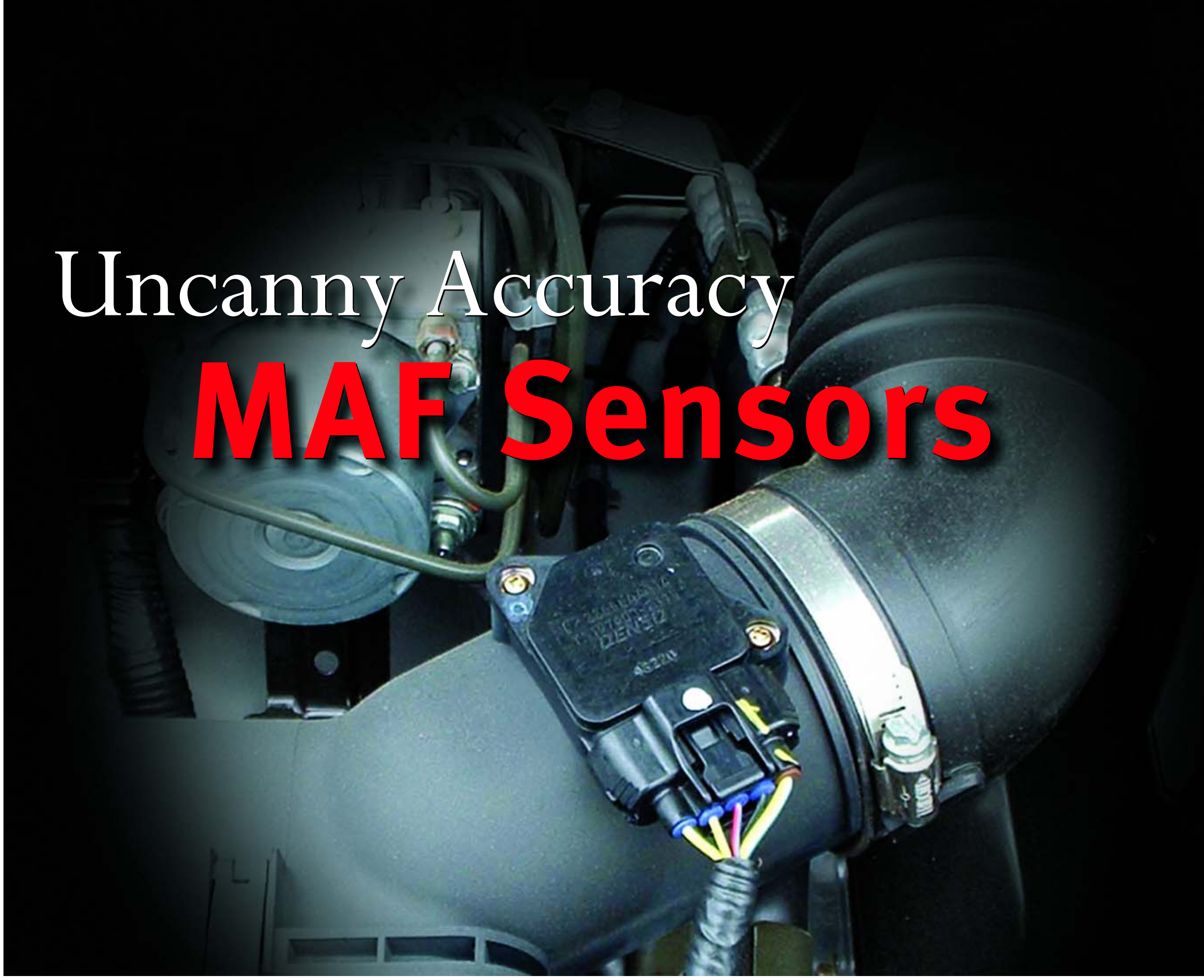
Uncanny Accuracy

MAF Sensors



Above: A requirement of OBD II regs, the Mass Air Flow sensor tells the computer the whole truth about how much air the engine is ingesting.

Suppose you were in the business of selling air. You could calculate the amount delivered by using a complicated formula that takes pressure, temperature, and the diameter of the valve into account, but that would be slow, unwieldy, and probably not very accurate.

You'd improve the efficiency of your operation considerably if you had a way of directly measuring the volume flowing into your customers' air canisters in cubic feet per minute. That would sure speed things up, but it wouldn't be perfect, either. On cold days, they'd be getting a big bargain because any gas is denser when it's cold than when it's hot — in essence, you'd be giving them a baker's dozen and then some. Sales would go way up (and profits way down) in winter as soon as your patrons realized that fact of physical reality. And they'd always try to buy at sea level in dry weather because altitude and humidity affect density, too.

To keep from losing your shirt, you'd still have to use a formula that varied the price per cubic foot according to temperature, altitude, and moisture content. Wouldn't it be a lot easier, faster, and more precise if you had a meter that read out in the actual weight instead of just the volume? Sure it would.

Which brings us to engines. Speed-density EFI systems, such as you might find on typical older Japanese cars, use computer power to calculate the mass of intake air from input on rpm, vacuum, throttle position, and intake air temperature sensor input. But, as we said, a direct reading by means of an airflow sensor aids swiftness and accuracy, which are both critical if optimum performance, high fuel efficiency, and low emissions are to be achieved. Since air/fuel ratios are by weight (stoichiometric is 14.7 lbs. of air to one lb. of gasoline — in gallons it would be about 2,000 to one), however, measuring mass makes even more sense, so for many years we've had the MAF that does just that. In fact, it's always been a basic requirement for meeting OBD II regs, which became mandatory in '96 (Subaru beat that by a year). It looks like research and development of virtual sensors may soon allow the carmakers to fulfill this requirement without using an actual MAF — sort of a much more sophisticated version of the speed-density concept — but don't hold your breath.

A mass air flow sensor has some other advantages besides its ability to account for density: no moving parts, restrictions, or compensating sensors. A typical MAF has a wire or film element that's kept heated to a specified temperature above ambient and is exposed to intake air. Through a Wheatstone bridge circuit and dedicated electronics, the amount of current required to maintain that temperature becomes the signal to the computer. High air flow obviously has a greater cooling effect than low, but so does the denser air of cold days and low altitudes, so the PCM gets the true data on mass it needs to provide the longer injector pulse width that extra oxygen needs to fire dependably. Some units produce an analog voltage output, while others send out a varying frequency digital signal — a square-wave.

From various authorities, we've compiled quite a list of probable symptoms of MAF trouble. Some tell you to expect starting problems both hot and cold, hesitation, stalling (especially under load), rough idle, and low power output. Others say the engine will fire up, then die. Still others give stalling, poor idle, black smoke, and engagement of the fail-safe mode as evidence of air mass measurement problems.

Contamination of the sensing element, which slows response, will result in stumble, which brings us to the most prominent logical effect of a bad or non-existent MAF signal: transient throttle glitches, including stalling, sagging, and missing. If it's far enough out of range to cause the PCM to shift to LOS (Limited Operating Strategy), overall performance and driveability will be lousy.

But don't let these symptoms cause you to jump to an unfortunate conclusion and automatically replace that expensive sensor. Plenty of other malfunctioning components can result in the same kinds of annoying and inefficient engine behavior. So, as we say over and over in ***The End Wrench***, check the basics first. That means ignition, compression, fuel pressure and volume, etc. A restricted air filter element may make trouble, too. Then there are all the other sensors and the wiring and connections that are part of every electronic engine management system. In short, don't blame the MAF right off because most of them have proved to be pretty dependable.

A simple problem that would be embarrassing to overlook is a hole or rip in the duct between the sensor and the throttle body, which admits unmeasured air and leans out the mixture. We remember our first encounter with this situation. A car was being driven into the bay next to ours, and it was running badly — made us think of an old carbureted car with a huge vacuum leak, say from a disconnected brake booster hose.

While the other tech was unpacking his favorite scan tool, we popped the hood and took a look around. Having just read an article on MAF sensors, we felt under the duct to the throttle body and our fingers went right through. As mentioned above, it was a case of what's known in the business as "false air" — it's getting in downstream of where measurement of intake mass is taken, thus causing the PCM to provide an injector pulse width that's way too short, which leans out the blend (BTW, an open PCV can do the same thing).

Just to back up the obvious, we put some duct tape over the holes, started it up, and it idled and revved like the good engine it was. That's what we call efficient diagnosis, and it illustrates two important points: One, always check the basics before you engage in high-tech troubleshooting. And, two, OBD, whether I or II, can't do everything.

A nagging question remains, though: What causes holes or splits in that duct? Gnawing mice, or maybe contact with a belt or pulley? Neither seems too likely. Perhaps it's rough handling during previous service, or just that hot environment under the hood.

Left: *A look down the throat of an early Subaru MAF, circa 1985 or so.*

Below: *Not only holes in the intake duct itself, but any vac leak in a hose that connects to it can cause the false air problem.*