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## White Paper:

### Stainless Steel Brake Lines Q&A

#### **Why are flexible brake hoses used in the first place?**

From the factory, nearly every production passenger car has short, flexible hoses that run from the fixed, hard metal brake tubes to the calipers (or wheel cylinders as the case may be). These flexible hoses are necessary because the wheel ends are free to move relative to the body of the vehicle. Inflexible tubes would not allow for the articulation of the wheel ends without subsequent failure.

#### **What are OEM hoses made from?**

Typically, OEM hoses contain a compliant polymeric inner hose to transmit brake fluid pressure from the brake tubes to the caliper. While the polymeric tube itself does a good job of withstanding attack from the brake fluid, it must be protected from the outside world and is consequently wrapped (overmolded) with a thick, rubber coating. Hollow fasteners at one or both ends of the hose provide a direct flow path and a leak-free connection system.

#### **So how are Stainless Steel lines different?**

Stainless Steel lines (they are actually hoses, but we'll use the common term "lines" from this point forward in this FAQ) are similar to OEM hoses in function, but differ greatly in execution. Unlike OEM hoses, SS lines incorporate a low-compliance Teflon inner hose. In addition, instead of covering the Teflon with overmolded rubber a woven braid of Stainless Steel strands is placed over the hose for protection. As with an OEM hose, the ends are terminated with hollow fasteners to allow for the leak-free passage of brake fluid.

#### **So why is that better than the OEM rubber design?**

Stainless Steel lines provide a number of benefits as compared to their OEM rubber overmolded counterparts.

1. The SS braid provides superior protection from flying roadway debris.
2. The SS braid and Teflon hose reduce expansion during pressurization.
3. They provide the race car look.

#### **I understand the protection benefit, but can you explain the reduced expansion benefit?**

Any time that an object is subjected to internal pressure, it expands. The amount of expansion will be proportional to the amount of pressure present and the rigidity of the holding structure. In the case of brake hoses, we are subjecting Teflon to internal pressures as high as 3000PSI. Because the Teflon is relatively flexible (which makes it ideal for the job in one regard), it will expand under these conditions. This expansion creates additional fluid volume in the hydraulic circuit which is felt by the driver as a soft or mushy pedal. Rubber overmolding does little to reduce expansion under pressure, as rubber is also a relatively flexible material. A woven braid of Stainless Steel, however, can greatly increase the rigidity of the hose under pressure while still allowing adequate flexibility for wheel end movement. In many cases, this reduced expansion can be felt by the driver as a firmer or more responsive brake pedal. In addition, the reduced compliance will result in a faster transient response of the brake system. In other words, the time from the driver hitting the brake pedal until deceleration is generated will be decreased by a small amount. The benefit will vary based on each individual application, but in general overall deceleration can be attained more quickly, resulting in slightly shorter stopping distances.

#### **What impacts will SS lines have on my vehicle's P-T (pressure vs. torque) relationship?**

None. Because brake lines and hoses do not affect the torque generated at the wheel end, the P-T relationship remains unchanged when SS lines are installed. Only changes to a vehicle's caliper, rotor, or brake pad coefficient of friction will impact the P-T relationship.

#### **Well then, will SS lines impact my vehicle's P-V (pressure vs. volume) relationship?**

Absolutely. Because SS lines are much less compliant than their OEM counterparts, the P-V relationship will be reduced to some degree (less volume will be required at a given pressure). This is exactly the reason that a car equipped with SS lines has a firmer brake pedal.

However, because the P-T relationship remains unchanged with SS lines, the impact to ABS, TCS, and other brake control systems is typically negligible. Our own BBK kit testing indicates that most ABS, TCS, and other brake control systems are robust to the small changes affected by the addition of SS lines. On the other hand, testing at StopTech (and at major OEMs as well) has shown that while decreases in the P-V relationship typically are invisible to SS lines, increases in the P-V relationship are not (as would be found with an inappropriately-sized BBK).

In summary, because SS lines and a properly sized and balanced BBK only serve to reduce the P-V relationship, we have time and time again demonstrated appropriate system integration with these products. Our in-house testing allows us to make this statement for every platform we service.

#### **Will I feel a difference on my car if I install SS lines?**

The amount of perceived difference will vary by each car's individual design, age, and usage. Those cars with a significant amount of flexible OEM line or those that have seen years or use and aging will typically display a more dramatic improvement in pedal feel than new cars with shorter lines.

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### **What is the difference between lines that are “DOT compliant” and “DOT approved”?**

The United States Department of Transportation (DOT) has established numerous standards for automotive components and subsystems. The regulation for brake hoses happens to be FMVSS106. In this document, anything and everything pertaining to automotive brake hoses has been laid out in gory detail – at least, those things important to the federal government.

If a manufacturer claims their SS lines are “DOT compliant”, it means that their SS lines have passed all FMVSS106 requirements, and they have submitted the test data to the government for official certification. This does not mean they are acceptable for use on your car, but it does mean they pass the government minimum standards.

Another term you may hear in this context is “DOT approved.” However, the DOT is not in the business of actually approving or disproving compliance – they don’t typically run any tests on aftermarket components themselves. Under these circumstances, one can only surmise that these manufacturers are trying to state that their lines are actually “DOT compliant”, but it never hurts to ask before you buy.

### **So, do I need to use only DOT compliant SS lines on my car?**

Not necessarily. The DOT requirements must be met in full for official government approval, so even if a SS line passes every performance test but is labeled with the wrong type of tag (or something equally trivial) it would fail certification. While this might mean something to an auto manufacturer or assembly plant, it is meaningless to the performance enthusiast.

All the DOT compliance means is that the lines have passed a minimum set of government standards which may or may not be important to you. Does this mean that DOT compliant lines are the best for your car? Not necessarily, but the certification should indicate that the manufacturer understands the product and is trying to hold itself to a certain standard.

### **Why do some SS lines have a clear plastic covering?**

Under certain conditions, dirt and other abrasive contaminants can find their way between the SS braid and the Teflon inner hose. Over time these contaminants can be ground into the Teflon line to the point that a leak can develop. Naturally, a leak in the brake system is never a good thing.

Some manufacturers have taken the extra step to cover the SS braid with a polymeric coating to prevent contaminants from working their way into the Teflon liner. While this coating is not necessary for short-term longevity, hoses without the coating should be inspected and replaced on a more frequent basis.

### **Why do some SS lines have plastic molded over the end fittings?**

Some SS line manufacturers have adopted the practice of molding a semi-rigid polymer over the fittings at either or both ends of the line. These features act as a strain relief for the SS braid where the fitting is secured to the line. In some cases, lines without these features can fail certain dynamic portions of FMVSS106, as the SS braid can wear itself into the Teflon line where it is secured to the end fitting.

### **Do I need to take any special precautions when installing my SS lines?**

In general, no. The most important thing to note is that the routing of the SS line should match either the original stock routing or the instructions included for a new routing (if applicable). Because the SS braid will eventually wear through just about anything (once the protective outer layer is worn away), be sure that there is adequate clearance to all other moving parts under conditions of full wheel travel and full steering.

It should also be mentioned that after installation care should be taken to examine your SS line routing to ensure that the line is not stressed when the wheels are turned to full lock. This is best done with the wheel hanging at full droop to amplify any routing concerns. Of course the line should never come in direct contact with any part of the tire, but the line should not be pulled radially with respect to the overmolded end fittings either.

### **by James Walker, Jr. of scR motorsports, exclusively for StopTech**

James Walker, Jr. is currently the supervisor of vehicle performance development for brake control systems at Delphi Energy & Chassis. His prior professional experience includes brake control system development, design, release, and application engineering at Kelsey-Hayes, Saturn Corporation, General Motors, Bosch, and the Ford Motor Company. Mr. Walker created scR motorsports consulting in 1997, and subsequently competed in seven years of SCCA Club Racing in the Showroom Stock and Improved Touring categories.

Through scR motorsports, he has been actively serving as an industry advisor to Kettering University in the fields of brake system design and brake control systems. He also serves as a brake control system consultant for StopTech, a manufacturer of high-performance racing brake systems. In addition, Mr. Walker contributes regularly to several automotive publications focusing on brake system analysis, design, and modification for racing and other high-performance applications. He is a recipient of the SAE Forest R. McFarland Award for distinction in professional development/education. Mr. Walker has a B.S. in mechanical engineering from GMI Engineering & Management Institute.

To find out more about Mr. Walker and scR Motorsports, visit their website at [www.teamscR.com](http://www.teamscR.com)

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Stoptech is the performance engineering and manufacturing division of Centric Parts. It is the leader in Balanced Brake Upgrades for production cars and has three patents in basic brake technology and one other pending. With a worldwide network of resellers, StopTech's product line includes Balanced Brake Upgrades for approximately 450 applications featuring StopTech's own six-, four- and two-piston calipers, two-piece AeroRotor Direct Replacement Kits, braided stainless steel brake lines and slotted and drilled original-dimension rotors. StopTech also stocks a wide range of performance brake pads. The company's website, [www.stoptech.com](http://www.stoptech.com), is a clearinghouse of performance brake information, and provides details on StopTech products.

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