Motor Age
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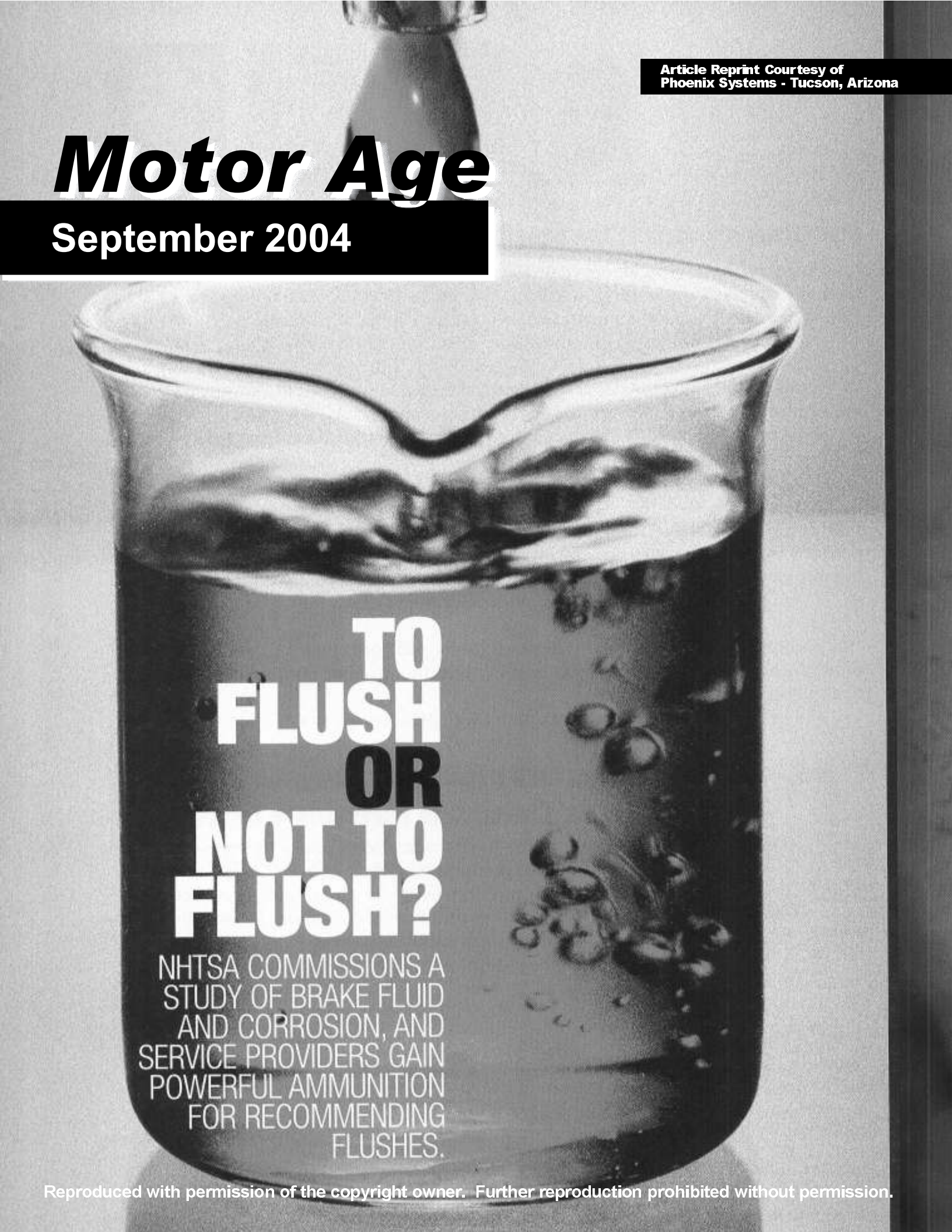


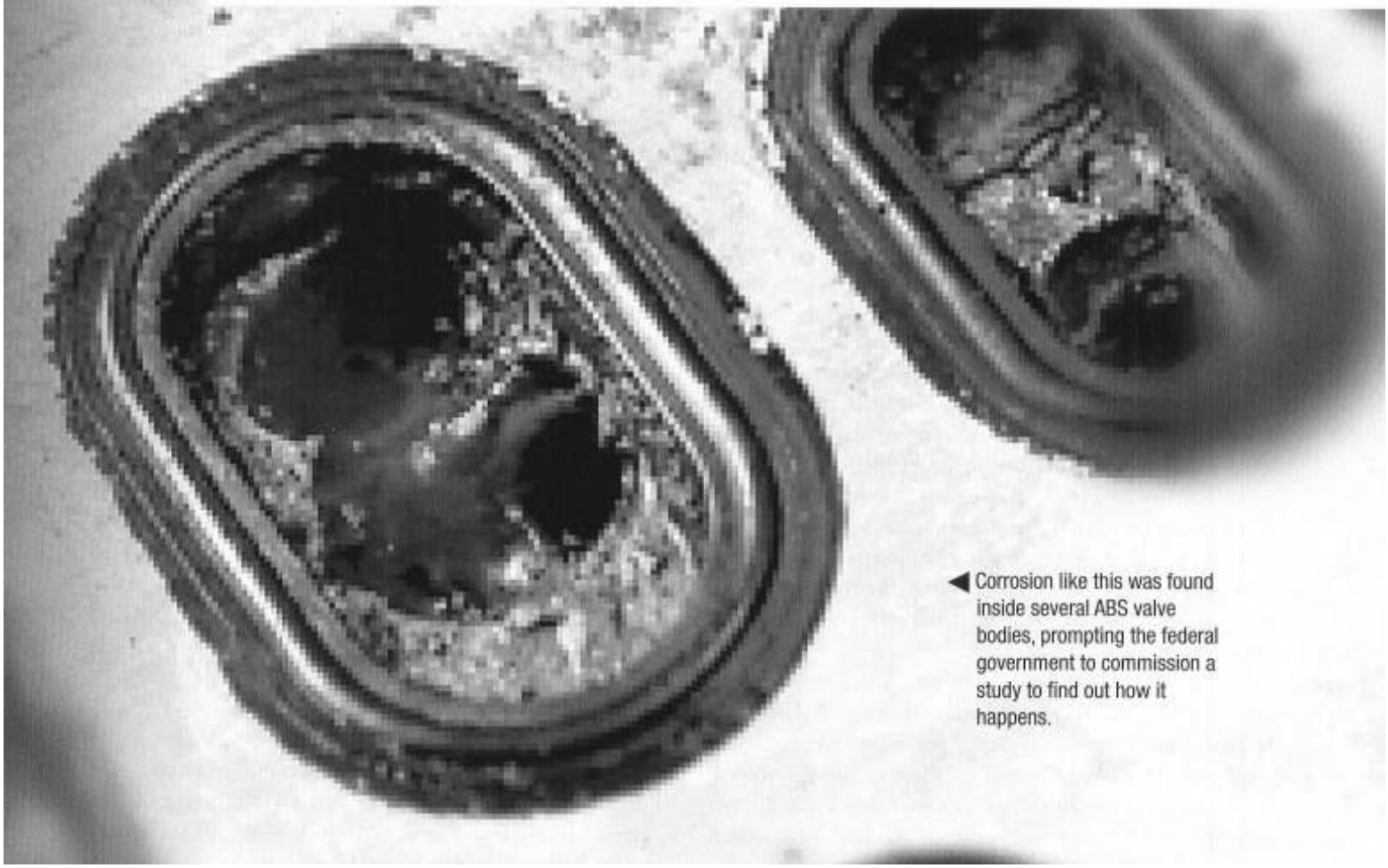
TO FLUSH OR NOT TO FLUSH?

NHTSA COMMISSIONS A STUDY OF BRAKE FLUID AND CORROSION, AND SERVICE PROVIDERS GAIN POWERFUL AMMUNITION FOR RECOMMENDING FLUSHES.

At least some of your customers probably understand why we change the oil in an engine. It's to remove acids, carbon and other contaminants that accelerate the wear on seals, bearings and various moving parts. Some might even understand that we change transmission fluid because the friction material gradually wears off the clutches, contaminating the fluid with a sludge that can wear seals and jamb valves. And those who've read their owner's manual might even know that we change coolant because the corrosion inhibitors eventually lose their effectiveness with time and miles.

But who knows why anyone would recommend changing brake fluid? There are no combustion or friction materials to generate harmful byproducts, and it's a sealed system, so air, moisture or other contaminants cannot enter. So why do some manufacturers recommend changing brake fluid? Even more puzzling, why do others recommend against it?

At least part of the answer can be found in a study completed in 1998 by the National Institute of Standards and Technology (NIST) at the request of the National Highway Transportation Safety Administration (NHTSA). The study was initiated in response to vehicle owners' complaints about the operation and performance of their vehicles' antilock braking systems (ABS). NHTSA found deposits of what looked like corrosion residue in some ABS control valves, so they asked the NIST researchers to



◀ Corrosion like this was found inside several ABS valve bodies, prompting the federal government to commission a study to find out how it happens.

TO FLUSH OR NOT TO FLUSH?

The corrosion on this caliper piston is mostly likely caused by environmental conditions. When circulated by ABS operation, deposits can be transported to other parts in the system.

study how brake fluid ages while it's in a brake system, hoping to learn how it influences corrosion.

Researchers learned a great deal, and their work has helped the service industry develop tools that test for corrosion in the brake system. Although some manufacturers have been recommending periodic brake fluid flushing for decades, they never provided a good explanation as to why. Some people in the service industry view the NIST report as long-awaited scientific confirmation that changing brake fluid is a good maintenance practice. Whether or not that's so, the report does provide good background information that can help service professionals reach their own conclusions and prove their case to a customer.

FLUID COMPOSITION

When hydraulic brakes were first developed in the 1920s, the only material available for seals, hoses and other hydraulic parts was natural rubber. The first brake fluid was a mixture of castor oil and alcohol. But when synthetic elastomers and plastic parts became available, natural rubber was still in use, and brake fluid had to be compatible with all of these materials. That meant a solvent would be needed so that a wider variety of fluids could be mixed together. While there were several reasonable choices, the industry settled on glycol ether as the standard base solvent for hydraulic brake fluid.

Glycol ether describes a group of a dozen different solvents that can be easily mixed with other fluids. These solvents won't attack natural or synthetic elastomers and won't make them swell and disintegrate the way some other solvents can. However, these solvents will attack many other materials, and if you've ever spilled brake fluid on a painted fender, you already understand just how aggressive it can be.

Another thing that makes glycol ether a good hydraulic fluid is that it has both low viscosity and a high boiling point, so it flows just about the same way over a wide temperature range. Other components in brake fluid are polyglycol lubricants – solvent modifiers that make the fluid compatible with a wider range of elastomers – and an additive package. Some of the additives are corrosion inhibitors, pH stabilizers and anti-oxidants, which are all designed to improve stability of the fluid and long-term performance of the brake system.

With so many different fluid components available, the industry needed some rules to make sure any brand of brake fluid would work in any system. The U.S. Department of Transportation (DOT) provided those rules, but instead of specifying which solvents, oils or other chemicals can and cannot be used to make brake fluid, they wisely chose to set performance standards. That leaves the industry free to make improvements without being tied to specific chemicals.

Brake fluid must pass 14 different tests for approval. These tests measure things such as viscosity, evaporation loss and the fluid's ability to inhibit corrosion. While all brake fluids must meet the same corrosion and elastomer compatibility standards, the performance specifications we're most familiar with are the wet and dry boiling temperatures. Those are the standards used to differentiate DOT 3, DOT 4 and DOT 5 brake fluids.

THE NIST TEST

Because most new cars are equipped with DOT 3 brake fluid, that's what NIST used for all its testing. As noted earlier, the study was requested because signs of brake system corrosion were found in the ABS valves of vehicles whose owners had complained about ABS operation. The goal of

Photos: Phoenix Systems

Corrosion clogging this inlet filter (right) and valve (top) might be circulating through the system, but corrosion also is occurring locally on the valve body housing and on the plunger inside (above).

the study was to understand how brake fluid influences corrosion in a brake system and how that influence changes over time-in-service.

Most of the corrosion in a brake system is caused by environmental contaminants like water, salt and oxygen. Wheel cylinders and calipers are out in the environment, and they are subjected to heat cycles that can distort the sealing surfaces. That's where contaminants are most likely to enter the brake system. The report suggests that environmentally caused corrosion in these areas may have always existed, but in vehicles without ABS, brake fluid doesn't circulate through the system. Its movement is more like a control cable in its housing: There is back-and-forth motion of the fluid, but the same fluid touches the same parts of the system all the time. Any environmental contamination or corrosion will remain local. Over the years, better materials and coatings have been developed to survive such attacks, so it has become less of a problem on newer cars. But on cars with ABS, brake fluid circulates during ABS operation, so deposits caused by environmental corrosion can be carried by the fluid to other parts of the system. While not mentioned in the report, people in the field — that's you — understand what kind of problems that can cause.

This study also discovered another mechanism for brake system corrosion. In about one-third of the test vehicles, corrosion was found on parts made of ferrous metals, and many of the corrosion pits were filled in with copper. The copper came from the steel brake lines, which are built up of spiral-wrapped layers of steel and joined together with a brazing alloy that contains copper. So the researchers focused on how copper might be removed from the brake lines and deposited in the shallow pits in the iron.

To quote the report: "The copper in the brake lines corrodes at a slow rate over several months or years resulting in copper ions in the brake fluid. These ions then act as oxidizers and plate out in the ABS valves when the corrosion inhibitors can no longer prevent corrosion of the ferrous components." In other words, the brake fluid constantly corrodes the copper in the brake lines, and the copper leaches into the brake fluid as ions, atoms with an electrical charge. When the corrosion inhibitors in the brake fluid eventually "wear out," as they always do, these copper ions become the oxidizer that corrodes the parts made of iron and steel. Because they have an electrical charge, the copper ions are attracted to the ferrous metals and actually electroplated into the pits.

MEASUREMENT

In addition to searching for the cause and sources of corrosion, the study also focused on ways to measure it by, among other things, measuring the conductivity of brake fluid. Electrical conductivity is the measure of a material's ability to transport an electric charge. Metals have high conductivity; glass has very low conductivity. The conductivity of liquids depends on the liquid itself, but a conductive material dissolved in a liquid will increase its conductivity. As you might expect, brake fluid's conductivity increased during the test when water was added to form a 2 percent

Photos: Phoenix Systems

solution, a common real-world moisture content. But when copper ions were added in a concentration, only 25 percent of the maximum allowed for DOT 3 brake fluid, conductivity increased more than six times.

This is the smoking gun needed by the service industry to justify changing brake fluid. Measuring the conductivity of brake fluid in a vehicle will give a measure of the fluid's copper content, which will then indicate the condition of the fluid's corrosion inhibitors. Conductivity meters can do this, and test strips can clearly indicate the presence of "oxidation catalysts" – ions in the fluid. However, in vehicles without ABS or where the ABS is rarely activated, it's likely that fluid in the reservoir would have a lower reading than fluid in the rest of the system.

As a side note, the test report suggested that the DOT's test for copper corrosion caused by brake fluid is probably inadequate, and that the maximum allowable copper ion limit should be reduced.

BOTTOM LINE

The NIST study looked only at brake fluid and how it might contribute to corrosion of materials in a brake system. It did not study brake systems and did not even speculate about how corrosion might affect brake system operation. However, based on that report and reports from the service industry, we'll go out on a limb here and draw some conclusions of our own.

Anyone who notices color differences between new and used brake fluid knows that brake fluid changes with age and use. The questions are, what does the color change mean and what should be done about it? Identifying color changes in the shop is difficult, because so many different chemical changes are possible that the color change is almost meaningless. Without some kind of test equipment, there is no way to know the condition of the brake fluid.

Brake fluid ages at different rates and in different ways, depending largely on climate and the way the vehicle is typically used. It's a safe bet that vehicles in humid climates, and particularly those in the rust-belt states, will eventually suffer corrosion in the hydraulic system due to moisture contamination, mostly at the calipers and wheel cylinders. Vehicles in dryer climates will suffer less environmental corrosion. In either case, vehicles with ABS will distribute that environmentally caused corrosion and/or its residue throughout the hydraulic system. This residue can jamb ABS valves.

A second non-environmental form of corrosion occurs in all systems as the brake fluid ages and its corrosion inhibitors become depleted. Again, the speed of this corrosion may be influenced by outside conditions, but in every case the brake fluid itself corrodes the copper in the brake lines. The resulting copper ions can travel through the hydraulic system even without being circulated by antilock brakes, but will travel much faster in vehicles with ABS. The copper ions corrode ferrous metal parts, including the ABS control valves. The corrosion is slow and no one has conclusively determined if and when it may cause problems with ABS operation. But ...

Auto manufacturers recognized long ago that brake fluid's chemistry changes over time-in-service and that it cannot be counted on to prevent corrosion indefinitely. Today there are ways to measure the moisture content in brake fluid, but as shown in the NIST report, moisture is not the only factor that causes corrosion. A measurement of the brake fluid's chemistry is a better indication of the potential for corrosion. Even so, brake system corrosion still cannot be accurately determined, only predicted based on worst-case conditions. Therefore, some manufacturers recommend flushing the hydraulic system, including the ABS valves, every two years. The goal is to flush corrosion deposits and corrosion-causing copper ions out of the system, and to install new fluid with a fresh charge of corrosion inhibitors.

Some manufacturers have cited business reasons, environmental impact and warranty concerns as reasons for not recommending brake fluid flushes. But their brake fluids and ABS components are not significantly different from the other manufacturers' cars. In fact, sometimes the identical antilock braking system is installed on cars from manufacturers on both sides of the issue.

IF YOU DO

If you decide to flush a brake system, it is absolutely critical to use the factory-specified brake bleeding procedure. The job often requires a scan tool and special software to run the ABS pump and activate the valves. Also, proper training should be considered an essential tool for the job. Doing the job incompletely can easily cause more problems than it will prevent, and doing the job improperly can cause personal injury to the tech, as well as to the next person to drive the vehicle.

Servicing a hydraulic brake system has always been one of the most safety-critical jobs anyone can do on a vehicle, and surprisingly one of the easiest to do correctly. On vehicles with ABS, it's not so easy anymore, but the price of doing it incorrectly may be higher than the price of not doing it at all.