(Perhaps) The Most Forgotten (Automotive) Fluid

by Lee Carroll

Whenever we think about automotive fluids, we probably think in this order:

Gas
Oil
Cooling
Transmission
Differential
Power Steering
Brake Fluid

But when it comes to brake fluid, we only think in terms of topping off the master cylinder - almost never a thought to what is happening beyond the master cylinder – and so, it is the most forgotten fluid.

There are two major types of brake fluid (with a third used in a few cars*: DOT 3, DOT 4, and DOT 5.1). These are glycol-based brake fluids, and have been the traditional brake fluids that we are used to using. The second type is DOT 5 – silicone-based brake fluid. DOT 5 has several advantages over DOT 3, 4, 5.1, but there are several provisos that go with this newer type of brake fluid.

You have heard about brake fluids for years, and I guess that you believe that you know just what follows. Well, hopefully I'll come up with a number of factors with which you are not familiar. Important factors and those that will cause you to rethink brake fluids.

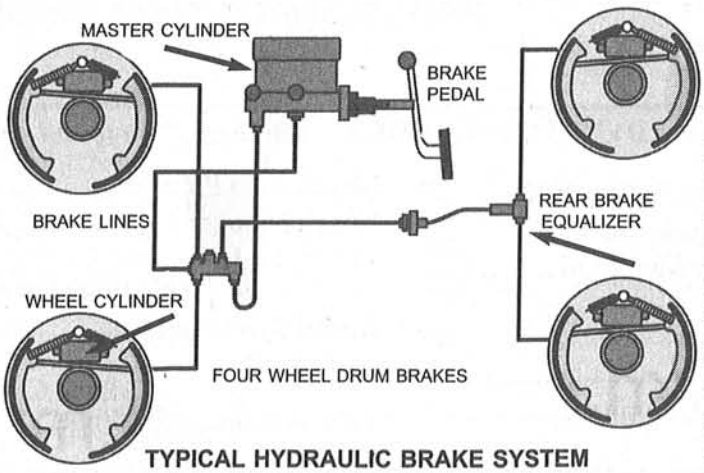
Let's start with basics, and work up from there. The hydraulic brake system is a sealed system – that's not entirely true either, but we'll get to that. The hydraulic brake system contains several major parts. These may vary, or even not exist in some early applications. First is the reservoir – it holds excess fluid to refill the system as needed, and provides an air block to the brake system. The reservoir may be part of the master cylinder, or it may be a separate unit.

The master cylinder uses the mechanical pressure of the applied brake and increases it dramatically to provide additional force to move the brake fluid through the brake system. Today, most master cylinders consist of two separate chambers – one for the front wheels (the larger of the two) and one for the rear brakes. The dual system is a safety feature. If one of the two brakes systems (front or rear) fails, the other will still provide some braking power. Early hydraulic brake systems used a single-chamber master cylinder. The one chamber powered all four wheels.

From the master cylinder, a series of tubes carry the fluid to the wheels. With a two-chamber system, one line carries the fluid to the front wheels, and the other to the rear wheels. Each line divides and services the left wheel (front or rear) and the right wheel (front or rear).

More modern vehicles use a compensator to equalize the pressure between the left side (generally closer to the master cylinder) and the right side (generally further away from the master cylinder so that the brakes are applied evenly.

Each line terminates within the wheel at a wheel cylinder. The wheel cylinder consists of a metal housing containing two pistons. As the fluid is forced into the wheel cylinder, the pistons are forced out, each applying pressure



TYPICAL HYDRAULIC BRAKE SYSTEM

against the brake shoes (newer cars use disc brakes. To this point, the theory is the same. Disc brakes use brake rotors and calipers. Older cars use brake shoes and brake pads. Newer cars also may incorporate several brake assists functions. We will not discuss the brakes beyond the wheel cylinder in this article).

When pressure is applied to the brake pedal, the fluid is forced through the system and forces the wheel cylinders to apply pressure to the brake shoes/calipers. Return springs on the brake shoes force the fluid back into the sealed system when the brake pressure is released.

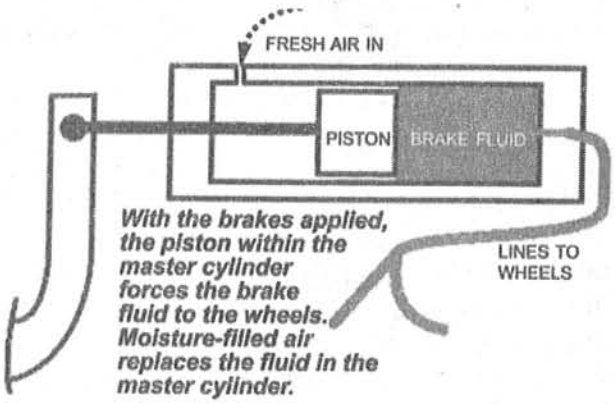
One of the primary features about brake fluid is the compressibility, or more accurately, lack of compressibility. Fluids are not very compressible, but some are more compressible than others. Ethylene-glycol and silicone, in their 'dry' form, are not very comprisable. In that way they are able to force the brake fluid through the lines to the wheel cylinders with a minimum amount of loss due to fluid compressibility.

Simply speaking, that's it! A basic sealed hydraulic system. I mentioned that the hydraulic system is a sealed system. Not completely though. In order to allow the brake fluid to evacuate the master cylinder into the brake lines, a void is created above the reservoir. The void must be filled with air for the system to operate. An air bleeder is incorporated into the reservoir (whether part of the master cylinder or a separate unit) to bring air in, and to allow air to leave as the brakes are released.

Ambient fresh air – the stuff that you breathe, contains moisture – water vapor. As the brakes are applied, that moisture-laden air is sucked into the reservoir, and some of that water vapor is absorbed by the ethylene-glycol brake fluid. Ethylene-glycol is hygroscopic; that is it is able to absorb water from the air. The moisture absorbed into the reservoir fluid is diffused through the brake system, allowing the water to affect all of the fluid within the 'sealed' system.

There are two types of 'air' that can affect the brake system: 'dissolved air' (air absorbed from the atmosphere) and 'entrapped' or 'free' air (bubbles of air within the brake system). It is the dissolved air that we are immediately concerned with. The entrapped air bubbles cause a 'soft' pedal due to the fact the air bubbles are compressible, unlike the hydraulic fluid. Typically, bleeding the brakes will remove the air bubbles from the brake lines.

It is not necessary to discuss the amount or percentages of dissolved air within the brake lines that will affect the brake system. Suffice it to say that the dissolved air contains water that mixes with the ethylene-glycol brake fluid. After a certain point, the brake fluid cannot retain the water, and it precipitates out as water droplets. Not only do these water droplets alter the specifications of the brake fluid, but they also will cause rusting within the steel brake lines, the master cylinder and the wheel cylinders. It is recommended that the brake fluid be completely flushed and replaced every one to two years, and fresh brake fluid be used to replace the old stuff that contains dissolved air. Brake fluid is typically clear or translucent, not dirty or rust-colored. A visual inspection is one way of ascertaining that the brake fluid is in need of replacement. Test strips, indicating metal content of brake fluid are also available to help determine the efficacy of the brake fluid.



We've discussed several of the attributes of brake fluid: compressibility and hydro-

scopic ability. But there are many more factors that go into brake fluid meeting federal standards: High temperature stability, Ph, reserve alkalinity and boiling points. Simply addressed, the brakes get very hot and transfer that heat to the wheel cylinders and to the brake fluid. The fluid must be able to retain its viscosity under the high-heat adverse conditions. The Ph refers to the level of acidity or alkalinity in the brake fluid. In general, a high Ph (higher alkalinity) is better for corrosion control, but the higher Ph does affect other factors in brake fluid performance. The difference is generally not enough to worry about, if the fluid is changed at regular intervals. The reserve alkalinity is a cushion allowing additional higher Ph numbers when the car is used under high stress braking situations, like racing, extreme temperatures, or other applications where the brakes are allowed to get more-than-normally hot. It is not a factor that we, in our antique or classic cars, have to be very concerned about. Use a quality brake fluid, and it will meet the needs of virtually all street cars.

Of greater concern is the boiling point of brake fluid. The boiling point is measured in two ways: dry boiling point and wet boiling point. The boiling points for the various DOT levels (DOT 3, DOT 4, DOT 5.1, DOT 5) are given as both dry boiling points and wet boiling points.

What is the difference between 'Dry' and 'Wet'? Dry is the boiling point measured with brand new, out-of-the-package brake fluid, before it has had a chance to absorb water, other fluids, or paint solvents from the system. Wet is the boiling point of brake fluid containing 3.7% +/- 0.05% water. It can get very complicated beyond this point – the water content measured as a percentage is the standard, but the actual water measured by weight can vary considerably between DOT 3, DOT4 and DOT 5.1 fluids. Let's not even go there. For our type of driving, it doesn't mean much. For racing, special brake fluids are available. The qualities of the fluid become more important under those circumstances.

Characteristics of common braking fluids

	Dry boiling point	Wet boiling point	Primary constituent
DOT 3	401 °F (205°C)	284 °F (140°C)	glycol ether
DOT 4	446 °F (230°C)	311 °F (155° C)	glycol ether/ borate ester
LHM+*	480 °F (249°C)	480 °F (249°C)	mineral oil* Used primarily some French cars and in some Rolls-Royces
DOT 5	500 °F (260°C)	(356 °F (180°C)	silicone
DOT 5.1	500 °F (260°C)	(356 °F (180°C)	glycol ether/ borate ester

I guess this is as good a time as any to look at the components of brake fluid. Glycol-based fluids consist of a mixture of ingredients with as many as ten separate substances making up the final product. These substances can be broken down into four key components:

- A lubricant, such as polyethylene or polypropylene, to keep parts moving freely - 20-40%.
- A solvent dilutent, usually glycol ether, which determines the fluid's boiling point and viscosity and accounts for 50-80% of the fluid.
- A modifier-coupler, which changes the amount of swelling of exposed rubber parts.
- Inhibitors, to prevent corrosion and oxidization.

As brake fluid gets old(er) the modifier-couplers and the inhibitors lose their effectiveness. This is another reason that brake fluids should be flushed and replaced in that one-two year window mentioned before.

What are the advantages (or disadvantages) of DOT 5 silicone brake fluid over the ethylene-glycol or propylene-glycol fluids?

DOT 5 (silicone brake fluid) was originally introduced to give a higher boiling temperature over glycol-based DOT 4 brake fluid. Purple in color and sometimes referred to as

'synthetic brake fluid', DOT 5 is not compatible with any of the glycol-ether based DOT fluids.

As you can see in the chart above, the boiling points for DOT 5 and DOT 5.1 are the same. There is no advantage to silicone over glycol-based fluids when it comes to boiling points.

DOT 5 is also more compressible than the other DOT brake fluids which can lead to a sluggish or spongy brake pedal feel.

Perhaps the biggest advantage of DOT 5 is that it is hydrophobic and does not absorb water from the atmosphere like regular DOT brake fluid will.

Think before you decide to drain the DOT 3, DOT 4 or DOT 5.1 and replace it with DOT 5 silicone brake fluid, because DOT 5 is not compatible with glycol based fluids, ALL components of the brake system have to be changed to new parts, or all of the old fluid must be removed. Solvents will remove the DOT fluids from 'hard parts', but rubber parts have absorbed DOT glycol fluids and must be replaced with new parts.

Over the years, rumors/stories have abounded that DOT 5 will leak out, whereas glycol fluids do not. That may have been so in the early products, but that problem has virtually been eliminated through chemistry in the modern DOT 5 products.

WARNINGS AND PROVISOS

DOT 5 is not compatible with DOT 3, DOT 4, or DOT 5.1 brake fluids. They may not be mixed, or systems filled with DOT glycol fluids cannot be refilled with DOT 5.

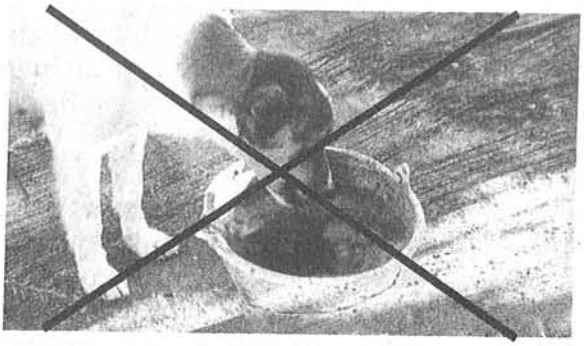
DOT 3, DOT 4 and DOT 5.1 have different compressibility and boiling points. Although they may be mixed, the characteristics of the resultant fluid will be changed.

DOT 3, DOT 4 and DOT 5.1 are hydroscopic – they will absorb water. The problems associated with the dissolved air/water are discussed above.

Brake fluid is extremely harmful to painted surface. DO NOT spill or splash brake fluid on painted finishes. It is also a serious eye irritant. Avoid getting brake fluid in your eyes or on your skin.

Brake fluids contain additives (discussed above) which begin to deteriorate as soon as the seal is broken on the bottle. After one or two years, many of the attributes offered by the additives have been lost and the fluid should be changed.

Glycol-based brake fluids are poison. They should never be taken internally, and never left in a container which might be accessible to pets or other wild animals. The sweet taste is an attraction, but fluid contact with animals must be avoided.



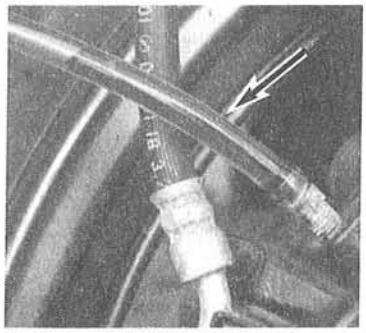
HOW TO FLUSH THE BRAKE SYSTEM OF OLD FLUID

Flushing the brake system is a rather simple job, but it does require two, and preferably three, people to make the job as easy as possible. Simply bleeding the brakes to get rid of entrapped air bubbles requires almost the same amount of work as a full flushing. It makes sense to do a full flushing as long as you are doing the brake bleeding.

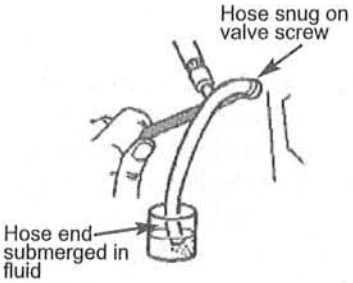
The first person (let's call him/her the **DRIVER**) is the one who sits in the driver's

seat and depresses the brake pedal on orders from the second person – we'll call him the **MECHANIC**. The third person – the **FILLER** – will have the very important, although fairly easy, job of keeping adequate fluid in the master cylinder reservoir or the remote reservoir. If the fluid level drops too low, air will get into the system, and the entire job will have to be re-done. (In lieu of the third person, either the mechanic or the driver will have to regularly check and refill the fluid in the master cylinder.)

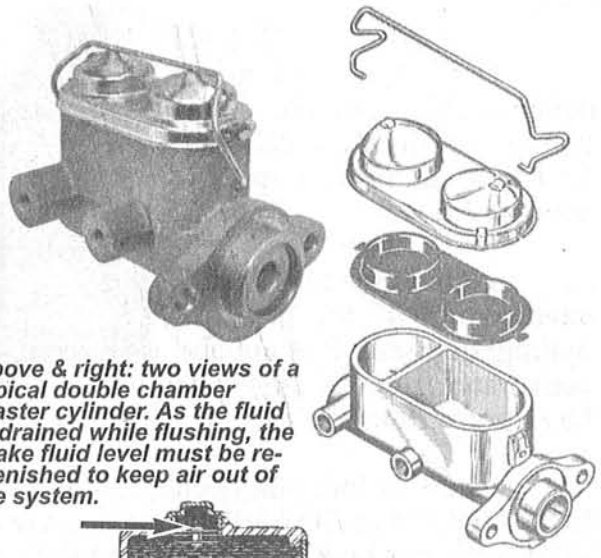
It may be easier for the mechanic if the car is raised on jack stands to provide additional clearance to work. Beginning with the wheel farthest from the master cylinder (normally the rear-right wheel) the mechanic will attach a piece of clear hose to the bleeder valve, with the other end in a collection container. A clear hose is recommended so that air bubbles can be seen leaving the system, and it can be seen when the fresh brake fluid has completely replaced the old fluid. The mechanic will require a suitably sized open end or box-end wrench to open and close the bleeder valve. When he is ready, the mechanic will open the bleeder valve and call out to the driver, "DEPRESS." The driver will then depress the brake pedal and hold it down while the mechanic closes the valve.



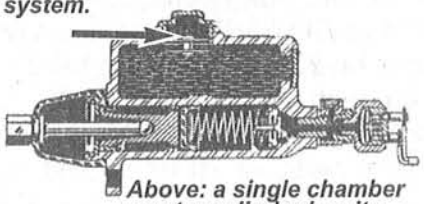
A PIECE OF CLEAR HOSE, FIRMLY ATTACHED TO THE BLEEDER VALVE MAKES IT EASY TO WATCH THE FLUID FLOW FROM THE VALVE.



The mechanic will then call out, "RELEASE and PUMP," and the driver will release the brake pedal and pump it three times to bring the pedal back up. The driver must not release or pump the brake pedal while the bleeder valve is open or air and old fluid will re-enter the system.



Above & right: two views of a typical double chamber master cylinder. As the fluid is drained while flushing, the brake fluid level must be replenished to keep air out of the system.



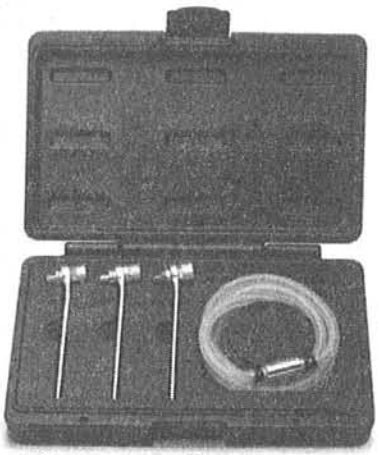
Above: a single chamber master cylinder has its reservoir above the pump mechanism. Arrow indicates fluid in reservoir.

After the brake pedal has been pumped, and before it is again depressed, the filler will remove the cover from the master cylinder or reservoir, replace the fluid that has been lost (this needn't be done each time the pedal is pumped, but be sure the fluid level does not drop to allow air to enter the system). Once the filler has replaced the lost fluid, the cover should be replaced on the master cylinder to prevent splashing – it can be held in place by hand. It is not necessary to replace the bail retainer each time. The filler can then call out, "FILLED," and the mechanic can repeat the DEPRESS AND RELEASE procedure.

When the fluid runs clean and the old fluid has all been flushed from that line, the mechanic can close the bleeder valve, remove the hose, and move on to the next farthest wheel (generally the rear left). The entire pro-

cedure has to be repeated to clear that line of any old fluid. After wheel two is completed, the mechanic can move onto wheel three (front right) and then finally to wheel four (front left). Be sure that each bleeder valve is closed securely.

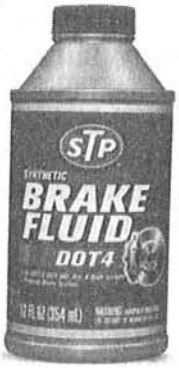
To simplify the job, Eastwood Company offers a brake bleeding tool (#31509) which incorporates a one-way valve so that it is not necessary to open and close the bleeder valve between depressing the brake. It also contains three of the most common size wrenches for brake bleeder valves. See *Skinned Knuckles* magazine, May 2017 – Does It Work or is it Snake Oil? for a review.



The Eastwood brake bleeder kit with its one-way valve, hose and three wrenches makes flushing the brake system easier.

After the flushing is completed, the reservoir is refilled and the reservoir bail is secured, the area around the master cylinder should be washed down with a garden hose or buckets of water so that paint is not removed from the master cylinder or adjacent areas. Dispose of the old brake fluid properly, preferably at a haz-mat collection station. Make a note in the Owner's Manual as to when the brake system was flushed so that it can be done again at a suitable interval.

Our recommendation for cars before 1960 or so would be to use DOT 4 or DOT 5.1 brake fluid. Both have a higher boiling point than DOT 3. Since the quality of brake fluid is not tested by the Department of Transportation (DOT), we recommend that you use a well known and branded quality of brake fluid rather than a cheaper, unknown brand.



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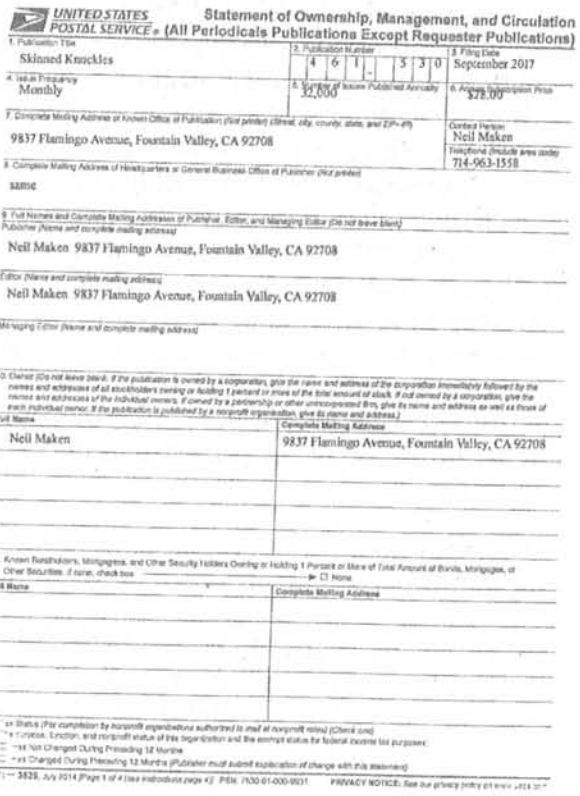

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