SOME MUSINGS ON BRAKE FLUID

Or, why is the paint under my master cylinder so crinkly and loose?

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Brake Fluid. What is it, and what does it do? When you step on your brake pedal, the pedal moves a piston inside a "Master Cylinder," which displaces a special hydraulic fluid into "slave cylinders," which causes pressure to be applied via the slave cylinders to brake pads and brake shoes, creating friction which causes the car to slow down, and perhaps come to a full stop. One way to think of this is that we convert motion, using friction, into heat. In this process, energy is neither created nor consumed, but transformed. Most of our Triumphs have disk brakes in front, and drum brakes in back. The front calipers act as slaves to the Master , as do the wheel cylinders in back. Pressure is transferred from the foot to the pads and shoes to create the desired friction. The actual transfer medium, which is the subject of these musings, is the brake fluid. Many times we find "brake boosters," which use engine vacuum to help apply more hydraulic pressure with less foot pressure in a mode we can think of as "power assisted brakes," but we'll confine these musings to brake fluid. Boosters can be a whole separate discussion of their own. And of course, power assisted brakes still require brake fluid.

So what is this stuff we call "brake fluid?" There are several varieties, but all share the property of limited compressibility. That means that no matter how hard we stomp on the brake pedal, the volume and density of the fluid doesn't change much. But the fluid moves as we displace it, so first the pads and shoes move out of their "relaxed" position and make contact with the disks and drums. Then, as we apply more pressure to the pedal, the pads and shoes press harder on the disks and drums, increasing the friction. There should be no "squishiness" in the brake pedal. That's an important consideration when trying to get friction applied in a hurry - consider the desired result when a deer suddenly appears ahead of you while driving. Or an unwitting pedestrian glued to their phone while texting. The pedal should not go to the floor, and should only travel a short distance before that solid "brakes applied" feeling kicks in. If there's excess travel before the "applied" feeling occurs, nine time out of ten the rear brakes need adjusting a little more outward. the tenth time there's air in the system, which is highly compressible. Yet another topic for a future discussion.

So let's take a look at brake fluid classifications. The serious student may do extensive research and discover that there are at least 3 National or International Standards Bodies that set standards for brake fluid. While there may be minor variations between the standards as written, they pretty much all prescribe the same standards, and most of us can simply refer to brake fluid with a "DOT number." That's Department Of Transportation, for the curious. The DOT number refers primarily to the temperature tolerance of the fluid, with one notable exception, which we'll address in a minute. DOT-3 is the basic stuff. It has a specified wet boiling point of not less than 284 degrees F. By the way, we use the "wet" boiling point to account for the presence of a little moisture in the fluid, which more closely approximates "real world" conditions. The "dry" boiling point represents fresh fluid right out of the container, possibly in a lab environment. So why is the boiling point important? Because when brake fluid boils, it transforms from a virtually non-compressible liquid into a very compressible gas. The

colloquial description for this condition is "my brakes went away." There are other reasons for brakes to fade, or go away, but the boiling point is a consideration. Remember that brakes work by converting motion to heat via friction. It may be worth noting that there is a Ranger Station about a third of the way from the top of Pike's Peak, where a Ranger will check the temperature of a car's brakes when they arrive there on the way down from the top. Cars with overheated brakes must pull over and wait for the brakes to cool, so that the brakes don't "go away" during the trip down the rest of the mountain.

DOT-3 is composed of "glycol ether" and "borate esters." My exposure to Chemistry in High School and a College Chemistry for Non Majors course fails me at this point, so I can only say "that's nice." What it means to us is that DOT-3 is virtually non-compressible, and with a 284 degree boiling point is good enough for boulevard cruising and a little "spirited driving" on back roads on Sunday morning when nobody is looking - and little to no other traffic on the road.

And while we're on the subject, let's address the issue of "synthetic" brake fluid. Yes, synthetic motor oils seem to deliver significantly improved results over traditional mineral oils. But, as best I can determine, all brake fluid is "synthetic" in the sense that it doesn't occur naturally in nature. There are, to elaborate, no spectacular "brake fluid falls" to visit by hiking half a mile into the back country. At least in my knowledge. So, it seems that with or without the "synthetic" label, it's pretty much the same stuff. Chalk one up for the good folks in Marketing.

For a higher boiling point, DOT-4 is specified to tolerate up to 311 degrees F when "wet." Otherwise, DOT-3 and DOT-4 are pretty much the same thing. They're interchangeable, and they can be mixed. (Pick your own boiling point by mixing to percentages?" Probably not - but could be done if one's heart desired.) DOT-4 might be a consideration if some serious rallying, European style, is in the offing, and has been used as the "Gold Standard" by the racing community in prior years.

Ah but then there's DOT-5. DOT-5 is Silicone based. I'm reminded of the scene in the film "Moonstruck" where Vincent Gardenia as Cosmo Castorini is waxing poetic about copper pipe. He says "there are three kinds of pipe. There's lead, and there's iron, and then there's copper. I only use copper." So to paraphrase, "there's DOT-3, and there's DOT-4, and then - there's DOT-5. I only use DOT-5." Well, almost. DOT-3 and DOT-4 share a quality we'll call Hygroscopic. That's a 4 syllable word that means that the fluids readily take up water. Or water in the form of moisture, which is why it makes more sense to use the wet boiling point. Moisture, in any hydraulic system, is not a good thing. Water can start and support corrosion, or rust. Rust is bad, because it creates a scaly coating, which erodes rubber cups and seals, allowing brake fluid to slip past the seal and not do its job when the pedal is pressed. Why does the brake pedal suddenly go to the floor with no pedal pressure the Spring? Rusted cylinders, somewhere, most likely.

DOT-5, on the other hand, is hygrophobic. Another 4 syllable word that in this case means that it repels, and does not absorb moisture. So this is a very good thing. I have personal experience with DOT-5, and I can verify that I have very few brake (or clutch, for that matter) hydraulic issues while using DOT-5, and the conversion to DOT-5 was based on frustration with prior use of DOT-3 and DOT-4. Another welcome feature of DOT-5 is that it doesn't affect paint. Both DOT-3 and DOT-4, if left to sit on a

painted surface, can cause the paint to lose its grip and lift off the surface. Hence the crinkly and lifted paint sometimes found under brake or clutch master cylinders, which is a result of a well intentioned spill left not wiped up quickly.

So why don't we all just leap to DOT-5 and never look back? Because, as with all things, there's a catch. A couple of catches, actually. DOT-5 can absorb a little air, and as such can be "slightly" compressible. That can lead to a softer or even a slightly "spongy" brake pedal. The braking force is still there, but it might mean a little more pedal travel, or a softer pedal at first, and some drivers aren't comfortable with that. One way to mitigate the softness is to go to braided stainless steel brake hoses. I can get pretty firm pedals using this dodge. The other catch is more insidious. Apparently, the major suppliers like Moss, and the major rebuilders, like Apple Hydraulics, will not warranty their products or results if DOT-5 is used. And why is that?

Here's where we begin to encounter a high degree of uncertainty. There' a mix of facts, pseudo facts and Urban Legends. I think that there are two possible reasons that DOT-5 voids a warranty. One is that perhaps the fluid molecules in DOT-5 are a little smaller than the molecules in DOT-3 and DOT-4. That means that in that all important sealing edge in a master or slave cylinder, where the piston cup meets the cylinder wall, a little imperfection could allow the cylinder to leak if DOT-5 is used, whereas DOT-3 and DOT-4 will hold. I think unusual leakage with DOT-5 can occur but rarely, and that's pretty much fact.

The other possible reason is that while DOT-3 and DOT-4 contain some "swelling agents," which will cause seals to expand and fit more tightly, apparently there could be a difference with respect to DOT-5. A pseudo fact seems to be that DOT-5 will cause the rubber elements in the system, seals and pressure cups, to expand, jamming up the system, particularly if DOT-5 is used following use with DOT-3 or DOT-4. I've had someone swear to me that they had that experience. i've not looked into this extensively, but I did take a rubber part from my '58 Mercedes and drop it into a small container of DOT-5 for a few months. Nothing happened other than the rubber part got wet. Because I haven't pursued this extensively, I can suspect that possibly not all DOT-5s are the same, which seems unlikely but possible. I can say with certainty that I've personally accredited two brands of DOT-5 that passed the "Rubber Mercedes Part" test - SSBC brand, which is getting hard to find and very expensive, and Cartel, which I can order from Amazon.

As a real life example of a DOT-5 issue, my Mercedes uses, or did use, a hydraulic brake light switch. The switch hangs upside down off the end of the booster cylinder. The switch is activated by hydraulic pressure in the braking system. My experience is that when running DOT-5, the brake light switch fails pretty much within a couple of weeks. Obviously, that doesn't happen with DOT-3. I suspect the DOT-5 finds a way past the seals, or possibly swells the switch piston, but whatever. I literally fabricated a bracket to hold a traditional mechanical brake light switch activated by the movement of the brake pedal to solve this problem. And I still run DOT-5 in that car.

An Urban Legend seems to be that in order to go from DOT-3 or DOT-4 to DOT-5 the entire system must be cleaned flushed, and maybe even rebuilt. Uh, that's a legend that seems questionable. My process,

when converting a car to DOT-5, is to go to the farthest slave cylinder, usually the left or right rear, and start bleeding at that cylinder while continuing to top off the reservoir with DOT-5. DOT-3 and DOT-4 are amber in color, and DOT-5 is purple. When I start getting (clean) purple at that slave cylinder, I move to the other rear, then the right front, and finally the left front. When all four "corners" bleed clean purple, top off the reservoir and walk away. I've not had a problem doing this yet. Now, in the interests of full disclosure, yes I have subsequently needed to rebuild or replace some hydraulic components in cars running DOT-5 that once ran DOT-3 or DOT-4. There seems to be some truth to the theory that since DOT-5 doesn't mix with DOT-3 or DOT-4, there could be some pockets of left over DOT-3 or DOT-4 in wheel cylinders and calipers, and hence rust can still occur. Fair enough. I've had pretty good success though, waiting for that to happen if it does, and replacing / rebuilding as needed when needed, as opposed to "just doing it" all up front. I don't think I've ever had to replace all the components after a conversion to DOT-5. And possibly that corrosion had already begun before I did the conversion to DOT-5.

So in my mind it comes down to the vehicle specs, one's patience and one's tolerance for risk. Modern ABS systems specify DOT-3 or DOT-4 due to the potential slight compressibility of DOT-5, which could mess with the computer's understanding of how to manage a wheel slip or skid. And for a car that's driven daily, or almost so, there seems to be enough heat generated in the braking systems to keep moisture absorption to a minimum, so DOT-3 or DOT-4 is less problematic. Nevertheless, White Post Restorations, which is an upscale restoration shop in Virginia, recommends replacing DOT-3 and DOT-4 on a three year interval to avoid problems.

But what about a car that's only driven occasionally, and probably not much at all in the Winter? In those cases, the hygrophobic quality of DOT-5 is, at least in my mind, a big plus. For a full disclosure, I have seen what I considered to be a very premature failure of a clutch master cylinder that was pushing DOT-5, but that was an unusual and rare (for me) condition. Between Eileen and myself we currently own 4 cars which I would consider "classics." Eileen owns the TR-6, and I own the MGB, the 280Z and my late Father's Mercedes 220S sedan. I run DOT-5 in all of them, and my hydraulic system issues are virtually non-existent. I've accepted the risk that I might have to rebuild or replace a cylinder here or there, but I'd rather run DOT-5 and not have to replace brake fluid in all of them every three years. It's clearly a matter of personal choice.

There's one more fluid spec we haven't covered, which is DOT-5.1. DOT-5.1 is also composed of glycol ether and borate esters, but with a still higher wet boiling point of 374 degrees F. I think DOT 5.1 is suitable for out and out competition driving, due to its higher boiling point, but I also think it's an overkill for the bulk of us who aren't doing Vintage racing.

When I do a web search for brake fluid, I do find some other varieties out there. I will freely confess that I have no knowledge and clearly no experience with them. For me, it's important that a car be able to start, turn and stop on demand. Especially stop. Nevertheless, technology does advance and improve. As we as members of the British Car Community learn more about other alternatives, I would hope that the knowledge is shared. Happy motoring! (And stopping!)