Technical Tips: - Brake Fluid

To keep the science to just one sentence and written in layman's terms; brakes work by converting kinetic energy (the energy in the mass of a moving car) into heat energy, through the friction of brake pads contacting discs / drums.

As we all know, water boils at 100°C but fresh brake fluid boils at more than double that temperature. This allows the brakes on your car to be applied numerous times in quick succession, such as when driving down a steep road, without the fear of brake issues due to the temperature build up in the brake disc and caliper and in the brake drum and its slave cylinder.

Brake fade in rear brake drums is mostly a consequence of the brake shoe material overheating due to the drum's limited ability to dissipate heat quickly enough. The heat generated causes the brake shoe lining to give off gases which build up on its surface, preventing direct contact with the inside of the brake drum. Racers sometimes drill small holes through the contact area of the drum circumference to allow this gas to escape.

Extreme braking when competing on a race-track is not the only way to induce brake fade. Stopping a heavily laden car also increases the heat that the brake components experience, as does braking to keep your car within the speed limit when driving down a long steep decline, or by frequent brief applications of the brake pedal such as driving down winding hilly roads.

With a fresh fill of the correct grade of brake fluid, there shouldn't be any braking distance reduction noticeable in street-driving conditions. Good quality brake fluid can't be compressed, so all of the effort at the brake pedal is transferred directly to the pistons in the slave cylinders. However, if water contamination exists, the water will vaporise into a gas above 100° Celsius. A liquid resists being compressed but a gas doesn't. This is what's happening if you experience the brake pedal feeling "spongy" or worse still, when the brake pedal is able to be pushed to the floor while having little or no effect on retarding the speed of your vehicle.

This is why it's critical not to have any air or water in the brake's hydraulic system.

Brake fade is a different, temporary phenomenon which occurs if poor quality or incorrect grade brake pads are used, which allow released gases from the over-heated pad material to actually force the pads away from the discs, as previously described for drums. Slotted, or cross-drilled brake discs are used to allow these gases to escape.

Brake fluid grades explained.
DOT3, DOT4, DOT5 & DOT5.1 grades are available for sale. "DOT" is the abbreviation of Department Of Transport, the US rating standard for brake fluids used around the globe.
To confuse consumers, DOT5 is a Silicone based fluid while the others are all PolyGlycol Ethers with lubricant and corrosion resistance additives.

The production of Castor Oil based DOT2 has stopped but DOT3 is still available to purchase but it's very rare for current model cars to use this older grade of brake fluid. DOT3 should not be used, even though it's what might've been used by the factory during the production period of Classic cars. The performance of DOT3 drops off rapidly as moisture is absorbed and therefore it needs to be flushed and replaced more frequently.

DOT4 was developed to replace the poor performing DOT3. It's much less hydroscopic than DOT3, so it has better high temperature performance and only needs replacing every two years.

DOT5 is a Silicone product which I'll deal with next, after covering the last Glycol based brake fluid.

DOT5.1 is the highest recognised grade of brake fluid, which has the same temperature ratings as Silicone fluid, which is why it's unfortunately been given a similar name which means that it could be confused with DOT5. **DOT5 and DOT5.1 must not be mixed.**
DOT5.1 exceeds the demands that all but racing cars can require.
It's unnecessary for the owner of a street-driving classic car to pay the higher price for the "racing" grades of brake fluid with even higher temperature ratings.

Silicone brake fluid has some excellent properties such as a high boiling point, it won't damage your car's paintwork if it gets spilled or dripped, which of course is a great benefit.
The chemistry of Glycol based brake fluid is similar to automotive paints, which is why it does such a good job of dissolving the paint on your concours Classic. It's such a shame to see bubbling paintwork around the master cylinder pedal box in the engine bay of so many cars; mine included.

The disadvantages of Silicone brake fluid is that it can be more compressible than Glycol brake fluid, so a slight "spongy" brake pedal can sometimes be felt, which the driver has to get used to. This is because it readily captures air, which as we know can compress, unlike a Glycol fluid.

Brake fluid manufacturers strongly recommend that Silicone and Glycol Ether brake fluid are not mixed. If changing from the Glycol type to Silicone, the brake system should be replaced with new parts or at least flushed thoroughly a few times before being re-filled. If you decide to change back to Glycol brake fluid from Silicone, this should only be done if the master cylinder and all four slave cylinders are replaced, or dismantled, thoroughly cleaned and rebuilt with new seals. The tiniest remnants of the Silicone fluid must be removed before filling with Glycol fluid.

Due to its higher viscosity and poor lubrication properties, Silicone brake fluid must not be used in modern cars with ABS brakes.

When atmospheric moisture gets into Silicone brake fluid, it can cause corrosion in the slave cylinders, but fortunately in our relatively dry South Australian climate this is less likely to occur here than in other parts of the world. It also helps if the brake slave cylinders have been rebuilt with stainless steel sleeves and pistons.

While Silicone brake fluid has the benefit of not being hydroscopic, if any water droplets do get into it, the water doesn't get absorbed on a molecular level like it does in normal brake fluid, instead, it stays as "free water" droplets, separate from the brake fluid, which will boil at lower temperatures causing brake fade and will also corrode brake lines and unions from the inside out.

An important warning about Silicone brake fluid is that because it doesn't trap water on a molecular level like Glycol fluids do, any water in the Silicone fluid remains as water droplets which eventually collect in the lowest / furthest points of the braking system, that is, the rear wheel cylinders and front calipers, which then causes corrosion in these areas. Corrosion of steel, aluminium or copper can occur when water droplets are present in Silicone fluid. For this reason, owners MUST bleed off an amount of Silicone brake fluid from all four slave cylinders every 12-months. This doesn't mean draining the entire system but just removing a small amount where water could be present at all four wheels, before topping up the master cylinder.

Silicone brake fluid isn't a fill and forget product that some people might believe it to be.

Silicone brake fluid has its Pros & Cons, depending on which properties are deemed more important for the vehicle owner's purposes and DOT3 fluid should be replaced with DOT4 the next time the fluid is replaced. DOT3 and DOT4 can be mixed but the DOT4 properties are diluted in the DOT3, so if you have DOT3 in your car now, it's best to flush DOT3 fluid from the system and have a full top up of fresh DOT4.

Some manufacturers produce a brake fluid that they call, for example, DOT4+, DOT4 Plus or DOT4 Super. These products have a similar chemistry to standard DOT4 but they exceed the minimum requirement of DOT4 standards, which the manufacturer wants to emphasise to customers. For just a couple of dollars more, it's probably a good idea to go for the higher temperature rated DOT4s.

Keep your Classic's brake and clutch master cylinders topped up at all times and completely flush the brake fluid at the factory specified intervals. Having seen so many Classic cars with dangerously contaminated brake fluid, even with degraded pieces of the internal brake system seals in it, I cannot stress the importance of changing the car's brake fluid at least every 3 years. Apart from ineffective brake fluid, the water molecules in the fluid rusts metallic master cylinders from the inside-out and rusts the brake caliper pistons which causes them to seize. I've seen so many like this.

This replacement of the brake fluid is not determined by the kilometres driven, the climatic conditions of the car's location, the car's age, whether the car is raced or if it's locked in a garage for 24-months.

The reason why brake fluid must be flushed and replaced at least every three years is because it's hydroscopic; meaning that it attracts water. Water in the brake fluid reduces its ability to avoid boiling which greatly reduces the braking ability of the vehicle, and it will be a cause of rust inside the master cylinders, slave cylinders, brake lines and unions.

Do not think that water can't find its way into the apparently "closed" hydraulic braking system of your car, it does, but not in the way that you might imagine.
Water contamination of brake fluid is not from actual water droplets, it occurs at a molecular level.
Individual H_2O molecules in the atmosphere are readily absorbed by brake fluid, which draws the water molecules through the air vent in the master cylinder cap, and from condensation in the air above the fluid level in the master cylinder, and even through the molecular structure of flexible rubber brake hoses.

Hydraulic master cylinders were changed by the Factory from being metal to a translucent plastic material so the fluid level can be seen without removing the cap. Think about this for a second; Glycol based brake fluid will be absorbing atmospheric moisture in just the short time it takes you to remove the master cylinder cap, have a quick look at the fluid level and then replace the cap.

It's reported that a minimal amount of water molecules will even be absorbed through the "seal" and threaded cap on new brake fluid bottles on the shelf of your favourite car parts shop. You can possibly imagine how much contamination there could be in that part-used bottle of brake fluid that's been sitting on your garage shelf for the past few years.
Unless you're mechanic who works on multiple car's brakes every week, you should always purchase a small bottle of brake fluid. They're usually sold in 500mL bottles for this reason.
Any bottles of brake fluid on your shelf that've been opened longer than three months ago should be disposed of responsibly. Check the date of manufacture of new bottles being sold to ensure that they are less than 24-months old, and even less than 12-months old is better still.

This water contamination is an on-going process and the more time that passes, the greater the amount of water will be absorbed inside the "closed" hydraulic system.
You won't see water droplets sitting on top of the brake fluid in the master cylinder because the molecules are held in suspension within the brake fluid.

You can't visually check the condition of brake fluid, although some brands darken their colour with age.
Water contamination in brake fluid has to be measured by equipment that measures the boiling point of the fluid in the master cylinder. There are battery operated tools that resemble a marker pen which are dipped into the master cylinder, and when a button is pressed, it measures the electrical current passing from one of its probes to the other one, through the water held in suspension in the brake fluid. These tools, it could be argued, are better than nothing but in reality they can give a false reading and also, they usually don't take into account the properties of different grades of brake fluid.

The only way to test brake fluid properly is to use a tool that heats a sample of brake fluid from the master cylinder, to test the actual boiling point of the fluid. Despite these tools being quite expensive, I recently considered buying one but thought better of it. These tools are for mechanic's use, so that they can quickly determine the condition of the brake fluid in a car that they haven't worked on before. However, it's far better not to bother checking the boiling point of your car's brake fluid and to simply flush the system every two or three years, as recommended, or more frequently if the car is being raced.

Temperature rating standards for the different grades of fluid are shown in the table below. Most manufacturers exceed these minimum performance requirements.

Grade	Dry B.P.	Wet B.P.	Change Interval
DOT3	205°C	140°C	Flush every 12-months
DOT4	230°C	155°C	Flush every 24-months
DOT5	260°C	180°C	Partial bleed every 12-months
DOT5.1	260°C	180°C	Flush every 24-months
Castrol React SRF	310°C	270°C	Racing fluid only. Flush every 12-18 months.

The “Wet” Boiling Point (BP) is calculated at a water content of just 3.7%, which is the amount of water that if exceeded, make the brake fluid dangerously ineffective.

My personal recommendation for brake fluid is to use Castrol React Performance in any street car, and (at eight times the price!), I use Castrol React SRF in my race-tuned car.

Additional tips for those who aren’t aware; the brake fluid level in the master cylinder will drop over time to compensate for wear of the brake friction material.
As the pads wear down, the fluid needs to push the pistons further out of the brake calipers to make contact between the pads and the disc, so more fluid is held in the slave cylinder and less in the master cylinder.
Keep the master cylinder topped up to its full level to avoid it getting too low to operate the brakes, and to avoid too much water-laden air being on top of the fluid in the cylinder.

When replacing the brake pads on your car, with the worn down pads removed, you’ll need to squeeze the pistons back into the calipers so that the thicker, new pads will fit. Before squeezing the pistons back into the calipers as far as they’ll go, make sure to release the caliper bleed nipple so that the excess brake fluid is expelled, rather than being forced towards the master cylinder, because this could cause the seals to invert inside the master cylinder, or for fluid to leak out of the master cylinder causing all sorts of mess.

I hope that this information about brake fluids is interesting and not too controversial. The unbiased information that I’ve presented is based on my own experience, from years of racing and from scores of hours research from dozens of websites and technical reference books. As always though, it’s up to the individual owners of Classic cars to make their own decisions.

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