Brake Fade
And
Ti Brake Shields
by Sherwood Lee

Porsche owners are fortunate recipients of pretty decent factory-equipped brakes. From the early, non-assisted, 4-wheel discs in 1966 to the current, state-of-the art ceramic rotors and “generously-sized” Brembo calipers, Porsches have always excelled in producing vehicles superbly balanced in many areas of performance, but especially their brake systems.

Brakes, however, have thermal limits. These limits depend on the amount of heat energy brake components must deal with and dissipate. This in turn relates to the rate of speed reduction and/or the number of times this must occur from speed. While stock brakes are perfectly adequate, perhaps overkill for “normal”, even spirited street driving, these same brakes used in track or high-performance conditions can quickly reach their limits especially when engine modifications have increased the vehicle’s speed potential. These limits are the result of brake fade in one form or another.

Figure 1: Typical Brake Caliper Parts
Brake Fade

A loss of brake effectiveness is due to brake fade. It is the primary problem one experiences during high performance braking. The symptoms range from less braking effectiveness to a total loss of brakes, sometimes with potentially fatal results. There are three kinds of brake fade commonly experienced during spirited driving:

1. Pad fade
2. Green fade
3. Fluid fade

Pad fade

Pad fade can be caused by several factors. All friction materials have a coefficient of friction curve relating to temperature. Friction materials are designed to work at an optimum temperature when the coefficient of friction is the highest. When brakes are used too frequently, if the pad material is not adequate for the temperature, then the coefficient of friction can decrease. Brake materials are different, and with enough temperature the material can melt and cause the coefficient of friction to rapidly decrease to the point where the material will melt and/or change its frictional characteristics and cause a lubrication effect.

As temperature increases, the friction material can melt and the resins that bind the friction material can vaporize and “out-gas”. These vaporized gases prevent intimate contact with the rotor which, in turn, reduces friction. Some pad materials change slowly at elevated temperatures while other materials react with a sudden and dangerous loss of friction. The result is “glazed” brake pads and rotors.

How To Reduce Pad Fade?

Use pads with a high temperature high coefficient of friction. There are four basic types of brake pads. Ranked in order of effectiveness from normal to aggressive driving:

1. Organic Usually light brown or tan
2. Semi-Metallic Light tan with metal flecks to dark gray
3. Full Metallic Dark gray to black
4. Carbon Dark gray to black

There are trade-offs here. A less aggressive brake material may be fine for normal street driving but may be ineffective for repeated stops from high speed. An aggressive brake material may be ineffective when the brakes are not up to temperature resulting in a loss of braking effectiveness for street driving conditions but may be just the ticket for repeated braking from high speed.

Green Fade

This is the type of brake fade caused by hard braking on relatively new pads. With new pads, the resins that bind the friction material will “out-gas” at relatively low temperatures. This is caused by not “bedding” the pads rather than being caused by elevated braking temperatures. Green fade typically occurs much earlier than normal pad fade. This can catch an unaware driver off-guard who may be used to the way the car behaves during normally braking. Green fade can happen even after changing the brakes and driving normally for many hundreds of miles. The first aggressive stop may result in a loss of friction thanks to green fade.

How To Reduce Green Fade?

“Bedding” or “breaking-in” the brake pads will eliminate green fade. By bedding the pads correctly, the resin gases vaporize without overheating the pad material. It is generally recommended to bed-in new pads on used rotors. Older rotors tend to be more dimensionally stable and less likely to warp or cracking during the bedding process.

Brake pads will also bed-in faster if the rotor is not shiny. Break up the rotor surface with a sanding disc (approx. 200 grit) on a drill motor. As with all newly installed brake pads, step on the brakes to verify the pads contact the rotor surface before you actually have to stop the car. Some manufacturers have specific bedding instructions. Here is one bedding procedure:

a. At a vehicle speed of approximately 50 mph, apply the brakes while applying throttle to maintain vehicle speed. Drag the brakes for about 8-10 seconds, then release them
b. Drive for about a minute to allow the brakes to cool, then drag the brakes again for another 15-20 seconds. Brakes may begin to smoke and braking efficiency may decrease slightly (green fade)
c. Drive for a minute to cool off the brakes, then drag brakes for about 25-30 seconds
d. Drive for a couple of minutes to cool off the brakes
e. Repeat process 2-3 times.

At the track, do not apply the parking brake after shutting down as this might warp the rotors. Try a cool-down lap to allow the brakes to cool off. After hard running, heat soak can damage the caliper seals and warp the rotors.

Brake Fluid Fade

Fluid fade is caused by overheated brake fluid. The energy converted during braking creates tremendous heat which must be handled by the rotors, calipers, brake pads and the brake fluid. When fluid reaches a critical temperature, it boils. Regular brake fluids boil around 400°F, the best ones are stable up to 500°F and higher. Whatever the rating, when brake fluid boils air bubbles are created. Fluid in a closed system cannot be compressed. However, air can be compressed, and when boiling brake fluid creates air bubbles, the brake pedal and master cylinder travel is used up compressing the air and thus unable to hydraulically move the pads against the brake rotor.
Since brake fluid is hygroscopic (affinity to absorb moisture), fluid (or the water in it) will boil at lower temperatures. This is the main reason to change fluid at prescribed intervals. Fluid fade can occur gradually as brake components heat up, especially during repeated braking from high speed. The heat generated by friction must go somewhere. Brake components act as heat sinks as they absorb the friction-generated heat from braking. When more heat is generated than can be dissipated, the fluid will boil.

How to Reduce Fluid Fade?

Brake fluid fade can be avoided by using fresh, heavy duty brake fluid (Motul, Castrol SRF, AP600, etc. are commonly used fluids in track cars.). Use a brake fluid with high wet and dry boiling specifications. There are excellent, high temperature brake fluids on the market (see enclosed Heavy Duty Brake Fluid Chart).

On a street driven vehicle, change fluid every year and top up using fresh fluid from an unopened can. On a track car, change brake fluid and bleed the system before each race. This schedule minimizes the presence of water (and corrosion) in the brake system, maintains the high boiling point of the fluid and provides the additional margin to help prevent fluid fade.

Seine Systems’ Solution to Brake Fluid Fade

Using Titanium Brake Shields to Reduce Brake Fluid Fade

During braking, brake fluid is heated by the transfer of heat from the brake pad backing plate directly to the caliper piston(s). The opposite end of the caliper piston is in direct contact with the brake fluid inside the brake caliper. Thus, heat generated by the frictional material of the pad transfers directly to the caliper piston and brake fluid. Notice the relatively small fluid chamber in a caliper (Figures 1 and 3). This small volume of fluid must absorb and withstand tremendous amounts of heat and still remain stable.

One solution is to use larger brake components (caliper and rotor) so the increased mass can absorb more heat. However, this option is expensive and may be limited by race rules. The additional weight also adds unsprung weight which can affect vehicle handling. Another solution is to use brake materials that inhibit heat transfer to the fluid. Most OEM caliper pistons are made of steel. However, stainless steel is better than steel in this regard and pistons made from this material can sometimes be added to certain brake calipers. Some aftermarket brake calipers are equipped with stainless steel pistons.

Titanium possesses even lower heat conductivity numbers than steel (7x) or stainless steel (3x). Taking advantage of this semi-exotic material (high strength-to-weight ratio and expensive),
some brake manufacturers (e.g. Alcon, Wilwood) use titanium pistons or titanium coatings on the caliper pistons to help shield the brake fluid from high brake temperatures.

Seine Systems’ solution is to use titanium as a heat shield. Shaped like the brake pad itself, the Ti Brake Shield (Figure 2) sandwiches between the caliper piston and the brake pad. With a shield installed behind each brake pad (Figure 4 and 5), heat transfer between brake pad and brake fluid is reduced by as much as 50ºF. This often provides the margin needed to prevent fluid boiling and a loss of brakes. In fact, some racers have found that air ducting is not needed or no longer necessary when using these shields. In addition to its low thermal conductivity, titanium has high tensile strength. Titanium also has excellent corrosion resistance to salt water and is resistant to a broad range of acids, alkalis and chemicals for long life. Total added weight is only 4-6 oz./wheel (depending on application).
Here is a chart that compares the thermal conductivity of various materials. Seine Systems uses aircraft grade titanium alloy. Notice that different grades of Titanium are not the same.

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*Seine Systems Ti Brake Heat Shields are made from this aircraft grade titanium alloy.

**Summary**

To help prevent brake loss due to fluid fade, interpose a low thermal conductive material between the brake fluid and hot brake system parts. Titanium, especially the alloy grade used in this product, has superior (low) heat conductivity characteristics. While installing larger brake calipers and rotors is always an option, upgrades are costly and perhaps unnecessary. In addition, many race organizations place limits on the type of brake modifications allowed in order to participate or to remain in class. Ti Brake Shields are a cost effective upgrade to improve the efficiency of your brake system.

For these reasons, **Ti Brake Shields** provide the next logical step toward better brakes.

**Bibliography:**
- Smith, Carroll, *Engineer to Win*, Motorbooks International, 1984
## Ti Brake Shield Applications: Part No. TBS-1

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