The final part of a three-part investigation **03**/03

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Written by

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Brake expectations

Written by John Boggiano

Porsche Ceramic Composite Brakes (PCCB) – what are they, and should they be seen as the Holy Grail of performance brakes? In the third part of our three-part feature, we examine further problems and determine their causes and incidence, plus how to avoid them

Degradation of Friction Surface

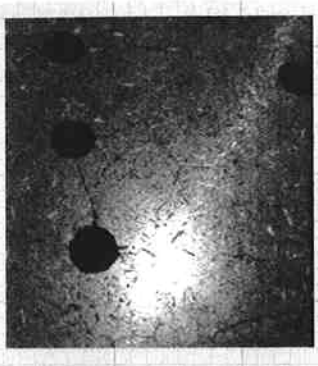
More seriously than the potential problems that we've considered in the first two parts of our investigation, there have been several other reports of apparent structural failures of PCCB discs. It's fair to say that as development has progressed, these reports have become far less frequent, but they haven't gone away altogether. As implied, the first generation of PCCB seem to have had by far the highest rate of incidence of these problems.

Ongoing development of PCCB has majored on improving the cooling, both by modification of the cross holes and internal channels, plus improved thermal conductivity of the discs themselves, and by improved ducting of cooling air via aerodynamic paraphernalia on the cars so equipped. This leads us towards the logical conclusion that many or most of these failures have been caused by overheating of the disc and/or pads. In photographs of some PCCB so affected, it is even possible to see scorch/heat marks on the calipers and/or mounting 'bells'.

Initially, this may seem a strange conclusion; after all, resistance to extreme temperatures is one of the carbon-ceramic composite's fortes – we have already seen that PCCB discs can be heated to around 1,350 degrees Celsius before there's a significant change in their performance, compared to around 700 degrees for iron discs (brake fluid would be boiling by the time it reached around 250-300 degrees, but it is somewhat insulated from the heat source). But there is a big difference in the way the materials behave at their respective limits. More pertinently, it's possible that the pads in particular may deteriorate rapidly after overheating and there is much evidence from affected owners that they may fragment or disintegrate, a process perhaps contributed to by part-bonding to the disc's friction surface (especially if proper bedding in has not been carried out, which can deposit a protective layer on the disc surface). Damage to the disc friction surface might then occur as the pads' backing plates make contact with it or the overheated pad material crumbles and loses its smooth surface, or perhaps even adheres to, and pulls at it.

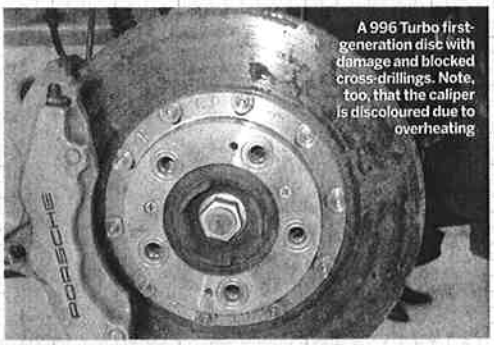
There has been some speculation that the metal mounting pins within the pad material may also cause damage to the disc. The reality is that these comprise Pagid's patented Safety Lock system, which has been created and developed specifically to reduce the risk of disintegration of the pad material under very high loads and temperatures. The pins are softer than the ceramic material of the pad itself and will not damage the PCCB discs, but their exposure (which occurs when pad thickness is roughly the same as the braking plates') seems to represent a sensible moment to change to new pads, as beyond this point, overheating becomes progressively easier to do with extreme use.

A driver pushing iron discs beyond their thermal limit will find (if he's lucky) that his brakes will go spongy and then fade; if he's unlucky (or just not sensitive to such things), he may suddenly find himself with a completely non-functional brake pedal. That's very unpleasant but easily rectified ➲



If you found hairline cracks between drillings on a steel disc, you'd have to replace it. However, on a PCCB disc such a crack is simply due to stress relief in the production process and is nothing to worry about

This second-generation disc has covered 18,000 miles including no less than 57 trackdays. As you can see, there is no discernable wear to the disc – a steel disc would be noticeably lipped after such use



A 996 Turbo first-generation disc with damage and blocked cross-drillings. Note, too, that the caliper is discoloured due to overheating

These friction pads have broken up, most likely because of heat damage

Points to look for

When examining PCCB, perhaps on a potential purchase, pay attention to the following:

01 Check around the edge of each disc for damage – officially two x 10mm (and a maximum of three damaged areas per disc) is acceptable, although you might feel otherwise...

02 On second-generation discs, check circular wear-indicators (three small, equally spaced points on each disc face) – depending on lighting conditions, they may be discernible by colour or texture, but they should be flush with the surface – an indentation (caused by carbon-burn) indicates wear.

03 It is acceptable for a car to have first-generation discs on one axle and second generation on the other, but they must not be mixed on a single axle.

04 Remember that fine, superficial surface cracking from the cross-drilled holes is perfectly normal and is a result of the manufacturing process rather than an acquired fault. In this respect, PCCB are quite different from cast-iron discs.

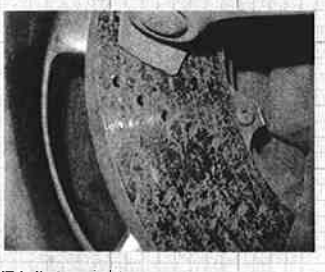
05 Note that areas of roughness, if present, should not exceed 1cm² at any point. That is to say, any area of 1cm² must not consist entirely of worn, roughened surface. They are, however, a sign that wearing of the surface is taking place.

06 Check the thickness of the brake pads, bearing in mind minimum suggested thickness of just less than that of backing plate.

07 Feel the overall texture of surface; it should be smooth or matt, not rough.

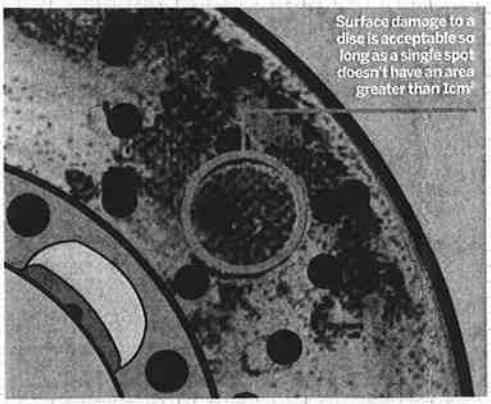
08 Completely blocked cross-drilled holes could be a sign of hard use and/or neglect.

09 Check the caliper and 'top hat/bell' for any signs of discoloration due to overheating. There should be no areas looking scorched or burnt as this might indicate a sticking caliper, or some extremely hard use.



This first-generation disc on a 996 Turbo is worn but is still serviceable

A severely damaged first-generation disc. Replacement won't be cheap...



Surface damage to a disc is acceptable so long as a single spot doesn't have an area greater than 1cm²

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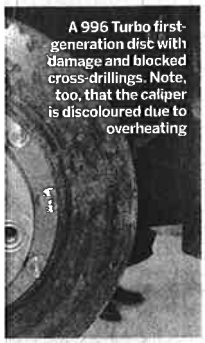

A 996 Turbo first-generation disc with damage and blocked cross-drillings. Note, too, that the caliper is discoloured due to overheating

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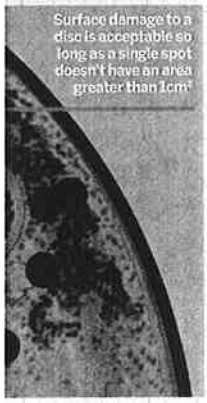


Surface damage to a disc is acceptable so long as a single spot doesn't have an area greater than 1cm²

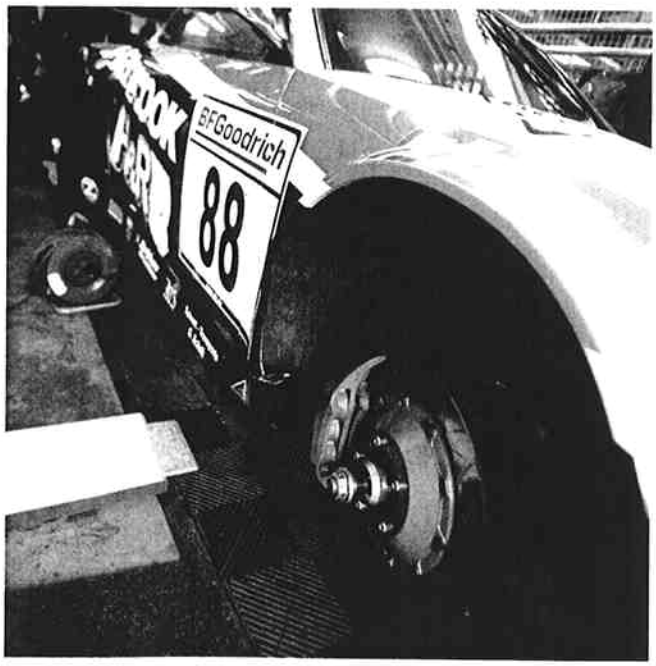
by letting the brakes cool right down (and, perhaps, ultimately changing the fluid and so on) – no harm done, as long as you didn't hit anything...

PCCB are different, though. They were specifically developed to be fade-free and to handle extremely high temperatures without complaint, but eventually, something has to give. We have seen some speculation that the problem might be exacerbated in the earliest PCCB-equipped cars by the 'hammering' action of the ABS (particularly as the brake fluid approaches or exceeds its boiling point), the modulation parameters of which have apparently subsequently been altered on later cars. We have seen no corroboration of this idea, however.

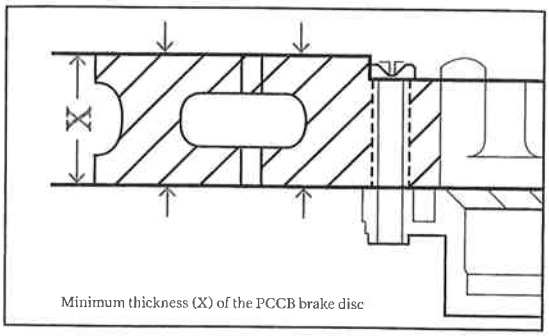
Why should drivers be pushing their PCCB so hard, to temperatures well beyond the limits of a conventional braking system? Simply because they can – that lack of any indication through the middle pedal that there's anything amiss, coupled with stupendous stopping power from the brakes even under extremely high loads leads one to push ever harder...

It's a situation not helped by the intensive development process of PCCB. With the likes of Walter Röhrl at the wheel, it's pretty obvious that brakes are going to be tested hard. But with lesser mortals at the helm, while the materials might not be pushed to the limits of their performance parameters in most respects, overheating is much more likely. A professional racing driver or skilled test driver doesn't pussyfoot around when it comes to braking: at the braking point, they're on, hard; the moment sufficient speed has been removed, they're off again. Application and release are smooth and progressive but rapid, and the time that the pads are actually pressed against the disc is minimised. As a result, heat build-up is reduced and its rapid dissipation facilitated. Contrast that with the braking technique of many amateur drivers and trackday heroes (and I'm including myself in this category): braking is unnecessarily gentle, starts too early and is consequently prolonged, which then results in rapid heat build-up and potential problems.

For many trackday participants, it's a problem made worse by a failure to allow the brakes sufficient time to cool before the car becomes stationary at the end of the session – a cooling-down lap, with minimal use of the brake pedal is an essential part of the process of caring for PCCB, especially with regard to the brake pads. They will not cool adequately or evenly when the car is at rest back in the paddock, as they have been deprived of the vital flow of air through the body of the discs.



After trackday use a cooling-down lap is essential. PCCB will not cool adequately or evenly when the car is at rest back in the paddock (left), as they have been deprived of the vital flow of cooling air



Minimum thickness (X) of the PCCB brake disc

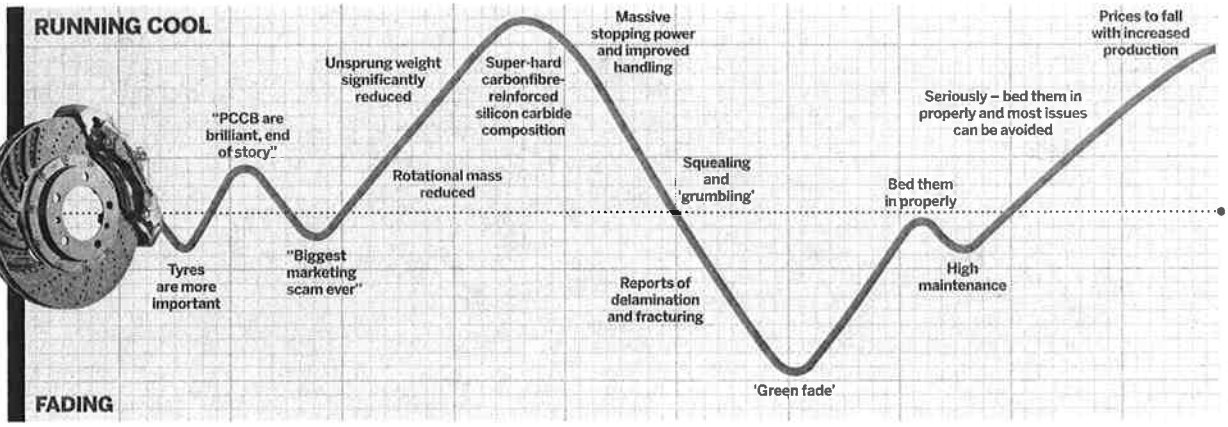
Check the thickness of the disc – the minimum thickness is stamped on the rim of the mounting 'top hat', between a pair of securing nuts

Wear

This brings us to the fourth potential problem affecting PCCB – wear. When PCCB were launched, much was made of the ceramic material's tremendous strength and hardness – claims were made (rather rashly, as history was to reveal) that PCCB discs would last the lifetime of the car no matter how hard they were used, and marketing photographs showed 911s on track with PCCB discs glowing red. Yes, well, even Porsche learns by its mistakes and I think it's fair to say we won't be seeing that sort of thing again any time soon! The people who were in charge of the marketing department back then are probably now working their way up from the bottom again...

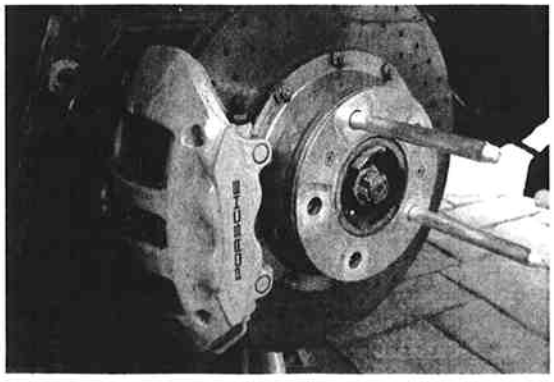
Like any friction surface, the outer layer of the PCCB composite is subject to wear. True enough, this is vastly reduced compared to a conventional iron disc, but it's there nonetheless. Second-generation PCCB discs even feature wear indicators: circular regions about 1cm in diameter at three points around the disc. These wear sacrificially, so that a wearing disc will develop distinct and precise pits at these points. In addition, wear presents itself as a progressive roughening of the disc's friction surface and, sometimes, fine surface cracks around the cross-drilled holes may appear. Strictly speaking, the latter are stress-relief fractures created during production of the disc, but often not visible. Porsche's technical material states that roughened areas must not exceed 1cm² at any point, although they may still take the form of extended areas.

As this process continues and more areas of the disc become affected, the disc is still serviceable as long as the roughness doesn't exceed roughly 70 micrometers unless it is accompanied by pronounced fracturing of the surface. Now that might not mean very much ➲



"It's as well to remember the benefits of PCCB in comparison to even a high-quality iron setup"

to you and me, but the rule of thumb seems to be that the surface should feel 'matt' rather than 'rough'. To quote Porsche's Technical Bulletin on the subject: "In the advanced stages of fibre burnout and the initial destruction of the Si and SiC matrix, the depressions... become more pronounced. Large sections of the surface are still intact, the depressions form an even, fine-grained pattern. The surface still feels matt, and the roughness is not yet pronounced. No replacement necessary!" It goes on to state that replacement is only required when roughness is beyond 100 micrometres (noticeably rough to the touch) and only "...remains of the original surface are left".



Follow the bedding-in procedure, take extra care to maintain (this disc is having its drilling cleaned out) and your PCCB will last a very long time

So that acts as guidance on what to look for on the disc surface as it begins to wear, but as you might expect, the discs also have a minimum measurable thickness. This is stamped on what Porsche calls the 'brake disc chamber' (in fact it's on the rim of the 'top hat', between one pair of securing nuts), in the form: 'Min. Th. 33.7mm' or similar. Adjacent to this figure, there's also a note of the total weight of the unit (disc plus mounting bell) – this, too, can be used as a guide, although it is intended only for use in a racing environment (where the wear indicators may become blocked with pad material): obviously it's not a parameter that's easy or quick for a home mechanic to measure. The limit in this case is a 2.5 per cent loss.

With predominantly road use, you can expect your PCCB to last a very long time indeed, unless they become damaged, of course. Naturally, it's almost impossible to put a precise and reliable figure on these things (there are just so many variables involved), but you can be confident that by the time they need replacing, you would have spent a good proportion of their cost on cast-iron discs along the way if you had gone down that route. Even in the case of first-generation PCCB, wear is not necessarily a problem: many owners have contacted us to point out that their first-generation discs are at 40k, 50k and 65k miles and still going strong. Several of these owners actually combine road and track use, and at least one runs his with the harder compound motorsport pads.

But it's inevitable that the more aggressively the brakes are used, the greater the proportion of driving time that is spent on track and the harder the pads that are utilised, the greater the wear rate of PCCB (or any) discs will be. However, it is very important to appreciate that during the research for this feature, evidence of PCCB replacement due to simple, straightforward wear has proved very illusive, at least as far as non-racing use goes. We have heard reports of racing teams having problems with disc wear, but that's not an arena we need to look at here – racing teams are well capable of looking after themselves in our experience, and they also have somewhat larger budgets than most of the people who will be worrying about whether to buy a PCCB-shod 911 and who are reading this feature. In addition, even the keenest trackday hound is unlikely to use his brakes as fiercely as would happen during a race – poor technique notwithstanding.

Summing up

Having considered the problems that can occur with PCCB, it's important to bear in mind that none of these are common, especially for second-generation systems. Furthermore, before criticising the technology for being less than perfect in all circumstances, it's as well to remember just how many benefits PCCB has in comparison with even a high-quality cast-iron brake disc setup. It's also important to remember that no braking system is without potential problems and that they all have limits to their operating parameters and performance, as well as their own unique strengths and weaknesses. Perhaps the Achilles heel of PCCB is that a big problem leads inevitably to a huge expense, but that doesn't mean that such a thing is at all likely and neither does it mean that its risk can't be minimised or even eliminated.

In summary, while not discounting other very isolated problems perhaps caused by manufacturing defects, damage caused upon initial in or subsequent work and so on, overwhelming evidence is tha have proved to be a very succe product and a real and signific advance in brake technology. V problems exist are often not u this technology and can gener avoided or overcome easily on causes are appreciated and un

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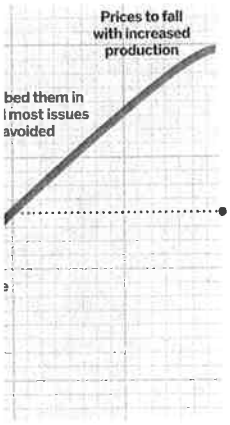

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damage caused upon initial installation or subsequent work and so on, the overwhelming evidence is that PCCB have proved to be a very successful product and a real and significant advance in brake technology. What problems exist are often not unique to this technology and can generally be avoided or overcome easily once their causes are appreciated and understood.

While some potential benefits are perhaps unlikely to make a meaningful difference for most drivers, others (such as the reduced weight and resistance to fading, wear and corrosion) are very significant. Those problems that have occurred seem to have been all but eliminated in the improved design of the second generation – whose enhanced cooling benefits the entire braking system – and their risk can be mitigated further by the thorough bedding in of new pads and especially by considerate use. We are well aware that a hardcore of PCCB sceptics will scoff at this conclusion, but that is our considered view nevertheless.

However, PCCB can be rather vulnerable to mechanical damage and this must be remembered when changing wheels, cleaning the in-disc holes and so forth. It is sensible to assume that care must be taken also when the possibility exists of small stones becoming trapped in the calipers, although the maker reports no known examples of damage so caused. Depending on usage conditions and the type of driving involved, PCCB (especially first generation) undoubtedly require the driver to pay consideration to his brakes to a degree unfamiliar to many and this fact goes against the grain for some. For our part, we would suggest treating them much as a responsible owner would treat his car's other components, for example, its tyres, or especially the engine – not using it hard from cold, not holding it for long periods at the redline, and generally taking good care of it. A good measure of mechanical sympathy is an asset for any driver.

Probably the most pertinent question we have sought to answer here is: 'Should I specify PCCB when ordering my new 911?' If you expect to do most of your driving on the road, even with a good dose of track driving thrown in, our answer would be an unequivocal 'Yes', but remember that you should take care of them as outlined in this feature. If the intended use of your PCCB-fitted 911 is going to be very heavily track-focused, so long as your braking technique is up to the setting and provided you accept the projected costs of fairly frequent pad changes, then again the answer is also a resounding 'Yes'. But on no account neglect the process of bedding in each new set of brake pads.

When buying a used 911 with PCCB, check their condition carefully. If the car has good-condition discs, but they are first generation, go ahead, but be mindful of the caveats when it comes to track driving in particular. Be sensible; for example, don't stay out for very long periods if it's an 'open pit lane' day rather than sessions.

Treated with care and respect, and with a full understanding of their properties and characteristics, the overwhelming evidence is that PCCB are a tremendous asset for your 911, whatever its intended use. As prices drop – and they will, as production levels increase over the next few years – the case for PCCB will become even more clear cut. Even with replacement costs as they are today, bearing in mind what we have learned over the course of this feature, there is no reason for apprehension and there are many reasons to seek out those yellow calipers on your next 911.

It seems the future of performance brakes really has arrived after all. **911**

Do you agree?
Clearly still a subject of much contention, why not continue the debate at: www.total911.com/forum

Acknowledgements

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