# The Truths and Myths of nitrogen

Lately there seems to be more and more hype about nitrogen gas for tires offered by tire companies and nitrogen services. Some services will "purge" your tires of air and replace it with near pure nitrogen for $20 per tire. Some tire shops are charging as much as $5 -10 per tire to fill them with nitrogen claiming everything from improved fuel mileage to a more comfortable ride. Is there any truth to this?

Here we will take a close look at some facts and let you make up your own mind. At the bottom we show the results of our real-world gas comparison test that you might find interesting. In this article we refer to "gas" which includes air, nitrogen, and CO2.

**Claim #1. "N2 doesn't expand with heat like air because it's drier so your tire pressures stay more constant through tire temperature changes."**

Here's a claim that we've heard more times than we';d like to admit. Bottled nitrogen is dry, drier than typical air, and it is said that a drier gas will exhibit less pressure change to temperature changes. This would mean that as my N2 filled tires heat up, the pressure will not go up as much as if they were filled with air. The dryness of CO2 is also put into question since it is a "liquid" gas under pressure. CO2 vapor is very dry. Don't forget that N2 is also a liquid gas under certain pressure and temperature. The truth is, the differences in thermal expansion values (TEV) between N2, air, and CO2 at automotive tire pressures is virtually undetectable to a driver. In our own tests we compared the pressure changes of N2, air, and CO2 through a wide temperature range and found that they all expanded (increased in pressure) at virtually the same rate (see Gas Test).

**Claim #2. "N2 permeates (leaks) through tires slower than air therefore your tires will maintain their pressure longer and require less maintenance."**

Although it is true that nitrogen does permeate through tire rubber slower than oxygen and CO2, there are two things to know. First, the gas permeation difference between oxygen, CO2 and nitrogen through a tire wall is very minute. Second, this difference is made even more insignificant for N2 since oxygen only makes up

17% of air and most of "air" (78%) is nitrogen. Diffusion speed through the walls of your tires has more to do with the quality, the wall thickness, and the age of your tires. More often, tire deflation is due to a leak in the stem core, the stem seal, cracks in the stem, a bad tire to wheel bead seal, cracks in the tire wall, or objects like nails stuck through the tire tread. Also, did you know that your tires may grow during the first 1-2 days as it gets used to being inflated which would reduce the tire pressure. Tire manufacturers recommend checking your tire pressures often no matter what type of gas you';re using to fill your tires. Bottom line: If gas permeation was the only way a tire would lose its "air" there would be very little detectable difference between air (which is already 80% nitrogen), nitrogen, and CO2.

**Claim #3. "N2 is safer because it is non-combustible and therefore less likely that your tires will catch on fire."**

This is true and is one reason aircraft tires are filled with nitrogen. But when was the last time your tires had to skid on pavement from 150 mph carrying 75 tons of vehicle, passenger and cargo weight? The chances are your tire is not going to burst into flames because of the additional 17% oxygen content inside your tires especially since your tires are surrounded by air anyway. If you have ever seen a tire smoking on the freeway chances are the tire was overheating from under-inflation. Putting nitrogen inside your tire will not prevent a tire from overheating. "But didn't I read that nitrogen will make my tires run cooler?" This statement is false. N2 cannot dissipate heat from a tire any faster than air or CO2 nor can it decrease heat producing friction between your tire tread and the road.

**Claim #4. "N2 is safer for my tires because air contains oxygen and oxygen corrodes the inside of my tires."**

Although it is true that oxygen permeating through the tire';s carcass may cause a certain level of oxidation, tire failures are typically not due to corrosion from the air inside. Don't forget, the outside of a tire is also exposed to oxygen not to mention harmful UV rays and ozone, the occasional curb bump, random road hazards, road salt and even dog urine. In fact, the leading cause of premature tire failure is tread separation caused by overheating; the overheating caused by friction from insufficient tire pressure. Premature tire failure is typically not caused by tire deterioration from the inside. $CO_2$ vapor is dry and inert and also poses no corrosion issues to your tires. There is, however, one other possible cause for corrosion of tires that sit for long periods and that is moisture permeation from the ground. It is recommended that a moisture barrier (plastic sheet) be placed beneath each tire before long term outdoor storing.

**Claim #5. "$N_2$ is inert and therefore will not corrode the inside of my metal wheels."**

This is TRUE, but who cares? Air won't corrode your wheels to the point of failure either, neither will $CO_2$. Metal wheels Don't commonly fail due to corrosion from the inside of the rim. Wheels are well engineered parts of your car and for good reason. They support tons of moving weight over uneven terrain and obstacles. Have you ever heard of swapping out old wheels for new ones because the rims were made unsafe due to corrosion?

**Claim #6. $N_2$ in tires provides a smoother ride.**

Yes, this is an actual claim in a nitrogen supplier's literature. Since nitrogen is no "softer" than air or $CO_2$ our assumption for the claim is that if the nitrogen pressure doesn't increase as much as air the tires stay softer as the tire heats up. This is false (see Gas Test).

**Claim #7. "$N_2$ is used in aircraft tires and the NASA space shuttle tires so it must have advantages for me too."**

Aircraft tire manuals state that oxygen content in the tires must not exceed 5%. This is to minimize combustibility. These tires also see extreme temperature and altitude swings that your car or RV tire will never experience.

**Claim #8. "N2 in my tires will save me in fuel costs."**

Fuel savings from tires depends on tire pressures. As long as tires are kept up to their proper pressures it does not matter which "gas" is in them. And no matter which gas you choose you should keep up a regular and frequent tire pressure check procedure because you never know when you may have picked up a nail or other tire damage that could be causing a leak.

**Claim #9. N2 will make my tires last longer.**

Tread longevity depends on tire pressure maintenance, alignment, and a properly working steering and suspension system. The only difference N2 makes in the interior of the tire is that there is no oxygen being diffused into the tire';s rubber. Interior carcass deterioration from an air filled tire is not an issue to be concerned about especially when compared to the affects of heat, UV, moisture, ozone, and road hazards that the tires are constantly exposed to.

## <u>THE GAS TEST</u>

Ideal Gas Law Formula Shmormula.

I wanted to see for myself what different pressure changes I would see between N2, "air", and CO2 so I came up with my own test. I decided I could not use tires for comparison testing because of the numerous potential variables like stem leaks, bead seals, tread damage, flaws in the rubber, etc. I also wanted to test the gases in the most extreme temperature range as possible, as quickly as possible so fitting the gases in the freezer would also be a plus. Instead of tires I used high pressure aluminum bottles fitted with a valve and a pressure gauge. All were leak-tested at 600 PSI to ensure a leak-free test vessel. I did two tests; one at a low pressure representing normal car or light truck tire pressures and the second at a high pressure representing RV and tractor tire pressures. Here are my results.

Low Pressure Test:


Figure 1 - I used an infra red surface thermometer to measure bottle temperatures. Each bottle was allowed to stabilize to temperature for at least three hours to ensure that the gas temperature was the same as the surface temperature. Our freezer got our bottles down to -11ºF in this test for a good starting temperature.

Figure 2 - This photo shows the three bottles fresh out of the freezer at -11ºF and

all with a starting pressure of 40 PSI. Almost immediately after removal from the freezer the bottles started to frost up on the surface. Each bottle is marked with its gas contents (CO2, N2, Air).

Figure 3 - Our shop temperature was 88ºF so this became our next test temperature. All bottles were allowed to stabilize at this temperature for at least three hours. As you can see the pressure on the gauges of all of the bottles is virtually identical at 52 PSI. So far all of the gases have increased in temperature by 99ºF and in pressure by 12 PSI.

Figure 4 - We found out that if you stick a black aluminum bottle on top of a steel car hauler in the afternoon sun for a few hours you can get some damn hot bottles. You are seeing a bottle temperature of 117.3ºF


Figure 5 - At 117degrees F our gauges show a near identical pressure on all of them at ~57 PSI. Note: The "air" bottle gauge seems to show a higher pressure than the other gauges This is due partly to the angle of the camera to the gauge pointer. All gauges showed pressures within 1 PSI of each other.

**Conclusion of Low Pressure Gas Test:**
Through a 128ºF temperature swing from -11ºF to 117ºF all gas samples showed virtually an identical pressure increase of 17 PSI from 40 PSI to 57 PSI. For an automotive tire this temperature delta represents an extreme real-life case but it shows that the Ideal Gas Law formula does apply to these gases and when it comes to thermal pressure stability none has any apparent advantage over the other.

**High Pressure Gas Test:**

As gas pressures move further away from atmosphere (14.6 PSI) the Ideal Gas Law becomes less accurate. So how would the gases react to temperature at the high tire pressure range such as those found on RVs and tractor trailers?


Weeks separated our two tests and surprisingly when we checked the start temperature of the bottles for high pressure test it was at a super cold 20 degrees below zero F. All the better.

The bottles were left in the freezer for days before they were removed for our test to ensure they were all leak-free .

The bottles were removed from the freezer and within seconds in the warm mid day heat our bottles began to frost up and then thaw out.

One odd phenomenon that I noticed was how each bottle seemed to thaw out differently. The N2 (left) thawed from the bottom first similar to the air (right) while the CO2 (center) seemed to thaw quickly and evenly.

Within three minutes out of the freezer in 90ºF ambient temperature our bottles'; surface temperature had gone from -20F to over 40F and continued to climb at a rapid pace. Outside temperature is over 100* in the shade here. Bottle pressures at this moment all show approximately 95 PSI.

Once our bottles had warmed up to near ambient temperatures I brought them into our air conditioned office and allowed them to stabilize to the office temperature of 75 degrees F.

At 75 degrees F. So far the bottles have gained 95 degrees (-20 to 75) and all show an identical pressure of 100 PSI, an increase of 21 PSI.


It's 101F in the shade and our bottles are now temperature stabilized.


In the 101˚F temperature (121˚F increase) the gauges showed a difference of about 2 PSI. (Pressures: N2-103 PSI, CO2-105 PSI, AIR- 103 PSI).

Hot, hot, hot. Afternoon sun + steel deck = 134 *F! After a couple hours in the hot sun our thermometer showed a bottle temperature of 134*F. This is hotter than your tires should ever get but if they did your tire pressure would be virtually the same whether you had them filled with N2, CO2, or air. (Pressures: N2-108 PSI, CO2-110 PSI, AIR-108 PSI).

**Conclusion of High Pressure Gas Test:**
At the higher tire pressure commonly seen in RV tires we took the gases through a temperature range of 154ºF (-20ºF up to 134ºF). Our start pressure was 80 PSI @ -20ºF and over the 154ºF temperature increase we saw the gas pressures all increase virtually the same amount to within 2 PSI of each other. In the end, the N2 and "air" test samples topped at 108 PSI while the CO2 sample topped out at 110 PSI. Note that the pressure changes that we saw in our bottles are the same as what you'd experience in your big RV tires despite the difference in volume. What does this mean? No matter which of these gases is in your RV tires, your handling, performance and tire wear will be the same.

THE IDEAL GAS LAW FORMULA might help explain why different gases expand at virtually the same rate as their temperature increases.
A gas may be completely described by its makeup, pressure, temperature, and volume. Where P is the pressure, V is the volume, n is the number of mols of gas, T is the absolute temperature, and R is the Universal Gas Constant,

$$PV = nRT$$

This formula is the "Ideal Gas Law Formula." Although there is no such thing as an ideal gas the formula is pretty accurate for N2, CO2, and oxygen as we assume that the gas molecules are point masses and the collisions of the molecules are totally elastic. (A completely elastic collision means that the energy of the molecules before a collision equals the energy of the molecules after a collision, or, to put it another way, there is no attraction among the molecules.) The formula becomes less accurate as the gas becomes very compressed and as the temperature decreases but here "very compressed" pressures are well above even the highest tire pressures and "decreased temperatures" are extremely cold, too cold for tires. There are some correction factors for both of these factors for each gas to convert it to a Real Gas Law Formula, but the Ideal Gas Law is a good estimation of the way $N_2$, $CO_2$ and "air" should react through temperature changes. What does all this mean? It simply means that "air", nitrogen vapor, and $CO_2$ vapor should all react pretty much the same within normal tire pressures (0-120 PSI) and temperatures.