

INNOVATIVE BRAKE TECHNOLOGY™

TECH ARTICLE

Editors Note: *Innovative Brake Technology by The Brake Man, Inc., has a long and distinguished history of developing leading edge technology for the automotive and racing industry. Warren Gilliland, the President and CEO, has been designing advanced brake systems since 1967, far longer than any other American aftermarket company. Mr. Gilliland's focus and commitment to technological leadership have formed the core competencies at The Brake Man, Inc. From the early days At Hurst/Airheart in the late 60's, and throughout the 80's at JFZ Engineered Products, the key technologies that are foundational to The Brake Man, Inc. have been the source of setting the trends for advancement of the industry. The Brake Man is among the most knowledgeable sources of information for improving brake systems, while supplying high quality brake components, and most importantly, a reliable source of information on how to make the system produce the best results.*

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SPRINT CARS FINDING NEW SPEED IN THE BRAKE SYSTEM

Everybody already knows the best way to build the fastest sprint car. It's simple. Buy the lightest weight chassis you can find, put the biggest, baddest motor in it, buy titanium till the budget can't handle it, and drill holes in everything including the center out of bolts to get every last ounce out. Right? Not necessarily.

If you have an unlimited budget, this might be a good start, but it is far from the best way, and very far from fact. This year at the Performance Racing Industry trade show, it was apparent that racers realize they can no longer afford to put their entire racing budget into the motor. They are coming to realize that to be successful, they must use their budgets wisely to make the most of what they spend. They also realize that an expensive motor is no good if you can't keep your foot on the throttle.

If you are like most teams and don't have an unlimited budget, then it is even more important that you focus on improving your lap times as much as possible with what you do have to spend. Believe it or not, the greatest lap times improvement is NOT in the motor. Until your chassis and brakes are as good as they can be, pouring more money into more horsepower will not improve the lap times nearly as much.

To prove this point, we talked to several drivers' this year that entered races with motors far smaller than their competition. Because they had concentrated on the other key aspects of the car, they found themselves to be highly competitive while being "out horse powered" by as much as 100 BHP! Why is this possible?

Just as with motor development, improvements in other components on the racecar are improving the ability of the car to get around the racetrack with greater speed and efficiency. Unfortunately, to a great extent, the sprint car builders and owners have been so focused on merely decreasing weight that they have overlooked several new developments. These new developments could have improved the car far more than 10 times the same amount of money spent on the motor.

It never ceases to amaze me that a driver or crew chief would walk into our booth at the show, pick up our caliper, and, using his arm like a scale, determine that it would never find it's way onto his race car. Making an immediate determination about the brake based on how much it weighed, the individual lost the opportunity to learn about the incredible advantage he/she could get from the proper components and setup.

I find this interesting in that anyone familiar with racing knows this is an evolving sport. Every year, new products or methods find their way into the established, accepted ways the cars are built. I do not know of a single racer that would feel they could show up with the most advanced sprint car from the 1988 season, and expect to win even a single race. Yet most teams make little or no effort to explore the marketplace in search of the next item that could help them make their car faster or handle better. How much research are you doing?

Why is it that less than 5% of all people involved in motorsports seem to be the individuals making all of the advances. It's simple. They look. They are not afraid to check into new products, listen to the "sales pitch", ask intelligent questions based on their own experience, and then make changes. This is why the same teams seem to constantly run up front. They are never content to rest on their laurels. They know the other teams will be trying to catch them and they must find a way to constantly improve or be caught. You have the power to determine how much higher you finish.

Yes, it's true that for years, the only truly important item to all sprint car people was "the weight". Teams would spend massive amounts of money in search of ounces. Well, this may come as a shock, but if you focus your attention on building the lightest weight sprint car, and this is your only focus, you lose. To run up front, the only true motivation during the building cycle should be the clock. What parts need to go on the car to make it travel around the racetrack the fastest, and more importantly, the most consistently. If you have the fastest racecar for one lap of qualifying, but your car can't handle 50 laps, you lose. If your car handles well for 5 laps and then becomes uncontrollable, you lose.

A racecar that is a consistent winner has several characteristics. First, it must be durable. If your sprint car is not durable, the DNF's, (Did Not Finish), will keep you from ever being successful. Second, the racecar must have great handling characteristics. If the driver cannot control the car, he has to work harder and is constantly distracted from concentrating on the driving aspect. Third, the vehicle must be consistent. If during the course of the race, the handling characteristics are dramatically altered, it is much more difficult to establish a rhythm that is so important to successful drivers. Obviously, small changes can't be avoided such as tire pressure and changing track conditions, but you don't need to add to the driver's challenges by rapidly deteriorating vehicle dynamics.

For example, in the late eighties and early nineties, racers were on a light wheel kick. To such an extent that several wheel manufacturers made wheels that were only really good for a one lap qualifying session. The resultant failures were so dramatic that finally the buying public realized the cost and resultant loss from failures did not make it worthwhile. Another example was that in the early nineties, in the interest of weight, racers were drilling so many holes in the aluminum torsion bar arms, the cars were actually slowing down because the aluminum arm could no longer bend the steel torsion bar without deflecting. This deflection resulted in suspension and handling problems that far outweighed the advantage of the few ounces saved in the arms. This really caused a big problem, because for some time, racers' blamed the torsion bars for the problem and were throwing away perfectly good bars.

There are many more examples, and I'm sure you have already thought of a few of your own, but hopefully, you understand that the above examples illustrate the point of "the law of diminishing returns". Basically, what this means is that the weight you removed just hurt your car more than helped, so it should be put back on. In other words, you need to take a hard look at your decision making process for how you choose the components that will go on your racecar.

Which leads us as to why I wrote this article. With respect to brakes, we have been able to prove that there is more competitive advantage to be gained in the brake system than in any other portion of the car. While engines have been exploited for many years, and shocks and suspension have made major advances recently, the brake system on most sprint cars is woefully inadequate and out of date.

Much of the reason for this is again, the focus on weight. In an engine, we are taking heat and turning it into energy. A brake system does just the opposite, taking energy and turning it into heat. Why is it that a racer has no problem loading an engine weighing 500 pounds of sprung weight, (the worse kind), into the sprint car, but is unhappy when the brake system, both front and rear may total 20 pounds of unsprung weight? Also, consider the fact that the 20 pound brake system must reverse all the momentum produced by the 500 pound motor and fight the motor while doing it! If 5 more pounds of brakes will improve the entire handling characteristics of the sprint car and improve lap times by 3-4 tenths of a second, why do they remain so incapable of making the decision to refocus their true goal to make the racecar better? Because they have been led to believe that the weight is the most critical factor, one that is really not true, but is impossible to get out of their heads.

To illustrate that point, several racers have told me that they have NEVER had a reliable brake system on their car. They have never felt safe or in control. Why, because they did not know the car could be made to stop safely. To make matters worse, they were still trying to remove more weight from the brakes, while at the same time, complaining they had no brakes! Their only defense was that "All sprint cars have the same problem", which, by the way, is another untrue statement. We can prove it.

For the most part, much of this has to do with perception. Because the sprint car usually does not weigh more than 1300-1400 pounds, many racers feel it should not take that much to stop it. The truth is that a sprint car has some very unusual stopping problems. First, a sprint car is always under load from the motor, due to the fact it has no neutral. Second, although it has a front brake, that brake is really only for turning. The entire responsibility for truly stopping the car falls on the inboard rear brake assembly alone. This means one caliper dumping all the heat to stop the car into one rotor, mounted in the worst "dead air" spot on the car, which is behind the driver's seat.

Combine this with the fact that racers are willing to compromise stopping ability for a few more ounces of weight reduction and it becomes clear why very few cars are able to “stall the motor”, any time they want. Notice that I said very few. That means that some cars truly can. Why is this? Because they researched and learned what it takes to put together a good system.

Almost every sprint car driver will tell you that the position of the brake pedal in the car is not where he would like it to be, rather it is adjusted way out behind his leg in an uncomfortable position to push. Why? Because since the brakes will go bad during the race and the pedal will drop, he needs the space between the firewall to have even a fighting chance of having brakes at the end of the race. Do you think a driver is fastest while trying to drive while he is uncomfortable? Absolutely not.

Next, if the calipers chosen are too small or too weak to handle the job, the flex in the caliper will drag, which robs horsepower down the straightaway. It also binds the chassis in the corner and further robs throttle response off the corner. In fact, on several cars we have set up, the throttle response, combined with how much deeper the car can go into the corner, means that gear changes have been necessary due to the increased rpm's. Since the apex angle is different, the car exits the corner straighter, allowing the driver to get on the throttle sooner. Combined with deeper corner entry, this has effect of making the straightaway longer. This is why watching your gearing is so important when you improve your brake system.

Based upon “the law of diminishing returns”, does this really sound like a smart trade off? Not really, because even those of you who think that it does, forget that if the brakes are dragging, you are forced to carry a heavier rotor to dissipate the heat. Since rotating unsprung weight is more important than unsprung weight, you are using a heavier rotor than you need to compensate for the too small; too weak caliper you picked.

Even little things you take for granted can get you in trouble. For instance, at least half of all the sprint racers I've talked to, still use “off the shelf” brake fluid. Quality brake fluid is the first line of defense and if you use the cheap stuff, expect your brakes to be gone first. Quality fluid does not need to be expensive; you just need to go research from reliable sources to find one that will provide the protection, yet not cost a fortune. The two most important factors are, compressibility, (not all fluids are created equal), and moisture absorption rates, (also vary greatly from fluid to fluid). That's why we have technical information always available to you.

Another “little” thing is the choice of brake lines. Using unprotected Teflon line is foolish and leads to low, spongy pedals. It can also result in total brake failure, as it is prone to serious damage. Use your head, this is no place to cut a cost corner. Steel braided lines also differ. Don't just go for the cheapest.

What about the right rear brake setup many teams use? Is this really a good idea? Not really. First, on most chassis, a right rear brake will cause the birdcage to “cam”. This will make the rear of the car want to come around rather violently. This is OK if you only run the bottom, but is a disaster if you want to run the top. You will not be able to hold the car on the cushion if you have a right rear. Also, if weight were really a concern, why would you want a right rear caliper, rotor, pads and bracket, when a capable system is available and can unbind the chassis without it?

A quality caliper is really the key to a great brake system. Not all calipers are created equal. Some are far stronger than others are, just as \$30,000 motors more than likely have more horsepower than \$15,000 motors. The choice is yours. Brake drag and excessive heat, coupled with an uncontrollable racecar, or a few bucks more to make major improvements in the money you pick up at the pay window after the race. (Read the article on “The Hidden Cost of Racing”.) By the way, our tests have proven that spending \$500 more on the brakes gains you as much lap time improvement as spending over \$10,000 on the motor. Think what this means to your budget!

Rotors are another big factor, but not as you might think. The rotor acts as a lever for the caliper to input torque, as a friction surface for the pad, and a way for the heat from the brake to be dissipated. **BRAKE PADS DON'T WORK AS WELL ON TITANIUM.** The only way to get a pad to “bite” titanium is by coating the titanium. Unfortunately, the coating wears off rapidly and changes the torque while it does so. If you have been reading this article carefully, you already know that we are looking for consistency for the driver, and this isn't it. The Revolution steel rotor provides a great combination of low weight, good surface for pad bite, ability to tolerate high temperatures and a good ability to dissipate heat. There is a reason why some parts work far better than others. Removing that last pound in rotating weight often costs you more than its worth. Remember “the law of diminishing returns”.

While quality, strong calipers are very important, the installation and assembly is critical too.

For instance, a residual valve is a key component on a sprint car for two reasons. First, the use of ultra lightweight axles is becoming more prevalent, and, just like wheels, is now overdone. The axle is deflecting causing the rotor to bang into the caliper and pad, causing the pad to want to eject and the piston to be pushed back into the housing. Also, a rough, rutted racetrack also causes vibration and rotor knockback that can cause a “deep pedal”. A residual valve will help stop this. Yes, I know it does not work with some weaker calipers, but remember, we are talking about building a sound, quality brake system where everything works as it should. If the residual valve creates drag, you either have the wrong valve, (never use a 10 pound valve), or the caliper is too weak for the job.

The routing of the plumbing is critical too. You can create a nightmare for bleeding your system by improperly routing brake lines. Never make any sharp up and then down turns. Fluid must move smoothly forcing the air in front of it to the calipers for removal. Fluid will move up the line and then roll under the air bubble in a sharp loop, leaving the air trapped in the line. If your braided line has an up and down loop, pull it over horizontally during bleeding to help the air move to the caliper. Make sure the routing is proper on your car.

Even the pedals on some sprint cars are still not correct. The master cylinder pushrod must be pushed directly into the piston. If it is tilted at an angle, this will produce a loss of force and will prematurely wear out the master cylinder. This is also a place to remember that the master cylinder is also important to the pedal travel. Quality masters live longer and produce better results. Also, don't assume that a 1" bore master is automatically right for you. For example, our system almost never uses a 1" master cylinder because you do not need that much fluid movement, so we are able to make the driver more comfortable by using a smaller size.

Lastly, brake pads need to provide a consistent torque over the temperature range. If you use a pad that changes with temperature remember that your front rotor temperature and rear rotor temperature is seldom the same. As you input heat, changing the temperature to the pad, "bite" will change affecting the balance. We make a variety of different pad compounds with different torque values. They are perfect for fine tuning the balance of the car. For example, if your left front caliper is pulling too hard or not hard enough, changing to a more aggressive or less aggressive compound will help you fine tune to your driving style. Since the pads don't change with temperature, mixing is acceptable. (Don't forget our goal of consistency). If you don't know about your pads, then find a truly knowledgeable source and ask.

Just be aware that until you can drive your sprint car the entire race without ever tapping the pedal down the straightaway, and never have your pedal change position during the race, you don't have a safe brake system providing confidence and control. The most capable driver on the track will be the one with the most confidence in his car and the most focus on driving. Being distracted with brake loss, inconsistent pedal height or rolling out of the throttle because the car is giving up, will stop you from being competitive at the end of the race, which, by the way, is when races are won.

To be truly competitive, you must work with what you have and stay focused on the goal to put the most competitive, durable, great handling car on the track, that you possibly can. Budget and weight, while being important are not the goal. If you want to win, you want to have a car that can get you there. In case you hadn't noticed, in this article, we addressed EVERY major brake complaint sprint car teams have, and how to fix it. Your answers are here. A good brake system can help you finish an average of up to 5 spots higher every race. Would this have made you a champion?

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