

## Vacuum Gauges 101

©2003, E. Ievins

extracted from our email list  
a teaching by Erik Ievins

- > My daughter asked me a very interesting question
- > this weekend. "What do those numbers mean," as
- > she referred to the performance gauge. Does anyone
- > know? 15 to 20 is economy and idle. 15 to 20 what?

---

Smart kid ya got there, Don. 😊

Your indicator is a vacuum gauge, calibrated in inches of mercury. Technically, "vacuum" is not the perfect terminology to describe low air pressure, but it's a familiar word so we'll use it. Most people seem to think of vacuum as if it were "negative pressure".

Whoa, let's back up a tiny bit and find out why this is wrong. It may help to know that, scientifically, a perfect vacuum would be considered an "absolute pressure" of zero. Remember seeing storm weather on a barometer, which measures atmospheric pressure, typically reading between 29-31 inches? Yep, that's absolute air pressure. Indeed, the air we breathe all day long is under pressure. We can measure it in pounds per square inch (PSI, about 14.7) or about 30 inches of mercury or simply call it "1 atmosphere" of pressure. But no matter how we measure it, since we human beings are so familiar with breathing standard air pressure all day long (and not to mention we're a bit egocentric), we tend to think of it as "zero" pressure even when it really isn't. And this is how your dashboard gauge is calibrated: zero is standard atmospheric pressure. Given this point of reference, a perfect vacuum (absence of all air pressure) would therefore be equivalent to about -30 in/Hg of pressure. But nobody uses negative pressure readings; we think of "vacuum" instead, and we just refer to it as 30 inches of mercury.

But why mercury? Wish I knew. Here's my educated guess:

Let's think about atmospheric pressure, and why it might be measured in "pounds per square inch". Imagine the air above you... there's a *lot* of it, from wherever you are above sea level, all the way up to the edge of the Earth's atmosphere. If you could take a "column" of that air, 1" x 1", it would "weigh" about 15 lbs (14.7 actually.) But that's an awfully tall column of air, more than we can relate to. It's easier to measure it with a comparison to something much heavier, such as mercury. In order to provide an "atmospheric" pressure of about 15 psi, that corresponding 1" square column of liquid would be about 30 inches tall.

How does theory apply, under the hood? As a piston tries to draw air into the engine, but the throttle plate is nearly closed and doesn't want to let that air in, a vacuum (pressure drop, actually) is created in the intake manifold under the carburetor. This is where the vacuum gauge measures. When you use the gas pedal to open the throttle plate, air can rush in to fill the void. (Actually, the atmospheric pressure is pushing air in.) With the throttle wide open, ambient air can rush into the intake manifold about as fast as the piston moves down to ask for more, so there is no longer any significant pressure drop across the throttle plate, and the air in the intake manifold will be at atmospheric pressure (remember, the gauge calls it "zero".) And of course, with the engine off, all of the air in the intake manifold settles to atmospheric pressure also, so the gauge will again rest at zero. A good strong vacuum reading means the engine is asking for lots of air (and fuel), and the throttle plate won't

let very much in. Closed-throttle deceleration is perhaps where you'll see the highest numbers.

There are several reasons why this knowledge can be useful. When you're driving, the higher the vacuum reading you see, the less air (and hence, less fuel) is getting into the engine. Add-on vacuum gauges have been available for decades. My Dad remembers seeing them sold as MPG indicators, and wondered how they could be, when they only went up to about 25 but his Dad's VW could easily get 30... In truth, they're not calibrated very well to give a totally accurate MPG reading, but in some cars it's pretty close. And from a relative standpoint, anything you can alter in your driving style that improves the vacuum level will improve your gas mileage at that instant, so it all adds up.

Most dashboard gauges are "damped" somewhat, to keep minor flutter variations from showing up jittery. But with a testing vacuum gauge, many more diagnostics are possible, since the air rushing into an engine is affected by many things, and a jumpy needle can tell a lot. See our Vacuum Gauge Diagnostic page for some interesting examples.

As a side note, do dashboard vacuum gauges still exist today? Sure... it's not uncommon to find one in a turbocharged vehicle. A turbo-boost gauge has a vacuum half and a boost half, thereby being able to show either negative or positive pressure. In the rather unfortunate cost-cutting trend toward ubiquitous idiot lights, a lack of gauges is a little unnerving if you've gotten used to using them... in the days of factory-available vacuum gauges, cars were a lot more interesting.

=====  
Erik Ievins

