What's stopping you ... ?

tech talk

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A vehicle's brake system is an extremely important element of its primary safety systems.

It is essential that the braking system performance is maintained at the highest level, irrespective of how hard you drive the car, or the age of the vehicle.

In this article we will be discussing all things brake related, with particular emphasis on the NA and NB models of the MX-5.

The brake system works by transmitting the driver's foot pressure on the brake pedal, through the master cylinder to the brake calipers, in order to clamp the friction material on the brake pads against the metal brake disc rotors. The foot pressure is multiplied by the mechanical pedal ratio and the hydraulic ratio of the master cylinder and booster and the brake caliper pistons. Essentially the moving vehicle's kinetic energy is converted into heat energy in the brake rotors.

Brake Rotor Discs

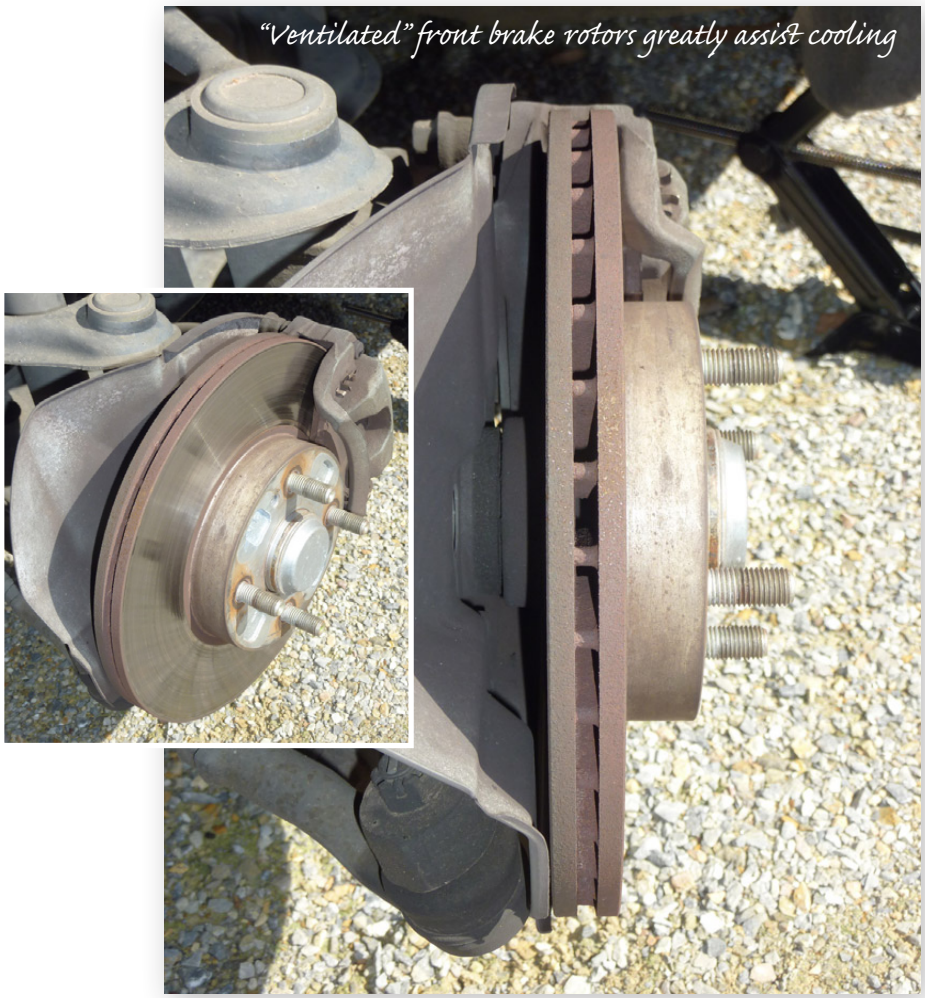
Despite the 50% front/rear weight distribution of the MX-5, the weight transfer to the front under braking means that those brakes do more work then the rears. Hence front rotor diameter, weight and brake pad surface area are larger than on the rear.

All MX-5s are fitted with what are called "ventilated" front rotors and with solid rear units. Ventilated rotors by virtue of their design induce air to flow out through the opening on the perimeter of the rotor to greatly assist cooling.

Each front rotor on an NA8/NB8A weighs 5kg and the rear units weigh 3kg. The NA6 used smaller rotors, and the NB8B uses larger rotors, and the high mass helps minimise the temperature rise when braking.

Nevertheless it is easily possible to generate some extremely high rotor temperatures under heavy braking. A 1070kg MX-5 can expect the following rotor temperature rise from an initial braking event, but temperatures will be considerably higher on subsequent stops because of the elevated starting temperature.

Starting Speed (kmh)	Final Speed (kmh)	Temp. Rise (°C)
160	120	70
160	100	100
160	80	120
160	60	140
160	40	150
160	0	160



"Ventilated" front brake rotors greatly assist cooling

Aftermarket "slotted" ventilated rotors are used by some in our motor sport program. The slots are designed to scrape off water and debris that would prevent the pads clamping the rotor cleanly. They are typically not necessary for cars that do not see the track and indeed are not essential on any lightly modified track MX-5.

Rotor discs wear out and must be replaced periodically. The minimum allowable thickness is usually stamped or cast on the rotor. Discs are made of cast iron and there are few if any direct-replacement "upgrade" rotors available – most do the same job.

Brake Pads

Brake pads are a key element of the brake system, and must be chosen carefully for the intended application. Some selection considerations are: maximum operating temperature, co-efficient of friction when both cold and hot, wear rate, rotor wear, dust generation and cost, amongst others.

Standard pads like the factory ones can overheat if used at the track – when overheated, the coefficient of friction drops dramatically. This results in a hard pedal feel, but the car does not slow down!

Beware that some high performance pads need to be "warm" to operate and are less than effective on the first or second application – not so good for public road use. Race pads also typically cause the rotors to wear much faster when cold, say if used on the road.

Which brake pads to use?

There is a vast range of pads available, and each is a compromise for a particular purpose. No one pad is suitable for all applications. The pads supplied by Mazda dealers as part of your routine service program or through the Spare Parts Dept. will meet all public road use requirements and light track use, as will pads from

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Bendix and other manufacturers. On our race car we use either QFM A1R1 or Hawke HP+, which are also suitable for some road use.

Due to their small size and weight, brake pads are ideal to purchase over the internet from the USA. You can discuss pad selection with members of the Club.

Brake Fluid

Brake fluid is possibly the most neglected component of any car maintenance program. When fresh, all brake fluids are virtually incompressible and the system works as its mechanical and hydraulic design allows. However, there are a couple of important issues.

(a) **Overheated brake fluid can (and will) boil in the caliper** and as with any boiling fluid, gas bubbles are produced. This gas is compressible and leads to a "soft" brake pedal with long travel and ineffective brakes. We have already noted that substantial rotor temperature increases can be generated from a single brake application.

(b) **All brake fluids absorb moisture** from the atmosphere relatively quickly regardless of use and this dramatically reduces the boiling point of the brake fluid. As water content in the fluid increases so the boiling point decreases, with the increased likelihood of creating vapour in the caliper and wheel cylinder and hence ineffective brakes.

Brake fluids are classified by the USA Department of Transport as **DOT 3** or **DOT 4**.

In comparing various brake fluids, the Dry Boiling Point at 0% water content and the Wet Boiling Point at 3.7% are commonly used. The table below shows the "MINIMUM" dry and wet boiling points.

	DOT 3	DOT 4
Dry BP (°C)	205	230
Wet BP (°C)	140	155

DOT 3 and DOT 4 brake fluids are compatible with each other and may be interchanged or mixed with no ill effects. DOT 5 fluid is silicone based and not compatible with the brake system of the MX-5. Some fluids are labelled DOT 5.1 and these are compatible, however the whole system should be flushed, not just topped up before using DOT 5.1 fluid.

The following table shows the typical Brake Fluid Boiling Point (BP) vs % Water Content for both DOT 3 and DOT 4 brake fluid.

Moisture Content	DOT 3 BP	DOT 4 BP
0%	252	276
1%	218	237
2%	182	204
3%	160	180
4%	137	163
5%	129	149
6%	126	138
7%	121	135

Field tests in the USA show that the average 12 months old car has 2% moisture. Furthermore, there was an average water content of 2.6% in cars with an average age of eight years – indeed 25% of these had over 4%.

Brake fluid is corrosive to paint, so take care handling it and, if you spill any, wash it off immediately (but don't let water get into the system!).

Which Brake Fluid to Use?

For normal use any DOT 3 or DOT 4 fluid should be suitable provided it is replaced every 12 months. Only buy the small 500mL containers. Beware – some brake fluids are obscenely expensive. On the race car, we use Penrite SIN brake fluid ($20 for 500mL at Repco) with Dry BP of 310°C and Wet BP of 198°C.

Just remember, that no matter how good the brake fluid is, it will absorb moisture and require regular replacement. How regular will depend upon the use of your car (road, road and track, track) and the feel of the brake pedal under heavy braking.

Brake Calipers

The calipers are the "claws" over the rotor – they hold the pads in place and have a hydraulic cylinder that clamps the pad to the rotor.

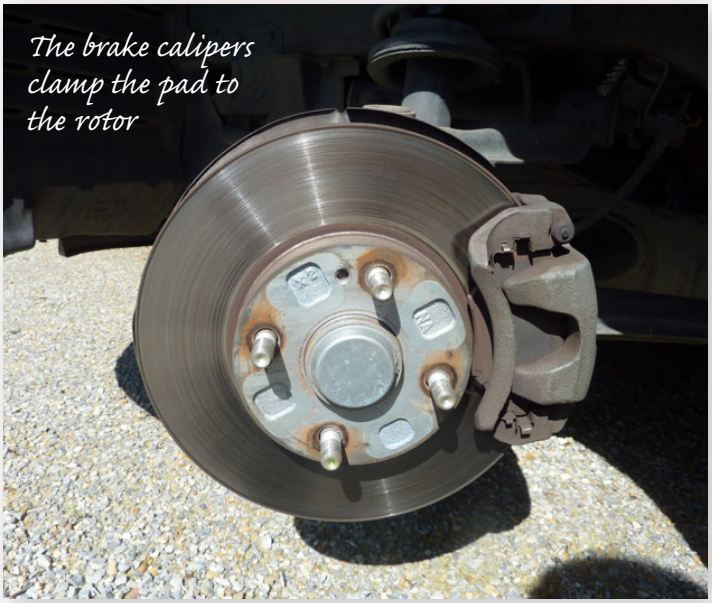
The MX-5 uses a "single piston" caliper design, which pushes the inside pad onto the rotor. The caliper is mounted on slider pins, which allow the caliper to move, causing the "claws" to pull the outside pad onto the rotor also.

If the slider pins are not well lubricated, brake performance will be reduced because the outside pad will not be pulled in properly – the inside pad will do all the work, will wear faster than the outside pad, and can possibly overheat and fade.

The rear caliper also contains a special self-adjusting mechanism for the handbrake that compensates for pad wear. You need to manually wind this mechanism back when installing new, thicker, brake pads. This mechanism can occasionally fail, resulting in ineffective rear brakes and difficulty changing pads.

Brake Proportioning

Because weight transfers to the front under deceleration, the front brakes need to do more work than the rears. How much more depends on how fast you decelerate. To prevent the rear brakes from locking up (which results in an uncontrollable skid), the brake force going to them must be progressively reduced the harder you brake. This is called



The brake calipers clamp the pad to the rotor

proportioning. For optimum braking performance, both the front and rear brakes should be at the limit of lockup, but this varies depending on the amount of grip you have on the road.

Next to the brake master cylinder (of non-ABS cars) is a small valve called a proportioning valve. This progressively reduces the hydraulic pressure to the rear brakes as you brake harder. This valve rarely has problems. ABS-equipped cars do not use mechanical proportioning; they rely on the electronics of the ABS system to limit the rear pressure as required.

ABS

ABS stands for "anti-lock braking system" and has been fitted standard to all MX-5s from and including the 2000 NB8B model. Sensors on each wheel detect when that wheel is about to stop rotating and a microprocessor tells the brakes to ease off and re-apply several times each second to achieve optimum braking. The driver can simply "jam on the brakes" without fear of locking up the wheels, even if the wheels are on different surfaces. Importantly, it enables the driver to still steer the car unlike when the front brakes/wheels are "locked up". When ABS activates, it causes a rapid pulsing sensation through the brake pedal – this is normal, and you should not ease off the pedal if you feel this!

Brake Lines and Caliper Seals

With some MX-5s already celebrating their 21st birthday and many being over 10 years old it may be time to consider replacing the flexible brake lines and shouting your car a new set of caliper seals. Our race car has ADR-compliant "braided brake lines" and new brake caliper seals fitted, not for a performance advantage but to ensure the system works efficiently and for "peace of mind".

Bedding In

Bedding in is the process of conforming new pads and/or rotors to each other. This must be done correctly and carefully as braking performance will not be optimal until the process is completed. Typically the process involves heating up the pads progressively with a number of slow-downs, followed by a cooling down period.

New pads usually come with instructions on bedding in; otherwise you should refer to the manufacturer or your mechanic for advice. Be aware that brakes that have not been bedded in may fade suddenly if overheated!

Upgrades

The brake systems on NA and NB models are interchangeable as a complete set, so if you have an early car and want to upgrade you can install the calipers, mounting brackets, and rotors from a later model. The NC uses different brakes that are not interchangeable.

The proportioning valve can be upgraded to later model variants that have more rear bias, or aftermarket adjustable versions, to make the best use of the rear brakes.

Many other aftermarket upgrades are possible, the limit is only your wallet! Any brake system changes should be tested carefully to ensure correct operation.

DIY Brakes ???

Unless you are sure of your ability to work on brake systems, this work is best left to your "professional mechanical service provider".

Brake System Faults and Troubleshooting

There are a few common faults on the MX-5's brake system. Fortunately none is really serious, but as your brakes are so important you or your mechanic should investigate ASAP.

Here are some tips for finding common brake problems:

SYMPTOM	POSSIBLE CAUSE	SOLUTION
Loud squealing	Brake pads are fully worn and the squealer bracket is rubbing on the rotor.	Replace brake pads.
Hard pedal feel, but poor braking (on track)	Pads overheated.	Use a higher temperature pad.
Soft, spongy pedal, goes to floor	Fluid overheated / boiling.	Replace brake fluid.
Warning light (Ⓘ) on dashboard is on	Handbrake is on.	Check handbrake is off.
	Brake fluid level is low.	Check and top up master cylinder reservoir, inspect brake system for leaks.
Rear pad(s) worn quickly / rear brake stuck on / dragging / overheating	Handbrake adjuster mechanism inside rear caliper is jammed.	Rebuild or replace rear calipers.
Inside pad wears faster than outside pad, poor braking performance	Slider pins are seizing.	Clean and lubricate sliders with high temperature grease.
Cannot retract rear caliper	You cannot push the piston back like on the front brakes.	Find and remove the short, unidentified bolt on the inside of the caliper. Retract the caliper using a 4mm hex key in the hole.
Brakes shudder	"Warped" or uneven rotors.	Have rotors "skimmed" by a professional brake repair shop. Bed in properly. DO NOT apply handbrake when parking after a track session.
	Flat spot on tyre.	Replace damaged tyre. Rotate flat-spotted tyre to rear axle.