

Driver's Ed. Education
A Series of Specifics for Success
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#22 – Basic Handling Theory
“Understanding Understeer”

This is the text of a long letter I posted on the Rennlist 944 discussion board regarding a Lister's battle with Terminal 944 Understeer. Anyone who's driven a stock 944 knows what that is all about! The Lessons are hard learned, and often misunderstood. This by no means represents a complete lesson in how to set up your chassis (and it also assumes you are driving correctly!). However, it is a good starting point in the quest to unravel the mysteries of chassis tuning. It should at least get you thinking!

First, let me say that this stuff gets very esoteric, I'm not a trained engineer, and I'm by no means going to blow anybody away with a discussion of finite analysis or some such thing. However, out of fascination, I have studied the tire and suspension thing (from a skinned knuckle, seat-of-the-pants perspective, as always) and learned a lot.

Many people eventually seek to improve the handling of their cars. Once they have spent all their money on various bits, they are still not out of the woods. What they've gained is a lot of potential and more adjustability, but that comes at the expense of complexity, and it is all expensive junk without knowledge of its proper implementation.

Talking Tire Pressure

What is optimum tire pressure? Simply put, it is a pressure that allows the tire to work at maximum efficiency grip-wise (allows the tire to run at a temperature where maximum grip is achieved), while maintaining good mechanical support for tire life and safety. Incidentally, grip can be divided into two components; mechanical grip from the structure of the tire carcass, and chemical grip from the rubber compound. Is this optimum pressure the same for all cars, drivers, or tires? No. How do you find it?

TEST, TEST, TEST!

A less aggressive driver can run at lower pressures safely because he will not be over stressing the tire. At the level he is capable of, the tire will stay healthy. This is optimal for his "relaxed" style, and makes the car feel solidly connected to the road. However, a more aggressive driver running at the same pressure will rip the tires to shreds because they will overheat, possibly to the point of failure. This driver needs more pressure to maintain proper mechanical support for the tire, thus effectively LOWERING the operating temp RANGE

of the tire, and improving its mechanical and chemically-derived grip. Seems completely counter intuitive, but it is absolutely true.

Interestingly, most people I pole are running below the cold pressure level that would give the tires maximum performance. I can only assume that they are not driving hard enough to bring the higher (and correctly) pressured tire into its "sweet spot." The less aggressive (and informed) driver has arrived at his lower pressure settings either because most people told him to run what are in reality low pressures, or higher pressures made his car feel "scatey" and unnerved him. It may likely be beyond his personal comfort range (this is VERY common), but only through driving harder - and thereby increasing the heat in the tires - would the higher pressure start to feel good to him.

To simply state that to reduce understeer you raise or lower tire pressures is erroneous and misleading. To understand the notion of optimum tire pressures, visualize an equal-lateral triangle drawn on paper, point up. The optimum pressure for a tire would be at the tip of the triangle. Any pressure that deviated from that point would naturally effect the performance of the tire, and the handling of the car. If one were not at the optimal pressure to begin with, then set rules for adding or subtracting pressure could not be applied.

If one were running too low a pressure in the front to start with, and were experiencing lack of grip from overheating of the tires, raising the pressure would IMPROVE the ultimate grip at the front by better supporting the tire and reducing flex and friction-induced heat. The low pressure would have been allowing the tire to roll over (also reducing its contact patch), and also slide too much. Both of these will overheat the tire and reduce its grip.

If one were running AT the optimal front pressure, raising it would likely DECREASE the grip in the front because the tire then became stiffer and did not have the physical resilience to offer maximum grip. Also, the tire would likely be running at a lower temperature, which would decrease the chemically-derived grip of the compound. So, to make the Raise-it-or-Lower-it scenario work, we have to find that optimum pressure first. Only with this baseline can we assure we're making the right adjustment and getting what we intended.

Alignment Specs

Regarding camber and weight shift, it is quite true that many cars decamber a lot if driven hard in stock form. This does indeed often create a huge understeer situation, and also kills the tires in a hurry. One way of decreasing the understeer, and making the tires happier at the same time is to increase negative camber at the front. One can do this to a fairly high degree

(approaching 1.75 degrees) before the civility of the car's attitude in normal driving goes totally kablooey.

Also, regarding weight shift, I feel it is incorrect to say that weight shift is not an equally significant factor in cornering grip. One has a tendency to forget about the INSIDE tires, and the grip they have to offer. If your car leans over so far that the inside tires have little pressure on them, they are also not providing the grip that they could to help the outside tires with cornering loads.

Further, this weight shift can overload a tire's ability to stay in contact with the road. To make an analogy, weight shift, or inertia, is similar to flowing water; it will follow the path of least resistance. Most cars are sprung VERY softly in stock form, and it doesn't take too much to over-work the suspension. When you hit the brakes, the nose dives a lot, and puts a lot of load on the front tires. Also, if your 944 is at stock ride height, it is tail-up, and this causes even more weight to shift forward during braking. Not only does this potentially overload the front tires, but it under-loads the rears for the purposes of cornering grip AND braking.

Since tires are effectively part of the suspension, they too have some effect on how much weight shifts to which corner. Using the water analogy above, if you had found your tire's optimum pressure, you could very subtly alter the "flow" of inertia by changing tire pressure. If you had perfect pressures, but were looking to mitigate a slight understeer condition, you could reduce the front pressures slightly in order to induce more weight to shift forward, thereby increasing front grip. If you had adjustable spring perches, you could accomplish the same thing by raising the rear of the car slightly (this would ultimately be more advisable, if more difficult, given the capability).

Another point you need to think about is under what circumstances your understeer is occurring? If it is in tight corners where you have a lot of weight shift, then the above discussion of tire pressures is more pertinent. If the understeer is present during high speed cornering in a four-wheel drift mode, tire pressures are less important as they pertain to handling (but not tire health), and the emphasis would shift toward suspension tuning. In this mode, tire pressures should be optimized in general, but would not likely effect the cornering attitude to a large degree.

Take a Breath!!!! You can see that there are many factors involved in optimizing a car's suspension for battle. But where to start?

As a baseline, what you need to do is pay attention to your PRESSURE INCREASES from cold to hot. If you are getting very little pressure increase, then your understeer could be the result of over-inflation. The tires are mechanically too hard, and also not heating up

enough to get maximum grip. If you see a large pressure increase, then the heat you are generating in the tires is exceeding the chemical makeup of the compound and making them "greasy."

You can play with this pressure thing till you figure it out. Keep track of what you're doing, how the car feels, and what all of your fiddling gets you. If you have understeer, take the hot pressure. If it's not more than 5 pounds higher, try lowering it a pound and see what happens. This might give you a little more heat for compound grip, and also make the tire more resilient for mechanical grip. If you see approaching a 10 pound increase, then the tires are likely under-inflated, working too hard, and need more pressure to better support them and cool them down a bit.

Now, do I expect you'll solve your understeer with tire pressures? NO. You need either a little negative camber in the front, or an adjustable rear sway bar (BIG help!). I would also level the rear suspension for all-around improvement. I'd do all three if I were spending your money!! ;-} Isn't this fun?

If you find the tire talk a bit mysterious, go back and read the two R-tire articles that appear earlier in the series. They will help you understand the tires themselves. This article pertains to the tires as a part of a system called..... **the suspension!**

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