StarTuned®

Information for the Independent Mercedes-Benz Service Professional

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Diesels Part II

Driveability

Volume 2 Number 4

Mercedes-Benz

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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.

The worldwide carmaker 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 information sources combine to make this possible.

Feature articles, derived from approved company information sources, focus on being useful and interesting. Our digest of service bulletins will help you solve unanticipated problems quickly and expertly. Our list of Mercedes-Benz dealers can help you find original, genuine Mercedes-Benz factory parts.

We want *StarTuned* to be both useful and interesting, so please let us know just what kinds of features and other information 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.

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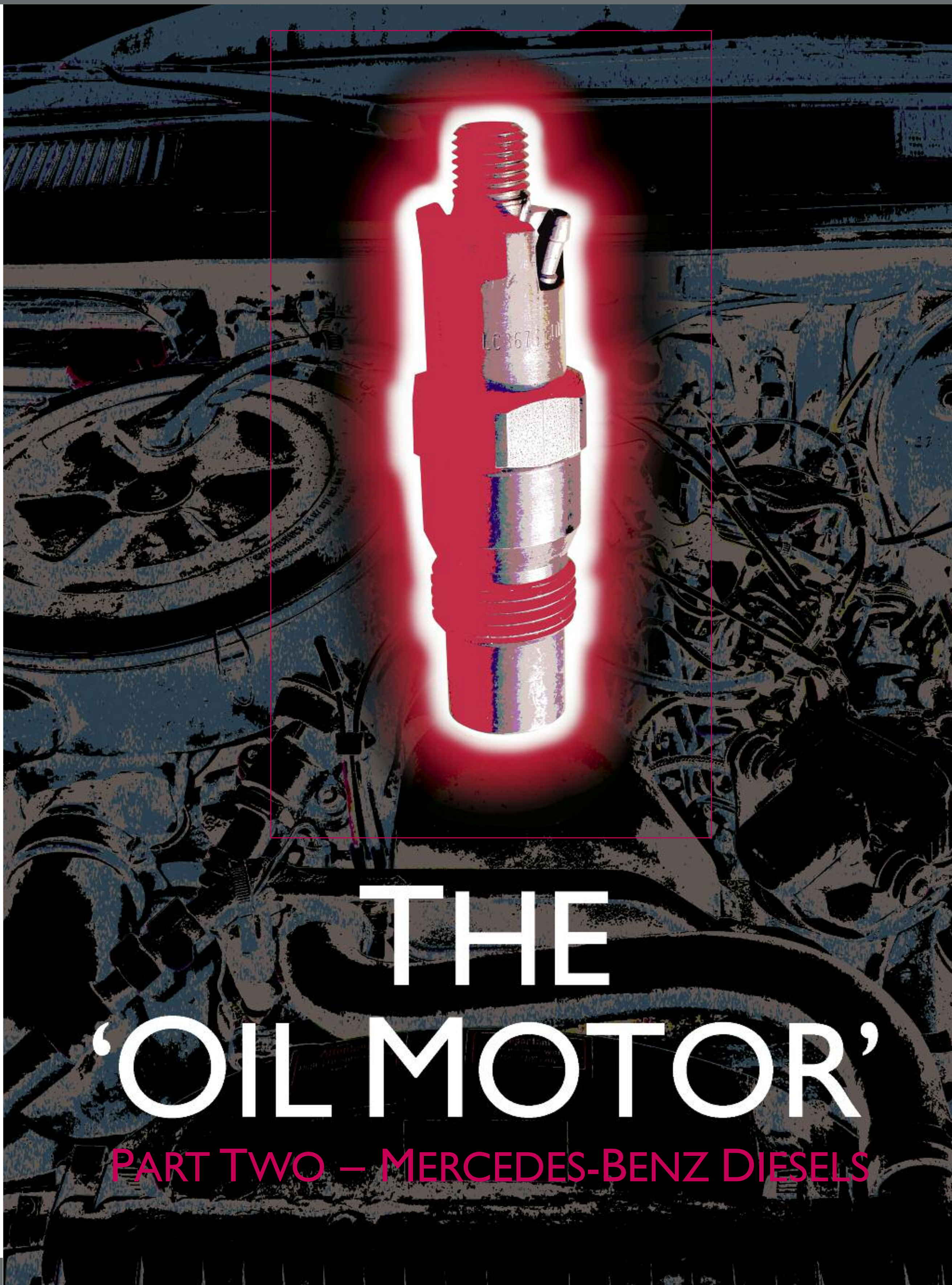


The 'Oil Motor'

Part Two – Mercedes-Benz Diesels

Diesel Efficiency

'Everyone knows' Diesel engines are more efficient than gasoline engines doing the same work, but 'everyone' does not know why that should be. Or worse, everyone 'knows' something that's mistaken. And 'knowing' something that's false can mean servicing or repairing a car inaccurately. The owner of a Diesel Mercedes-Benz probably expects a long useful life from the car and good fuel economy over that long useful life. Those are reasonable expectations, if you avoid 'knowing' something mistaken.

It's a mistake to contrast a gasoline engine with a Diesel without saying something more. The defining characteristic of a gasoline engine is the fuel it burns, gasoline or an alcohol blend very similar to gasoline in most respects. But the defining characteristic of a Diesel engine isn't the more energy-dense Diesel fuel it burns, but how it lights the combustion, by compression ignition instead of by spark ignition. In principle you could use anything as fuel for a Diesel engine as long as you could hammer it into the combustion chamber at the right moment, as the piston neared the top of the compression stroke. Some dual-fuel Diesel stationary engines today use 'Diesel fuel,' that is fuel oil, to start the burn and natural gas for the bulk of the torque production. Both the injectors and pumps of such Diesels are, of course, more complex than conventional injectors and pumps. There are even special military vehicle engines using both spark and compression ignition simultaneously. They can run on any flammable liquid, from drycleaning fluid to cooking oil to perfume or brandy. Or even on gasoline.

The real contrast is between efficiency of the spark-ignition engine, the 'gasoline' engine, and the compression-ignition engine. And the latter's real efficiency comes from what the Diesel doesn't have, a throttle, and (to a lesser extent) what it does have, a higher compression ratio. To understand, look back for a moment at the gasoline-, the spark-ignition engine. You vary the output torque by varying the intake air-fuel mixture volume. Actually, torque output follows the intake mass, but mass and volume are in cahoots, so you vary both at once with the throttle.

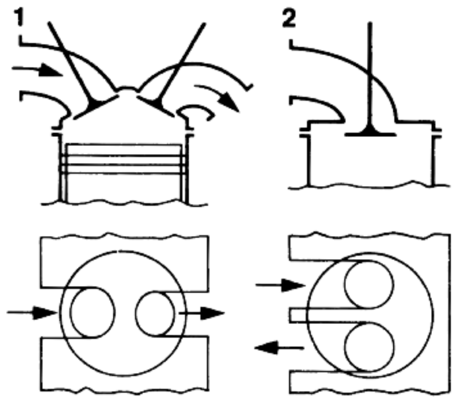
Gasoline engines rarely operate at sustained wide-open throttle. But anytime a throttle closes even partially, intake manifold vacuum rises (or equivalently, manifold pressure declines). Any vacuum in the intake manifold translates, once the intake valves open, into the same vacuum at the top of each piston during the intake stroke. It takes torque, that is, work derived from the chemical energy of the burned fuel, to pull that piston down its intake stroke because the pressure in the crankcase pushing up is at or about atmospheric. If there's a 10 psi. pressure difference between the crankcase pressure pushing up and the intake pressure (partial vacuum) above the piston, and if the piston top has an area of five inches square, you need a force of 50 pounds to pull that

An Afterglow, but not warm

With a cold engine we expect the glowplug lamp to come on for a few seconds after we turn the key on but before we crank. But what if it doesn't? What if the car is hard to start unless you hold the pedal to the floor as you crank, and then the glowplug lamp comes on after the engine starts running? Old-time Diesel engines, we learned, could run backwards until they broke, but can newer ones make clocks run backwards?

Nothing quite so dramatic: Many systems use a glowplug lamp that comes on after the engine starts to indicate that the system has detected one or more failed glowplugs. The owner's manual explains this clearly on vehicles where it is a feature, but you probably don't include reading the owner's manual as part of your diagnostic procedure and it's possible the car owner didn't read or doesn't remember that part. Some systems do turn the glowplugs back on under some circumstances, but they don't light the glowplug lamp when they do. Get out your ohmmeter and check them one at a time for continuity, wiring feed disconnected. If you find widely differing resistance but not open circuits, it's possible someone has previously installed the wrong plug for that system.

piston down. This is work the engine must derive from the torque it produces during the power strokes, work subtracted from the work delivered to the transmission and accessory drive pulley.



Multiply that work by the number of pistons, by the stroke and the engine rpm, and you can see why the gasoline engine has a lot of work to do internally even when, at idle, it's doing no useful external work at all. This unproductive 'work,' from energy consumed just to keep running, is often called the engine's pumping loss. That represents almost all the work done at idle, and it is an inefficiency at every power setting below wide-open throttle at the high point of the engine's rpm/torque curve.

The Diesel, in contrast, doesn't have to do any of this work overcoming manifold vacuum because its unthrottled manifold develops no significant vacuum (except for the aerodynamic drag through the intake channel surfaces). Dodging that unnecessary work is the main reason for the Diesel's much greater partial-load efficiency. It's also the reason, you've probably already figured out, why a Diesel has virtually no engine-braking downhill, absent an auxiliary compression brake. Not for nothing did people once say a gas-engined car coasting in gear downhill was "hanging by its connecting rods." It was converting downhill kinetic energy into pumping losses.

A Diesel engine operates with about equal efficiency over most of its dynamic range, from off-idle to high-cruise. That absent throttle is also why it burns so little fuel at idle: Many Diesel engines won't reach operating temperature if started cold and just left idling. In fact, they can 'coke' up since the combustion chamber surfaces never get up to operating temperature. Some cool down more quickly idling than shut down completely because coolant circulates heat to the block surface.

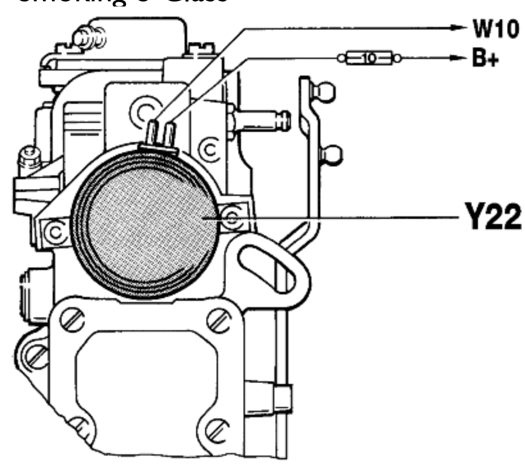
Industrial Diesel engines are usually direct-injection designs. The fuel injector sprays fuel directly into the combustion chamber, just above the piston or even into a pocket cast into the piston face. Direct injection provides greater manufacturing simplicity and about 18 percent better fuel economy (you don't lose heat through the prechamber if you don't have a prechamber).

Compression ratio also contributes to the Diesel's efficiency. Spark-ignition engines use compression ratios from about 8:1 to about 10:1 and must use elaborate knock-avoidance measures toward the top of that range. Diesel compression ratio ranges from about 17:1 to perhaps 23:1. The advantage of a higher compression ratio is thermal, deriving from the

Diesel Driveability

We talk a lot about driveability problems in this issue of StarTuned. Here are a few specific to Mercedes-Benz Diesel cars.

Smoking S-Class



Heavy smoke under acceleration is not what the owner of a turbocharged 3.5-L 140 had in mind. If you checked the air filter and the exhaust for blockage, if you checked the injectors for leaking or bad patterns, if you checked the valve timing and found it on the marks, if you checked the turbocharger seals and found no leaks, if you measured the oil consumption and found it well within the ordinary range, look carefully at the electronic Diesel system actuator on the injection pump. If someone mistakenly wired it backwards, it will do the backwards thing, leaning the mixture when it should go rich and richening it when it should go lean. Among other things, this will set many misleading false codes.

A Transparent Diagnosis

There's nothing more irritating than having somebody tell you to go back to basics. Of course, it's always right! The problem is which of the various basics involved in any automotive problem! If you find a car with hard starting and an intermittent cylinder miss that seems to travel around the engine, before you get too far into the exploratory surgery, try installing a short length of transparent fuel line between the fuel filter and the injection pump. Some cars come with them; some do not. Some that do have hoses that have turned opaque over the years.

If you can see bubbles entering the injection pump, the pump can feel them. And if it feels an air bubble, it can't develop sufficient pressure to open the injector for that power stroke. The fuel system is entirely hydraulic, and if any air gets in, you'll have an intermittent miss and hard starting.

chemistry: The more oxygen molecules you can get into a cylinder before the intake valve closes, the more power you can develop in the next power stroke from burning that oxygen with the fuel. What's more, the Diesel combustion can expand over the same increased ratio during the power stroke, a major reason why Diesel exhaust is hundreds of degrees cooler for the same power output than exhaust from a gasoline-fueled spark-ignition engine. Heat that goes into pushing the piston down and turning the crankshaft is heat put to work; heat that stays in the burning mixture and blows out the exhaust is heat wasted; it's inefficiency.

What does that mean for diagnosis and service of a Diesel engine? Its efficiency depends fundamentally upon the free flow of air into and out of the engine. Let there be any sustained restriction of intake air, and you have a throttle, whatever you call it. The most common causes of such restrictions are clogged air filters and pinched or crimped intake air tubes. Let there be any sustained restriction of exhaust, and you have the same effect on the other end: The engine must do unnecessary work to force the exhaust around or through the restriction. It takes a surprisingly small amount of intake or exhaust restriction to raise fuel consumption and lower maximum power output, and the more work you try to do the larger is the effect of the restriction.

Another aspect of the unthrottled Diesel is the sheer volume of air it pumps through itself. Under the same conditions of atmospheric dust and dirt, a Diesel will collect much more on the intake filter than even a much larger spark-ignition, gasoline engine, because it draws so much more air through. Intake and exhaust restrictions are not the only possible causes of increased fuel consumption and reduced power, of course. Check also for injector timing and spray pattern as well as all the ordinary symptoms of engine fatigue like worn rings or burned valves. And remember forces outside the engine, like dragging brakes or underinflated tires, can have similar effects. Nobody said any of this would be simple!

Emissions and the Return

The emissions characteristics of Diesel engines are a matter of great current controversy, but we won't go beyond the uncontroversial here. Diesel fuel is chemically very similar to heating oil, kerosene and jet fuel. It is very energy-dense, producing about 15 to 30 percent more Btu's per gallon than a gallon of gasoline. In addition, Diesel fuel is a much more complex hydrocarbon. Much less energy is required to extract it from crude oil than any other fuel commonly used for transportation (you get more gallons of Diesel fuel oil from a barrel of crude than anything else you could refine for because you're 'refining' less - it's closer to crude). Methanol, in contrast, is chemically very simple: an oxygen atom, a carbon atom and four hydrogen atoms. But methanol is much more complex to produce, either from crude oil or other sources. Simplicity of the fuel comes at the cost of complexity of the refining process.

Couple the refinery efficiency with the fuel economy and mechanical durability of the Diesel engine, add the dramatic reduction in carbon dioxide (the 'greenhouse-effect' gas) because the Diesel requires dramatically less fuel, and you'd think it would clearly be the first choice.

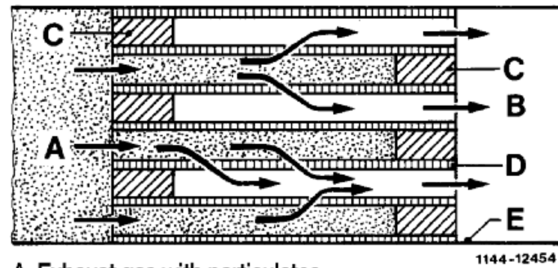
There are other clear emissions advantages, too. Because a Diesel runs so lean, it produces essentially no carbon monoxide (CO), the colorless, odorless and lethal component of gas engine exhaust. While modern gasoline engines produce much less carbon monoxide than earlier ones, they require extensive emissions controls to reduce CO to present levels. Diesel engines just never produced much CO in the first place, not even ancient ones like the 1936 260 D we showed last issue (page 4).

Running lean on the overall mixture scale, however, does not magically solve all emissions problems. If an injector does not atomize fuel finely enough or in the right cone pattern, the result can be the worst of two worlds at one and the same time. You might have black smoke from too rich a mixture in one part of the combustion chamber where the droplets are too large or too close, combined with NO_X from a nearby area where the mixture is too lean, in a space between the overrich pockets and the empty air. Proper combustion requires just the right atomization, just the right pattern and just the right timing. If you don't have those, either the injector or the pump or the setting is not functioning properly.

Oxides of nitrogen (NO_X) can form in a Diesel engine at very high combustion temperatures, just as in a gasoline-fueled engine, but an EGR system can prevent that formation by keeping peak combustion temperatures below the NO_X formation threshold. On the as-yet-unimported new Mercedes-Benz direct injection Diesels, a new deNO_X catalyst cleans up any residual NO_X. The system runs superlean for about two minutes, then rich for two seconds, then lean again.

But not so fast! And that *But* carries the capital B. Complex hydrocarbons and sulfur are the Diesel emission problems. It isn't that there is significantly higher quantity than on a gasoline engine: With the Diesel's inherently clean burn and modern engine management systems as well as burnoff particulate traps, you can keep the quantity down just as well. The problem is the variety. Diesel fuel, as we saw earlier, is a much more complex chemical compound than gasoline simply because it requires less refining. But that means the exhaust contains literally thousands of different chemical compounds, most of them untested for their effect on living organisms, atmospheric chemistry and so on.

Are they dangerous? Given the large variety and numerous questions about the chemistry, the expense and difficulty of the tests, the tests are not satisfacory or complete and perhaps never will be, so nobody will know with certainty. What's the reasonable choice to make under these conditions of uncertainty? Well, that's where the controversies come in. As long as the particulate traps, deNO_X catalysts and whatever other emissions controls work properly, the question doesn't force us to decide.



A. Exhaust gas with particulates
B. Filtered exhaust gas
C. Ceramic monolith
D. Porous cell walls
E. Steel cylinder

Present Diesel exhaust traps consist in a fine ceramic filter to catch particles of soot. When enough of them collect, they burn off in the exhaust. Later versions of Diesel exhaust treatment use reducing catalysts to remove NOx from the exhaust.

For years Diesel engines have had what some people call a 'Diesel catalyst.' It is, however, not really a catalyst but a ceramic exhaust filter, a particulate trap. When it captures enough waste hydrocarbons, either the temperature of the backpressure-enhanced exhaust or an electric heater ignite and burn off the captured particulates. If something goes wrong with the particulate, it clogs up, reducing the air through the engine and the power it can produce.

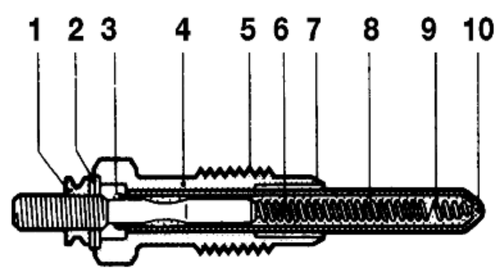
Batteries and Glowplugs

Diesel vehicles often have batteries with about twice the capacity of a gasoline engine, and even at that starting in the cold of winter can be a problem. Why?

For two reasons. First, most Diesels generally and all Mercedes-Benz car Diesels use glowplugs to start the engine and keep it running for the first few minutes when cold. A glowplug is a small electric heater, shrouded in a protective metal case, hot enough to push the injected fuel just over the autoignition point during cold cranking. If your hair is grey or gone, you may recall model airplanes, powered by two-cycle engines like the redoubtable Cox 49, which used a glowplug, heated electrically from a dry cell to start and kept hot thereafter by the residual heat of the previous combustion. Unlike the Cox glowplug, the Diesel glowplug is just along for the ride once the engine is running smoothly at operating temperature (though some later Diesel control systems turn the glowplugs back on at extended idle to make sure everything gets burned).

The Cox glowplug didn't have any timing advance beyond the chemistry of the fuel and the temperature of the filament, but perhaps ignition timing is not critical for an engine with a half-inch stroke and an operational speed of 20,000 rpm or so. Just like the Cox glowplug, the Diesel glowplug provides a place in the combustion chamber where it is hot enough to light the fuel-oil fire once the injection occurs, as long as there is sufficient pressure.

Type S-RSK pencil-type glow plug
1 Round nut, 2 Insulating washer, 3 Seal
4 Shell, 5 Thread, 6 Regulating coil,
7 Conical seat, 8 Insulating powder,
9 Heating coil, 10 Glow tube



And that "sufficient pressure" is the second reason for the large battery. A gasoline engine with good rings and valves will have, say, 150 psi. compression at crank. That corresponds to about a 10:1 compression ratio. But prechamber Diesel engines have over 20:1 compression. That's why, when you switch it off, a Diesel stops now, hard against the next compression stroke. The difficult part of starting any engine is to keep it turning fast enough during the compression stroke that the spinning inertia will carry it just beyond TDC even when the ignition - spark or injection - and the combustion pressure rise occur slightly earlier. If it's not turning fast enough, the air doesn't get hot enough to cross the fuel's autoignition threshold, so no combustion and

no start occurs. Or with a weaker crank still, the crankshaft slows or stops on each compression stroke, and there's not even a full crank. Notice it's not the horsepower of the starter that's in question but the torque at the critical combustion moment in the compression stroke.

The starter would never be able to outmuscle the combustion pressure. It's the inertia of the crankshaft and other rotating mass. Doubt it? Ever watch somebody start an old aircraft radial engine by pulling the propeller by hand? How many old-time aviators do you suppose had multi-horsepower arms? They were able to get things spinning fast enough by hand that the stored rotating inertia of the prop and crank could carry the engine through the compression stroke and into the first power stroke. Thereafter it could run on the normal four-cycle principles.

On older Diesels, some engines could bounce backward at the beginning of injection and continue to run backwards, though not for long: You can imagine how effectively an oil pump works turning the wrong way. Mercedes-Benz Diesels from the 1950's and 1960's have spring-loaded air throttles, essentially check valves, in the intake channel, in part to snap closed and stop an engine that tries to run counterclockwise.

So a Diesel battery must have the capacity to heat the glowplugs, perhaps a 50 or 100 amp draw for as long as a minute, yet still retain sufficient reserve to spin the starter against at least twice the resistance a gasoline engine starter must overcome. It must provide about twice the storage and cranking capacity of a battery for a similar sized gasoline engine.

Older Mercedes-Benz Diesels used a bank of resistance coils to limit the current through the glowplugs to an amperage that is sufficient to heat the surface of the glowplug enough to 'spark' the combustion when injection occurs but not enough to burn out the glowplug prematurely. Later Diesel systems use electronic current limiters, combined internally with the glowplug control relay. That system conserves electrical energy since there are no resistance coils to heat and in principle allows a somewhat smaller battery.

With all that even on a 40-below winter morning, the compressed air adjacent to the glowplug in a Diesel engine can momentarily achieve the 400+ degrees or so necessary to fire that first power stroke. With the first power stroke, of course, the crankshaft spins faster and generates hotter compression strokes than the electric starter motor could ever wind up, so there's little continuing problem. Most modern engine systems turn the glowplugs back on for a short time after startup to preclude cylinder miss.

So why don't gasoline engines need glowplugs at 40-below? It's just as cold as for them, and gasoline has an even higher autoignition temperature. Besides, their puny 8 or 10 to 1 compression ratio can't heat the intake mixture very much. Because the spark between the plug electrodes is much hotter than any glowplug and you only need the maximum temperature in one place to start the combustion.

Fair enough, then, why don't Diesels have spark plugs instead of glowplugs for cold starts? After all, the spark would be just as hot for them. Two reasons: The plugs can't be made economically to withstand the combustion pressures in the Diesel powerstroke (the ceramic would pound out), and the plugs would foul with carbon after any short trip, grounding the spark.

So why do you need glowplugs in all cylinders, then? It seems like once the engine runs on its own after the first combustion and power stroke, it ought to turn fast enough to compress the next cylinder fast enough to achieve a temperature high enough for autoignition. Seems like it, perhaps, but not necessarily. There's a certain temperature/pressure/fuel combination that must occur, or there won't be combustion. The most reliable symptom of a burned-out glowplug, in fact, is a temporary cylinder miss when first started, combined with the telltale white smoke from fuel in the still-cold exhaust. If that problem goes away relatively quickly with the first few minutes' engine heat, get out your continuity tester and check the glowplug resistances.

Unlike the spark-ignition engine with a spark kernel of indefinitely high temperature, the compression-ignition engine may not necessarily reach the autoignition temperature for the next power stroke. And if it doesn't, the crankshaft will slow, probably thumping to a stop after one or two more incomplete compression strokes. So even on Diesel vehicles that turn the glowplugs off during cranking (to devote all the battery power available to spinning the crank as fast as possible), the plugs retain heat for the next few cycles. Most systems turn the glowplugs back on once the engine is running on its own power. This avoids misfire, stalling and emissions problems when unburned fuel blows into the exhaust pipe, there to turn to smoke, white or black depending on the temperature and whether there has been any combustion.

It will take correspondingly longer, obviously, to recharge the battery for the next start, the colder the engine and the air are. Short-tripping in a Diesel in the coldest part of the winter is a good way to regularly meet people in the jump-start business. Most later Mercedes-Benz Diesels start relatively easily because the Electronic Diesel System attunes preglow time more accurately to coolant and ambient temperatures than the old controllers with a box of resistors and a relay could, making better use of the available battery power.

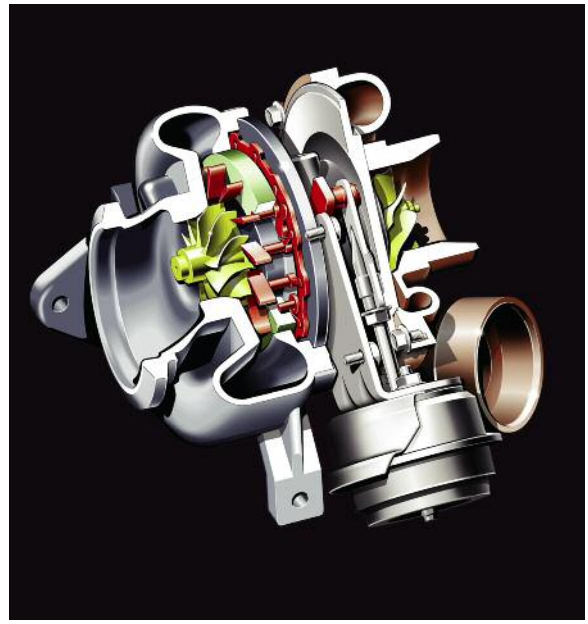
Here's a safety note when jump-starting: You'll probably be using a gasoline-engine vehicle as the electricity source and jumper cables suited to starting gasoline engines. Because of the gasoline engine's smaller battery, don't just set the cables and crank! The gas engine battery and charging system aren't up to the surge in amp draw. Chances are, the cables aren't either. Leave the cables connected and charge the big Diesel battery for at least five minutes before you turn the key to preglow. Sometimes an immediate second preglow period is advisable before cranking in the very coldest weather. Oh, and you know about the cable-hookup precautions to avoid exploding the battery? They get more serious as the battery gets larger: The bigger the battery, the bigger the acid-spattering boom.

Check glowplugs for continuity, terminal to block, with the harness pulled. Resistance should be very low when cold and (on older models) go somewhat higher when hot, but when a glowplug burns out, its resistance goes open. Glowplugs have internal resistance-heater filaments. An individual burnt out glowplug will often cause an initial miss with white smoke (fuel) through the exhaust. In very cold weather, loss of that one cylinder can be enough to keep the engine from starting because the crank slows so much for that missing cylinder. In the absence of the auxiliary heat, the compressed air in the cylinder may not quite reach the autoignition threshold of the fuel. Raising engine speed with the fuel pedal can often get rid of the smoke for the moment, and once the engine begins to warm up the glowplugs are no longer needed.

But a new plug is the only fix. Like light bulbs, glowplug useful life is measured in on-off sequences, not in miles traveled. A Diesel cab, with the engine started and stopped just once a day, might use the same glowplugs for many years; another car with the same engine could go through them more often, if it restarts frequently. However, some Diesel drivers have gone for years without noticing a burned out glowplug - if they regularly use a block heater whenever the engine is cold. In northern climates, a block heater is a wise precaution, not just to insure regular starting, but to extend the life of the battery, starter and charging system as well as to reduce the period of relatively high emissions while the engine warms. For the same reason, you should never just start a Diesel engine and let it run at cold idle expecting to 'warm up' the engine. A driver who does so is filling his combustion chambers and exhaust with soft carbon that will appear in the form of smoke as soon as he starts driving. The proper way to warm an engine is to get underway as soon as the engine is running reliably and keep it under moderate load until you reach operating temperature. This is true for gasoline engines, too, of course.

Turbochargers and Superchargers

Mercedes-Benz has generally used exhaust-gas-driven turbochargers for Diesel engines and crankshaft-pulley-driven superchargers for gasoline engines, starting with Diesel turbochargers in 1979. Both work by forcing more air into the intake manifold, raising its pressure above the ambient and cramming more oxygen molecules into the cylinder. This allows the injection of additional fuel and results in a still more powerful power stroke. For the same displacement engine and the same crankshaft rpm, you can develop dramatically more torque. A turbocharger consists of two turbine 'fans' in separate chambers, sharing a common shaft. Exhaust gas spins one side, and the shaft carries the energy to the other to compress the incoming air. A supercharger consists of two or more counterrotating lobes in a shaped chamber. A belt-driven pulley on an electric clutch like an A/C compressor powers the supercharger. When it spins, it forces more air into the engine than ordinary ambient pressure would deliver.



There are a couple of reasons Mercedes-Benz engineers like turbochargers for Diesels and reserve superchargers (which they like to call "Kompressors" because that's the German word as well) for gasoline-fueled, spark-ignition engines. To raise the pressure of the incoming air by a given measure, a turbocharger heats the gas more than a supercharger does, simply because of the speed and friction of the turbocharger blades. On the gasoline engine, this raises problems of knock, of detonation and all the octane/detonation issues. A supercharger bites off relatively larger 'pieces' of intake air, heating less, so it avoids the heat problems. What's more, most of the time it's switched off. On a compression-ignition Diesel engine, however, heating the intake gas is far less of a problem - you want the stuff to get hotter; that's part of the plan. Of course, when you heat air it expands, which flies in the face of the purpose of the turbocharger/supercharger, so very often the turbocharged air runs through an intercooler, basically a radiator for pressurized air. This doesn't change the pressure, but it lowers the temperature, which means we get the increased number of oxygen molecules we were after for more power.

Many vehicles use a turbocharger to increase the output of their Diesel engines, some with intercoolers as well. This is conjecture, but I suppose within reasonable limits a turbocharger costs the Diesel engine nothing under circumstances when no turbocharging is needed, at part loads and idle. The increased intake air volume merely becomes increased powerstroke pressure by the same factor less a smidgen for heat loss. An unthrottled Diesel engine can use virtually unlimited quantities of intake air with no adverse consequences.

On a gasoline engine, however, you're locked into a narrow fuel/air ratio and only occasionally want greatly increased airflow, on those very occasions when you signal the engine with your right foot that you want to put distance between your self of the immediate future and your current, more static self. A turbocharger inherently must wait while exhaust pressure builds and then intake pressure builds from that. A supercharger delivers increased intake pressure on the next piston stroke. But a supercharger is more complex than a turbocharger and generally less suited to passenger diesel cars. Turbochargers are simpler in these applications, and Mercedes-Benz has generally used them that way.

A turbocharger increases exhaust backpressure, generally a bad thing, as it builds intake pressure, generally a good thing. But what energy goes into compressing the intake air during the compression stroke comes out equally during the power stroke. People often liken this to the energy stored in a spring: Except for a bit radiated away as heat, you get back about as much on the extension as you soaked up on the compression. Some heavy trucks use only pneumatic springs, after all, and don't gradually sink onto their frames.

Earlier Mercedes-Benz turbochargers were just the two fans and shaft in the nautilus-shell scroll casting we described, but later they include wastegates, to bypass the turbocharger when the pressure reaches a maximum threshold and more recently the variable-geometry turbocharger, allowing constant pressure at differing gas flow and turbocharger rpm conditions.

Runaway Diesel!

As they wear out, most engines just develop less and less power, start smoking more and eventually get junked or overhauled. That's true of most Diesels, too, but not all. Occasionally one goes out of business dramatically, spectacularly, explosively - a 'runaway' Diesel. Often a runaway Diesel stops only when a connecting rod stump punches a hole through the side of the engine block. Poke around Diesel junkyards a bit, and you'll learn this end is by no means uncommon.

Here's how the engine runs away: As any engine wears, the rings and valves wear. That means a certain amount of lubricating oil gets into the combustion chamber, past the worn rings, past the hardened seals, down the loosened valve guides. Often, but not always, this means increased exhaust smoke, especially on a gasoline engine. But a Diesel engine runs on oil naturally. It can burn some crankcase oil without much smoke, more than a gasoline engine can.

What's more, on many older engines the owners, perhaps the second or third owners by this time, become less rigorous about engine oil change schedules. Not only does that allow carbon and grit to accumulate in the oil, it also allows fuel to contaminate and dilute it (and every time an engine, any engine, starts cold, fuel drains around the pistons into the crankcase). A gas engine can boil the fuel out if it runs hot long enough because the crankcase oil will reach and hold a steady 220-225 degrees F (gasoline boils at about 168 degrees). A Diesel engine will get just as hot at steady cruise, but the fuel oil doesn't vaporize at the crankcase oil's maximum temperature. So that engine must wait for an oil change to flush out the fuel-contaminated oil. Fuel-contaminated lubricating oil doesn't just lose viscosity and lubricating properties, allowing more rapid wear and further fuel contamination; the oil also develops a lower and lower flashpoint, eventually approaching the flashpoint of the fuel itself. Now the engine is closing in on the 'runaway.'

Diesel engines can have four different kinds of 'smoke,' two white, one blue and one black; none of them good.

White 'smoke' can be engine coolant (i.e., antifreeze steam) from a blown head gasket or casting crack, or it can be clouds of tiny fuel droplets and vapor, blown through the engine unburned from lack of sufficient atomization and temperature. Steam doesn't go away until you run out of coolant; white fuel vapor goes away once the engine reaches operating temperature. Your nose will immediately resolve this diagnostic quandary.

Blue smoke, just as on a gasoline/spark engine, comes from crankcase lubricating oil, drawn past the rings or down the valve guides and partially burned in the combustion chamber. Diesel combustion can mask burned crankcase oil for a while, but once it becomes permanent and noticeable, replacement or remanufacture of the engine is the next step.

Finally, black smoke is unburned fuel after the engine is warm enough to burn it but didn't. There wasn't enough oxygen to burn that fuel dose, apparently. Either the air filter is so clogged as to reduce airflow, or the fuel spray atomization is so poor that the droplets are too large, or the pattern is too densely clustered to burn the fuel in the available combustion time.

Let a brew of oil and fuel contaminant leaking back around the rings and down the valves into the combustion chamber reach a certain threshold, the amount needed to sustain combustion, and you have a 'runaway' Diesel on your hands, usually after a sustained application of full power. The driver releases the fuel pedal at the top of a hill, but the engine does not slow down. Because ignition does not occur at the most favorable advance angle, the engine doesn't develop full power, but this ordinarily happens just as the driver also releases the clutch or just tries to coast with an automatic transmission. Because of the uncontrolled combustion timing, there's usually strong detonation at the same time. The engine increases rpm rapidly, but since it's not burning fuel from the injectors, when the governor shuts off all the fuel, this has no decelerating effect on the engine. Neither would turning off the ignition key, which also stops fuel. The crankshaft can and will go right past redline. The only 'governor' at that point is whichever comes first, valve float or connecting rod failure.

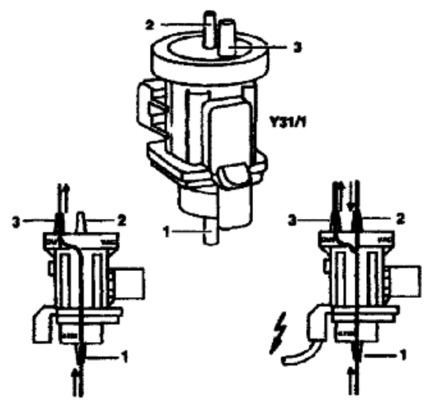
This is not a 'slippery slope.' It's a drop off a cliff. You have seconds, not minutes, to recognize the problem and solve it. Engine speed can increase now without any limit other than the volume of oil past the rings and valves (and less frequently past a turbocharger turbine seal). And the faster it goes, the more oil is likely to blow by. So the faster it goes, the faster it goes. Actually, of course, blowby will stop as soon as there's a large hole in the crankcase casting, bleeding off the pressure. An engine running beyond redline for even a short time sets up resonances in the connecting rods, and one of them will punch out. When that rod decides to part company from its piston and the crankshaft, the runaway engine stops, with a roar and a bang, in a cloud of smoke and steam.

How can you reign in a 'runaway' Diesel? Two ways: Mechanically halt the crankshaft, or mechanically stop the air. With a stick shift car, put it in gear, stand on the brakes and release the clutch. As with any car, the brakes are much more powerful than the engine and will clamp the car and the crankshaft to a standstill. What if it's not stick shift? Sometimes standing on the brakes will hold the engine to a speed where it will stop, anyway; after all, the engine can't put out maximum power with the wrong fuel igniting whenever it feels like catching fire. In any case, you'll probably be able to hold it below redline. That could cook the transmission, but if the alternative is letting the engine throw a rod, it may be prudent anyway.

You can 'strangle' a runaway Diesel (or any engine, runaway or not, Diesel or not) by capping the exhaust to prevent the engine from exhaling. That may be harder to do than you expect, of course, considering both the temperature and pressure of the exhaust. There will also be quite a bit of noise and smoke. In principle, you could stop the engine by choking off the intake air as well, but that would ordinarily take too long. Usually a 'runaway' Diesel engine runs away for good unless somebody is smart and very quick.

Who Guards the Guards?

Looked simple enough, a 1997 E300D with a Check Engine light and a code P0400, EGR flow malfunction. You test the valve; you test the vacuum and exhaust tubes and passages. Everything looks good except the valve itself is not functional. Replacement of the valve and resetting the memory fixed everything for 30 miles, when the car came back with the CEL and the same code. Bad part, maybe?

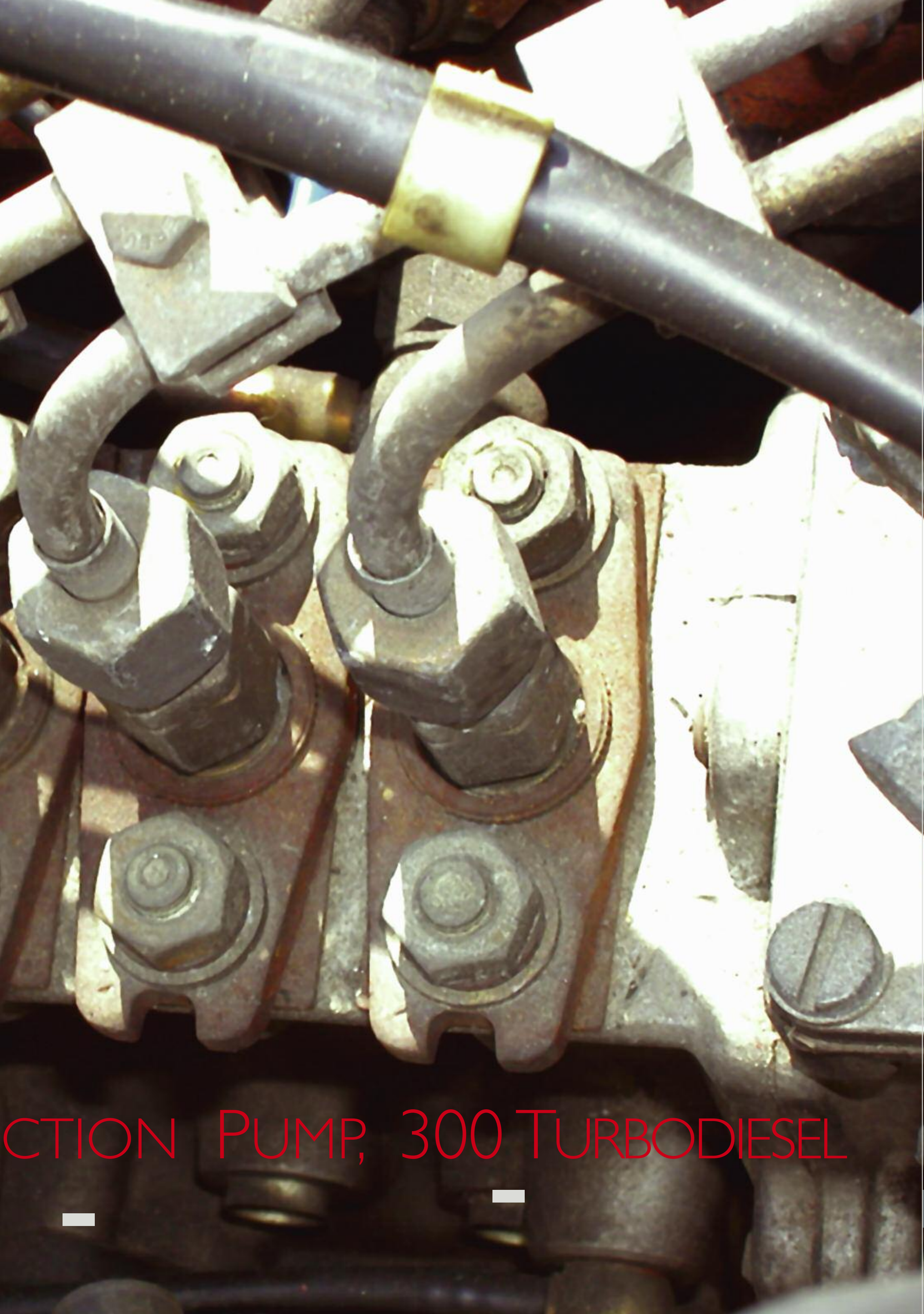


Not much chance of that! But keep in mind a fault code flags not a part but a circuit, a mechanical or electrical subsystem! We always assume, naturally enough, that the parts operating under the greatest load or temperature or vibration must be the ones that fail, but not necessarily. The EGR transducer is an electronically controlled vacuum metering device that directs a flow of vacuum to the EGR valve sufficient to induce sufficient EGR flow to prevent the formation of NOX in the combustion chambers. Like the EDS electronic actuator, it is a duty-cycle-controlled device. If it develops an open or a short or internal leaks, the system computer will lose control of the positioning of the EGR valve. Shortly after the engine gets up to normal operating temperature, it starts monitoring the EGR position sensor, which reports no movement, thus triggering the P0400.

A failure of any component or connection on the circuit could set a code misleading to those who think the code refers to a part!

StarTuned
Information for the Independent Mercedes-Benz Service Professional December 2002

Fuel Inje



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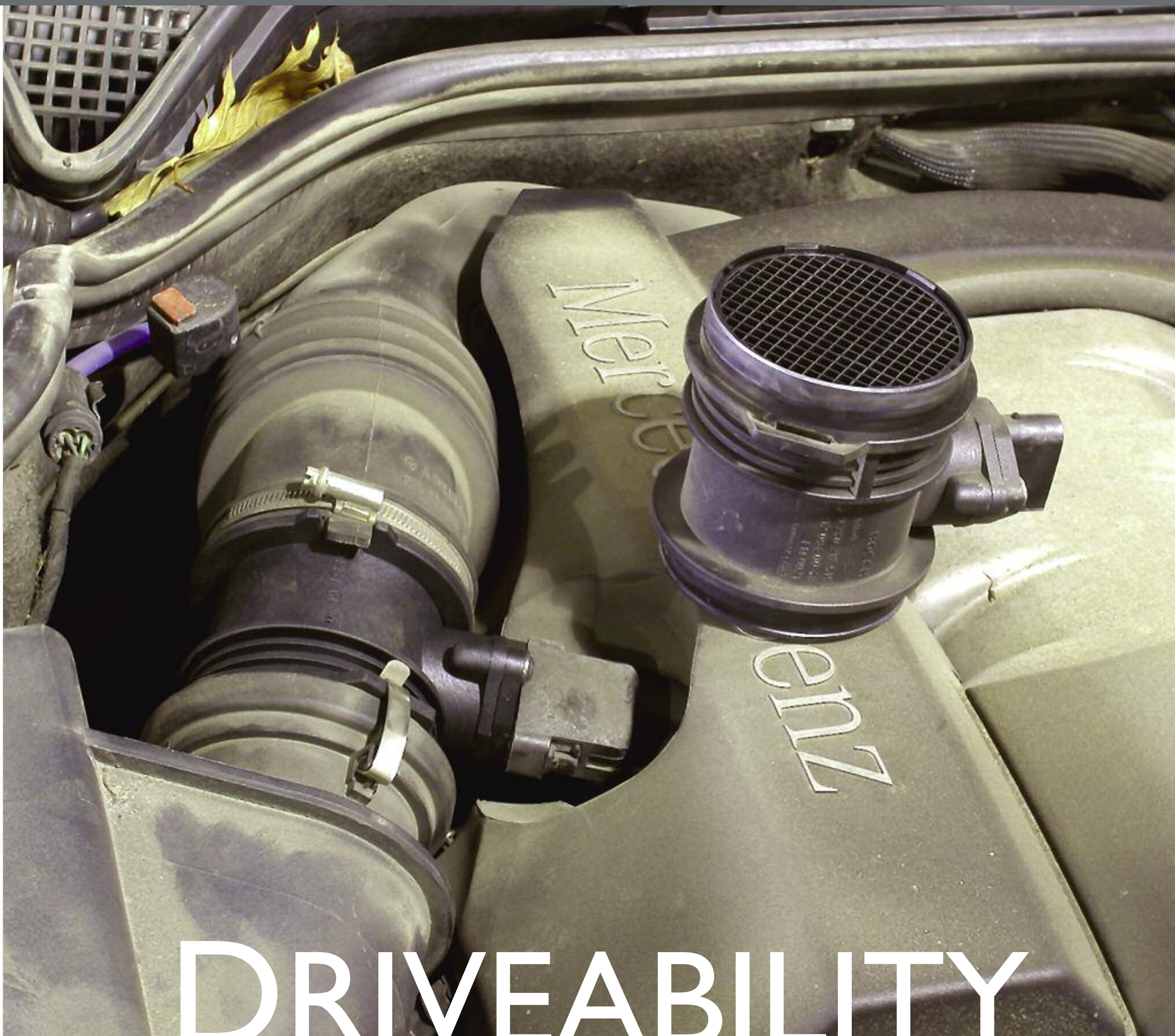
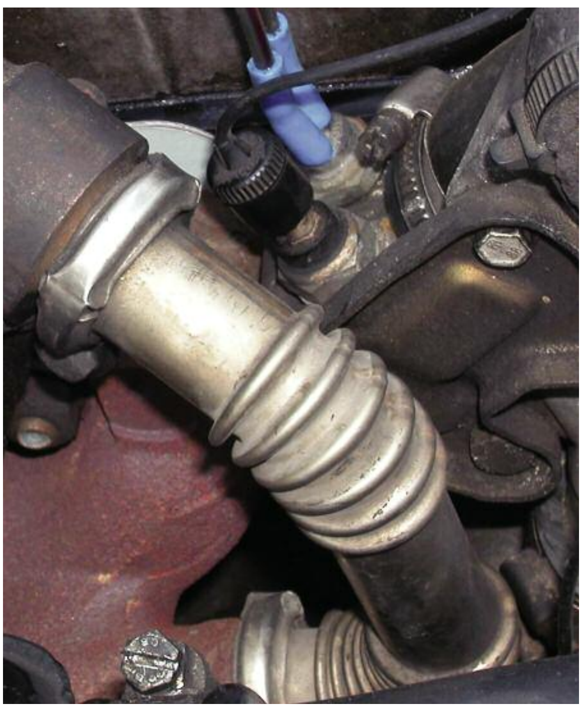


Driveability
Coded & Uncoded

Mass airflow sensors rarely just die; they're killed. By debris from or through the air filter. By deposits from bad gas. But the diagnostic problem is, they seldom die clean and quick. Instead, they tell lies until they're caught and executed. They report false readings because of those contaminants. The computer has no reason to doubt a MAF sensor that's always told the truth before, particularly if what it's reporting now is within the range of plausible.

Moved into Smogchek!

While the CEL in his '93 400 SEL had been on for several years, the motorist couldn't tell anything was different from the way the car ran. When he checked the oil, it didn't show any more rapid consumption than before. When he asked a local shop about it, they pulled a code and reassured him, "That's just your EGR. Don't worry about it. The car will work fine anyway. We don't have emissions inspections here." The driver was reassured and drove with the lamp on. But after a year or so he moved to a more urban area, an area where they did have emissions inspections. However good a car you had and however well it ran, if your CEL was on, you weren't going to get that little colored stickum square for the corner of your rear plate.



So he took the car to get the CEL turned off. Of course by that time, the EGR valve had seized in place. The frequent thermal cycles as the manifold warmed up and cooled down encouraged the growth of rust, which locked the valve permanently. It may have been nothing more than a porous vacuum hose to begin with, but leave things alone long enough, and new problems may spread to everything on the subsystem. While we're talking about the EGR here, this is true for most other automotive systems as well, particularly those related to emissions controls.

A Bouquet of Trans Codes

Many people evidently cannot drive without snacking, and snacking means spilling. That may cause unpredictable problems, however, because it's not clear what the effects on electrical contacts and connections in the gearshift console may be. Who knows what the resistance of sensor switch contact points soaked with Coca-Cola and then dried might be? Find a bouquet of transmission codes and the transmission locked in limp-home? Among your other tests, check to see whether there are any dried flakes of soft drink on the switch that tells the computer what the gearshift position is. So check the switch.

Wilts under Load

The car was a well-cared-for 126 with the 5.6-liter engine. It had always enjoyed careful maintenance and still looked showroom new. But, its owner reported, of late it lost power when you tried to accelerate. The car would always start easily, hot or cold. The engine could idle until the tank ran dry. There was no problem getting into gear or underway, until you opened the throttle. Then it would bog and stall.

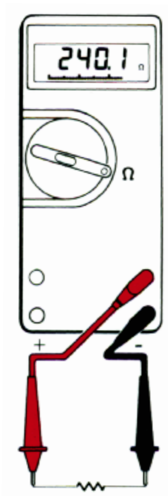
The shop quickly found the fuel pressure, 70 to 80 psi. at idle, fell quickly to 50 when you opened the throttle. At that pressure, of course, insufficient fuel flows through the injectors, and the engine stops. The natural first step? Replace the fuel filter. It sounded just like a mostly clogged filter since enough fuel could flow for idle but not for load. Sawing the old one open to check was disappointing: There was no significant dirt, not enough to visibly clog the element. But there's no harm in replacing a fuel filter, so on they went.

Next, they replaced the pressure regulator. This part is too expensive to use as a guess-and-hope diagnostic tool, but they had a spare on hand. There was nothing wrong with the original, it turned out. At least there was not much time spent in that SWAG-test.

You could hear and feel both fuel pumps (this system uses two, a 'lift pump' and a pressure pump), so that left the possibility something had clogged or crimped the in-tank pickup. This is not the easiest tank in the world to remove, nor the easiest to get back in once their inspection exonerated the pickup: There's nothing there to pinch off fuel delivery.

So now the shop turned to a set of tests they realized they should have done earlier: pressure and volume. Pressure, as we saw above, was OK at crank and idle, but not at run. There's no way to check volume during running, of course, but it seemed adequate with the line disconnected and routed into a graduated beaker.

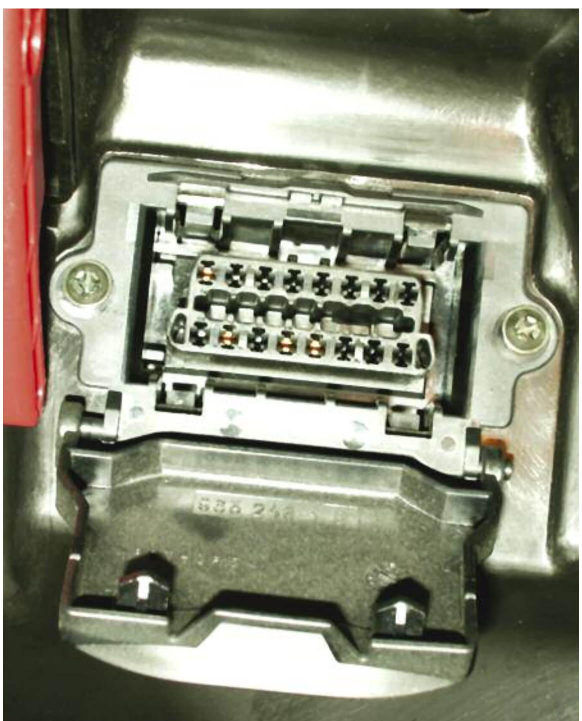
Finally, they teed a pressure gauge between the tanks. The first pump, the 'lift pump,' put out a mere 5 psi., not nearly enough to keep the engine in business. Usually we think of the first pump as the quantity pump and the second as the pressure



Checking Resistance under Load

Many electrical components change their current-draw properties under load, so a static measurement of resistance through the isolated circuit may be misleading: An imperfect connector on a radio circuit may have no detectable effect; the same condition on a starter circuit may leave the driver stranded. You need to check ground returns.

The best way is to measure voltage drop. This involves using volts to detect resistance. Set your multimeter to its lowest DC voltage scale and bridge each connection in sequence. Only the load itself should show any significant voltage drop (but remember a ballast resistor is a load). If you find more than a trace of voltage drop, that is a positive voltage reading, you've found excessive resistance. How much resistance? It doesn't matter, more than may be compatible with proper electric function. Clean or replace that connector.



All Mercedes-Benz vehicles built after OBD II went into effect have the standardized OBD II connector. On this car, as on most, it is under a hinged cover under the dash and just adjacent to the red hood release lever (left). The OBD II connector provides all the information required under the regulations relevant to the emissions systems of the vehicle. This covers almost everything having to do with running functions of the engine and its controls. You can read the information through this terminal using any OBD II-compliant scanner.

pump, but in fact, you won't get enough of either if either pump has failed. Failure in a pump is not always electrical failure; in this case, the electric motor in the pump worked fine, but the impeller elements somehow did not move the gasoline along. Replacement of the worn-out rear pump restored the 126 to its usual order.

Stumbling Hunter

This one was a '93 CE with the 3.2-liter engine. The problem occurred only at idle and only once the engine warmed up. At every other speed, there was no noticeable problem at all.

When cold, the engine idled steady as a rock at about 900 rpm, but once the coolant began to warm toward normal and the computer tried to lower the idle speed, it began to hunt, surging back and forth over several hundred rpm, nearly stalling at the bottom.There was an unhelpful code for fuel trim.

Fuel pressures were right, as were all the scope patterns for spark. You could hear some static on the radio, so the shop replaced the static suppression condenser, but that had no effect on how the engine idled (did get rid of the program static, of course).

They checked for vacuum leaks, though realizing afterwards that would only have increased idle speed, not necessarily made it hunt. Finally, they substituted a known-good MAF sensor, and the problem went away.

So what was going on? Why did the engine hunt for true idle when warm? Why did the computer think the problem was fuel trim? We're in the realm of conjecture now, naturally, but let us know if you have a better guess. I think the MAF was contaminated but just barely, perhaps by something covering just a fraction of its surface. At most operational

Mercedes-Benz cars go to virtually every country in the world, including many where OBD II regulations are unknown. Nonetheless, the cars employ multiple systems to various purposes, including optimizing exhaust emissions for environmental purposes, control of the ABS and other traction-control systems for vehicle safety, climate control and other circuits for the comfort and convenience of the driver and passengers and so on. The diagnostic terminal in the fuse box allows access to all these aspects of the vehicle's control system, as long as you have equipment to read it.

loads, this constant inaccuracy was so small the signal from the oxygen sensor was enough to correct for it. That was even, my conjecture continues, enough when the engine was cold and turning over relatively fast (there's about twice as much air going through an engine at 900 rpm as at 600 factoring in friction and pumping losses).

But when the coolant warmed enough to drop the idle, the inaccuracy from the MAF sensor loomed proportionately larger, and the oxygen sensor was unable to correct beyond its range. That meant engine speed dropped as the MAF sensor thought there was less air going through and reduced the fuel volume, and then it picked up when the computer noticed the crankshaft speed was too low and opened the idle speed control. Of course, then the MAF inaccuracy went away and the mixture fell back within the oxygen sensor's correction authority. Then the engine speed increased too much, and the computer closed the idle passage, repeating the hunting cycle. Got a better theory? Yours may be right, so tell us about it.

Misfire, Stalling, Hesitation Cold

This particular car was a 1991 300 SL, but it could have been almost any other model or year once you know the problem. The customer used it infrequently, but for long trips when he did. So at first he ignored it when the engine ran a bit rough when first started up. After all, the car hadn't been started in several weeks, he reasoned. It needed a bit of a run to get everything working properly again.

Well, that's nonsense, of course. Either a car works properly or it doesn't, and there's no need to 'circulate the juices' or whatever. For a motorist to think so is one thing, but not for a professional mechanic. When it got to the shop, the pros there were not satisfied with that explanation. Unfortunately, there weren't any codes, but the behavior of the engine started cold was consistent.

In this case, they made just the right spot-diagnosis: the coolant temperature sensor. Nothing else could cause those kinds of problems without preventing the engine from starting. Ordinarily, we expect to find a defective coolant sensor reading either direct continuity or an open circuit. But its repertoire of failure includes everything in between, and in particular, plausible but false readings. The computer has no independent source of temperature information to compare it against, so it will assume the CTS is right in the absence of clearly contradictory information. Often that's enough to let the

The diagnostic tool connector is the gateway to the interface for whole system diagnosis. It fits precisely into the diagnostic socket and locks in place with its thread. Coupled with the rest of the diagnostic equipment, this can allow access to current operating parameters and those recorded in the various histories of the on-board systems. Connected through the proper interface devices to a laptop, it can record and display information either in the workbay or underway on the road.

engine start but run poorly. Of course, once it's warmed up the system will substitute other values for the temperature and let the engine run normally, sometimes but not always setting a code (depending on what the false reading was).

Smoke up the Shaft!

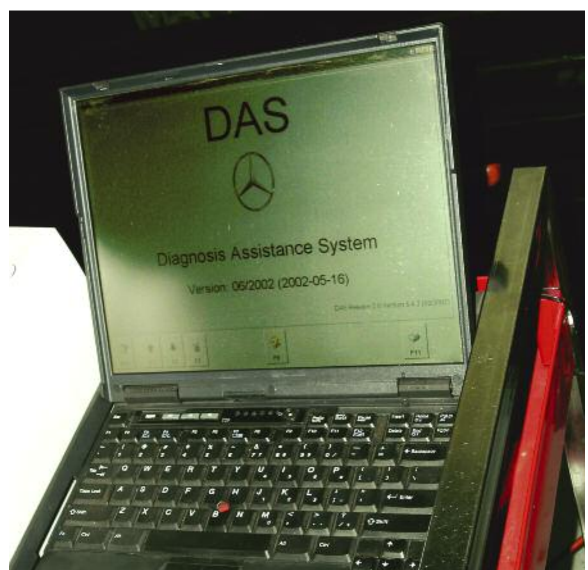
The car had come in with a ragged idle and an EGR code. Just a few days before, the shop had received its brand-new smoke machine to diagnose all the things related to vacuum leaks. They found a leak around the EGR valve shaft, so they ordered a new EGR valve and installed it. To their consternation, the new valve seeped smoke around the shaft, too! So they got another EGR, this time from the dealer. But it seeped smoke around the shaft, too!

The terminal is common to all Mercedes-Benz vehicles within the production range. The box serves to sort out the information, to protect the diagnostic computer and to identify the specific car. This box is the interface between the car's computer and the diagnostic computer

There is no specification for testing smoke-machine smoke around the EGR valve. It has nothing more to do with rough idle than a misadjusted headlight might. In the absence of other ideas about how to solve a problem, it is not a reliable test to just roll up the latest piece of diagnostic equipment and see what you can do with it. Occasionally there are problems the carmaker did not anticipate, but these are seldom or very rarely to be discovered by random testing. If you have a ragged idle, go through the proper tests first. You could measure the resistance between the right front fender sheet metal and the rear bumper. You could check the headlight aim with the latest tool. What would those tests tell you about running problems? Nothing. Stick to tests relevant to the systems you're working on.

CEL and EGR Codes

You have to wonder what happens to good EGR valves replaced by other good EGR valves. In any case, you know the replacement didn't solve the CEL or other problem. When you have a code for an EGR valve or other good reason to suppose it's not working properly, that does not mean the valve itself has failed. That is one of several possibilities, but not the only one. It's at least as likely the EGR tube and passages have clogged with carbon, blocking the recirculation of exhaust gas. You can either ream these passages out with a steel cable frayed at one end or just replace them with new ones. The advantage of replacing them is the elimination of rough surfaces that will allow new carbon to deposit in the future, but just cleaning them will often work for a long time.



The Diagnostic Assistance System is the current Mercedes-Benz factory diagnostic software system. If you do enough work on Mercedes-Benz cars, it is probably worth your while to invest in this equipment. It allows full access to each computer-controlled system on the car. While it can't tell you the tire pressure yet, don't count on that being permanently out of the system's reach.

Air injection pumps are among the oldest of emissions controls. When the engine starts dead cold, the mixture has to be much richer because it is hard to get fuel vaporization without operating heat. But this leaves an unwelcome amount of hydrocarbons in the exhaust, exhaust that is still too cold to trigger the effects of the catalytic converter. The air injection system blows air into the exhaust manifold immediately behind the exhaust valves, where the exhaust is still hot enough to burn. Air injection runs for two or three minutes immediately after startup and then shuts off for the next cold start. Once these pumps were belt-driven; newer ones are usually electrical. By anecdotal report, the most frequent problems are defective check valves, allowing exhaust to blow back into the system, and cracked vacuum lines, defeating activation of the system by the computer.

Misfire, Backfiring

How can an engine have consistent and pronounced stumble, misfire and backfiring, yet show no codes and no peculiarities on the scope patterns, spark or fuel? That was the problem the shop had with a 1990 300 SE.

All the gravy work had already been done, and presumably paid for, at other shops. It had new filters everywhere, new wires, cap, rotor and wires. There were even new serpentine belts and tires, but the shop was reluctant to ask whether they had been an attempt to solve the problem. Blasting carb cleaner down the tube reduced the problem slightly as long as you kept up the spray, but there was no reason to doubt the fuel system. Besides the new filter, the pulsewidths were plausible and the volume and pressure were on the money. They suspected a bad EHA, but there was no difference in the way the engine ran with the EHA connected or not, other than the CEL that turned on.

When all else fails, as they say, go back to basics. If you were working on a 1965 car with the same symptoms, you'd check for fuel (which they had), for spark (which they had) and for compression (which they had). Then if you could get the engine running at all, you'd check for manifold vacuum, which they did. With cars sold all over the world and operated at all altitudes and climates, there's no spec for that, but their reading was 12 in-Hg. They'd never seen an engine that ran with that kind of vacuum at idle.

A bit more testing led to the timing chain, which had worn enough to throw the camshafts out of time. You read sometimes about timing chains stretching. They don't stretch, of course, because that's not what happens to steel. But they wear at the pivot pins and might allow excessive slack, which is for practical purposes indistinguishable from stretch.

Diagnosing the vapor recovery system can be among the more difficult tests on a vehicle. The purpose of the system is to capture in a charcoal canister the most volatile vapors given off by the fuel and then to route them into the intake manifold and combustion chamber once the engine is running at normal temperature and cruise load. The purge solenoid here activates to open the vapor lines and vent the stored vapors in the canister. Most problems with the vapor recovery system derive from fault codes stored, fault codes indicating a leak detected by vacuum or pressure loss.

No gas engine runs without spark, and some engines have multiple sparks, like this dual-spark engine. In any case, all coils work the same way, as transformers: They take the primary voltage and current and build with them a magnetic field. When the primary circuit suddenly shuts off, the magnetic coil suddenly collapses, and in the collapse it generates a very high voltage (and very low amperage) in the secondary windings. Coils are still relatively simple, checked with resistance measurements. Unfortunately, they can still be misleading: Only the way they work counts, not the way they measure. Some coils have internal circuit specs within specs but break down under use (an ohmmeter doesn't stress the insulation much, after all). Check them, but then test them with a grounded plug tester.

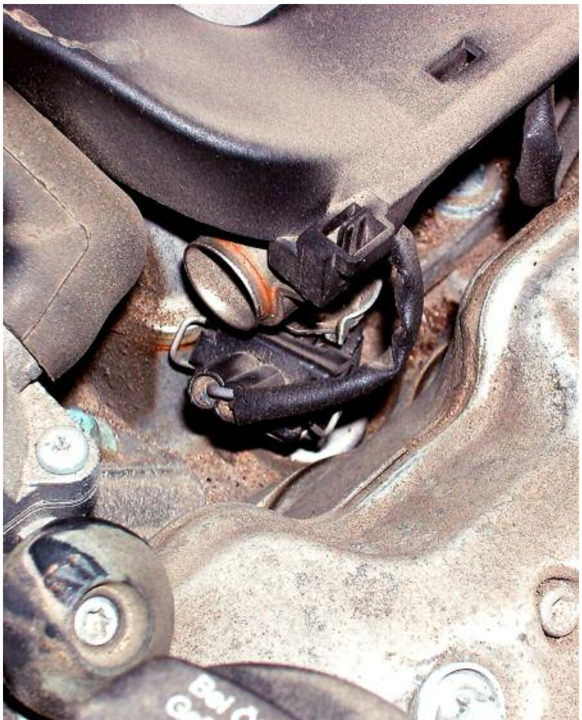
However subtle and complex automotive engines become, they are still cast metal and steel, and those parts are subject to wear. Diagnosis has to include the physical state of the engine if it is to discover all the problems that can occur.

Plugged and Re-plugged, but!

This one didn't fit the trouble-tree charts at all, nor did it set any codes, and you'll understand why. The '93 190 ran fine at all speeds but idle. It worked fine at idle for two or three seconds, after which the idle speed motor shut down and dropped idle to stall the engine.

The shop checked the crankshaft signal, which had to be there for the engine to run at any speed, but they wanted to see whether there was something odd about the trace. It was normal. The coolant temperature and the CTS signal were right on the money. So were the airflow signal, the oxygen sensor signal and everything else they could think to check, including voltage drops at grounds everywhere the engine management system worked. This was beginning to look like what the car needed was a new ECM.

But they knew from the owner, this car had made the rounds to different shops previously, not for this problem but for a high idle, solved by replacement of a non functional TPS. So they began looking it over for boners that may have been built in. There was nothing obvious, no golf tees in vacuum lines, no slabbed-off EGR valves. Oddly, unplugging the new



Just as no engine can run without spark, no engine can run without fuel. It's astonishing how many years the basic pulsed Bosch fuel injector has done the job on engines of every kind. Even at that, an injector cleaning is a worthwhile occasional service, using a suitable cleaner. If one injector proves defective, check the others very carefully as well. As finite-life elements in the engine's controls, the entire set is likely to need replacement at about the same time.

TPS did not affect the idle speed. But the prospect of buying a new ECM that might prove unnecessary makes you very careful about your inspections, and eventually they found the problem. The connectors to the TPS and to the airflow position sensor had been inadvertently switched! Each of them uses the identical three-pin terminal, but the TPS circuit has four wires instead of the airflow position sensor's three. Once the connectors were correctly attached, the idle problem was gone. The moral of the story? Always speak well of other shops, but check their work.

Scrambled Brains

The car, a '93 300E, came in under its own power, but backfiring and running very poorly at any throttle setting. The motorist, however, wanted the charging system checked since his battery had gone completely dead overnight and he'd had to start the car with a jump.

Cam sensors have become more important as engine control systems have become more complex. Originally they served principally to sequence the fuel injection systems once Mercedes-Benz went from the CIS-E systems to the SFI systems. But as camshafts become themselves variable, the performance of the engine, both in terms of emissions and in terms of output, the sensors had to become more and more sensitive.

The charging system was working perfectly, and once fully charged the battery held its charge. There was no continuing power drain, so the shop supposed the motorist must have left a door open or something else pulling a small current load. Poor running, however, proved much harder to solve.

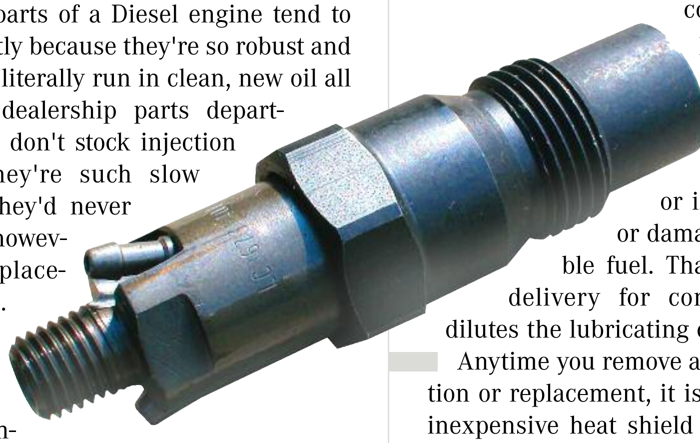
The CEL was on and there were many codes set, too many to be of any help. After recording them all and clearing them, the one that persisted was 13, oxygen sensor at lean/rich limit. When they checked the sensor, it went to full rich at idle and to full lean at every other throttle setting. The shop went over each of the sensors and each of the actuators, and everything was working properly. Realizing that if they had good information going in but bad information coming out, they realized this was one of those rare ones that really did need a new computer. But why?

Once the motorist returned he did explain that when he first hooked up the jumper cables, there was a big spark. So he turned the cables around and got the car started that way. He'd reversed the polarity, one of the best ways to scramble microprocessor brains. Evidently the reason it didn't pop the fuse on the overvoltage protection relay was that the battery was discharged so much that the bulk of the current went through it rather than into the circuits, leaving just enough to fry the fuel control circuits but not enough to melt the fuse.

PARTS NEWS

DIESEL INJECTORS

The fuel system parts of a Diesel engine tend to last a long time, partly because they're so robust and partly because they literally run in clean, new oil all the time. Several dealership parts departments told me they don't stock injection pumps because they're such slow movers; one said they'd never sold one. Injectors, however, do require replacement sometimes. Since their tip is exposed to the thermal and chemical stress of the combustion chamber, it can sustain accelerated wear or corrosion if something goes wrong in there. For an injector to fail one of two things happen: It doesn't spray when or where it should or it sprays when or where it shouldn't. If it plugs up with debris or deposits or if the same causes make the pattern change and the atomization fail, the fuel will not enter the prechamber in either the quantity or the configuration required for proper burning. If there is wear at the tip, preventing it from sealing against the residual hydraulic fuel pressure, or if something lodges it open or damages the spring, it can dribble fuel. That makes the beginning of delivery for combustion inaccurate and dilutes the lubricating oil with fuel.



Anytime you remove an injector either for inspection or replacement, it is a good idea to replace the inexpensive heat shield at the bottom of the bore. The heat shield works in part by the spring force it applies to the injector and the prechamber surface, and the amount of this force determines in part how much heat it can carry away from the business end of the injector. It's also usually easier to replace the bypass hoses than to refurbish the old ones.

MAF SENSOR

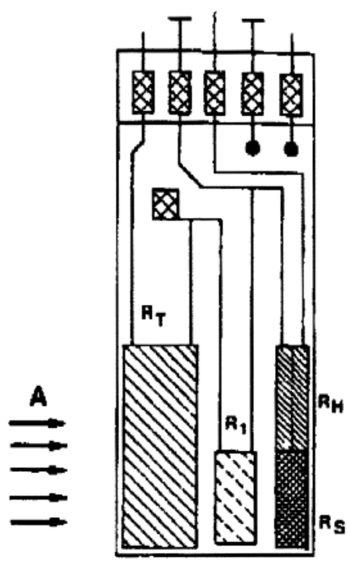
The mass-airflow sensor is the most accurate device to date to track the exact amount of air ingested into an engine. It works, as you know by tracking the change of temperature and thus the resistance and current in a special element in the center of the sensor. With no moving parts and nothing exposed that can corrode, these should last forever in principle. However they are subject to contamination if deposits or small objects collect on the sensor wire, materials that are not removed during the burn-off cycle after the engine shuts down. Sometimes these deposits are from fuel condensed on the wire later, particularly when someone most frequently uses the car for very short trips, never allowing the engine to reach and sustain operating temperatures. Sometimes they come from particles that break loose from the inside of the air filter and lodge where they can slow the air blowing over the sensor. Sometimes the air filter has a crack in it or the owner drives with the air filter removed.

It's nearly impossible to clean the sensor without destroying it, so the sensor needs replaced. While you're at it, a new air filter is an excellent piece of mechanical insurance to add.

FACTORY SERVICE BULLETINS

These suggestions and solutions for technical problems come from service bulletins and other technical sources at Mercedes-Benz selected and rewritten for independent repair shops. Your genuine Mercedes-Benz parts source can obtain any item designated by a part number. In keeping with our driveability and Diesel themes, the bulletins this issue have to do with them.

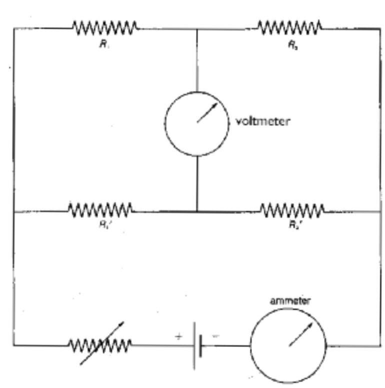
MAF Sensor Troubles
All Models with Motronic



A. Intake air stream
B Heat
R_H Heat resistor
R_S Sensor resistor
R_T Air temperature resistor
R_1 Trim resistor

The mass airflow sensor is the major input to the computer that reports the amount of air entering the engine, a factor critical to bringing the fuel mixture into as close as possible an approximation of the ideal that fine-tuning from the oxygen sensor feedback signal can serve for the final measure. The control system can keep the engine running if the MAF signal fails completely, but it is not always possible for the computer to tell the sensor is wrong.

Here's what the sensor does: The computer uses its signal to determine the minimum injected fuel quantity, the warm-up enrichment and the acceleration enrichment. It is factored into the calculation of ignition timing during warm-up and at WOT. The computer uses the MAF signal as well as other inputs to determine whether the catalytic converter is operational, when to employ the feedback mixture signal, camshaft adjustment, overheat protection, how to correct for intake air temperature and when to reduce power to protect the transmission.



Here's how it works to do that: Its internal resistors are arranged as a Wheatstone bridge. A Wheatstone bridge is a set of resistors of known and unknown resistance that can determine the value of the unknown resistance to great precision. The unknowns are the resistors that change value with the air temperature and (the hot-film, earlier the hot-wire) with the amount of heat carried off by the passing airstream. The electronics of the system increase or decrease the current through the Wheatstone bridge circuit to keep the voltage across the middle of the resistors at zero. While the diagram shows a rheostat, current actually varies by duty-cycle. The duty-cycle required to keep the cross-bridge voltage constant corresponds accurately (though not linearly) to the mass of the airflow.

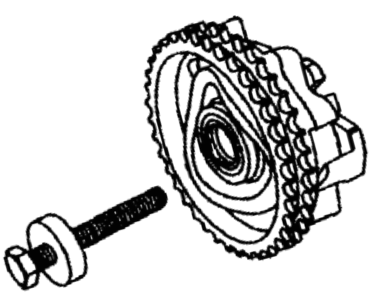
Resistance, as we know from basic electrical theory, varies with the current flow. So for a given circuit, the resistance increases as more current passes and decreases with less current. Check the resistance through a lamp filament when it's very bright, and you'll find more of a voltage drop (corresponding to more resistance) than you will through the same lamp filament if you dim the light. In exactly the same way, current flow varies with the resistance, so when a larger air mass carries off more heat from the MAF element, its resistance goes down. That throws off the Wheatstone bridge voltmeter, and the electronics increase the duty-cycle and current through it, raising the resistance back to put the bridge voltmeter in balance again. Needless to say, this happens instantaneously; there is no dipping and spiking.

Things can burn out in a MAF sensor, but they rarely do. The more frequent problem is the gradual accumulation of small amounts of debris and deposits over the sensor. As these contaminants accumulate, the sensor reports an air mass that is gradually smaller and smaller than the true intake air mass. The computer can employ various algorithms to correct for this, using information from the manifold pressure and air temperature sensors, the throttle position sensor and others, finally correcting the delivered injector pulsewidth with feedback from the oxygen sensor. But this can't go on indefinitely before the sensor signal falls outside of correction range. And while people try it, cleaning a MAF sensor frequently damages the sensor more than the original problem (if there was one).

The problem is that a false MAF signal can remain within a plausible range given throttle position and other factors, yet still be off enough to drive the mixture out of stoichiometry. At a certain point, then, SWAG-testing with another MAF sensor becomes the reasonable next diagnostic step.

WIS

Centrifugal Advance Drum
All Diesels



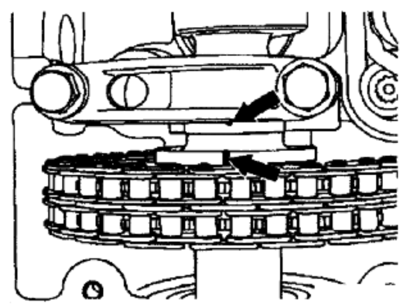
If you're changing an injection pump or even replacing a timing chain, you may have occasion to remove the centrifugal advance device at the chain-end of the pump shaft. Before you go back to the compressor to ratchet the air pressure control switch up, keep in mind the bolt holding that drum to the shaft tightens counterclockwise; it's a 'left-handed' bolt. With enough force, you can turn it the other way, but not far and not inexpensively.

G/11/02

'Stretched' Timing Chain
Model 124 with Engines 602 or 606, Model 140 with 603

Diesel engines are very durable, but they do decline in specific ways over time. Here are the symptoms you might expect from a 'stretched' (i.e., worn) timing chain:

- Rattling or other noises from the chain cover area
- Rough running engine
- Hard starting
- Loss of power (consistent)
- Increased lubricating oil consumption

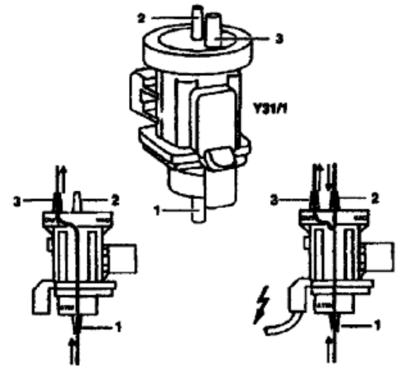


Here's the best way to determine whether there has been timing chain 'stretch' beyond specifications:

With the timing cover off, turn the engine by hand with the crankshaft bolt in the normal direction until the timing mark on the camshaft lines up with the mark on the camshaft bearing cap. Then check the position of the crankshaft pulley compared to the graduated scale and the needle on the block. If the camshaft timing is off by 3 to 10 degrees, replace the timing chain. While you're inside the cover, turn the crankshaft through two complete cycles so you can inspect every tooth on every sprocket. Some wear on the chain guides is normal, but there should not be any on the sprocket teeth.

SI 05/91

The *Other* EGR
All Recent Diesel Models



Codes flagging emissions system failures as well as driveability symptoms that point to EGR as a problem can involve more than just the EGR valve itself. Besides the EGR position sensor atop the EGR valve, one of the more likely problem areas is the EGR system's vacuum transducer. This component connects vacuum from the vacuum pump (the same one that builds vacuum for the power brake pneumatic circuit) to actuate the EGR valve under circumstances when there should be circulation. The transducer has a pneumatic line to the pump, to the EGR valve and a vent to atmospheric pressure. It gets a duty-cycle pulsed signal from the computer to open, close or move the valve; and it achieves these objectives by connecting the vacuum source (line 2 on our diagram) to the EGR valve itself or to atmospheric pressure.

If there is no signal to the transducer, it leaves the valve closed. If its internal diaphragm fails, it leaves the valve closed. If it shorts its internal coil, it leaves the valve closed. If a leak develops between the vacuum pump terminal and the EGR, however, it can cause constant application of EGR. The system does not distinguish a failure of the transducer from a failure of the valve; you have to determine that by testing.

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615-742-8000

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

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

Harlingen
Cardenas Autoplex
956-425-6000

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

Houston
Mercedes-Benz of Houston North
281-873-6000

Houston
Star Motor Cars
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Laredo
Powell Watson Motors
956-722-5182

Midland
Britt Imports
915-699-7993

Plano
Ewing Autohaus
972-599-0909

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

Temple
Garlyn Shelton Imports
254-771-0128

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

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

Richmond
David R. McGeorge
804-755-9300

Roanoke
West Motor
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
Sutherland Motors
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

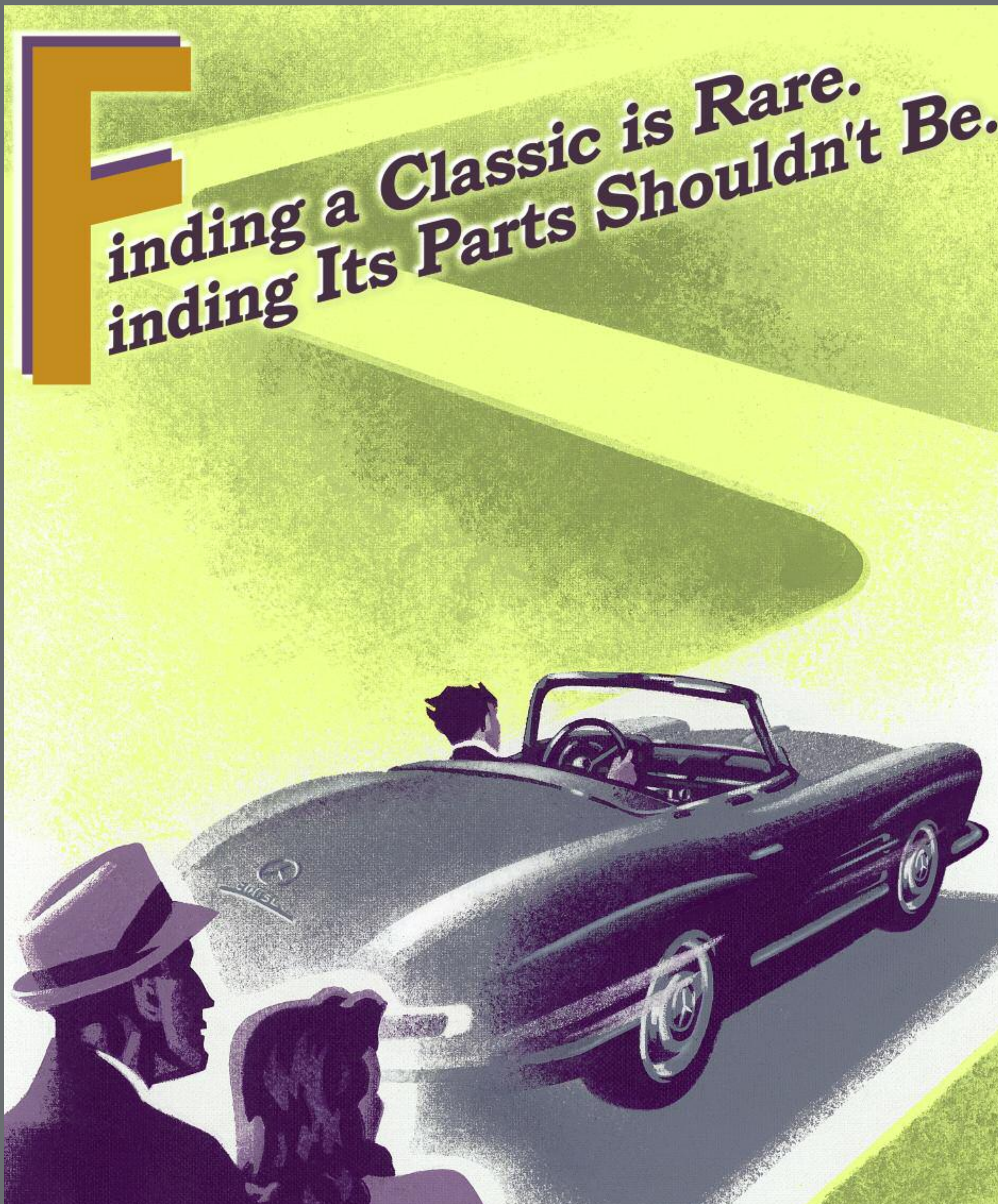
Appleton
Enterprise Motorcars
920-749-2020

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



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