Introduction - Brake Upgrades

Kinetic energy (the motion of the car) is converted to *HEAT* energy when the brakes are applied.

The amount of *HEAT* produced is directly influenced by:

1. The *WEIGHT* of the car.
2. The *SPEED* from which the car is braking.
3. How *OFTEN* the brakes are applied (and the *COOLING TIME* allowed between brake applications).

$$E = \tfrac{1}{2}MV^2 \qquad \text{Heat} = \tfrac{1}{2}(\text{Weight})(\text{Speed})^2$$

The key point is that additional vehicle weight and speed do not affect the amount of heat generated under braking in a LINEAR fashion. The effect is *EXPONENTIAL*.

- If you double the speed that you are braking from, you don't generate twice as much heat. You generate FOUR TIMES as much heat.

- **A stock Golf 7R accelerates from 0-60mph in around 4.6 sec**
- **A stock Golf 7R brakes from 60-0mph in around 3.8 sec**

Of course the above figures are dependent on many variables including driver reaction times, road surface condition, tires etc. The point is that roughly the same amount heat that is generated to get the car from 0-60mph is put back into the brakes during a 60-0mph emergency brake application.

The heat generated during acceleration is absorbed by the engine block and all surrounding components and is managed by a water-cooling system with a large radiator as well as other advanced heat management systems.

The majority of the heat generated during emergency braking is dumped into the two front brake discs weighing only 10.8kg / 23.8lbs each. The brake discs weigh a fraction of what the engine and related components weigh and they have no water-cooling system. The only cooling system the discs have is airflow and since they act as impellers, the airflow reduces as vehicle speed reduces (which is happening at the same time that brake disc temperature is rising).

The previous example discussed a single emergency stop but what happens when there are numerous consecutive brake applications in short succession (such as when driving aggressively in an urban environment or driving a canyon road or taking part in a track day)?

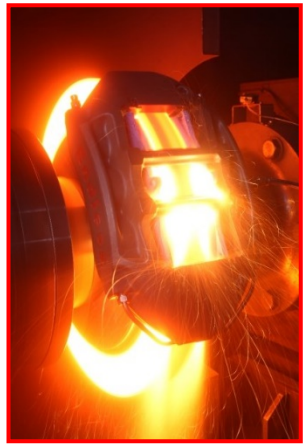
It's simple: If you keep putting more heat into the brake discs before they have had a chance to cool back to ambient temp then you have a compounding effect. You are putting heat into the brake discs faster than the discs can get rid of the heat. Eventually you will experience brake fade (when you run the brake pad friction material to above it's max operating temp), vapor lock (when you boil the brake fluid in your calipers) or eventually catastrophic failure of the brake discs (cracking or even shattering).

600 deg C / 1112 deg F

700 deg C / 1292 deg F

800 deg C / 1472 deg F

900 deg C / 1652 deg F



APR

APR's core business is making VW's, AUDI's and Porsche's faster. This means that more heat is going to be generated under braking on the street, at the drag strip or on the track.

There are two ways of dealing with this additional heat:

1. **Fit standard size brake components that can handle operating at higher temperatures than the factory fitted components –**

(UPGRADED STANDARD DIAMETER BRAKE DISCS)

2. **Fit larger brake components that increase thermal capacity and have features that allow them to cool more efficiently –**

(BIG BRAKE KITS)

1. UPGRADED STANDARD DIAMETER DISCS

Front

Rear

1. UPGRADED STANDARD DIAMETER BRAKE DISCS

- Cast from alloys that can handle operating at higher temperatures, for longer periods than factory discs can.
- Properly designed slot patterns can be tuned to positively influence ‘bite’ and ‘release’ characteristics.
- Properly designed slot patterns gently scrub the pad friction material surface hereby de-glazing the pads.
- There are limits to what can be achieved with upgraded standard diameter discs though as this solution adds no more thermal capacity to the system. The discs are capable of operating at higher temperatures but the higher temperatures will eventually start to affect other surrounding components in the brake system. For example: Pads may start to reach their max operating temp resulting in brake fade. You can fit track day or race pads but these tend to run noisy and are very abrasive to discs under street driving conditions. Eventually brake fluid will begin to reach it’s limit and boil leading to vapor lock - a very dangerous situation. Rubber brake hoses, caliper seals, and rubber boots will all start to fail if peak brake temps get too high.
- At the end of the day upgraded standard diameter brake discs should be considered a cost-effective brake upgrade that is best suited to tuned street cars. For highly tuned street cars or any form of track day use a big brake kit is highly recommended.
- Of course the truth is that many customers will buy slotted discs simply for the Aesthetic appeal.

2. BIG BRAKE KITS

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- Larger diameter and wider discs add significant thermal capacity to the brake system.
- Advanced, directional cooling vanes get rid of heat far more efficiently.
- 2-piece discs allow disc friction rings to expand & contract independent of the disc hats, hereby greatly reducing stresses and 'coning effect' of the discs at high operating temperatures.
- Although the 2-piece discs in big brake kits are larger, they often weigh significantly less that the factory 1-piece discs as a result of the lightweight, billet hats. This reduces un-sprung weight, rotational mass and gyroscopic effect.
- Lower operating temperatures increase disc life significantly.
- Larger pad volume increases pad life significantly.
- Compliance or 'flex' is greatly reduced throughout the system resulting in a firmer brake pedal and improved brake modulation.
    - Stainless steel braided brake lines have far lower volumetric expansion that factory rubber brake hoses.
    - Billet multi-piston calipers are significantly more rigid than factory calipers.

Why are the vast majority of Big Brake Kits generally fitted to the front axle only?

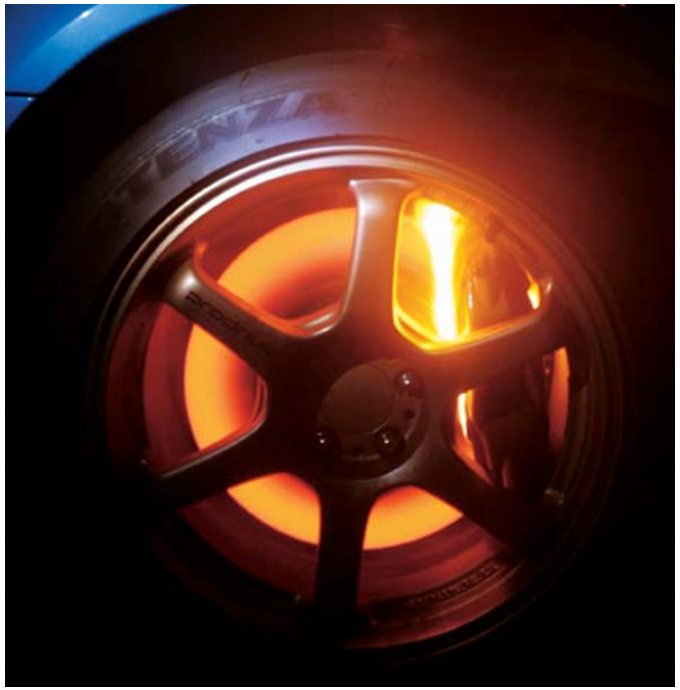
- **As a result of the weight transfer to the front axle under braking (and the simultaneous unloading of the rear axle), the front brake system is doing the majority of the braking. Big brake kits are therefore generally not technically required on the rear axle.**

- **At the cost of a Big Brake Kit (combined with the fact that they are typically not technically necessary) there is very little demand for rear Big Brake Kits.**

Brake upgrades for track day use – A case study:

- Car manufacturers design factory brake systems for street use with priorities such as stopping distance in a single emergency stop, low noise during daily commuting, acceptable disc / pad wear and low manufacturing costs at the top of the design brief.

- Factory brake systems / components are not suitable for track day use - PERIOD.



Brake upgrades for track day use – Continued:

- **It is common for a customer to attempt his first track day with his factory brakes. The rationale will often be: 1) "I'm an amateur, I'm not a race car driver, so I don't need upgraded brakes" or 2) "I only intend to do 1 or 2 track day events per year, so I don't need upgraded brakes".**

1. "I'm an amateur, I'm not a race car driver, so I don't need upgraded brakes":

- **They do not have the skill level to carry decent apex / corner speeds, meaning that they have to scrub off far more speed before each corner than a race car driver resulting in far higher brake temps.**
- **Their cars are often at full weight (unlike stripped out race cars) which results in far higher brake temps.**
- **Amateur track day enthusiasts are generally not willing to cut holes into the front fenders of their car in order to duct cool, high pressure air to the front brakes (as is the case with almost all race cars). The result higher brake temps.**
- **And finally, the worst point of all. Amateur track day enthusiasts often feel that they can buy faster lap times by adding horsepower, rather than working on building their driving skills to be able to carry more corner speed. This is a big mistake in terms of brake temperatures. If the driver does not improve his ability to carry more corner speed but he keeps adding more horsepower, then he simply arrives at very corner faster but his apex speed never increases and he therefore needs to scrub of more speed under braking. The result is massively increased brake temps.**

- **FACT: Amateur track day enthusiasts are often the 'worst case scenario' from a braking perspective!**

Brake upgrades for track day use – Continued:

2. “I only intend to do 1 or 2 track day events per year, so I don’t need upgraded brakes”:

- The number of track days that a customer plans to do in a year has nothing to do with having safe, consistent brakes during a single track day. It is all about the max operating temperatures that will be reached during a single track day and whether the brake components on the car will remain safe during that single event.
- There is nothing worse than an amateur experiencing dramatic brake fade or vapor lock during his first few events when he is pretty overwhelmed and inexperienced as a track driver at that point.
- Not only will a Big Brake Kit with the correct pad compound and correct brake fluid deliver increased brake consistency and safety but in the end the customer will end up saving themselves money by investing in a Big Brake Kit up front, before they start tracking their car.
- It is unfortunately far too common to see customers that are just getting into track days make the same mistakes. They start out trying with their factory brakes and often have scary and downright dangerous experiences with brake fade and/or vapor lock. Then they accept that they need a brake upgrade but don’t want to invest in a Big Brake Kit, so they opt for upgraded standard diameter discs, race pads and race brake fluid. This buys them some additional headroom in terms of brake fade and vapor lock but since they have added no more thermal capacity the peak brake temperatures run extremely high and discs and pads wear very quickly. The resulting running costs are so high that when the customer looks back over his first year of track day events, he could typically have fitted a Big Brake Kit, had less issues with extreme brake temps, had greatly improved safety and spent less money on brake parts.

Pad compound selection:

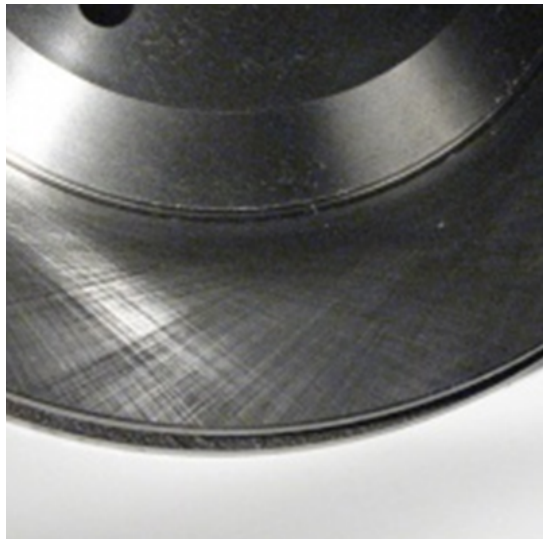
- **If the brake discs, calipers and brake lines are the 'Skeleton' of the brake system, then the pad compound is the 'Heart'.**
- **There is no single pad compound that can deliver quiet, comfortable braking on street with low noise and low disc wear, while also delivering the extreme fade resistance required for track day use.**
- **<u>APR now offer 3 x pad compounds:</u>**
  - **High performance street: This compound is now pre-loaded into all APR Big Brake Kits and is the best choice for general street use on high-performance cars.**
  - **Advanced street / entry-level track day: This compound is a recommended for advanced street driving on very high horsepower cars and for customers that want to take part in entry-level track days and do not want to change pads for their track day events. (An 'entry-level' track day is defined by the number of laps per session. Entry-level means around 6-8 laps per session and no more than 10 laps per session). While this pad compound has the heat range to handle entry-level track day use, pad wear will be fairly high under track day conditions.**
  - **Advanced track day: This compound is one of the very best track materials currently on the world market. It can be used to drive to and from track day events but elevated noise levels and increased disc wear will be experienced if it is used for daily street driving.**

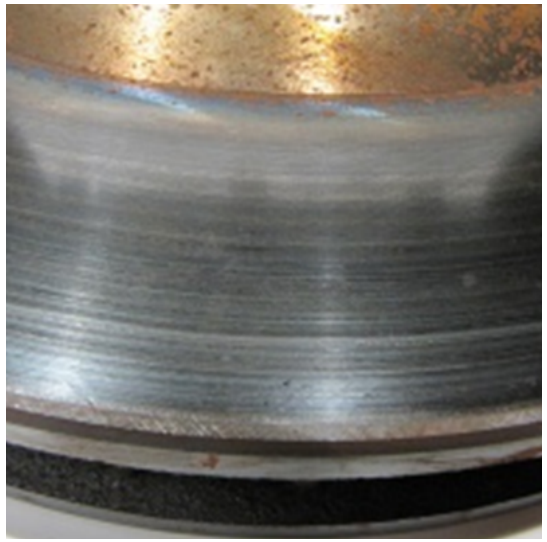
Why bed-in newly fitted discs / pads?

- **Remove residual stresses from the discs.**
- **Achieve good surface area contact between the pad and disc surfaces.**
- **Burnish the brake pads (green fade).**
- **Deposit a good friction material transfer film onto the disc surface.**

Bed-in procedure (High-Perf Street & Advanced Street / Entry-level Track Day pads):

1. Drive moderately for 300km (188 miles) after fitting new discs and pads or BBK to achieve good surface area contact between discs and pads and complete final stress relieve of the discs.
2. On a quiet back road and perform 10 x consecutive brake applications from 120 – 40kph (75 – 25mph).
3. Drive on for a few minutes to let the brake discs cool.
4. The Blue MTR tab on the discs should have turned white when you return.
5. A smooth blue / grey film should be visible on the disc surface after bed-in (see below right).





Bed-in procedure (Advanced Track-day pads):

1. Complete 2 x laps at a moderate pace to ensure good surface area contact between pads and discs.
2. Gradually increase pace for another 6 x laps to build disc temperatures.
3. Complete 2 x cool down laps using the brakes as little as possible to bring down disc temperatures.
4. The Green MTR tab on the discs should have turned white when you return to the pits.
5. A smooth blue / grey film should be visible on the disc surface after bed-in (as per image below).

Signs that you are running a pad compound beyond its max operating temperature:

- **Uneven / erratic friction material deposit visible on the disc surfaces.**

Key points regarding fitment:

1. Fit correct disc assembly to the correct side of the car (slots and cooling vanes).
2. Cleaning of hubs is CRITICAL!
3. Use correct torque settings when assembling.
4. Tips on initial bleed (attach brake line to caliper first, then at chassis second).
5. Service bleed after a week.
6. Use tissue paper to soak up residual fluid in bleed screws.