the disc thickness every time the pads are replaced. Replace the disc before it reaches its wear limit.

2.3.6 EXCESSIVE PAD WEAR AND MOVEMENT OF THE SUPPORT

Description of defect: Disc thickness less than the limit value. The disc has been worn by the pad support as friction material is completely absent. The metal support plate has come out of its seat in the caliper and has almost entirely cut the disc brake surface from the carrier. The braking surfaces are near to breaking away from the carrier.
Consequences: Rasping noises, loss of effi ciency (considerable brake pedal slack), possible rubbing between the disc and caliper, thrust of the caliper is not symmetrical.
Advice: Check and, if necessary, repair the caliper. Replace the discs and pads.

2.4 DETERIORATION DUE TO OTHER BRAKING SYSTEM COMPONENTS

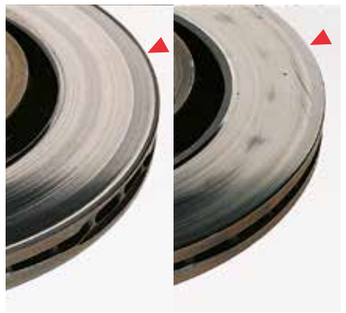
2.4.1 UNEVEN WEAR OF VARIOUS PARTS

Description of defect: A braking surface of one of the discs is in contact with the metal padsupport. Examining the pads it is noted that wear is uneven due to blocking of the caliper (the pads on the other caliper are in perfect condition).
Consequences: The caliper's two pads are completely worn down with consequent onset of noises and vibrations, the brake pedal has to be depressed completely. Braking distance is very long.
Advice: Check, repair or replace the caliper. Replace all discs and pads.

2.4.2 VITRIFIED DISC

Description of defect: Presence of a very fine deposit of friction material on the disc surface which now has a shiny fi nish (corrosion has then caused the detachment of part of this layer).
Consequences: Loss of braking effi ciency, braking distances too long. The pedal is very stiff but with no braking action.
Advice: Replace discs and pads. Use high, original, quality pads.

2.4.3 UNEVEN BRAKING SURFACE WEAR



Description of defect: The two pads were not positioned in the same manner with respect to the disc. Wear has not been the same for both surfaces. Heat spots can be noted at the centre of the braking surface due to high thermal exposure. The caliper and/or the pads were not fitted properly.
Consequences: Gradual onset of vibrations due to the heat spots. Possible appearance of cracks.
Advice: Check and, if necessary, repair the calipers. Check the pad model and friction material quality.

2.4.4 DEEP GROOVES AND SCORING

Description of defect: Deep scores caused by penetration of foreign bodies between pads and disc can be noted. This can be due to unsuitable pad material or the presence of badly distributed abrasives in the mixture.
Consequences: Very unpleasant noise both during braking and when travelling. Diminished efficiency as a result of the reduced contact surface between disc and pads.
Advice: Replace discs and pads.

2.4.5 FRICTION MATERIAL DEPOSITS

Description of defect: The braking surfaces are completely covered by very dark spots. These spots are due to deposits of pad friction material. This causes overheating which in turn leads to a transformation of the cast iron with the formation of very hard cementite. **Consequences:** Onset of vibrations that become progressively worse.
Advice: Only install friction material that is suited to the brake and vehicle.

2.4.6 BRAKING SURFACES PARTLY WORN BY THE PADS

Description of defect: The braking surface only shows wear in the outer area. The inner area never comes into contact with the pads as indicated by the presence of corrosion (rust). This situation could be caused by:
- incorrect installation of the caliper and hence the pad which does not make full contact with the disc
- loss of part of the friction material
- fitting of wrong pads

Consequences: Reduced braking torque. Increase in operating temperature as the surface on which the pad works is reduced (by about 50% in this example) compared to its normal working surface. There is a risk of localised overheating and therefore the onset of hot judder-type vibrations. Moreover, reduced system efficiency leads to high stress levels and therefore rapid and/or uneven wear (cold judder).
Advice: check the installation and correct functioning of the caliper. Check the fitting and condition of the pads. Check that the pad model is suitable for the particular vehicle.

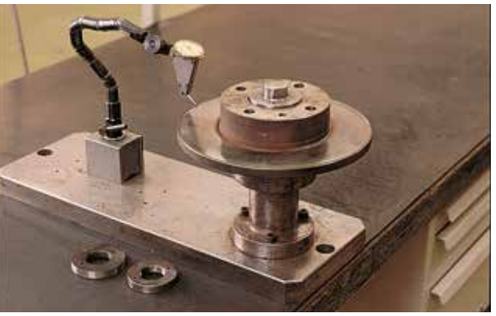
2.4.7 PARTIALLY WORN AND VITRIFIED BRAKING SURFACES

Description of defect: This disc shows a deterioration that is the sum of defects described in 4.4.2 and 4.4.6 above. In this case the pad only acts on the inner section of the braking surface. High stress has led to overheating, vitrifi cation (deposit) and detachment of friction material.
Consequences: Progressive reduction in efficiency of the system and, when friction material detaches, total ineffi ciency of the system.
Advice: As for 4.4.2 and 4.4.6.

2.4.8 CURVED PADS

Description of defect: The pads only act on the central section of the braking surface. They may be curved.
Consequences: Reduced braking action with the consequences described in points 4.4.6 and 4.4.7.
Advice: Check pad planarity and the functioning of the calipers.

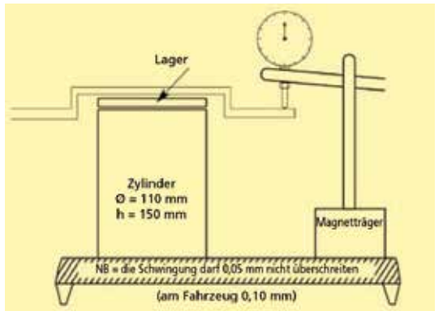
2.5 CHANGES IN DISC SIZE CHARACTERISTICS



Bench for checking discs.

When initial measurements of the fi tted disc and successive observation do not give clear answers, it may be useful to analyse disc dimensions further. Placing the disc on a bench as seen in the illustration, it is possible to measure its dimensions without these being affected by other brake components.

- After cleaning the surface coming into contact with the hub using sandpaper, the disc must be able to rest on the bench bearing without run out. This is done by holding the disc at the extremities of a diameter with the fi ngers and checking its vertical movement. If the disc is unstable this indicates distortion due to incorrect or excessive tightening.
- With the aid of a DTI Gauge mounted on a fi xed base it is possible to measure the disc's production run out, provided that it has not been rectifi ed by the mechanic at the time of fitting. This measurement is carried out by resting the DTI Gauge against the external or internal edge of the disc where the pads have not worn the braking surfaces. If the run out value measured is greater than 0.05 mm it means that the disc originally had a marked run out, a certain cause of vibration. If the value is less, then the acquired run out is measured by placing the point of the DTI Gauge at the centre of the braking surface: if it is beyond the tolerance this indicates incorrect installation that causes vibrations after a few thousand kilometres (cold judder due to a DTV increase).
- Lastly, when travelling, it is possible to determine if vibrations are caused by the front discs or the rear drums. Proceeding at low speed, pull lightly on the handbrake: if there are vibrations the problem concerns the rear drums (check and, if necessary, replace them).



Vibrations are produced by the rear drum: cracks and blue spots.

BREMBO ADVICE TO USERS

01 - Braking style - just like driving style - must always be adapted to climatic conditions and the state of road and traffic.

02 - Braking distance not only depends on braking system effi ciency but also on the conditions of tyres and suspension.

03 - Optimal braking within a limited distance is which provides maximum deceleration without locking the wheels, the consequences of which would be the loss of vehicle stability and an increase in braking distance.

04 - In the case of long downhill stretches it is advisable to use the engine brake and above all not to switch off the engine. After a brief stop, check pedal effi ciency before starting off again.

05 - When the situation requires a prolonged and continuous use of the braking system, release pressure on the brake pedal from time to time for a brief period.

06 - After stopping for a long period the fi rst braking actions will be affected by the stop, and also by climatic conditions. A certain number of braking actions should be performed in order to re-establish the full effi ciency of the disc-pad unit.

07 - Ensure that all parts of the braking system function correctly: fl uid level, pad and disc wear, rear brake lights, parking brake indicator, etc. Follow the manufacturers instructions as regards replacement of the brake fl uid (frequency, quality).

08 - Periodically check the effi ciency of the parking brake by trying to move the vehicle when this brake is on.

09 - Only use spare parts produced by recognised manufacturers.

10 - If possible, use a vehicle equipped with a braking control system (ABS, etc.).

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