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Brake fluid is possibly the single most neglected component of the automobile. Most high performance drivers check their tire pressures and change their engine oil at frequent intervals, but virtually no one ever changes the brake fluid in their street car. The function of brake fluid is to provide an incompressible medium to transmit the driver's foot pressure on the brake pedal through the master cylinder(s) to the calipers in order to clamp the friction material against the discs. The foot pressure is multiplied by the mechanical pedal ratio and the hydraulic ratio of the master cylinders, booster (if used) and caliper piston(s).

This is a simple concept. When fresh, all brake fluids are virtually incompressible and the system works as well as its mechanical and hydraulic design allows. There can be, however, significant problems in the proper functioning of brake fluid. Overheated brake fluid can (and will) boil in the caliper. Boiling produces gas bubbles within any boiling fluid. Gas is compressible so boiling brake fluid leads to a "soft" brake pedal with long travel. In extreme cases overheated brake fluid necessitates "pumping the brake pedal" in order to get a pedal at all.

This leads to a discussion of boiling points. Brake fluids are classified by both "dry boiling point" and "wet boiling point." They are also classified by US Department of Transportation (DOT) rating, DOT 3, DOT 4, DOT 5, and DOT 5.1.

The U.S. Government specifications for brake fluid, FMVSS 116, do not dictate the chemical composition of a given classification, or "grade" of brake fluid. Instead FMVSS116 defines the properties of the fluid, such as dry and wet boiling points (referred to as the equilibrium reflux boiling points, dry and wet), viscosity of the brake fluid grade at certain temperatures, high temperature stability, corrosion characteristics, and the effects of the fluid on seals, as well as other physical properties like the tendency to jell or separate (called stratification) or form sludge and/or crystalline deposits. Boiling point and viscosity are the most relevant properties to most consumers, including high performance customers. Viscosity is an important factor for proper operation of ABS and Active Handling Control systems on modern vehicles since in most cases the pressure and volume of fluid transferred is not measured. Instead, flow through a valve with a given orifice size over time are the control mechanism, so fluid maximum viscosity is a key characteristic.

This discussion does not require a thorough review of the Federal Standard, which also includes testing procedures and storage and labeling of containers, but one aspect of the regulation that deserves attention here is the importance of the container used to ship the brake fluid. Non-silicone-based brake fluid is strongly hygroscopic, meaning that it naturally absorbs water from the humidity in the air. That is why the shipping container and the brake reservoir have to function as a barrier to the moisture in the air reaching the brake fluid. Modern brake reservoirs are thick enough, and the bellow seals on top function well enough, to provide a long life to the fluid once in use. The container the fluid is delivered in is just as important. The best type of container is a metal one, as it performs the function of a moisture barrier much better than thin plastic bottles - even when those plastic bottles are made from engineered materials. The technology does not exist today to make the plastic container perform as well as metal at a reasonable cost.

DOT 3 fluids are usually glycol ether based, but as stated earlier, that is not because they are required to be. The brake fluid industry has determined by consensus that glycol ether fluids are the most economical way to meet the requirements.

By definition, DOT 3 fluids must have a minimum dry boiling point (measured with 0 percent water by volume) of 401°F and a minimum wet boiling point (measured with 3.7 percent water by volume) of 284°F. The specification says little more as far as the performance enthusiast is concerned.

DOT 4 fluids are also glycol ether based, but have a measure of borate esters added for improved properties including increased dry and wet boiling points. A seldom talked about characteristic is that because of this chemistry, the DOT 4 fluid will have a more stable and higher boiling point during the early portion of its life, but ironically once the fluid does actually begin to absorb water its boiling point will typically fall off more rapidly than a typical DOT 3. By FMVSS116 standards, DOT 4 fluids must have a minimum dry boiling point of 446°F and a minimum wet boiling point of 311°F.

DOT 4 is the grade applicable to most race engineered brake fluid in the world today, especially with regard to viscosity limit. Note that although the DOT 4 designation has a minimum dry and wet boiling point, a DOT 4 racing brake fluid may have a dry boiling point over 600F. Its viscosity is challenged, however, to be under the viscosity limit of 1,800 mm2/sec. Some claimed racing brake fluids exceed this important limit. Caution should be exercised if these fluids are used in race cars with ABS systems. This does not mean that DOT 4 fluids are necessarily better than DOT 3 fluids. Remember, the boiling points listed are minimums. There are certain DOT 3 fluids with higher boiling points than some DOT 4 fluids. The real differentiating factor is that DOT 4 fluid should be changed more often than a DOT 3 fluid, because of the effects and rates of water absorption.

The original **DOT 5** fluid specification was expected to be fulfilled by silicone based (SSBF) composition. It was designed for use in applications where its resistance to water absorption (and therefore low corrosion) was desired - like in military equipment. It has also found use in antique cars because it does not dissolve paint finishes. With SSBF, unfortunately, these characteristics were only achieved by unacceptably high compressibility. As such, the DOT 5 grade SSBF is of little value to any conventional automotive or high performance application.

Subsequently there have been non-silicone based fluids developed that meet DOT 5 wet and dry boiling point specifications and viscosity requirements. They are referred to as DOT 5.1 grade fluids. As a special case they are listed here for completeness.

Please remember that the specifications are minimums and therefore the non-SSBF DOT 5 fluids do not offer the highest boiling points available. There are no DOT 5.1 brake fluids that exceed the dry and wet boiling points of the best of currently available DOT 4 racing brake formulas. They do meet the lower viscosity specifications, however.

Fluid Grade	Dry ERBP (°F) @ 0.0% H2O	Wet ERBP (°F) @ 3.7% H2O	Viscosity Limit (Cp @-40°F)	Chemical Composition
DOT 3	401	284	1500 mm2/s	Glycol Ether Based
DOT 4	446	311	1800 mm2/s	Glycol Ether / Borate Ester
DOT 5 (SSBF)	500	356	900 mm2/s	Silicone Based
DOT 5.1	500	356	900 mm2/s	Borate Ester/ Glycol Ether

One last note on the DOT ratings: Systems designed for a particular type of fluid (especially prior to the wide distribution and use of DOT 4 fluids) should continue to be filled with that fluid. For example, in a car that was delivered with DOT 3 fluid, the internal components of the system (seals, brake hoses, and fittings for example) were specifically designed and tested for compatibility with the chemical composition of DOT 3 fluid. Because the DOT 4 grade fluid typically contains a different chemical composition, compatibility of system components may be an issue.