BY BRIAN AFTANAS

ANALYTICAL APPROACH

PROPER TIRE PRESSURE IS THE SINGLE MOST IMPORTANT ELEMENT OF NEUTRAL HANDLING. HERE'S HOW TO GET IT RIGHT.

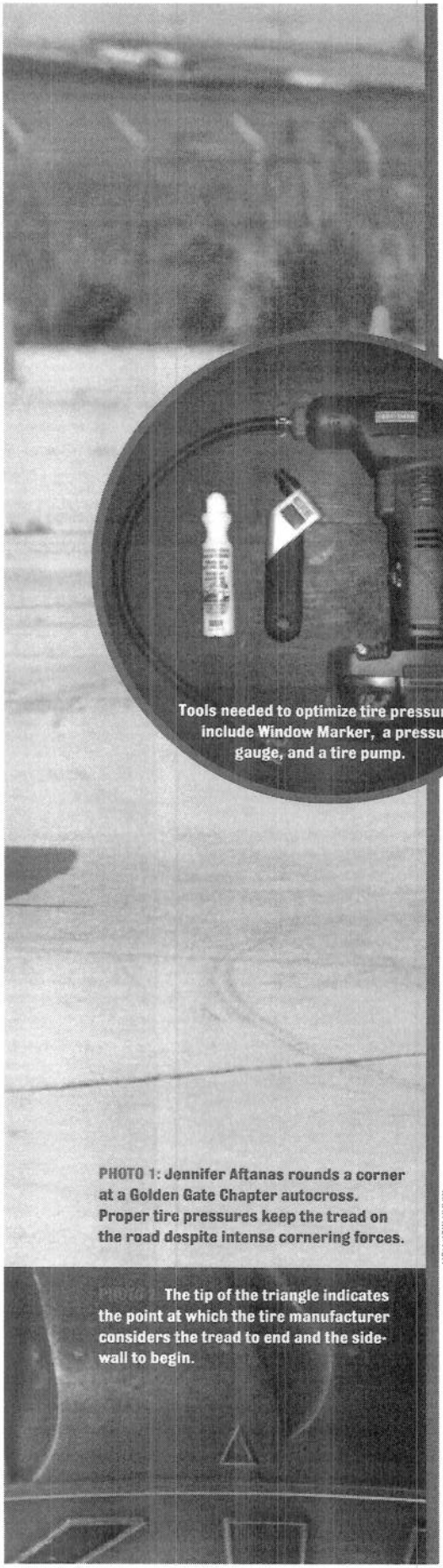
If you don't have traction, you can't go fast. Apart from the actual type of tires you've installed on your car, correct tire pressure is simply the most critical element, the key to traction in any autocross or race-track setup. Tire pressure is more important than spring rates, sway-bar settings, the cost of your shocks, or the size of the stickers you've put on your car.

Despite this, if you walk around an autocross paddock, you'll see people putting all kinds of pressure in their tires; some leave their tires at the Owner's Manual pressures, some set pressures based on the recommendation of a knowledgeable expert—or an Internet commandment—and some others experiment their way into a pressure setup that seems to work.

But few choose a truly analytical approach.

The problem is that you just can't get optimal tire pressures off a website. Optimal tires pressures are specific to *your* tires, on *your* car—with your suspension configuration and your driving style. Fortunately, determining optimal tire pressures for your individual setup is fairly easy to do; it does require some systematic analysis, but its easy to do.

First, let's review the physics. For a front-engine BMW, you are trying to A) maximize the traction of your front tires, and B) optimize the traction balance between your



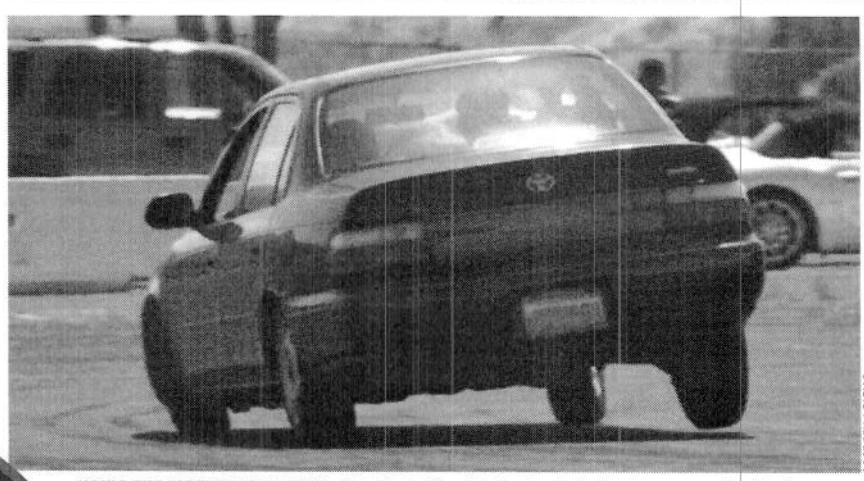
Tools needed to optimize tire pressure include Window Marker, a pressure gauge, and a tire pump.

BRIAN AFTANAS

PHOTO 1: Jennifer Aftanas rounds a corner at a Golden Gate Chapter autocross. Proper tire pressures keep the tread on the road despite intense cornering forces.

MARK MERVICH

PHOTO 2: The tip of the triangle indicates the point at which the tire manufacturer considers the tread to end and the sidewall to begin.



DWIGHT PRIESTLEY

USING THE SIDEWALLS TO TURN: At a Street Survival school, students are required to keep their tire pressures at the pressures recommended in their owners' manuals.

front and rear tires. Maximizing front traction maximizes your turning ability, but if you lack traction in the rear, you're in for severe oversteer. Optimizing traction between front and rear gives your car that fabled neutral handling balance for maximum cornering ability—a minimum of understeer (push) or oversteer (skid).

Neutral handling balance is complicated, dynamic, and subtle—but broadly speaking, it just means that your car neither understeers nor oversteers when cornering. Understeer is particularly misunderstood; many drivers think that when they crank over the steering wheel and the car continues to plow forward without turning, the car is understeering. That's not understeer, it's trying to defy the laws of physics. You have entered a corner harder than the front tires can grip. Oversteer is the opposite idea; the front wheels are turning fine, but the tail wants to swing wider than necessary to follow the front wheels.

The understeer and oversteer that racers talk about is a much more subtle thing. It can only be established in a steady-state turning situation, such as driving in a constant-diameter circle at increasing speed to see whether the front or rear tires subtly prefer to start sliding. It's even more complicated than that; slight changes in throttle will change the weight loads between front and back and change the balance. You can't test cornering balance just by pulling a hard right-hander leaving the grocery store.

But you can adjust that balance with a step-by-step analysis, perhaps to improve your autocross performance. The first step is to get the front tires to their maximum grip. A tire generates its maximum grip when there is only a tiny bit of slippage across the pavement, and when the grippiest part is in firm contact with the ground. That "grippiest part" is the tread on the bottom of the tire. This sounds obvious, and it should be simple—except that pneumatic tires roll over when cornering. Look at Photo #1, a picture of my daughter, Jennifer, coming through an autocross corner in her 1991 318i (that's me in the passenger seat). Notice how most of the vehicle's weight has transferred to the outside; the outside tires are heavily loaded, with the tire casing distorted, while the inside tires are hardly loaded at all; in fact, they're almost off the ground. Short of magically lowering the car's center of gravity, there is no way to reduce this weight transfer to the outside; even a race car will have its inside tires lift off of the ground.

But note that the outside tire, despite the intense sideways forces on it, still has its contact patch on the ground. Yes, the tire tread has shifted from the center of the wheel, but it has not rolled over far enough to allow the low-grip sidewall to touch the ground. Nor has the inboard side pulled the tread upward, lifting useful tread off of the ground. That's because that tire is inflated to 44 psi—compared to the owner's-manual-recommended 28 psi.

So we need to determine the front tire pressure where the tire does not roll over beyond the tire manufacturer's recommended roll-over limit. The tire manufacturer's recommended limit?! Yes; there are indicators on most tires where the manufacturer considers the tread to end and the sidewall to begin. Photo #2 shows a tiny triangle molded into the sidewall; the tip of the triangle points to where the tread ends and the sidewall begins. A properly inflated autocross or track tire will roll over only to the tip of this triangle, and no farther.

The simplest way to measure how much the tires roll over is to mark them with paint, go out for a run, and see how much paint

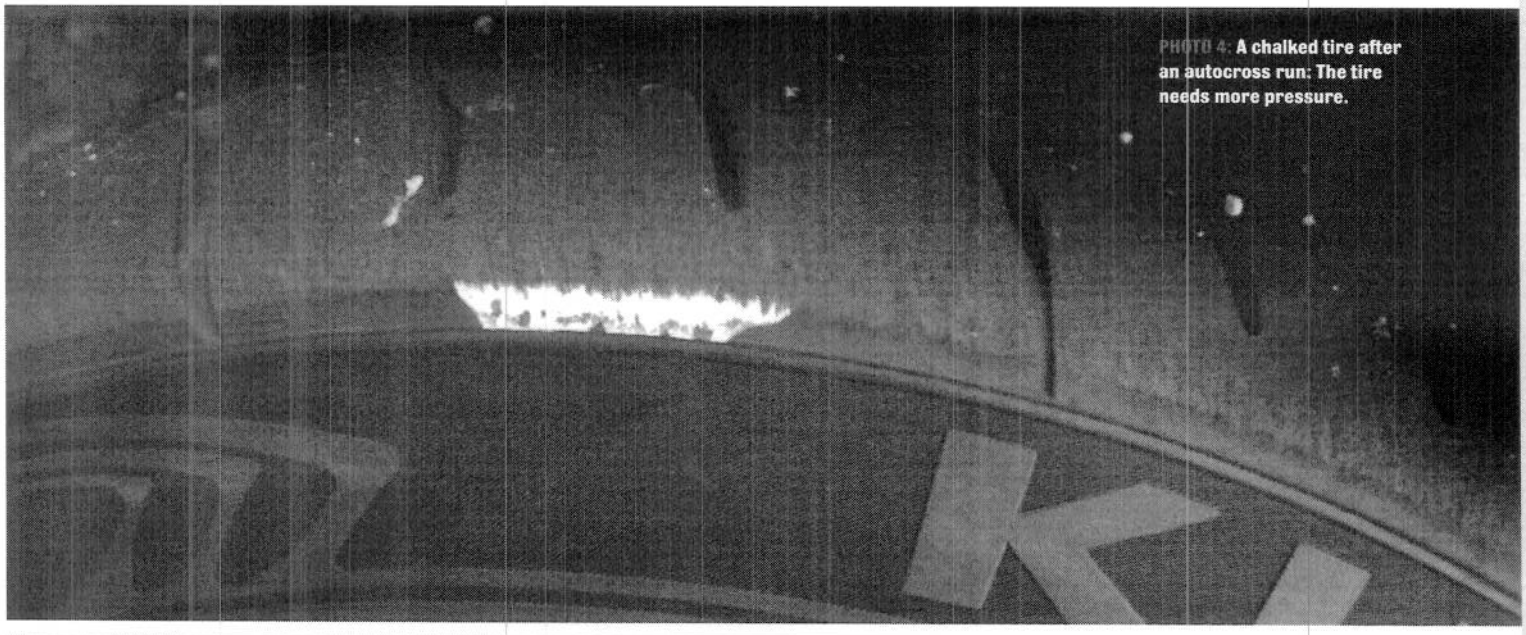


PHOTO 4: **A chalked tire after an autocross run: The tire needs more pressure.**

has scrubbed off. Photos #3 and #4 show a marked tire before and after an autocross run. In these photos, the tire pressure is still not high enough, since the tire rolled a little beyond the tips of the triangles—close, but not quite. More pressure is needed.

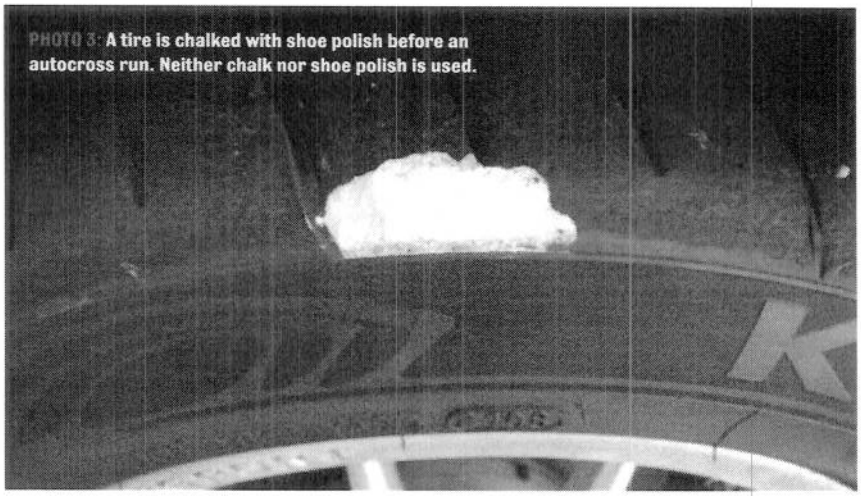


PHOTO 3: **A tire is chalked with shoe polish before an autocross run. Neither chalk nor shoe polish is used.**

Marking tires this way is called *chalking* the tires. The stuff used to chalk tires is called *shoe polish*—but you really use neither chalk nor shoe polish. The standard stuff is Window Marker, a white liquid you buy at any chain auto-parts store for about $3. In truth, anything that marks the tire is fine.

Continue chalking, making runs, and adjusting tire pressure until you've found the optimum pressure for your configuration. But do not exceed the manufacturer's maximum tire-pressure limit, which is also molded on the sidewall of the tire.

Once you've settled on optimum pressures, measure the pressure while the tires are still warm and note it. Re-measure the tires after they've cooled down, as the cold pressures are convenient to know prior to your first autocross run of the day. Tire pressures don't rise much from autocross use—maybe one or two psi—but you might as well compensate for the slight warming of the tires that does occur. Always keep in mind that the warm tire pressures are the most critical.

Once you've determined the best pressure for your front tires, it's time to focus on the rear tires. You start the same way—actually, you can determine the pressures which maximize front and rear tire traction at the same time. Ideally, every car is beautifully balanced with maximum traction settings front and rear. Miracles happen, but more likely you'll need to adjust something.

When working on the rear tire pressures, you are really adjusting the *feel* of the car. If you're just starting your autocross career, just keep all four tires at their maximum traction settings. It'll take you many autocross events—a season or two—before you really start noticing whether your car is prone to understeer or oversteer; it's that subtle. And you'll find that you may prefer a little understeer or oversteer.

BMW intentionally builds understeer into its cars, so it's likely that's what you'll first detect. Since the front tires are already set to their maximum traction, the only way to reduce understeer is by increasing oversteer—by *reducing* the traction of the rear tires from their practical maximum. There are three ways to do this: 1) *decrease* rear-tire pressure again so that the rear tires roll over onto their sidewalls a little; 2) *increase* the rear tire pressure even more, so that only the middle of the tread touches the ground; or 3) force the outside rear tire to take more than its share of the cornering load (compared to the front) by stiffening the rear springs. If you have adjustable sway bars—part of the spring system—you can set the rear one a little stiffer in addition to adjusting your rear tire pressures.

Actually, these finer adjustments are now at the level of personal preference. The goal is neutral handling. Again, this is a subtle thing, and a matter of preference; drifting—that is, lurid oversteer—is certainly the only way you should drive when co-starring in a Clive Owen movie, but it is not the fastest way around an autocross course or a race track.

Of course, expensive suspension modifications will affect your car's handling, too, along with tire width and compound. But too many people spend big money on suspension upgrades when the primary optimization is through tire pressure. And there's a definite thrill to posting better times than some over-modded M car, using nothing more high-tech than a $3 bottle of Window Marker. ◆