November **2009**

TST

Technicians Service Training

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Editor

Jerry "G" Truglia

Wide Range Air/Fuel Ratio Sensors

A new type of sensor has begun to appear. New diagnostic techniques are required.

A conventional zirconia oxygen sensor generates a very low voltage in response to changes in the oxygen content in the exhaust system. When it is operating properly, the oxygen sensor's output voltage ranges between 0 and 1 volt. The exhaust oxygen content, as measured by the oxygen sensor, theoretically indicates whether the engine is running rich or lean. If the oxygen sensor output voltage is high (close to 1 volt), the exhaust oxygen content is low and the engine is running rich. If the oxygen sensor output voltage is low (close to 0 volt), the exhaust oxygen content is high and the engine is running lean.

We've become accustomed to seeing the oxygen sensor's output voltage constantly range from high to low and back again. The extra oxygen present in the exhaust stream when the air/fuel ratio is slightly lean is used to recharge the catalytic converter with a fresh supply of oxygen molecules. This allows it to do a better job of oxidizing the HC, CO and NOx in the exhaust stream into harmless compounds. A toggling air/fuel mixture works pretty well, but today's tighter emission control requirements can only be met through more precise control of the air/fuel ratio.

(Con't on page 3)

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- ***Keep our fellow technicians up to date with the latest technology.***
- ***Provide training seminars for a reasonable price.***
- ***Deliver information that the technician can use now.***
- ***Keep technicians informed of information affecting our industry.***
- ***Increase consumer awareness of what a good technician is.***

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Wide Range Air/Fuel Ratio Sensors *(con't from p. 1)*

These changes have necessitated the development of a new type of oxygen sensor. It is commonly called an air/fuel ratio sensor, or A/F sensor for short. It can currently be found on many late model Toyota and Honda models, and other manufacturers are certain to follow. The A/F sensor has the ability to accurately measure air/fuel ratios over a wider range than a conventional oxygen sensor.

A conventional oxygen sensor is accurate near stoichiometric (14.7:1) only, but the A/F sensor is capable of measuring air/fuel ratios as lean as 23:1 and as rich as 11:1. This permits the PCM to more accurately meter the fuel, reducing emissions.

Though it may appear similar to a conventional oxygen sensor on the outside, the A/F sensor is constructed differently and has different operating characteristics. They are not interchangeable, although their harness connectors may look very similar. The A/F sensor operates at approximately 1200° F, which is much hotter than the conventional oxygen sensor's 600-750° F operating temperature. A more powerful internal heater is used to assure that the A/F sensor always operates in the necessary temperature range.

The most important difference between a conventional oxygen sensor and the Toyota A/F sensor is the way the A/F sensor signals the PCM when a change in the exhaust oxygen content occurs. Instead of the oxygen sensor's changes in signal voltage, the PCM watches the A/F sensor for changes in its current (amperage) output, relative to the amount of oxygen in the exhaust stream.

A circuit in the PCM detects the change and strength of the current flow from the A/F sensor and generates a voltage signal proportional to the exhaust oxygen content. This allows the PCM to judge the exact A/F ratio under a wide range of conditions and quickly adjust the amount of fuel needed to reach the stoichiometric point.

(Con't on page 4)

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Wide Range Air/Fuel Ratio Sensors *(con't from p. 3)*

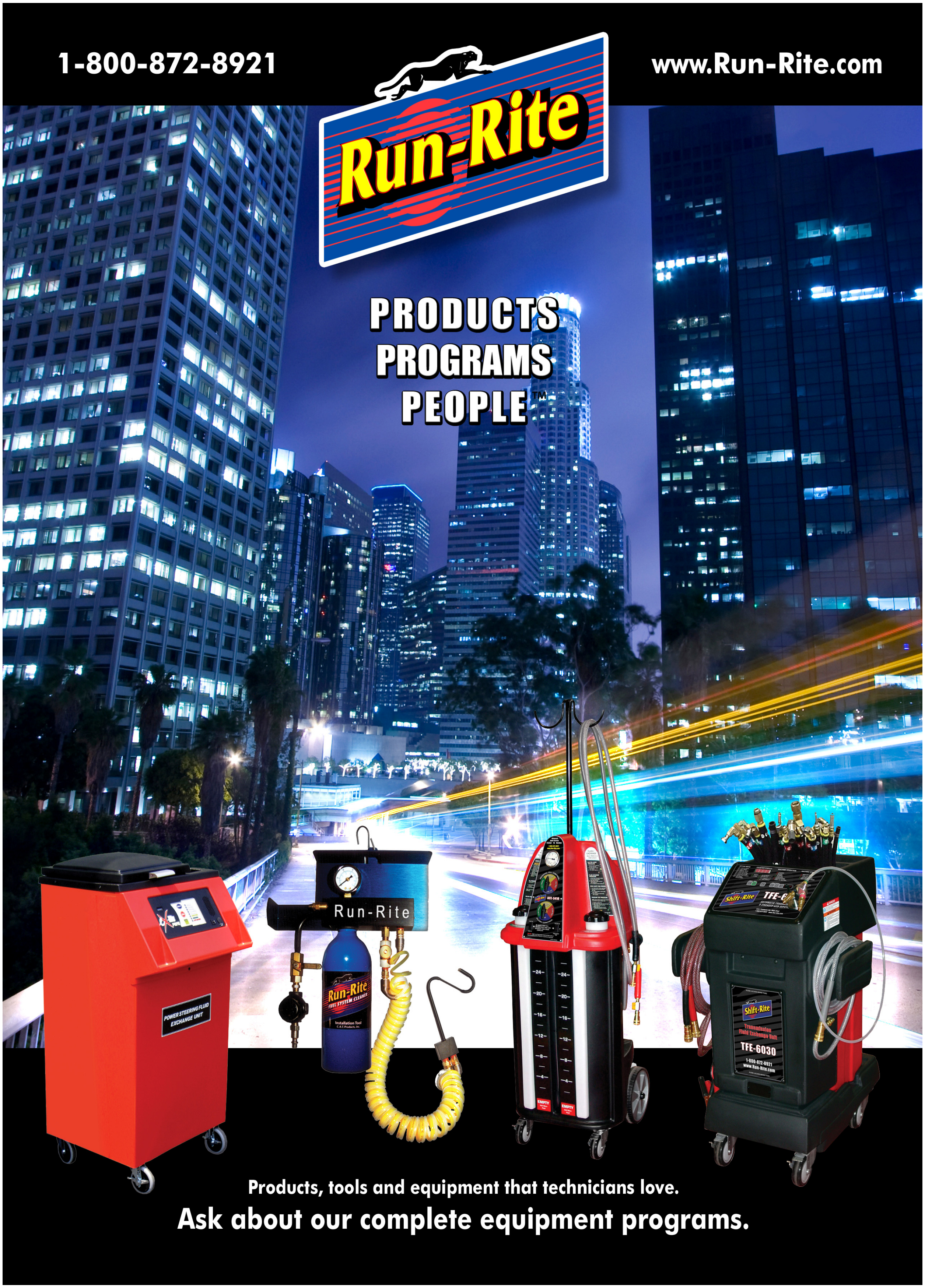
This change in operating strategy means a big change in the way you diagnose and repair this A/F sensor. With a conventional oxygen sensor, it is possible to backprobe the sensor's signal wire and observe its signal to the PCM with a DVOM, oscilloscope or graphing multimeter. While it is still possible to backprobe the A/F sensor's signal wire, the information you receive by doing so may be of little use to you, especially if it is incorrectly interpreted.

The A/F sensor has two signal wires, not one. The PCM provides a set voltage on each of these wires; neither is a ground. One is set at 3.0 volts, the other at 3.3 volts. With the A/F sensor connected to the PCM, attaching the leads of a DVOM to these sensor's two wires would reveal little change. The reading should remain nearly constant at 0.3 volt (300 millivolts), regardless of any changes in the A/F ratio. As the A/F sensor changes its output in response to fluctuations in the A/F ratio, the PCM's detection circuit maintains the steady 300 millivolt output.

To measure a four-wire A/F sensor's response using *voltage*, disconnect the sensor's four-wire connector, then attach jumper wires to maintain power to the sensor heater. Next, connect a scope or multimeter to the two *disconnected* sensor signal wires. When the A/F ratio is artificially richened or leaned, you'll see that the A/F sensor responds just like a conventional oxygen sensor. Its response swings between 0 and 1 volt, with 0 indicating a lean mixture and 1 indicating a rich mixture.

To measure a four-wire A/F sensor's response using *amperage*, install an ammeter *in series* with the PCM's 3.3 volt signal wire. The ammeter's negative (black) lead should be connected to the sensor lead and the positive (red) lead should be connected to the PCM wiring. The 3.0 volt signal wiring as well as the heater wires must remain connected (jumpered between connectors) during this test. Imagine the A/F sensor as a tiny generator that is capable of changing polarity. A lean exhaust will cause the A/F sensor to produce a positive-going ammeter reading, while a rich exhaust will cause it to produce a negative going ammeter reading. When the A/F ratio is at the stoichiometric point (Lambda), no current is generated and the ammeter shows 0 milliamps.

(Con't on page 7)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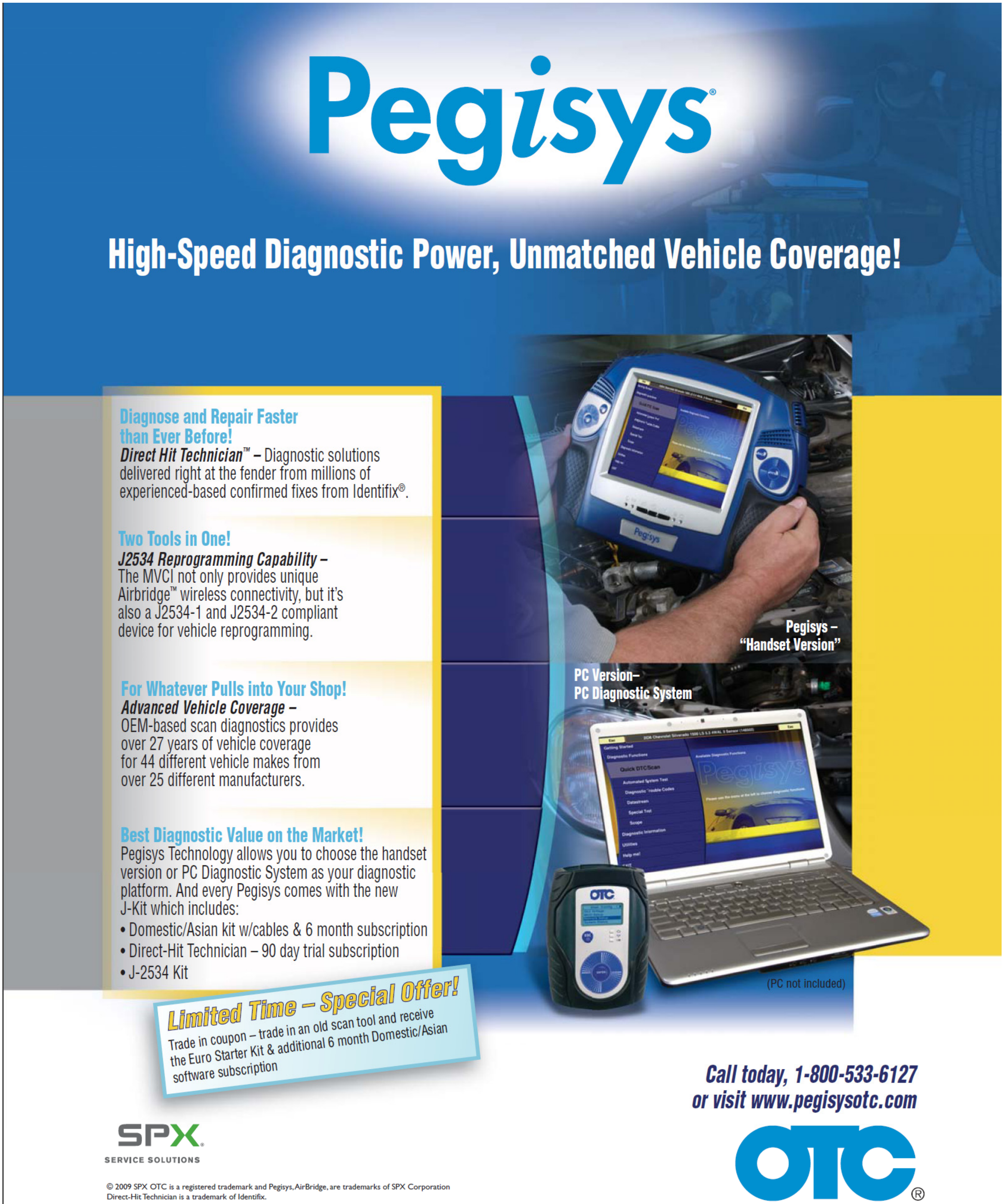
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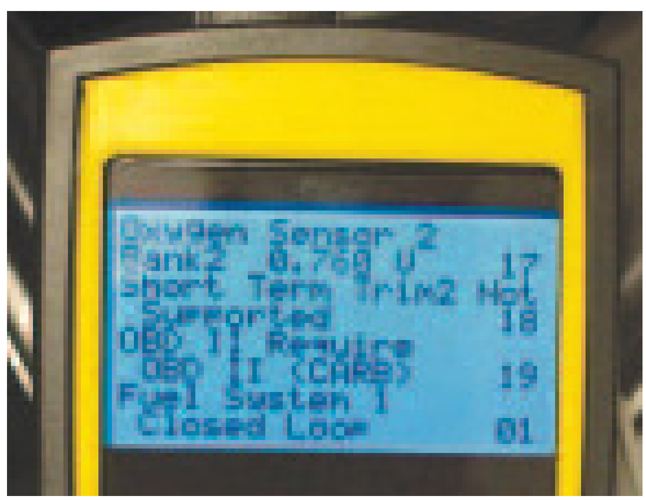
Wide Range Air/Fuel Ratio Sensors *(con't from p. 4)*

After providing power to the A/F sensor heater, we attached a DVOM to the two other sensor leads. After starting the engine, the sensor responded like a conventional O2 sensor.

Make sure your scan tool can handle data from a wide range A/F sensor. This generic OBD II scanner reported PIDs for both conventional rear O2 sensors, but had nothing to say about the front two wide range A/F sensors.



If you decide to forgo testing the A/F sensor directly at the sensor, always remember thatthe data you see on your scan tool has been processed and interpreted by the PCM. And in the case of the A/F ratio sensor, it's data that has been converted from a current reading into the voltage reading you see on the scanner. ***(Cn't on p. 9)***

Wide Range Air/Fuel Ratio Sensors *(con't from page 7)*

If your scan tool is equipped with the necessary software, the PCM's voltage detection circuitry will produce the following readings on your scan tool for the A/F sensor parameter identification (PID):

• A low exhaust oxygen content causes a negative current flow at the A/F sensor. The PCM detection circuit produces a voltage signal below 3.3 volts, indicating the air/fuel mixture is judged to be rich.

• Exhaust oxygen content at stoichiometry produces no current flow at the A/F sensor. The PCM detection circuit produces a voltage signal of 3.3 volts, indicating the air/fuel mixture is judged to be at 14.7:1.

• A high exhaust oxygen content causes a positive current flow at the A/F sensor. The PCM detection circuit produces a voltage signal above 3.3 volts, indicating the air/fuel mixture is judged to be lean.

Some scan tools are not equipped to read the data from the PCM's A/F sensor detection circuit. You may see no PID for the A/F sensor, which may lead you to believe the A/F sensor is faulty or the vehicle does not have an A/F sensor. Other scan tools apply a conversion factor to bring the A/F sensor PID into the more familiar 0 to 1 volt output range. This is accomplished by dividing the sensor detection circuit's original output by 5.

So a stoichiometric reading of 3.3 volts becomes 0.66 volts on the scan tool. A 4.0 volt (lean) detection circuit reading becomes 0.8 volts on the scan tool. And a 2.5 volt detection circuit reading becomes 0.5 volts on the scan tool.

(Con't on p. 11)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Thank you, G Truglia

Wide Range Air/Fuel Ratio Sensors *(con't from page 9)*

Everything seems fine until you notice that the A/F sensor voltage PID on your scan tool is exactly the opposite of what you're accustomed to seeing from a conventional oxygen sensor. The voltage output through the PCM's detection circuit and the interpreted PID on your scanner increases as the mixture goes lean and decreases as the mixture gets richer. Don't be fooled by your scanner.

During normal operation, the swings between rich and lean A/F ratios will be more subdued than you're accustomed to seeing. Don't look for the traditional toggle between very rich and very lean. The A/F ratio commanded by the PCM will remain fairly constant, unless there's a big change in engine speed or load. It's that consistency that helps the PCM deliver the cleanest possible emissions while retaining performance and driveability.

Article Courtesy of Wells Manufacturing Corp.

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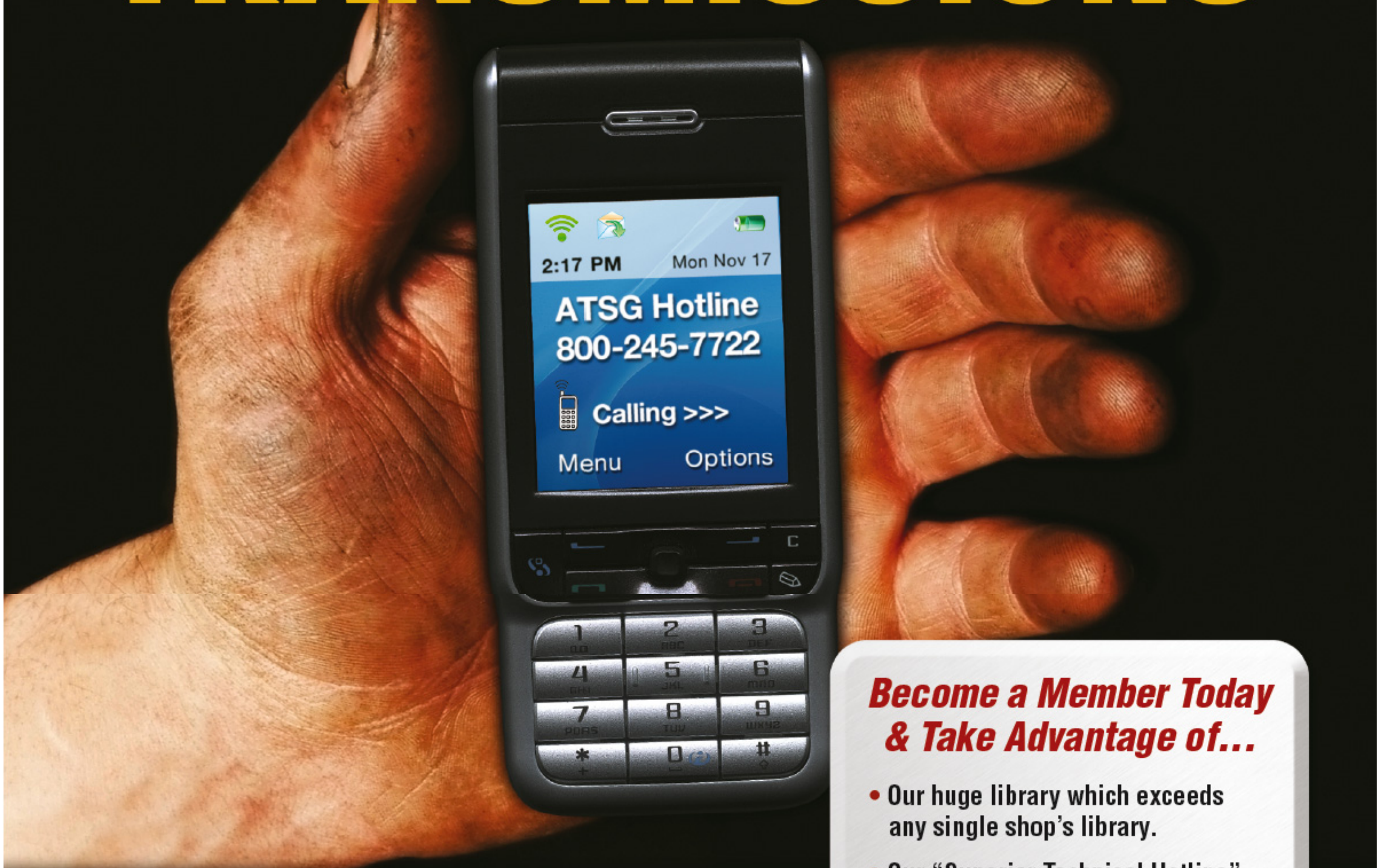

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