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Installing an **Air/Fuel Ratio Meter**

by Brendan Lopez PHOTOS BY THE AUTHOR

With the quest for improved performance comes the requisite responsibility to mitigate any excess emission levels and minimize the environmental impact of the hobby. Most cars on the road today, at least those built since the mid '70s, have a closed-loop engine-management system that controls the air/fuel ratio with varying degrees of accuracy. This system more or less compensates for changes to the engine within a moderate range.

Those of us who drive older cars have no such system and no way of knowing whether our cars are working as efficiently as possible. Regular tune-ups and checking fuel mileage is a pretty good method, but real-time analysis is sorely lacking for many.

One option is to add an oxygen sensor and air/fuel ratio meter to check the percentage of fuel left in the exhaust gases. Adding a meter alone can't adjust the ratio on the fly, but it can give you insight into potential performance and emissions problems.

Stoichiometric ratio is a number commonly thrown around when talking about fuel usage and economy. It refers to the optimal ratio of air to fuel—14.7:1 air to fuel. That is to say, for every 14.7 parts of air, there is one part of fuel, measured by mass and not by volume. For example, mixing 14.7-gallon-sized containers of air with one gallon of gasoline will not provide the correct ratio.

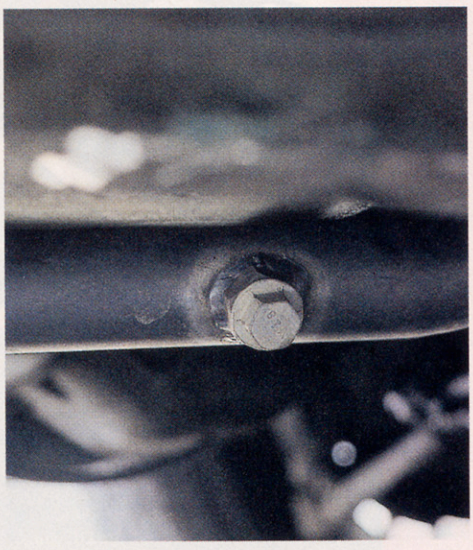
This becomes clear if you consider the amount of air consumed by an engine. Rounding off the math, a 2-liter engine, assuming it has a perfect volumetric efficiency, will ingest (more or less) 15 gallons of charge in 60 revolutions. Clearly, 60 revolutions doesn't take very long if the engine is turning 6000 rpm.

To measure the air/fuel ratio, an oxygen sensor is placed in the exhaust stream. After sampling the gases, the sensor sends back a voltage reading to the computer that is interpreted to calculate the air/fuel ratio. There are different types of oxygen sensors, but most of those used in modern cars, and by aftermarket gauges, are of the four-wire heated variety. These provide faster and more accurate readings, as they do not rely on the exhaust gases to bring them to operating temperature. The actual mechanics of how voltage is created is a bit confusing and doesn't add anything to the discussion at hand. Just realize that oxygen sensors are sensitive and should not be dropped. Chemicals introduced into the exhaust tract can also damage them. These include fuel additives, liquid gasket materials and exhaust sealing paste. Make sure anything you use is safe for oxygen sensors.

In engineering terms, stoichiometric ratio is expressed using the Greek letter lambda. For this reason, oxygen sensors used to be referred to as lambda sensors. With a lambda value of 1.0, the engine is said to have the proper air/fuel ratio. The lambda values also refer to the output voltage of the sensor. The

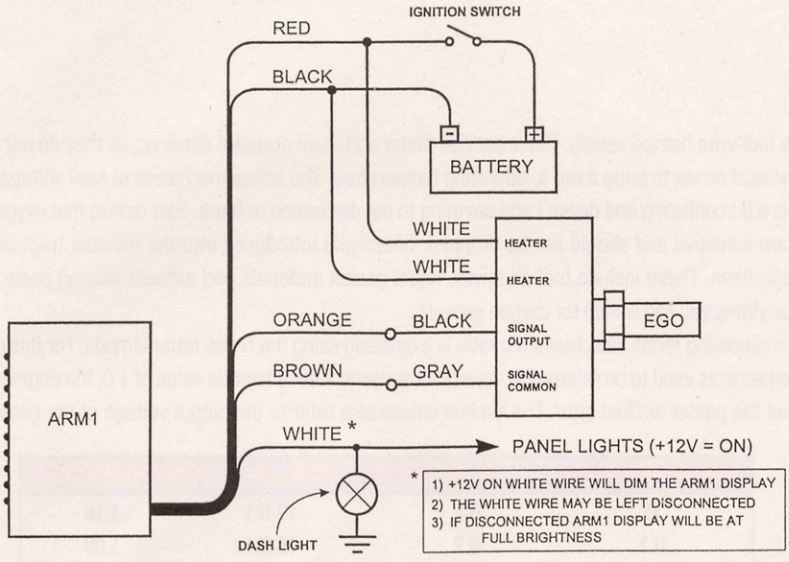
Min. Voltage	Max. Voltage	Air/Fuel Ratio	Lambda (l)
0	0.1	17.0:1	1.16
0.1	0.2	16.0:1	1.09
0.2	0.3	15.5:1	1.05
0.3	0.4	15.0:1	1.02
0.4	0.5	14.7:1	1.00
0.5	0.6	14.6:1	0.99
0.6	0.7	14.5:1	0.98
0.7	0.8	14.2:1	0.97
0.8	0.9	13.2:1	0.90
0.9	1.0	121.5:1	0.85

**Table is based on an oxygen sensor temperature of 1,200°F*



Above: Oxygen sensors are sensitive and should not be dropped. Also, the anti-seize compound smeared on the threads should be oxygen-sensor compatible.
Above right: Exhaust fittings such as this can be added in the exhaust stream. The cap seals it when the meter is not installed. Initially it was added for dyno use and a professional-quality Motec meter. For occasional tuning, the sensor and meter are hooked up.

Connections For Four-Wire EGO1 Sensor:



This diagram came with the Split Second meter and offers an easy explanation of the various wires and connections.

accompanying chart, provided by the air/fuel meter kit, shows the relationship of voltage to lambda; a 0.45-volt output is said to be optimal.

Adding a Meter

Adding an air/fuel ratio meter to a car not equipped with an oxygen sensor is a fairly straightforward process. It requires adding a threaded fitting into the exhaust pipe. You'll want to put it in the collector as far forward as possible. If it's placed too far back, you won't get good readings. A muffler shop can add the fitting, no problem. In the example shown, the fitting was added facing down, as it was only to be used when the vehicle is on a chassis dyno. For normal road-going use, it would be positioned up in the area of the transmission tunnel where it will be protected.

The wiring is job is easy enough. There are four wires coming off the oxygen sensor and five coming off the meter.

Looking at the sensor first, the two white wires are for the internal heating element and are connected to ground and a positive switched source (to keep it from being on all the time). It doesn't matter which white wire goes to which source.

The black wire on the sensor is the signal output and is connected to the orange wire on the meter. This is the voltage signal that tells the air/fuel ratio. The gray wire on the oxygen sensor connects to the brown wire on the meter. This is the signal common wire (negative). Connecting the white wire on the meter to the dash lights will dim the meter LEDs for nighttime use when the dash lights are one.

The two remaining wires on the meter, red and black, refer to the positive (switched source) and negatives that power the meter. Note that this meter has a series of recessed screws in the casing. One of these screws is hot when the meter is connected to power. The literature offers no explanation, only a caution.

Using Air/Fuel Ratio Meters

With your meter properly installed, you can then begin to understand what your engine is doing. When the LEDs read green, the air/fuel ratio is close to perfect. Yellow, orange and red colors indicate a lean running condition. If this

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happens consistently under heavy load, your engine could overheat, detonate or be damaged. Blue readings indicate a rich running condition, so you'll want to look at the ignition system or excess fuel delivery. Note that because this meter is not part of a closed-loop system, there is no mechanism to adjust the ratio on the fly. You are merely looking for trends in running conditions; you can then later adjust the parameters to cure the problem.

For example, Weber carburetors are notorious for delivering too much fuel under extreme throttle positions. Knowing how the jets, emulsion tubes and auxiliary venturis work together to deliver fuel enables you to change the fuel delivery curve.

Here is a small compact add-on air/fuel ratio meter that's smaller than a packet of cigarettes. Similar products are offered by many of the advertisers in this magazine. K&N has a round gauge designed to fit into a standard VDO-sized hole.

This also applies to fuel-injected cars if you've added a big cam and played with the fuel pressure and airflow meter. For running an aftermarket turbo or supercharger kit, or even a modified stock turbo, knowing of a lean running condition becomes critical.

Remember that the information you receive from any feedback device, whether it be a temperature gauge, pressure gauge or similar dial, cannot fix a problem, it can only clue you in. The rest is up to you.