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Running Out of Air

For many modern-Corvette owners, checking the tires is the last do-it-yourself job there is. As Paul Zazarine reports, those days might be ending, too. Photos courtesy Paul, Ingersoll-Rand, and General Motors.

For today's typical marginally mechanical motorist, checking and maintaining tire pressures is about the last job in the "self-service" category. Never mind that in all probability his hand gauge is wildly inaccurate, the gas station's air is bogged down with moisture, and the pump never runs long enough to fill that last tire. Chances are he's got all four tires at four different inflation rates and will never know the difference. As long as they look about right, he's not likely to notice the woozier ride, falloff in cornering, or low fuel mileage.

Corvette owners tend to be more attentive. They've got a substantial investment tied up in their cars, and they're much more attuned to big changes in handling or efficiency. In short, you don't find many $1.98 tire gauges in Corvette consoles. Unfortunately, an accurate pressure gauge is only the first in a long series of possible inflation concerns.

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And inflation, of course, is the key to the whole world of tires. Proper inflation improves tire longevity, cornering power, ride quality, directional stability, feedback, and—very dramatically—fuel mileage. Improper inflation quickly leads to a falloff in same.

The Corvette was the first American passenger car to offer an optional on-board tire-pressure monitoring system (TPMS): RPO UJ6 Low Tire Pressure Warning Indicator, a $325 item, debuted for '89. If the pressure inside any tire fell past a predetermined level, a sensor located inside that wheel rim sent a warning by radio signal to a receiver in the instrument panel. About a quarter of all '89s got TPMS, a ratio that stayed pretty constant through MY '96. After that, with the arrival of mandatory run-flat tires for the C5, on-board monitors became standard equipment. And it only stands to reason that the Corvette would be at the forefront of tire-monitoring technology. Since the dawn of the C4 era, this model has relied on stiff frames and super-wide, super-sticky rubber to give best-in-class cornering power. As a result, modern-Corvette drivers can spend endless hours discussing tire technology, tread types, water-dispersal patterns, and sidewall heights. Yet there's one critical aspect that very few even consider: The gas that's inflating those tires in the first place. From the dawn of the pneumatic tire, that has usually been straight compressed air. And why shouldn't it be? The atmosphere that surrounds us is free, non-flammable, fairly unreactive, and safe under pressure. So what *else* would one put in a tire?

One answer, increasingly, is pure nitrogen. Using nitrogen to inflate tires isn't new: Commercial and military aircraft (including the Space Shuttle); Formula One and NASCAR racers; extreme-duty loaders; and many other high-cost, high-risk apps have used nitrogen tire inflation for years, for reasons we'll get into shortly. But only pretty recently has the hardware, and the consumer interest, become common enough to make the same treatment an option on passenger cars.

There are some big theoretical advantages to nitrogen, especially on high-performance cars like Corvettes. For example, you might point out that you're already using mostly nitrogen when inflating a tire with plain compressed air. True enough: By volume, dry air contains about 78% nitrogen, 21% oxygen, and one percent other gasses. But the real issue there is the term "dry." Water vapor accounts for as much as five percent of the sea-level atmosphere by volume, and an even higher ratio can come out of the typical home or gas-station compressor. Water, of course, is a primary vector of oxidation, meaning the inside of the wheel/tire combo can see additional metal corrosion and rubber decay. (The dryer/receiver module used on most commercial air compressors helps, but a lot of water vapor still makes it through.)

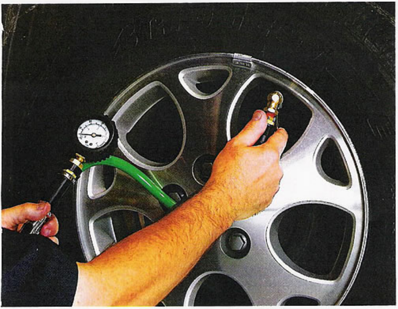
Nitrogen, which has less affinity for moisture and is purified to exclude it, may therefore prove a little easier on the wheel/tire's inner surfaces. Another advantage is that the moisture in typical compressed air is the main cause of heat-induced tire-pressure changes. As every Corvette owner knows, driving makes tires get hotter, and inflation pressures go up with heat. The bump is somewhere between three and seven psi on average, depending on tire type, environment, and driving conditions. Water vapor heats and expands much more readily than a vaporless gas, however, and purified nitrogen contains just about zero vapor. Thus, tire-temperature variations are much smaller, and the increase in pressure per degree is lower. In practice, with nitrogen you just set the cold pressure and go—it's basically going to stay there.

Not being three or four pounds underinflated on cold tires means less tire wear, better fuel economy, and usually better handling—the tires are able to express their ideal footprint at all times and have less unwanted flex at the sidewalls.

Perhaps the biggest potential advantage of nitrogen involves its molecular structure. Nitrogen molecules are significantly bigger than oxygen molecules, so much less of the gas sneaks through voids in the rubber and alloy of the wheel/tire combo. The *really* big inflation swings that most cars experience aren't due to heating and cooling, it turns out, but simply to time and neglect. Nitrogen helps fight that.

The National Highway Traffic Safety Administration (NHTSA) figures most drivers could raise their average fuel mileage by about three percent just by keeping their tires correctly inflated, but that task is a lot harder than most people assume. A typical, freshly filled tire loses one to two psi of compressed air per month, mostly from oxygen molecules passing right through the permeable tire.

Furthermore, as these oxygen molecules escape, they tend to oxidize and deteriorate the rubber they pass through, increasing its permeability even further. A study by David Coddington published in *Rubber and Plastic News* (Coddington is an employee of Exxon, it ought to be noted) took samples from tires of various ages and tested them for tearing strength. His data found that tear strength fell off steadily as a function of mileage, leveling out at something below 50% percent. Some of that loss came from flexing, some from UV exposure, and some from heat cycling, but the really arresting finding of the study pointed to oxidative corrosion: While oxygen-filled tires fell to around 40% of their OE tear strength, those filled with nitrogen retained over 80%.



In auto pneumatics, green has become the universal color to designate nitrogen equipment: hoses, tanks, even sometimes valve stems. Regular-air top-ups are harmless, but the nitrogen purge process has to be done over.

Nor is rubber the only material that suffers from oxidative corrosion. The steel, aluminum, or magnesium of the wheel corrodes too, exacerbating any leakage or strength issues. Corroded surfaces may prevent the tire beads from sealing completely, and the inevitable scale and dust caused by metallic oxidization can degrade the soft seals in the valve stems. On later-model Corvettes, corrosion is also a threat to the TPMS sensors.

So that's the good news. Inflating your tires with nitrogen may be beneficial in a variety of ways, most notably a reduction of corrosion, an increase in pressure consistency, and the various tire-life, handling, and economy gains that come with it.

Sure enough, the few owners who've done this conversion almost inevitably declare that they feel a big difference in how their Corvettes ride and handle. Well, maybe they do and maybe they don't. It takes an incredibly sensitive driver to detect a few psi difference in street situations. More likely, they're feeling a big improvement because they want to feel a big improvement—the same psychological effect has sold plenty of airboxes and mufflers on the aftermarket. Even a scientifically randomized survey would likely show real gains in fuel mileage and tread life, however.

The downside, of course, is the hassle and cost, though this seems to be changing. Outside of the aircraft and racing industries, a nitrogen fill used to be almost impossible to find, and the price was whatever the vendor decided: Twenty to 45 dollars per tire wasn't unheard of. In recent years the technology has gotten more common. Most big tire stores are set up for it now, at a cost of between two and ten dollars per wheel.

The process begins by purging the old air from your tires and refilling them halfway with nitrogen. After that they're deflated again, then re-filled to capacity. (This ensures higher nitrogen purity than a simple one-shot empty-and-fill.) If your tire develops a leak later and you're not near an outlet for nitrogen you can still top it off with compressed air, though it ought to be purged and refilled later when fixed.

Manufacturers such as Michelin, Goodyear, and Bridgestone all support nitrogen fills these days, citing the stable gas's ability to maintain inflation pressure over time. So should you make the switch? That depends. Basically, air is still free: If you check your tire pressures regularly and have no qualms with your Corvette's performance, you might decide there's no point in bothering. On the other hand, when you consider that you probably don't check your tires as often as you *think* you do, a small investment in nitrogen now might prevent bigger costs down the road. ❍

If the idea of filling a tire with nitrogen gets you all hot and sweaty, you're probably the kind of guy who's also a stickler for perfect wheel balance. After over- or under-inflation, incorrect balance is the most common error in tire/wheel setup, often resulting in annoying steering-wheel feedback, reduced tire life, dicey handling, degraded ride, and even long-term suspension damage.

The Corvette's big, ultra-high-performance tires and wheels require advanced balancing tools and skills that many smaller vendors just don't have. Thus, a constant vibration at one or more wheels usually just means you'd better go find a better technician. However, this symptom can also be due to a condition called *radial force vibration*, or "RFV."

Most people understand that "wheel balancing" means adding weights to counteract a relatively heavy area on the opposite side of the wheel/tire combo. But while RFV can have similar symptoms, the root cause has nothing to do with weight; instead, it's due to an imbalance in the relative stiffness of the tire at different locations or a relative high or low spot (called *uneven runout*) around its periphery.

Post-manufacture causes of runout include bent rims and uneven tread wear (ie, flat-spotting), but even some brand-new tires exhibit bad RFV. Internal variations in the tread, core belts, or sidewalls can all cause the condition. Indeed, no tire is perfectly round or uniformly flexible—they're mostly just close enough. Get a big enough error and you'll end up with steering-wheel shake or dynamic instabilities such as *wander* or *shimmy*.

The problems caused by a lump or a valley on the tread are easy to understand. But how can areas of varying stiffness translate to shimmies and bobbles? As any tire rolls under load it flexes, and if the rigidity of the tire isn't fairly uniform, that stiff section puts a little extra force back into the wheel every time it gets pushed to the road. The greater the flaw the bigger the vibration—from practically undetectable to totally undrivable.

Since wheel-and-tire imbalance is simple to detect and solve, that's the first thing to look for when chasing a running vibration. Traditional wheel balancing can't solve RFV issues—indeed, often there's not much that can—but all isn't necessarily lost. Height flaws can sometimes be cured by the skilful shaving and shaping of the affected area, a task that's made easier by an ever-improving stream of RFV-detection and -repair tools. In general, these devices isolate RFV issues by putting loaded rollers in contact with the spinning, fully inflated tire and detecting the vibrations that it sends back. This data is then used to write the tire off completely; or to indicate possible fixes (remounting the tire to the wheel in a different orientation often helps); or to recommend a better position for the suspect tire (a tire that's no good on one axle may be okay for the other; similarly, a specific flaw in one tire can sometimes be offset with a cancelling flaw in another). No matter what, a diagnosis of RFV can short-circuit the frustration of fighting an "unbalancable" tire.—*PZ*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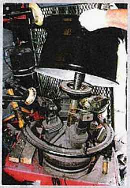

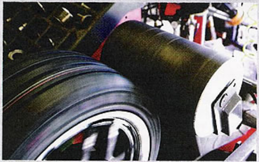

Most shops can check any Corvette wheel/tire's inflation, hubcentering collar, balance, weight, and physical condition. More sophisticated technology (in this case, a Hunter Engineering GSP700) and skills are needed for radial force vibration analysis.