StarTuned®

Information for the Independent Mercedes-Benz Service Professional

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Oxygen Sensors in Depth

How to Sell Sensors

Tire Pressure Monitoring

Volume 5 Number 4

Mercedes-Benz

To Our Readers:

Welcome to *StarTuned*, the magazine for independent service technicians working on Mercedes-Benz vehicles. Mercedes-Benz sponsors *StarTuned* and provides the information coming your way in each issue.

Mercedes-Benz wants to present what you need to know to diagnose and repair Mercedes-Benz cars accurately, quickly and the first time. Text, graphic, on-line and other technical sources combine to make this possible.

Feature articles, derived from approved company sources, focus on being useful and interesting. Our digest of technical information can help you solve unanticipated problems quickly and expertly. Our list of Mercedes-Benz dealers can help you find original, Genuine Mercedes-Benz Parts.

We want *StarTuned* to be both helpful and informative, so please let us know just what kinds of features and other diagnostic services you'd like to see in it. We'll continue to bring you selected service bulletins from Mercedes-Benz and articles covering the different systems on these vehicles.

Send your suggestions, questions or comments to us at:

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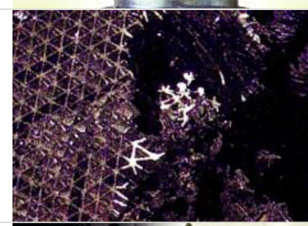
Feature Articles

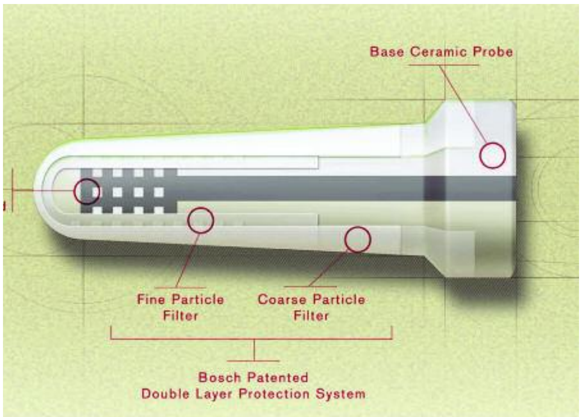


Departments


Can you purchase a partnership like you can a part?

Thimble to Planar
Oxygen Sensors In Depth

Oxygen sensors are evolving, as is borne out by the introduction of the wide-band type. Yet there are still many, many older style units out there in the real world for you to deal with. Here's everything you have to know from construction and operating principles to diagnosis and service.



Although all oxygen sensors are carefully constructed so that harmful particles don't get through to the platinum-coated zirconium, contamination is still the biggest killer.

Other pages in this issue of StarTuned will give you a solid understanding of the recently-introduced wide-band oxygen sensor, which amounts to a big improvement where emissions reduction and enhanced engine performance is concerned. But at least 90% of the cars you work on are not so equipped – we all know that Mercedes-Benz owners tend to keep their cars for years and years, and we often see specimens with over a quarter of a million miles on them. So, it's important that you also have a deep and comfortable understanding of previous oxygen sensor technology, failure modes, troubleshooting and replacement procedures. Hence, this article.

We remember being intrigued and astonished three decades ago when the oxygen sensor first appeared as the cornerstone of the Bosch Lambda-Sond system. The industry was just becoming accustomed to electronic ignition, and this step up into closed-loop engine management was staggering. It knocked the service business for a loop, and some of us haven't fully recovered yet. The motoring public, of course, is still blithely unaware of the whole concept – customers are commonly shocked to hear that their cars have a computer aboard, or that there's such a thing as a sensor that gives it input on the air/fuel mix. Mercedes-Benz was one of the first carmakers to adopt this concept as a means of staying at the forefront of engine efficiency and emissions control, so you might see examples nearly 30 years old in the bays of your shop.

Besides being amazed at the idea of on-board exhaust analysis by means of what's variously called an oxygen, O2, EGO, HEGO sensor, or Lambda probe, we were dubious at the time about the potential longevity of a sensitive component located in that horrendous blast of hot gases. How long could it possibly last?

That fear proved unfounded. Early on, replacement was recommended every 15,000 or 30,000 miles. Experience has shown that many specimens are still fine, thank you, after several times that, and regular retirement intervals were lengthened to 60,000, then eliminated altogether. "Many" is the key word, though. Lots of them do indeed die prematurely from causes that have nothing to do with the quality of their manufacture.

A study conducted for CARB (California Air Resources Board) many years ago stated that 70% of fuel injected vehicles that fail the state's emissions test have bad O2 sensors. Also, a faulty one can cause fuel economy to decline by 10-15%, costing a less heedful motorist maybe several hundred dollars a year, and perhaps melting down the cat in the process. While this situation has improved in the period since the study, it hasn't been eliminated.

Platinum-coated zirconium

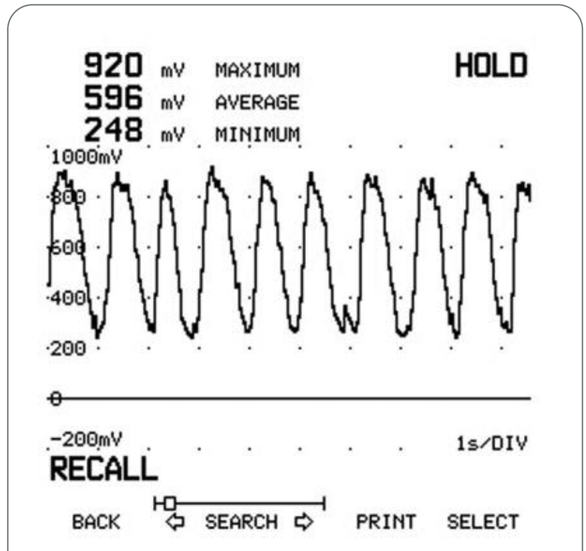
Not counting the wide-band type, there are really two basic varieties of mixture monitors, zirconium and titanium. Introduced in 1986, the latter is found only in a small percentage of the vehicles on the road, none of them from Mercedes-Benz, so we'll concentrate on the former here.

A basic zirconium oxygen sensor comprises a steel housing with a hex and threads, a louvered shield over the tip, and a hollow cone-shaped internal element made of zirconium dioxide (ZrO_2, a ceramic material) called a "thimble," which is coated inside and out with a thin layer of micro porous platinum. The outer layer is exposed to the exhaust stream, while the inner layer is vented to the atmosphere and attached to a wire that runs to the PCM (Powertrain Control Module).

It's actually a galvanic cell – think of a flashlight battery. The zirconium dioxide acts as the electrolyte, and the platinum layers serve as electrodes. Once the ZrO_2 reaches about 600 deg. F. (over 300 deg. C.), it becomes electrically conductive and attracts negatively charged ions of oxygen. These ions collect on the inner and outer platinum surfaces. Naturally, there's more oxygen in plain air than in exhaust, so the inner electrode will always collect more ions than the outer electrode, and this causes a voltage potential. Electrons will flow.

The concentration of oxygen in the exhaust stream determines the number of ions on the outer electrode, hence the amount of voltage produced. If the engine is running rich, little oxygen will be present in the exhaust, few ions will attach to the outer electrode, and voltage output will be relatively high. In a lean situation, more oxygen will be present, and that translates into more ions on the outer electrode, a smaller electrical potential, and less voltage. Here's a helpful memory trick: just remember "L=L" for Lean=Low.

The voltage is always small, never exceeding 1.3 volts (or, 1,300 mV) or so, with a typical operating range being between 100 and 900 mV. But it's enough for the computer to read. If it receives a sensor signal of less than about 450 mV, it recognizes a lean condition, and if it gets more than that amount of voltage, it registers a rich condition (it's one or the other, there's no in-between). Either way, it instantly corrects by adjusting the injection pulse width.



With a lab scope, you can easily see what kind of a signal the oxygen sensor is sending. This is obviously a good one – the pattern is perfectly normal.

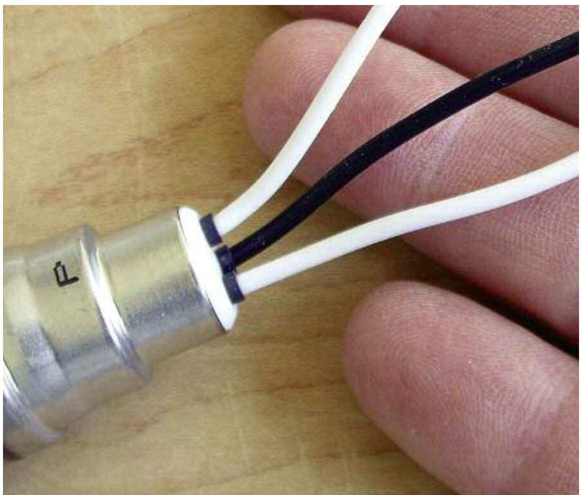
You may have heard the term "dithering" applied to O_2 sensors. The dictionary will tell you that a "dither" is a state of agitation or indecision. As a verb, it's a pretty good description of how this sensor's signal is supposed to be continuously switching from rich to lean and back.

No heat, no go

Remember the 600 deg. F. temperature mentioned above? Good, because it's important. Oxygen sensors simply will not produce voltage until they're hot, and many perfectly good units have been replaced because some technicians test them when the engine is first started, or after it's idled for a while, which allows the old one-wire unheated type to cool off. That's one reason the planar type is superior – it heats up fast.

With a cold sensor, the computer realizes it's not getting a signal and will operate in open loop, holding the mixture at a fixed setting. Since good fuel efficiency and minimum exhaust emissions can only be had during closed loop, it's desirable to get the sensor hot as soon as possible after the engine is started, and to keep it there while idling, so all late model thimble-type oxygen sensors are equipped with an electrical heating element, not to mention the rapid heating capabilities of the planar type.

Wires



Typically, the wire that carries the voltage signal to the PCM is black. The others here are current feed for the internal heating element and ground.

While your basic first-generation sensor will have one wire, you'll also see specimens with two, three, or four. In most cases, two means it's an ordinary unheated unit. The extra wire just provides a more dependable ground than thread contact in the manifold or head pipe. Three leads indicate a HEGO (Heated Exhaust Gas Oxygen, one for the signal, two for the heater circuit) sensor. Although the signal wire is typically black, it can be hard to tell which of the other two is ground and which is juice to the heating element, so a wiring diagram would be helpful. The fourth wire? Simply a dedicated ground for the signal portion.

Numerous

If all zirconium oxygen sensors work in pretty much the same way, why are there so many part numbers? To begin with, the replacement should have the right number of wires, as just mentioned. So there you have four right off, but it actually works out to more than that because of the different styles of pigtail connectors used in their harnesses of various models.

But there are other, more subtle considerations. For instance, there's the spacing of the louvers in the business end. Most common is the wide-slot type, but there's the narrow-slot variety, too. In unheated sensors, its purpose is to protect the ceramic from thermal shock in applications that put the sensor close to the exhaust ports by making it heat up more gradually. If you were to install a narrow-slot unit in a car that requires the wide-slot type, it would take a long time to heat up to operating temperature, and may keep throwing the car into open loop at idle because it's not staying hot enough to work. There's really no problem using a wide-slot in a narrow-slot application, however. With heated units, the situation is reversed. Narrow slots are used to keep the sensor from cooling off. All this is more evidence in the case for purchasing O.E. genuine parts.

A mention of the waterproof feature is appropriate here. All it means is that the reference air isn't picked up through a vent right at the sensor itself where water and other contaminants are plentiful. Instead, there's a sealed sleeve of insulation that runs up into the harness, or even all the way to the PCM, before it opens to the atmosphere. Since only a tiny amount of reference air is needed, enough will flow between the gaps in the stranded wires inside the insulation. You can get into trouble if you solder these cables because it wouldn't take much flux, solder, or melted plastic to block those essential gaps.

Substance abuse

Several things can wreck an oxygen sensor. Mechanical damage in the form of a broken element or wire certainly happens, but the most common killer is contamination. Lead, carbon, metals from motor oil additives, and silica (from high-volatile RTV silicone sealants or antifreeze - expect O2 sensor problems whenever you replace a blown head gasket) in the exhaust can all coat that precious platinum and make the unit sluggish or altogether inoperative. There have even been cases of sensor poisoning from gasoline with a high silicon content, 500 ppm when 4 ppm is enough to cause trouble. By the way, silica (SiO_2) appears as a fine white powder on the shield.

Deposits on the exhaust-side electrode increase voltage output, giving a false rich signal. This drives the system lean. But these coatings aren't always the kiss of death. Try running the engine at 3,000 rpm for a few minutes, or take a drive, then retest. You may have burned off whatever was interfering with juice generation. On the other hand, if silica or metal deposits get hot enough, they'll melt into a coating that can never be removed.

The most common oxygen sensor failure is gradual degradation. Over time, sensors slow down in frequency and lose amplitude. Prior to OBD II, computers did a poor job of self-diagnosing this. A scan tool is not very good for diagnosing a degraded sensor unless it has graphing capability, and even then it can be limited by the data transmission rate of the computer. Additionally, no scan tool that we've seen shows negative numbers when a negative-biased O2 sensor switches below zero volts.

For many highly-skilled diagnosticians, the lab scope (a.k.a. digital storage oscilloscope, or DSO) is the tool of choice for oxy sensor testing. In California, the DSO is required for emissions inspection and repair stations. OBD II testing of oxygen sensors includes a test for the speed of rich-to-lean transition as well as lean-to-rich and amplitude. The same test can be conducted with a lab scope.

The California BAR (Bureau of Auto Repair) -recommended procedure is as follows:

1. **Monitor O2 sensor operation and insure closed loop.**
2. **Feed propane to engine at a slow rate and wait until computer adaptive strategy restores O2 switching.**

Naturally, you'll want to fire up your scan tool as one of the first steps in O2 sensor evaluation.

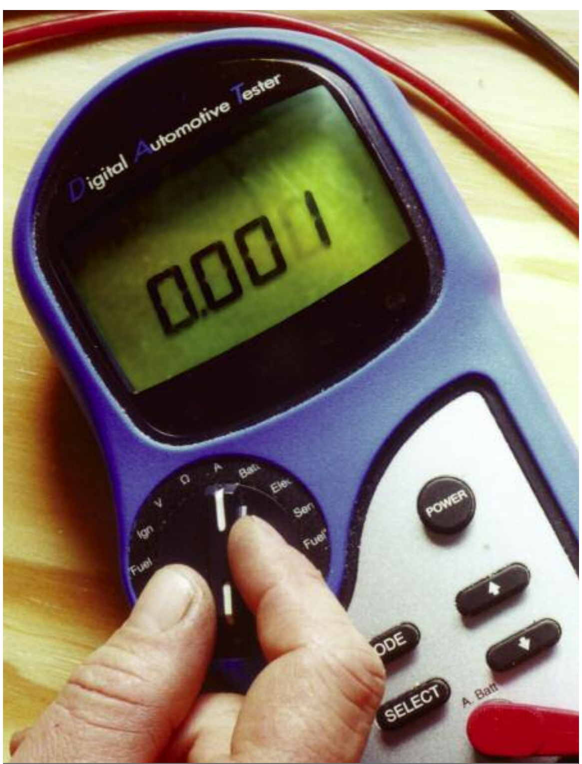
3. **Cut propane off (O2 sensor will swing lean).**
4. **At this point, goose the throttle to feed an enrichment command.**
5. **Press “Hold” on the scope to capture the lean-to-rich transition, and measure the response time with scope cursors.**

A fresh sensor will be able to make the transition in under 100ms and should be able to clear 800 mV on the rich side and drop below 175 mV on the lean side when the propane is first shut off.

The rich-to-lean transition is measured similarly except that a quick large vacuum leak after the mixture has been forced rich is used to get the swing to lean. If you're fast or have a recording lab scope, you can get both readings with the same test.

One thing that has proved to be abundantly true is that oxygen sensors do not survive well on a diet of coolant. Techs have told us they've been burned on head gasket replacement jobs that came back with a MIL (Malfunction Indicator Lamp) on, a dead oxygen sensor, and a typical customer comment, “It never did that before”. The techs were left to choose between two undesirable options: Installing the sensor and eating the cost, or trying to explain to the customer that the blown head gasket had killed the sensor. Customers who have just spent a large amount of money for a head gasket job are not usually very happy about springing for another bill. The moral of the story is to remember to write the cost of the oxygen sensor(s) into your repair estimate for head gasket replacement.

For some reason, most people have never even considered the possibility of contamination of the electrode on the reference air side, but it's a problem nevertheless. Typically, it comes from the smoke given off during the deterioration of silicone rubber seals or insulation, or from aerosol wire-drying chemicals, cleaners, etc. used under the hood. Blocking the reference air lowers the unit's voltage potential, making it send a false lean signal that drives the mixture rich, possibly cooking the catalyst.



Your DMM should have a voltage bar scale to make it useful in checking oxygen sensor output, but a graphing multi-meter, or even a lab scope, would give you better information.

Likely complaints

Symptoms of a lazy or dead oxygen sensor are surging, hesitation, poor overall performance, lousy gas mileage, and a rough or rolling idle (all with a warm engine – never blame the sensor for a cold driveability or performance problem), a failed state emissions test, and a plugged cat. As you know, it's an unfortunate fact that those problems can be caused by lots of other conditions besides a malfunctioning Lambda probe. So, you've got to do some testing.

The easiest way to tap into a sensor's signal lead is with a wire-piercing tool. This is done all the time in the real world without mishap. Just remember to seal the hole with Krazy Glue.

Numerous dedicated oxygen sensor testers have been offered over the years. This one's from the mid-'80s and still works fine.

Where equipment's concerned, the obvious first choice is your scan tool. Looking at O2 voltage and fuel trim is essential. Most techs, however, like to back up that data with direct checks. A quality DMM (Digital Multi-Meter) with a voltage bar scale, a graphing multimeter, or a lab scope will work fine here, but we're also happy with several job-specific testers we've tried. Typically, these have LEDs that tell you activity and voltage, and switches that allow you to stay in closed loop while monitoring, isolate the sensor from the computer for open loop checks, or send the PCM either a rich or lean signal.

By the way, Mercedes-Benz (along with all other carmakers) cautions us to use only meters or testers with high impedance. That's because there's a possibility of current flow breaking the bond between the zirconium dioxide and the platinum, or blowing a channel through the sandwich. And if you're checking it in parallel, an extra ground may skew the signal.

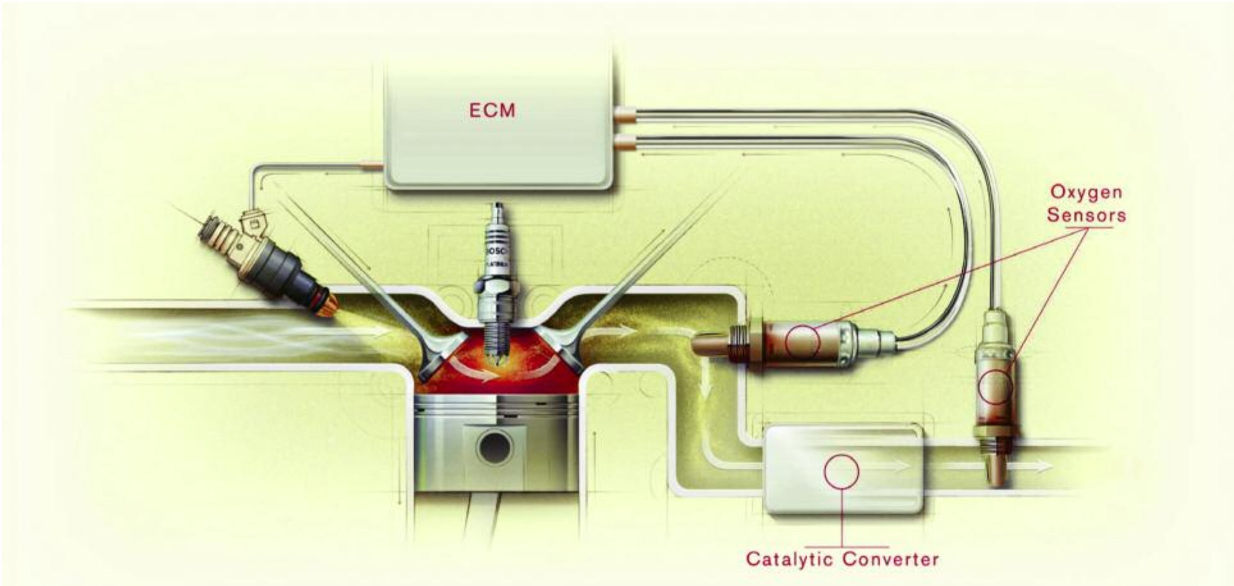
If the sensor is easily accessible, you might want to take it out for inspection. Shake it to listen for rattles that indicate a broken ceramic element, give it a careful visual exam, then hook a DMM across the pigtail and the shell and heat the tip with a propane torch (use the blue part of the flame). When it turns to a dull red, look for relatively high voltage, then move the flame away, which should make the reading drop.

Robert Bosch gives a very straightforward procedure for testing with the sensor isolated from the PCM. Start by warming up the engine, then disconnect the sensor's pigtail from the harness and attach it directly to your meter or tester. To check rich response, hold 2,500 rpm, and add propane to the intake until speed drops by 200 rpm. Or, pull and plug the vacuum hose to the fuel pressure regulator, which will increase psi and richen the blend. You should see the reading jump to 900 mV or more. If reaction is slow, or that voltage is never reached, try running it at 3,000 rpm for a few minutes, then check again. No improvement means you buy a new sensor.

Then, test lean response. Introduce a small vacuum leak, say by removing an accessory hose, and watch the reading. If it drops to .2V or lower in less than one second, the sensor's okay. If it falls sluggishly, or you never see it get down to .2V, give it the 3,000 rpm treatment and try again, but it's probably time for replacement.

Reconnect the pigtail to put the sensor back in touch with the PCM, then tap your meter into the signal wire, maintain 1,500 rpm, and you should see rapidly changing readings that average somewhere around half a volt as the computer keeps adjusting the blend. Deciding whether or not response is slow enough to justify replacement requires some judgment. A common rule of thumb for minimum activity is eight trips across the rich/lean line in ten seconds, and sometimes you can find specs for cross counts.

Sending the PCM a substitute O2 sensor signal will let you know how – and if – the system responds. While some factory manuals say you can use an ordinary dry cell to inject a rich signal, a sensor simulator would be a lot more



The addition of an oxygen sensor downstream of the catalytic converter makes it possible for OBD II to test the cat's capacity and efficiency.

helpful. If varying the substitute signal changes something (say, injector pulse width, loop status, ignition timing, idle speed or quality, etc.), you've learned two things: The wiring and connections between the sensor and the PCM are okay, and the computer itself is operational because it's responding to this input. Ergo, the sensor becomes your prime suspect.

OBD

Will pre-OBD II (in other words, 1996 or earlier) self-diagnostics help you nail a weak O2 sensor? Not really. Sure, the program monitors this critical input, but typically it's only looking for opens or grounds in the circuit, an always rich/always lean situation, or sensor cool down. It won't recognize a lazy specimen. So, this sensor is a likely cause of driveability complaints even if no codes are present.

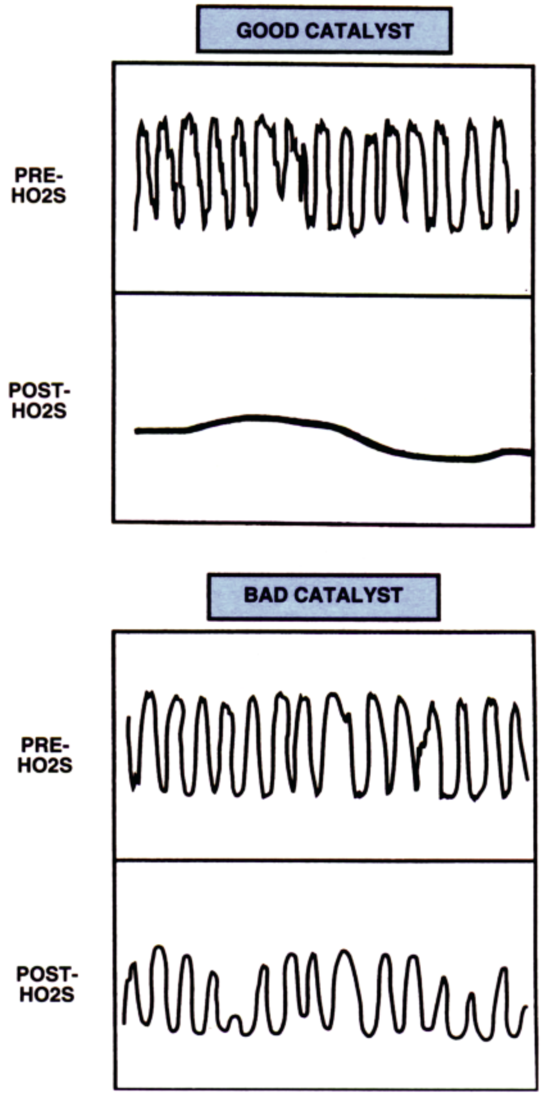
Things are different with OBD II vehicles. Not only is there a HEGO both upstream and downstream of the catalyst, but two types of tests are run on them. One monitors the sensor's activity, and the other checks the sensor's electrical heating element.

An oxygen sensor can fail the activity monitor for slow response rate, which is sometimes called a "big slope" for the way the wave looks on an oscilloscope. Or, it can fail for having too small a change in voltage output from rich to lean and vice versa.

A typical OBD II HEGO response test is done after the system achieves closed loop, and during steady state speed and load in the 30-50 mile-per-hour range. The test forces fuel control changes at high frequency. In other words, it superimposes a square wave on top of the regular injector pulse. This switches rapidly between 10% rich and 10% lean. Can the HEGO respond to this high frequency, or has it become too sluggish and lazy? And, can it produce big enough voltage swings? If it can't satisfy both standards, it fails.

Since any oxygen sensor is only accurate when it's hot, the HEGO heater monitor is intended to make sure the sensor is properly heated. In a common Daimler-Chrysler approach, the heating element itself isn't tested. Instead, the change in electrical resistance that the sensor's output circuit experiences at various temperatures is watched.

After the ignition has been turned off, the PCM sends a five-volt signal to the sensor every



The upper wave on this scope shows the signal the upstream oxygen sensor is sending, and the lower wave that for the downstream sensor. There should be a big difference, which indicates that the catalyst has sufficient oxygen storage capability. If both waves are similar, the cat is bad.

1.6 seconds. As the sensor cools down, its resistance increases, changing the voltage, which the PCM reads as temperature. Once the sensor is cool enough, the PCM commands a relay to complete the circuit to the heating element, then it watches as the sensor gets hotter and hotter. If it sees the proper voltage for several pulses, it passes the sensor.

A simple trick that can save frustration: To keep your oxygen sensor socket from spreading when you encounter a case of thread seizure, just tighten a hose clamp or two around it.

Etcetera

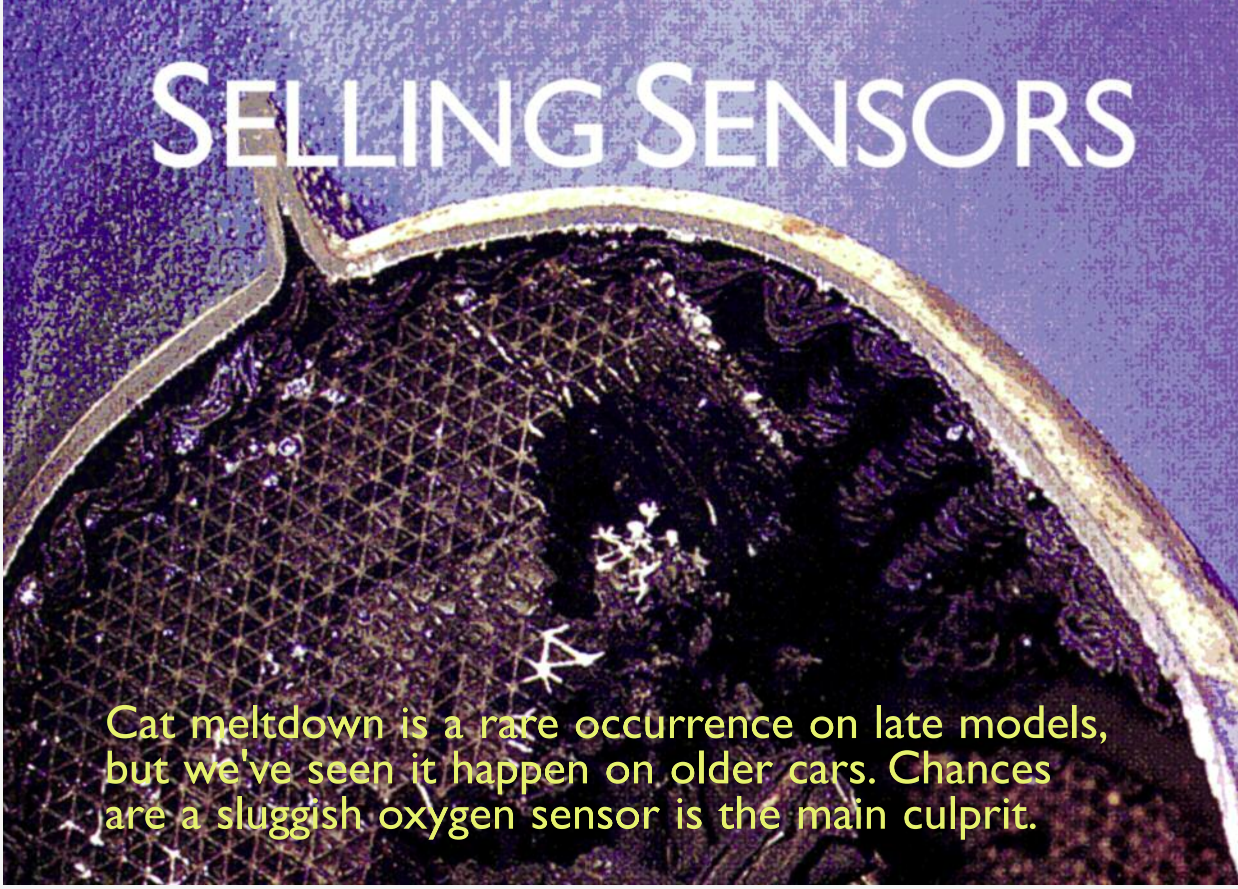
We'll conclude with some miscellaneous points:

• An oxygen sensor is an averaging device that responds to the leanest cylinder – it can't differentiate among them. If one injector is clogged, it'll pump enough O2 to fool the computer into thinking there's an overall lean condition. So, the PCM will fatten up the mix, perhaps increasing emissions.

• Whenever you replace an oxygen sensor, please make sure the threads are coated with the proper anti seize compound. Otherwise, the next guy who tries to remove it may have to blast. There's a good chance the next guy will be you.

• Afraid you'll spread your split oxygen sensor socket because the old sensor is in there so tight and you'll have to apply extraordinary torque? Try our old trick: Slip the socket over the sensor, then tighten a worm gear clamp or two around the socket to help keep it from spreading. Of course, this is a moot point if you're replacing the sensor – you can just snip off the wires and use a regular deep socket, perhaps even on your 1/2 in. impact gun. That ought to do it.

Selling Sensors



Cat meltdown is a rare occurrence on late models, but we've seen it happen on older cars. Chances are a sluggish oxygen sensor is the main culprit.

All of us in auto service know that the mixture monitor enables the engine management computer to maintain stoichiometry. That not only reduces fuel consumption and combats air pollution directly, it also allows the three-way cat to do its job of reducing NOx to harmless nitrogen and oxygen.

Fine, but your average customer hasn't got a clue about the whole situation. When you tell him he needs a new O2 sensor, you get a blank stare. If his catalyst has entered melt-down and you suggest that the oxygen sensor was probably the cause, he might suspect that you're trying to rip him off.

As one successful independent shop owner tells us, *"Oxygen sensors should probably be changed at 50,000 miles, but nobody's doing it. I'll bet a third of them out there aren't working right."*

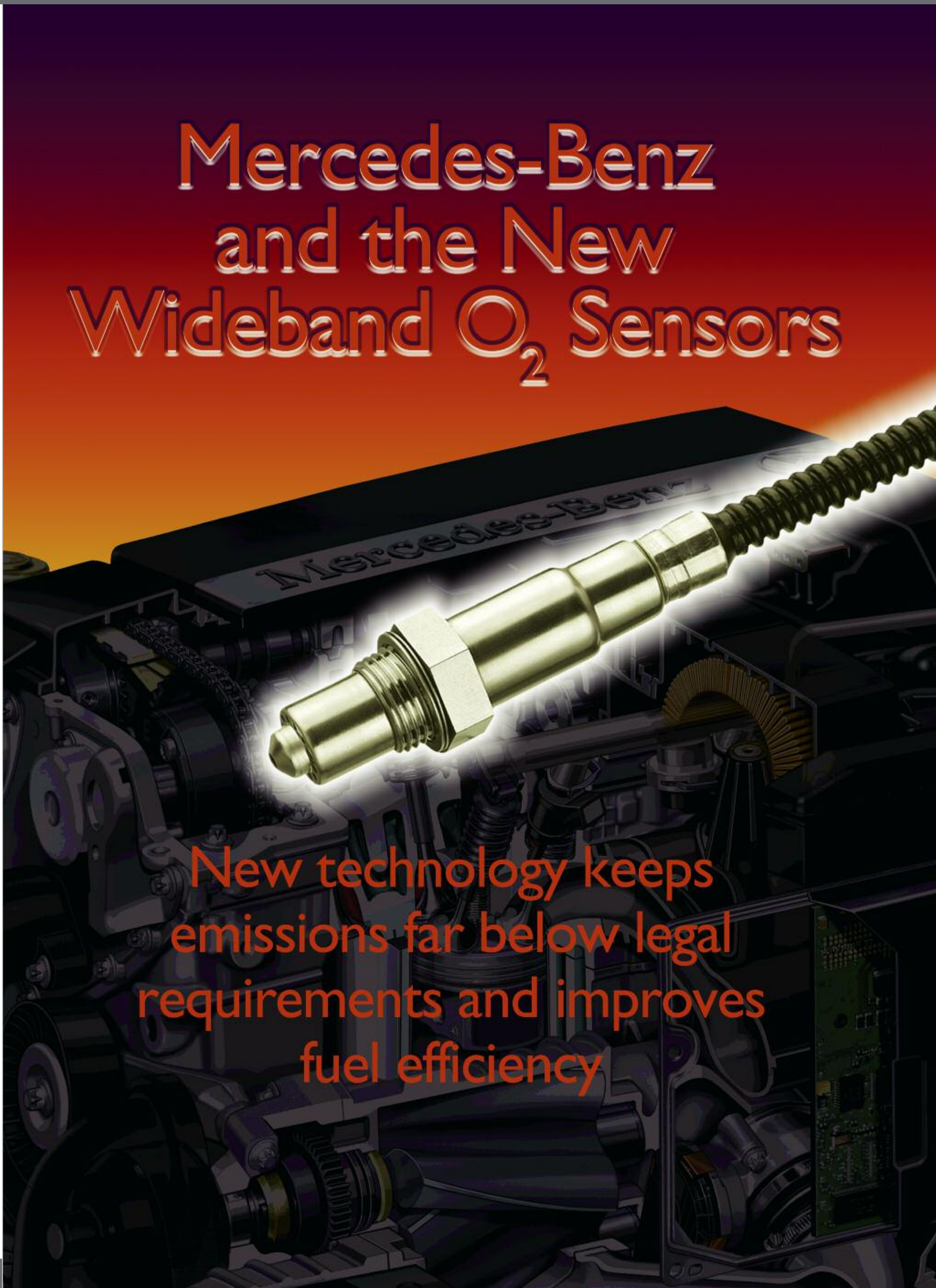
So, how do you get your patrons to have this needed maintenance done before trouble sets in? First, take the time to explain this high-tech aspect of their cars to them. Keep a diagram of inputs/outputs and some germane parts around.

Next, be positive. As another shop owner says, *"We don't sell an O2 sensor. We sell better mileage, better driveability, cleaner air. That happens to be controlled by the O2 sensor. We sell the benefits of replacing it."* Yet another adds, *"It's a win/win deal for everybody."* Two other things to mention are that most catalyst failures are due to a bad oxygen sensor, and that the average motorist will probably save as much in gas annually as the sensor costs.

We believe in checking O2 sensors whenever you've got a car in for any under-hood service from a tune-up to a valve job. You're probably going to do a scan anyway, and this can prevent dissatisfaction with your work. The first shop owner quoted above says simply, *"If it's slow, I tell the customer he needs one and this is the price, period."*

By the way, he has a nice agreement with the people at his local Meineke muffler shop. Whenever they replace a cat, they request that the customer take the car to his shop to have the oxygen sensor checked. This saves them warranty returns and brings some work for the shop owner.

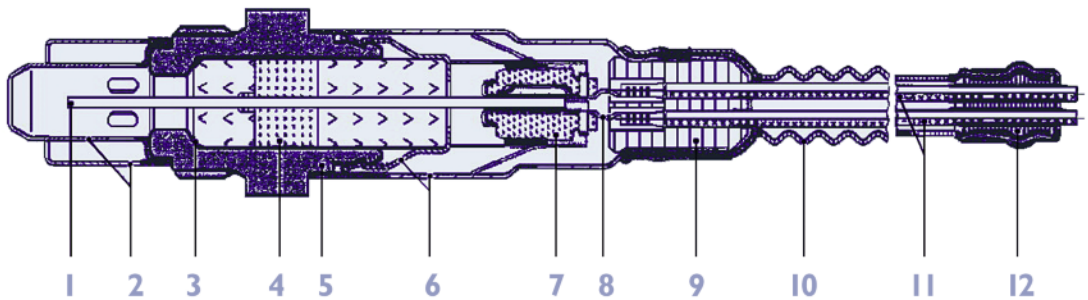
Mercedes-Benz and the New Wideband O_2 Sensors



New technology keeps emissions far below legal requirements and improves fuel efficiency

WIDEBAND OXYGEN SENSOR

1.Sensor element (combination of Nernst concentration cell and oxygen-pump cell), 2.Double protective tube, 3.Seal ring, 4.Seal packing, 5.Sensor housing, 6.Protective sleeve, 7.Contact holder, 8.Contact clip, 9.PTFE sleeve, 10.PTFE shaped sleeve, 11.Five connecting leads, 12.Seal

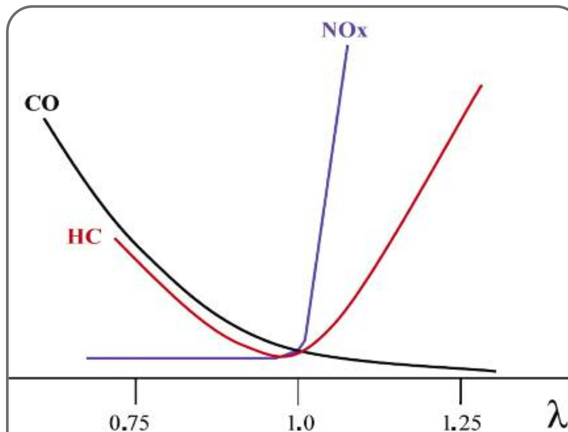


If you haven't yet encountered the wide-band oxygen sensor, it's time to get familiar with it. Here's what it looks like inside. Note that the pumping cell allows it to produce a signal directly proportional to the air/fuel ratio, as opposed to the high and low switching of traditional oxygen sensors.

If you hear someone say "oxygen sensor" and the words "planar" or "wideband" don't come to mind, you've fallen behind on oxygen sensor technology. The latest developments in oxygen sensors take air/fuel management technology to new levels of performance. And the new wideband sensors require new diagnostic techniques to identify potential problems.

In an ideal world, there would be no need for oxygen sensors. In theory, when you burn exactly one pound of gasoline using 14.7 pounds of air under optimal conditions, the gasoline burns completely. The technical term for the magic 14.7:1 number is the "stoichiometric" air/fuel ratio. At a constant stoichiometric ratio, the exhaust gas would contain only water and carbon dioxide (CO_2). Yes, carbon dioxide is considered one of the "greenhouse gases" that may contribute to global warming. So the exhaust could still be considered a pollutant. But in our ideal world, emission control would consist of primarily of capturing the water and carbon dioxide and storing the mixture in a seltzer water dispenser! Actually, the two are what plants need to grow.

But the internal combustion engine never operates in an ideal world under optimal conditions. And even minor variations from stoichiometric cause major increases in various pollutants, as the chart below shows.



Here's how exhaust gas emissions rise and fall in relation to the Lambda value. Generally, emissions increase whenever the mixture is not stoichiometric, which air/fuel ratio is represented by the number "1".

(Continued on page 20)

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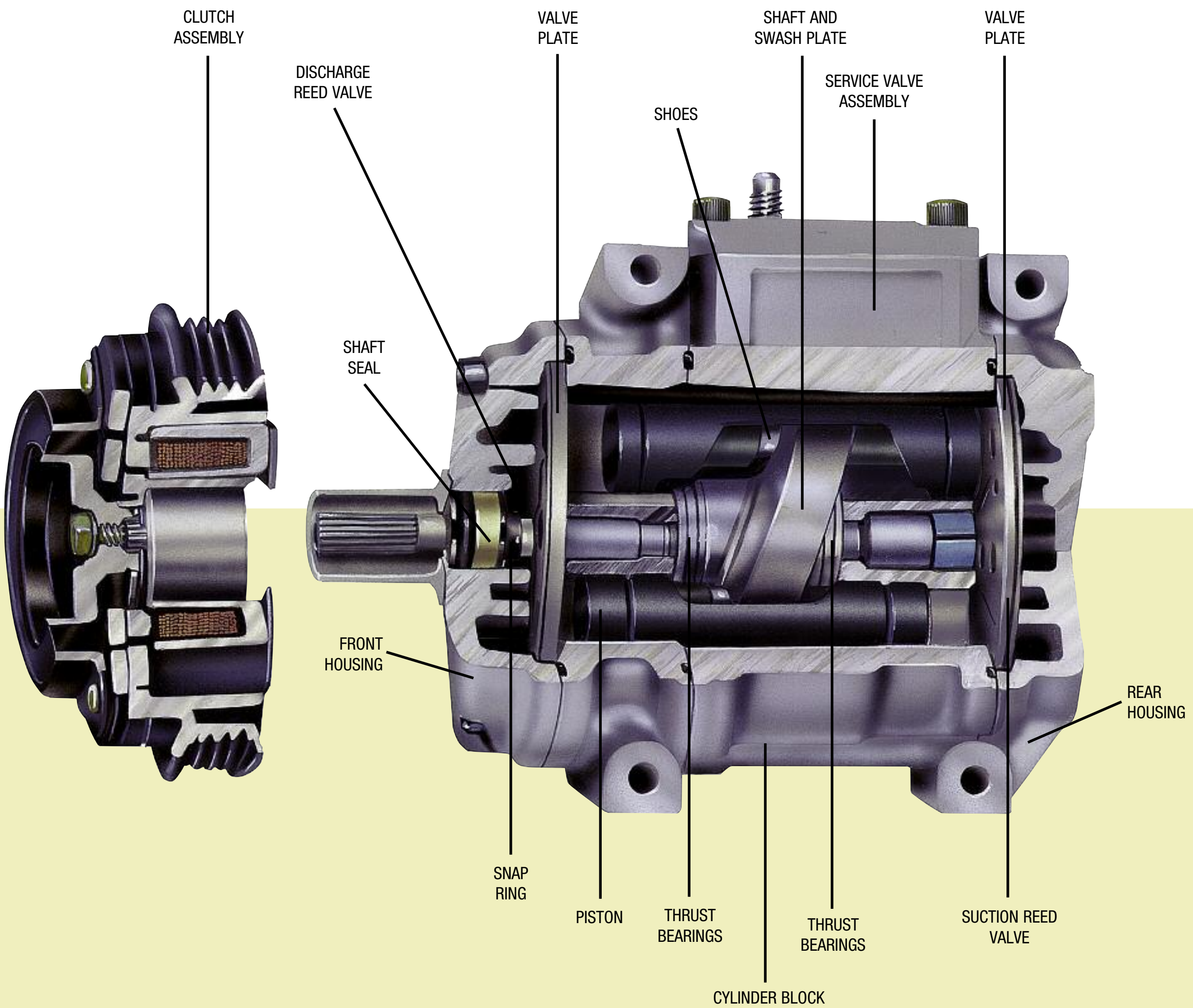


For more information about Genuine Mercedes-Benz Remanufactured A/C Compressors, contact your Mercedes-Benz dealer.

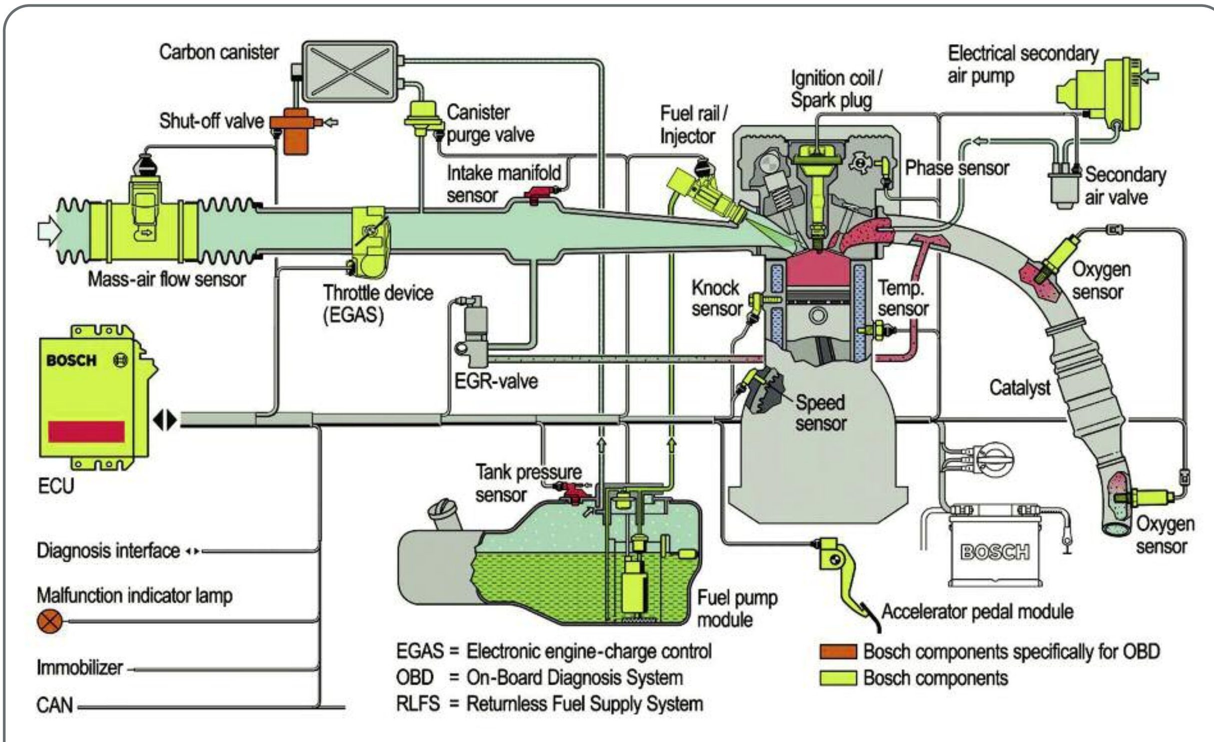
Mercedes-Benz

DENSO

Mercedes-Benz Genuine Remanufactured Parts

Remanufactured for Mercedes-Benz by DENSO

(Continued from page 17)



This OBD II-compliant Motronic system shows just how much is involved in modern engine management. Regardless of all the recent developments, however, oxygen sensors remain the linchpin of accurate air/fuel mixture control.

Lean mixtures do improve fuel economy, but at the expense of a greater output of oxides of nitrogen (NOx), and unburned hydrocarbons (HC) if they are lean enough to cause misfire.

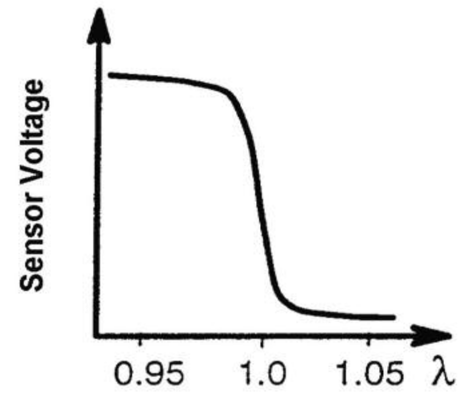
Rich mixtures not only hurt fuel economy, but also increase CO emissions (which are incompletely burned fuel molecules) and HC.

As the level of oxygen in the exhaust gas changes, output voltage from the oxygen sensor changes. The change in signal triggers the engine control module (ECM, or PCM for Powertrain Control Module, the SAE term standardized under J1930) to lean out or richen the fuel mixture to keep combustion as close to stoichiometric as possible.

Robert Bosch introduced oxygen sensors in 1976 as a key component of the revolutionary Lambda-Sond fuel injection system, and Mercedes-Benz was among the first carmakers to adopt this advance. The sensor continually monitored the amount of oxygen in the exhaust stream. The output voltage signal it sent to the engine controller changed as the oxygen level changed. When a lean condition (too much oxygen) was detected the output voltage dropped, triggering the engine controller to richen the mixture. A rich condition increased sensor output voltage, which prompted the controller to lean the mixture. Sensor and controller worked together, creating a “closed loop” system that automatically regulated engine operation.

Initially, Bosch called its new sensor a "Lambda sensor" because the oscilloscope curve tracking sensor voltage output to oxygen levels in the exhaust resembled the shape of "Lambda," the 11th letter of the Greek alphabet. You will also hear the term “Lambda value” when engineers talk about combustion and exhaust gas analysis. At 14.7:1, or stoichiometric, Lambda is one. When the mixture is lean, more than 14.7 pounds of air to one pound of fuel, Lambda is greater than one. Rich mixtures (less than 14.7 pounds of air for one pound of fuel) Lambda is less than one.

In the 30 years since oxygen sensors and closed loop systems were introduced, electronics



In a regular oxygen sensor, output voltage changes dramatically as the air/fuel mixture crosses the Lambda line. Remember, "lean equals low."

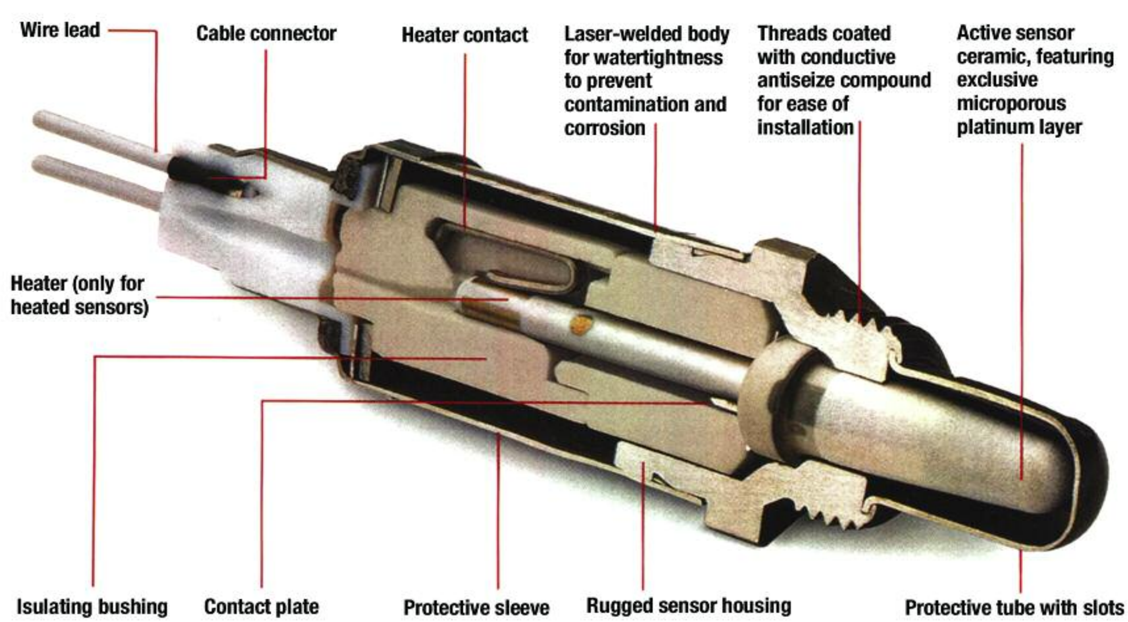
and computer controls have grown so sophisticated that even the least expensive new car has more onboard computer power than the NASA space craft that placed a man on the moon! However, despite all the changes in automotive electronics, one thing has remained constant—the oxygen sensor is the most critical component in controlling vehicle emissions.

The ECM is constantly bombarded with input from sensors located throughout the car. But the ECM "listens" to the oxygen sensor first and adjusts the air fuel mixture based on the sensor's output signal.

Modern oxygen sensors are so valuable to engine performance, even race cars, which are not required to comply with emission standards, use them to maximize performance. You will find oxygen sensors not only on sophisticated racers, like the ALMS GTS class, but also on NASCAR racers with their pushrod V-8 engines and quad carburetors. Some NASCAR teams mount eight sensors on an engine, one for every cylinder, to get optimal fuel distribution from the single carburetor.

Almost all of the oxygen sensors in use are from one of four generations of technology. A very small number of cars, estimated at less than 0.5% of the vehicles now on the road, use a titanium oxygen sensor. This technology doesn't fall within the four generations, but you don't have to worry about this sensor because the design was never used by Mercedes.

For 99.5%+ of the cars on the road today, the oxygen sensor will be in one of the following generations:

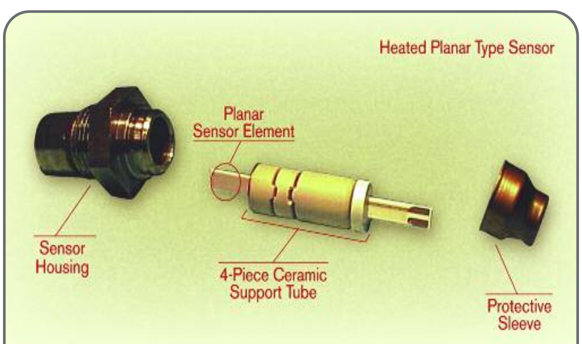


The ceramic thimble with its metallic coating actually acts as an electrical cell. The difference in the oxygen content of the reference air to that of exhaust gas is what generates voltage.

• **"Unheated thimble" and "heated thimble" sensors** were the first two generations. "Thimble" refers to the shape of the sensor tip, the portion that actually measures oxygen content. Unheated sensors were used from the late 1970s until the mid 1990s, although the heated design began to replace unheated in the early 1980s.

Unheated thimbles were adequate for early emission standards, but as their name implies, unheated thimbles did not start sensing oxygen levels until warmed up by the exhaust gas. During the critical engine start and warm-up phases when emissions are often very high, these sensors couldn't send a signal to the computer. Unheated thimble sensors also have a relatively short service life, often requiring replacement as often as every 30,000 miles.

Heated thimble sensors first appeared in 1982 and gradually replaced the older unheated design. To reduce emissions during starting and warm-up, an electrical heating element inside the sensor brings it to operating temperature much faster than its unheated counterpart. Heated thimble sensors were state-of-the-art until the introduction of the heated planar sensors in the late 1990s.



The planar type, which first appeared in 1998, uses a much lighter unified strip to produce voltage instead of that big thimble. With its integrated heater, it starts sending the PCM accurate signals almost immediately upon start-up.

• **Heated "planar" sensors** were first used in the United States in 1998 and represent the first major redesign of oxygen sensors since the original unheated thimbles. A heated planar oxygen sensor is fully active and providing output signals to the engine computer within a few seconds after engine start, helping to reduce start-up/warm-up emissions.

Instead of the ceramic thimble, heated planar sensors utilize a flat ceramic zirconia element, less than two millimeters thick, projecting into the exhaust stream. The electrodes, conductive layer of ceramic, and heater are laminated into a unified layered strip. This strip is smaller, lighter, and more resistant to contamination than the thimble design. The planar sensor's integrated heater element also requires less electrical power to reach operating temperature. That is a real advantage when you consider the number of amps necessary to bring a heated thimble type up to the 600 deg. F. required.

Because of their superior performance, heated planar sensors are now found on nearly 50 percent of all new vehicles. Planar sensors send oxygen level signals to the onboard computer five to seven times per second for much more precision in fuel management. To put this into historical perspective, the O2 sensors used on cars with feedback carburetors sent only one signal per second, and those used with throttle body injection provided only two to three signals per second.

In some applications, you can upgrade an older heated thimble sensor to a heated planar, but you can never go downscale – you cannot install a thimble sensor to replace a planar.

• **Heated Wideband Sensors** are the latest in oxygen sensor technology. This sensor upgrades the planar sensor's layered ceramic strip by adding a "pumping cell." The pumping cell allows the wideband sensor to produce a signal directly proportional to the air/fuel ratio instead of simply switching rich to lean at the 450 millivolt threshold. These heated wideband sensors operate at about 1,400 degrees F. (700 to 800 degrees C.), twice as hot as older designs. And they reach this temperature within 20 seconds after a cold start. Response time to changes in air/fuel ratios is less than 100 milliseconds, much faster than any previous sensor for optimal management of the air fuel ratio.

Although it may look very similar to a planar sensor from the outside, the wide-band type sends a completely different kind of signal to the computer, which results in much more accurate mixture control than can be achieved with the "dithering" of a regular thimble or planar oxygen sensor.

Heated Wideband oxygen sensors solve a major shortcoming of previous generation sensors. Although the early sensors responded to changes in oxygen level, the sensors did not truly “read” the exact level of oxygen. Instead, their voltage output simply shifted as the mixture moved back and forth between “too rich” and “too lean.”

At stoichiometric, when the air/fuel ratio is perfectly balanced, conventional sensors have an output voltage of about 0.45 volts (450 millivolts). When the fuel mixture goes even a little rich, the sensor's voltage output doesn’t increase slightly. It shoots up to its maximum output of about 0.9 volts. When the mixture is lean, sensor output voltage quickly drops to 0.1 volts.

Every time the oxygen sensor's output jumped back and forth, the engine computer responded by decreasing or increasing the amount of fuel delivered to the combustion chamber. The rapid flip-flopping by the sensor and the onboard computer tended to achieve something approaching “an average” stoichiometric condition. But averaging stoichiometric is not good enough for the latest emission control standards.

The new NLEV (National Low Emission Vehicle) standards, California's LEV (Low Emission Vehicle), ULEV (Ultra Low Emission Vehicle) and SULEV (Super Ultra Low Emission Vehicle) standards require more precise control over air/fuel ratios than thimble and planar sensors can provide. The earlier sensors don’t reach operating temperature fast enough, even those with a built-in heating unit. And no previous sensor type can send a precise voltage signal to the computer in response to minor changes in Lambda value. The wideband oxygen sensor overcomes these problems.

The wideband sensors provide precise readings for air/fuel ratios from super rich (Lambda 0.7, or an air/fuel ratio of about 11:1 – what you might see in a drag racer) to pure air (all air, no fuel). The wideband oxygen sensor receives a reference voltage from the engine computer and generates a signal current that varies according to the fuel mixture.

When the air/fuel mixture is perfectly balanced at 14.7:1, the wideband sensor produces no output current. As the air/fuel mixture starts to go rich, the sensor output goes from zero to about negative 2.0 milliamps. The maximum rich reading occurs at Lambda 0.7 (the 11:1 air/fuel ratio already mentioned, which is the borderline limit of a combustible mixture – any richer and the charge would not burn). When the air/fuel mixture is lean, the sensor produces a positive current that goes from zero up to 1.5 milliamps as the mixture becomes close to pure air.

Basically, the wideband oxygen sensor adds an "oxygen pump" to a planar sensor. This pump pulls a sample of the oxygen in the exhaust into a "diffusion" gap within the sensor. The sensor is designed so that a certain amount of current is needed to maintain a balanced oxygen level in the diffusion gap. The amount of current needed to maintain this balance is directly proportional to the oxygen level in the exhaust. This gives the engine computer the precise air/fuel measurements it needs to meet the new emission requirements.

Wideband Sensor Diagnostics

Wideband oxygen sensors and planar sensors should last up to 100,000 miles unless subject to some type of abuse, such as excessive oil consumption, or silicone sealant contamination. Although rare, sensors can be damaged by using poorly refined gasoline. An exhaust leak large enough to allow water, road salt, or dirt into the system can also damage a sensor.

Oxygen sensors don't die young from ordinary use; they are killed by something out of the ordinary. Be very suspicious of any oxygen sensor that fails far sooner than its expected service life. If you don't identify and correct the basic fault, the replacement sensor will soon fail also, just like the original. Not only will you be faced with a comeback for the cost of installing another sensor, you may have a tough time getting your customer to pay for the repair that you missed the first time.

Symptoms of a damaged wideband sensor are the same as those for any oxygen sensor:

- **MIL light or code set.**
- **Failed emissions test, usually with a high CO and/or a high HC reading.**
- **Damaged catalytic converter caused by prolonged exposure to an overly rich fuel mixture.**
- **Drop in fuel mileage attributed to a rich fuel mixture.**
- **Engine performance complaints such as "runs rough" or "sluggish."**

Unlike earlier sensors, you cannot use a voltmeter or oscilloscope to diagnose a faulty wideband oxygen sensor. A wideband sensor's output signal varies in both amplitude and direction. The only way to monitor a wideband sensor's operation is with a scan tool hooked to the onboard diagnostic link.

With the scan tool in place, you can read the actual air/fuel ratio and check the sensor's response to changes in the ratio. For example, going to wide-open throttle typically causes a brief very lean condition, followed by a rich condition. With the wideband oxygen sensor's rapid response capability, the scan tool should show a steady air/fuel ratio (as long as the sensor is operating properly).

You must consult the specific diagnostic steps for the model you are working on, but as a general rule, your scan tool should show an oxygen sensor code if the sensor reads out of its normal range, if the readings don't make sense to the computer (should indicate lean when lean conditions exist, etc.) or if the heater circuit fails.

Even wideband oxygen sensors can be fooled, just like other oxygen sensors, if there is an air leak between the exhaust manifold and head, or by a misfire that dumps an unburned air/fuel mixture into the exhaust. These situations cause a false condition that, in turn, signals the computer to mistakenly adjust the mixture.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What You Need to Know About Mercedes-Benz Tire Pressure Warning Systems

Here are the essential components of the Mercedes-Benz tire pressure monitoring system. Note that the sensor is mounted at the valve stem, and is vulnerable to damage during tire work

Don't be the one to make an embarrassing and expensive mistake

Being an independent, you don't often have the opportunity to make repairs on late-model Mercedes-Benz vehicles. Regular maintenance services perhaps, but most repairs will naturally go back to an authorized M-B dealer to be done under warranty.

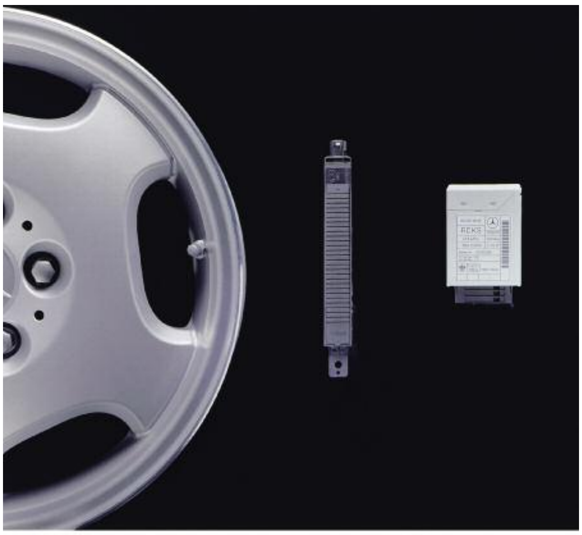
That is, except for tires. There's a good chance that a road hazard will bring a late-model Mercedes to your door to have a damaged tire fixed or replaced. When that happens, you sure don't want to so unaware of the tire pressure warning or monitoring system that you damage it in the process. Also, some of the cars that are equipped with the tire pressure monitoring system are already out of warranty. So, StarTuned is bringing you the following recommendations directly from MBUSA.

No interchange

First off, for the 2006 line some models have switched from Beru to Siemens tire monitoring systems. While the theory of operation is the same, the components of the two manufacturers are not interchangeable with each other. In other words, if you mix Beru and Siemens parts, the system will no longer function. So, if you should have an incidence of a damaged component, make sure you identify it accurately before you order a new one.

Unfortunately, in most cases of damage to the pressure monitoring sensors during the tire demounting/mounting process, such damage isn't recognized immediately. So, the wheel will be put back on, the lugs torqued, and the car taken off the lift and driven away before there's any indication of a problem. That makes this situation especially damaging to both your schedule and your reputation.

Note: Damaged Sensors cannot be claimed under warranty.



The tire pressure monitoring system monitors the air pressure (and temperature) in the tires and transmits this data by radio to special antennas in the wheel housings. The downstream microcomputer identifies the signals from each wheel by their individual codes and can therefore keep the driver fully informed of the air pressure in each of the four tires. If one of the tires starts losing air, a warning symbol is automatically activated in the central display. This symbol is color-coded to indicate varying degrees of urgency.

Any time you get a late-model Mercedes-Benz in for tire work, look at the valve stem as a preliminary. If the car is equipped with a tire pressure warning system, the stem will be made of aluminum, not rubber or steel.

When it comes to breaking the bead seal between the tire and the wheel, the most important thing to remember is to place the tire machine's "shovel" at the opposite side of the rim from the valve stem. In other words, depending on the type of equipment you have, make sure that neither the outside or inside bead breaking device will bear on the area of the wheel where the valve stem is positioned – that's where the sensor is mounted. There's a good chance that you will break it if you don't observe this. Ditto for the mounting operation -- the sweep of the bead mounting device should not include the area of the stem.

Speaking of mounting, you're probably used to slathering a copious amount of soapy, slippery lube on the wheel and the tire bead. With tire pressure monitoring systems, however, it's very important to avoid getting this solution on the sensor assembly as it may penetrate the sensor and ruin it. Be sparing, and avoid the sensor area altogether.

Reset

Avoiding mechanical damage to the components of the system is important, but there are also electronic issues to deal with. Whenever the new tires or wheels are installed, or even when the air pressure is adjusted to specifications, it's necessary to reset the tire pressuring monitoring system, just as was done during predelivery inspection.

Instructions for the particular model at hand will be explained in the Owner's Manual, but we'll run through those for early tire pressure monitoring-equipped Models 215 and 220 as our example:

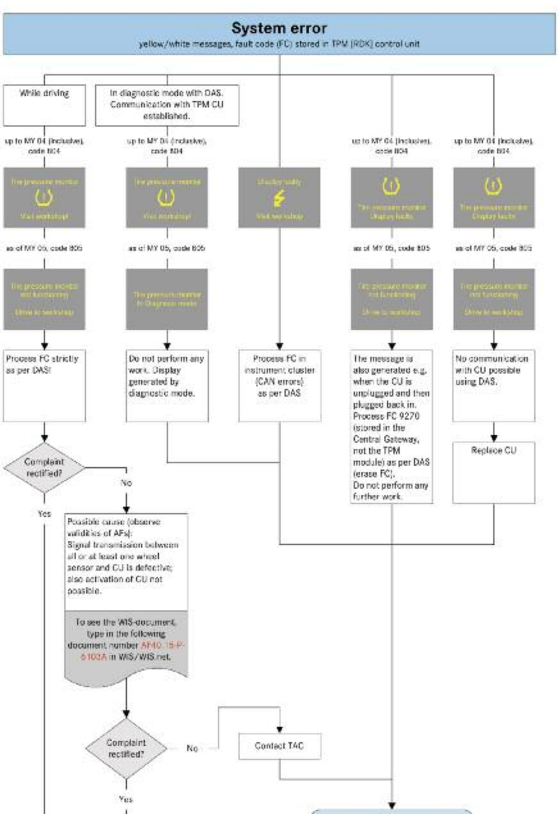
1. **Set tire pressure on all four tires to the proper value (see the label located on the fuel filler flap).**

2. **Turn the ignition key to Position 2, but do not start the engine.**

3. Using the left "menu" button (6, Figure 1) located on the steering wheel, call up the trip/main odometer.

4. Continue by pressing the left upper "page" button (4, Figure1), until the tire pressure display appears in the display located in the instrument cluster.

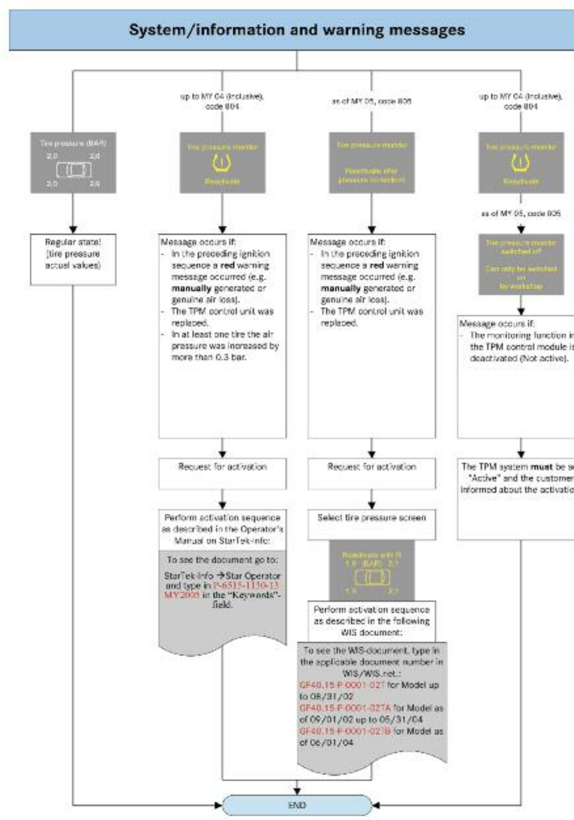
5. Next, press the "R" button on the instrument cluster and hold until the following message appears: "TIRE PRESSURE MONITORING REACTIVATE?" Selecting "YES" reactivates the tire pressure control.

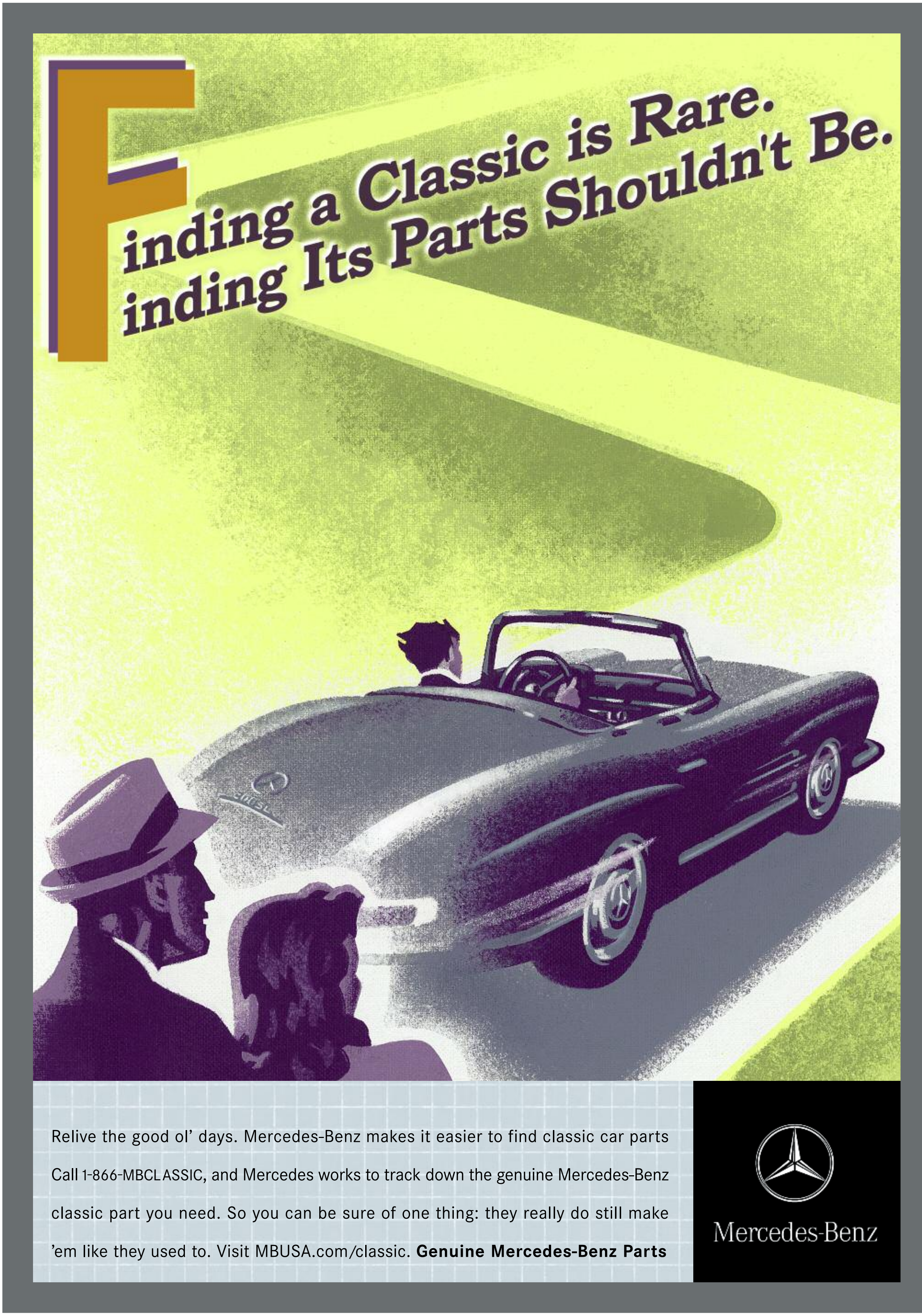


Upon setting the proper tire pressures and reactivating TPC, the tire pressure values will not yet be indicated in the instrument cluster display. So, it is necessary to drive the vehicle for a few minutes in order for the tire pressure values to be indicated in the instrument cluster display.

Troubleshooting

If you should ever need to diagnose one of these systems, the best thing to do is to log onto www.startekinfo.com and use the logic trees, such as the ones shown here:

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FACTORY SERVICE BULLETINS

These suggestions and solutions for technical problems come from service bulletins and other technical information published by Mercedes-Benz, selected and rewritten for independent repair shops.

Leak at Steering Rack Connection

Models 203, 209, 211 & 230

If you encounter leakage at the steering rack connection in the above models, the cause may be damage to the sealing ring of the hydraulic lines. In such instances, replacement of the rack will not resolve the situation. Instead, replace the

sealing ring at the steering gear connection. Refer to complete work instructions (including torque values) in WIS document AF46.20-P-4044AU. The parts needed are two O-rings (A 027 997 95 48) and one supporting ring for the steering rack high-pressure line connection (A 005 997 76 40).

Engine Rattling Noise After Cold Start

Model 203.040/740 with Engine 271.948

If you receive customer reports in the above model vehicles of rattling noise after engine cold start-up until oil pressure has normalized, the intake and exhaust camshaft adjusters should be replaced with the below modified parts. The modified camshaft adjusters can be identified with a green color coding. Both center bolts must also be replaced using a special tool socket, W001 589 65 09 00. Oil the thread when installing. Tightening torque of the center bolts is 90Nm.

Parts Information

1 Intake camshaft adjuster with green coding #A271 050 09 47

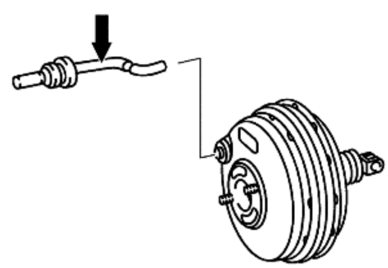
1 Exhaust camshaft adjuster with green coding #A271 050 10 47

2 Center Bolts #A271 050 01 71

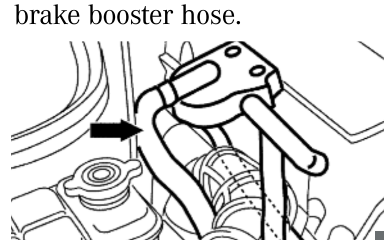
Brakes Hard to Apply with Cold Engine Models 170.447 (1999-2000), 202.024

If the brake pedal is hard to apply on these models, the cause is probably a combination of cold start vacuum equalization, engine fast idle necessary for catalyst warm up, and vehicle position.

To correct the problem:
1. Replace the existing brake booster hose with the modified brake booster hose (part number A 170 430 1729 for Model 170.447 and A 202 430 6029 for Model 202.024).



2. Replace the existing crankcase vent hose between the oil separator and the air filter housing (Figure 2) with the modified crankcase vent hose (part number A 111 018 33 82 for Model 170.447 and A 111 018 31 82 for Model 202.024), and connect it to the venturi on the brake booster hose.



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Albany
Hentschel Motorcars
912-883-2040

Athens
Mercedes-Benz of Athens
706-549-6600

Atlanta
Mercedes-Benz of South Atlanta
770-964-1600

Atlanta
RBM of Atlanta
770-390-0700

Atlanta
Mercedes-Benz of Buckhead
404–846-3500

Augusta
Rader
706-860-1111

Columbus
Columbus Motor
706-327-3636

Deluth
Atlanta Classic
770-279-3600

Macon
Jackson Automotive
478-477-4858

Savannah
Critz
912-354-7000

Hawaii

Honolulu
Mercedes-Benz of Honolulu
808-592-5600

Idaho

Boise
Lyle Pearson
208-377-3900

Pocatello
Robert Allen
208-232-1062

Illinois

Arlington Heights
Mercedes-Benz of Arlington Heights
847-259-4455

Barrington
Motor Werks of Barrington
847-381-8900

Bourbonnais
Napleton's Autowerks
815-933-8221

Champaign
Sullivan-Parkhill Imports
217-352-4161

Chicago
Mercedes-Benz of Chicago
312-944-0500

DeKalb
Brian Bemis Imports
815-758-5451

Hoffman Estates
Mercedes-Benz of Hoffman Estates
847-885-7000

Lake Bluff
Knauz Continental Autos
847-234-1700

Lincolnwood
Loeber Motors
847-675-1000

Loves Park
Napleton's Autowerks
815- 636-6600

Marion
Foley-Sweitzer
618-997-1313

Naperville
Mercedes-Benz of Naperville
630-305-4560

Normal
Sud's Motor Car
309-454-1101

Northbrook
Autohaus on Edens
847-272-7900

Orland Park
Mercedes-Benz of Orland Park
708-460-0400

Pekin
Sud's
309-347-3191

Peru
J.P. Chevrolet GEO Nissan
815-223-7000

Springfield
Isringhausen Imports
217-528-2277

Westmont
Laurel Motors
630-654-8100

Indiana

Evansville
D-Patrick
812-473-6500

Fort Wayne
Shaver Imports
260-432-7200

Indianapolis
World Wide Motors
317-580-6810

Lafayette
Mike Raisor Imports
765-448-4582

Mishawaka
Gurley-Leep Motorwerks
219-256-1500

Schererville
Napleton's Auto Werks of Indiana, Inc
219-865-3800

Iowa

Davenport
Lujack's Northpark
563-388-8610

Des Moines
Mercedes-Benz of Des Moines
515-334-8339

Iowa City
Autohaus, Ltd
319-354-2550

Kansas

Shawnee Mission
Aristocrat Motors
913-677-3300

Wichita
Scholfield Auto Plaza
316-688-5000

Kentucky

Ashland
Sim Fryson Motor
606-329-2288

Bowling Green
Bowling Green Imports
270-745-0001

Lexington
James Motor
859-268-1150

Louisville
Tafel Motors
502-896-4411

Louisiana

Alexandria
Walker Automotive
318-445-6421

Baton Rouge
Mercedes-Benz of Baton Rouge
225-490-3101

Lafayette
Moss Motors
337-235-9086

Metairie
Benson Motor
504-456-3727

Shreveport
Holmes European Motors
318-212-1212

Maine

Bangor
Quirk Auto Park of Bangor
207-941-1017

Falmouth
Sawdran LLC
888-318-8408

Maryland

Annapolis
Mercedes-Benz of Annapolis
410-268-2222

Bethesda
Euro Motorcars
301-986-8800

Cockeysville
Mercedes-Benz of Hunt Valley
410-666-7777

Germantown
Euro Motorcars Germantown, Inc.
240-686-1300

Hagerstown
Mercedes-Benz of Hagerstown
301-733-2301

Owings Mills
R & H Motor Cars
410-363-3900

Salisbury
Pohanka TM
410-548-3411

Silver Spring
Herb Gordon
301-890-3030

Massachusetts

Boston
Westwood
781-688-1000

Boyston
Wagner
508-869-6766

Haverhill
Smith Motor
978-372-2552

Hyannis
Trans-Atlantic Motors
508-775-4526

Lynnfield
Flagship Motorcars
781-596-9700

Natick
Foreign Motors West
508-655-5350

Somerville
Chambers Motorcars of Boston
617-666-4100

West Springfield
Lewbar Imports
413-733-5102

Westwood
Mercedes-Benz of Westwood
781-688-1000

Michigan

Acme
Napleton Motor Cars, LLC
231-938-3800

Ann Arbor
Auto-Strasse
734-663-3300

Bloomfield Hills
Mercedes-Benz of Bloomfield Hills
248-644-8400

Grand Blanc
Grand Blanc Motorcars
810-695-4400

Grand Rapids
Betten Imports
616-301-2100

Kalamazoo
Orrin B. Hayes
269-345-0167

Novi
Mercedes-Benz of Novi
248-426-9600

Okemos
Williams
517-484-1341

Rochester
Mercedes-Benz of Rochester
248-652-3800

Minnesota

Bloomington
Feldmann Imports
952-837-6300

Maplewood
Maplewood Imports
651-483-2681

Minnetonka
Sears Imported Autos
952-546-5301

Mississippi

Gulfport
Bert Allen Imports
228-864-6622

Jackson
Higginbotham
601-956-4211

Missouri

Columbia
Legend
573-875-5000

Creve Coeur
Plaza Motor
314-301-1715

Ellisville
Tri-Star Imports
636-458-5222

Joplin
Frank Fletcher Mercedes-Benz
888-474-4551

Kansas City
Jay Wolfe European
816-943-7000

Springfield
Elite
417-889-5750

Montana

Missoula
DeMarois Olds-GMC
406-721-4000

Nebraska

Lincoln
Husker
402-479-7600

Omaha
Mercedes-Benz of Omaha
402-384-9999

Nevada

Las Vegas
Fletcher Jones Imports
702-364-2758

Reno
Mercedes-Benz of Reno
775-326-4000

New Hampshire

Greenland
Dreher-Holloway
603-431-8585

Manchester
Holloway Motor Cars
of Manchester
603-669-6788

New Jersey

Bridgewater
Millennium
908-685-0800

Cherry Hill
Mercedes-Benz of Cherry Hill
856-663-0984

Edison
Ray Catena Motor Car
732-549-6606

Englewood
Benzel-Busch
201-567-1400

Fairfield
Globe
973-227-3600

Freehold
David Michael
732-462-5300

Lawrenceville
Mercedes-Benz of Princeton
609-771-8040

Little Silver
Contemporary Motor Cars
732-842-5353

Millville
Quality Lincoln Mercury Hyundai
856-327-3000

Morristown
Mercedes-Benz of Morristown
973-267-9200

Newton
Intercar
973-383-8300

Paramus
Prestige Motors
201-265-7800

Union
Ray Catena Motor Car
908-964-4000

West Atlantic City
Precision Cars of AtlanticCity
877-5MB-PARTS

New Mexico

Albuquerque
Premier Motorcars
505-821-4000

New York

Bayside
Helms Brothers
718-631-8181

Binghamton
Binghampton Motor Car Corp.
607-772-0700

Brooklyn
Sovereign Motor Cars
718-258-5100

Fayetteville
Romano Motors
315-637-4500

Goldens Bridge
Estate Motors
914-232-8122

Huntington
Mercedes-Benz of Huntington
631-549-2369

Larchmont
Mercedes-Benz of Larchmont
914-275-4000

Latham
Keeler Motor Car
518-785-4197

Long Island City
Silver Star Motors
718-361-2332

Massapequa
Sunrise Motors
631-789-1600

Nanuet
Mercedes-Benz of Nanuet
845-624-1500

New York
Mercedes-Benz Manhattan
212-629-1600

Rochester
Holtz House of Vehicles
585-424-4740

Rockville Centre
Lakeview
516-766-6900

Roslyn
Rallye Motors
516-625-1600

Smithtown
Mercedes-Benz of Smithtown
631-265-2204

Southampton
Mercedes-Benz of Southampton
631-283-0888

Wappingers Falls
Friendly Motorcars
845-298-0600

White Plains
Mercedes-Benz of White Plains
914-949-4000

Williamsville
Mercedes-Benz of Buffalo
716-633-0088

North Carolina

Asheville
Skyland
828-667-5213

Cary
Mercedes-Benz of Cary
919-380-1800

Charlotte
Beck Imports of the Carolinas
704-535-6400

Fayetteville
Valley Motors
910-487-0000

Greensboro
Mercedes-Benz of Greensboro
336-856-1552

Hickory
Hendrick Motors
828-322-5640

Raleigh
Leith
919-876-5432

Wilmington
Bob King Autohaus
910-799-3520

Winston-Salem
Mercedes-Benz of Winston-Salem
336-760-4580

North Dakota

Fargo
Valley Imports
701-277-1777

Ohio

Akron
Ganley
330-733-7511

Bedford
Mercedes-Benz of Bedford
440-439-0100

Canton
Kempthorn Motors
330-452-6511

Centerville
Ross Motor Cars
937-433-0990

Cincinnati
Mercedes-Benz of Cincinnati
513-984-9080

Columbus
Mercedes-Benz of Columbus
614-299-2144

Dublin
Crown Eurocars
614-799-4666

Forest Park
Mercedes-Benz of Cincinnati
513-851-8800

Mansfield
Weidner Motors
419-529-7800

North Olmsted
Mercedes-Benz of North Olmsted
440-716-2700

Sylvania
Vin Devers
419-885-5111

Tiffin
Coppus Motors
419-447-8131

Willoughby
Leikin Motor
440-946-6900

Youngstown
Fred Martin Ford
330-793-2444

West Chester
Mercedes-Benz of West Chester
513-870-1000

Oklahoma

Oklahoma City
Mercedes-Benz of Oklahoma City
405-236-1224

Tulsa
Jackie Cooper Imports
918-249-9393

Oregon

Bend
Mercedes-Benz of Bend
541-749-2500

Eugene
Mercedes-Benz of Eugene
541-687-8888

Medford
Legends Automotive Oregon, LLC
541-857-8072

Portland
Mercedes-Benz of Portland
503-228-8351

Salem
Valley Motor
503-585-1231

Wilsonville
Mercedes-Benz of Wilsonville
503-454-5000

Pennsylvania

Allentown
Knopf
610-439-1555

Camp Hill
Sun Motor Cars
717-737-3030

Devon
Mercedes-Benz of Devon
610-688-7905

Doylestown
Keenan Motors
215-348-0800

Erie
Contemporary Motorcar
814-868-8622

Ft. Washington
R&S Imports
215-646-6045

Greensburg
Bud Smail Motorcars
724-838-1200

Lancaster
Mercedes-Benz of Lancaster
717-569-2100

Reading
Tom Masano
610-777-6587

State College
Leitzinger Imports
814-238-2447

Washington
John Sisson Motors
724-206-6000

West Chester
Mercedes-Benz of West Chester
800-220-7278

Wexford
Bobby Rahal Motorcar
724-935-9300

Wilkes-Barre
Motorworld
570-829-3500

Puerto Rico

Carolina
Garage Isla Verde
787-620-1313

Rhode Island

Tiverton
Viti
401-624-6181

Warwick
Inskip
401-821-1515

South Carolina

Charleston
Baker Motor of Charleston
843-852-4000

Columbia
Dick Dyer and Associates
803-786-8888

Conway
Fowler Motors
843-347-4271

Florence
Newsome
843-662-8711

Greenville
Carlton Motorcars
864-213-8000

Hilton Head Island
Modern Classic Motors
843-681-8500

South Dakota

Sioux Falls
Vern Eide Motorcars
605-335-3000

Tennessee

Chattanooga
Long of Chattanooga
423-855-3726

Kingsport
Rick Hill Imports
423-224-2117

Knoxville
Mercedes-Benz of Knoxville
865-777-2222

Memphis
Mercedes-Benz of Memphis
901-345-6211

Nashville
Mercedes-Benz of Nashville
800-221-4841

Texas

Austin
Mercedes-Benz of Austin
512-454-6821

Beaumont
Mike Smith Autoplex German Imports
409-840-2000

Bedford
Park Place Motorcars
817-359-4700

Boerne
Mercedes-Benz of Boerne
830-981-6000

Corpus Christi
Ed Hicks Imports
361-854-1955

Dallas
Park Place Motorcars
214-526-8701

El Paso
Mercedes-Benz of El Paso
915-778-5341

Georgetown
Mercedes-Benz of Georgetown
512-868-9711

Harlingen
Cardenas Autoplex
956-425-6000

Houston
Mercedes-Benz of Houston Greenway
713-986-6400

Houston
Mercedes-Benz of Houston North
281–233-6000

Houston
Star Motor Cars
713-868-6800

Laredo
Powell Watson Motors
956-722-5182

League City
Alex Rodriguez
281-554-9100

Lubbock
Mercedes-Benz of Lubbock
800-698-7993

Midland
Britt Imports
915-699-7993

Plano
Ewing Autohaus
972-599-0909

San Antonio
Mercedes-Benz of San Antonio
210-366-9600

Sugar Land
Mercedes-Benz of Sugar Land
281-276-7600

Texarkana
Pete Mankins Pontiac-Cadillac
903-793-5661

Tyler
Classic-Tyler Motors
903-581-0600

Waco
Allen Samuels Chevrolet-GEO
254-772-8850

Wichita Falls
Patterson Auto Center
940-766-0293

Utah

Linden
Shaw & Miller Lindon, Inc.
801-222-4400

Salt Lake City
Ken Garff Imports
801-521-6111

Vermont

Shelburne
The Automaster
802-985-8482

Virginia

Alexandria
Mercedes-Benz of Alexandria
703-241-2150

Arlington
American Service Center
703-525-2100

Charlottesville
Brown European Imports
434-817-3380

Fredericksburg
Noble Cars
540-373-5200

Hampton
Tysinger Motor
757-865-8000

Lynchburg
Kenneth Hammersley Motors
434-385-6226

Midlothian
Mercedes-Benz of Richmond
804-545-9600

Richmond
David R. McGeorge
804-755-9300

Roanoke
Hammersley of Roanoke
540-344-6284

Vienna
H.B.L.
703-442-8200

Virginia Beach
Phillips
757-499-3771

Washington

Bellevue
Mercedes-Benz of Bellevue
425-455-8535

Bellingham
Wilson Toyota
360-676-0600

Fife
Mercedes-Benz of Tacoma
253-922-6820

Pasco
McCurley Imports
509-547-5555

Seattle
Phil Smart
206-324-5959

Spokane
Mercedes-Benz of Spokane
509-455-9100

Yakima
Hahn Motor
509-453-9171

West Virginia

Charleston
Smith Company Motor Cars
304-746-0600

Morgantown
University Motors
304-296-4401

Parkersburg
Astorg Motor
304-422-6403

Wisconsin

Appleton
Enterprise Motorcars
920-749-2020

Glendale
Concours Motors
414-290-1400

Madison
Z European
608-258-4000

Wausau
Rosemurgy International Auto Mall, Inc.
715-675-7775

West Allis
International Autos
414-543-3000