

STARTUNED®

Information for the Independent Mercedes-Benz Service Professional

December 2003 U.S. \$6.00 € 12.50



Fire & Ash

ESP



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.

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 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 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.

Send your suggestions, questions or comments to us at:

StarTuned

One Mercedes Drive

Montvale, New Jersey 07645

Phone: 1 800 225 6262, ext. 2647

e-mail: StarTuned@mbusa.com



STARTUNED®

Information for the Independent Mercedes-Benz Service Professional

December 2003 U.S. \$6.00 € 12.50

Group Publisher
Christopher M. Ayers, Jr.
cayers@cmacomm.com

Editor
Joe Woods
jwoods@cmacomm.com

**MBUSA Technical
Content Advisor**
John Heibler
heiblerj@mbusa.com

Project Director
Andrew Brzozowski
BrzozowskiA@mbusa.com

Art Director
Jef Sturm
jsturm@cmacomm.com

Production Manager
Joe Cristiano
jcristiano@cmacomm.com

Circulation Manager
Phillip A. Helon
phelon@cmacomm.com

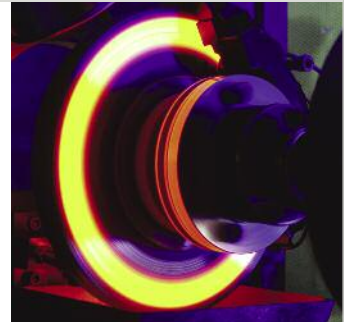
List Consultant
NFocus

StarTuned is a quarterly publication of Mercedes-Benz USA, LLC ("MBUSA"). No part of this newsletter may be reproduced without the express written permission of MBUSA. **Editorial and Circulation Offices:** 598 Pine Point Drive, Akron, Ohio 44333. **Caution:** Vehicle servicing performed by untrained persons could result in serious injury to those persons or others. Information contained in this newsletter is intended for use by trained, professional auto repair technicians **ONLY**. This information is provided to inform these technicians of conditions which *may* occur in *some* vehicles or to provide information which could assist them in proper servicing of these vehicles. Properly trained technicians have the equipment, tools, safety instructions, and know-how to perform repairs correctly and safely. If a condition is described, **DO NOT** assume that a topic covered in these pages automatically applies to your vehicle or that your vehicle has that condition. *StarTuned* is a registered trademark of MBUSA.

FEATURE ARTICLES

04 FIRE AND ASH

Brakes are machines to convert momentum to heat. They must shed some dust at work. Here's why.



10 ESP

It seems magical, the way ESP retains traction even when it seems lost. But once you understand how it works, the magic is technology.



DEPARTMENTS

25 PARTS NEWS

Whether for vehicles long out of production or for modern ones, your best source for Genuine Mercedes-Benz Parts is Mercedes-Benz.

26 FACTORY SERVICE BULLETINS

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

27 GENUINE MERCEDES-BENZ PARTS... NEARBY

Wherever you are in the United States, there's a nearby source of genuine factory parts for your customers' Mercedes-Benz vehicles.



Mercedes-Benz



FIRE

AND

HEAT

**SPEED INTO HEAT,
THAT'S BRAKES AT WORK**

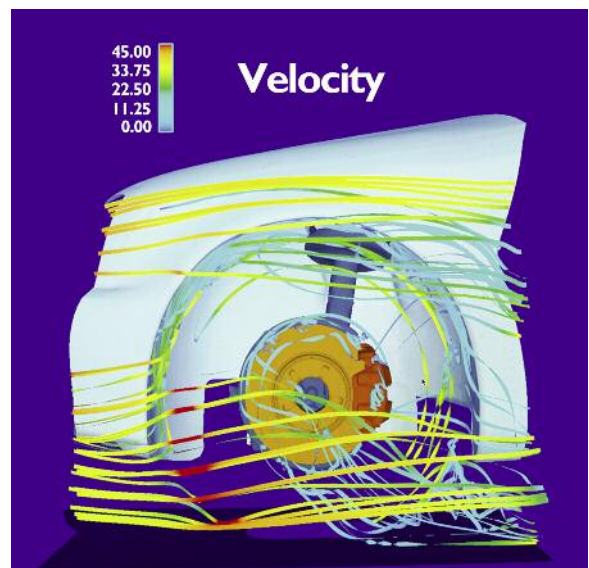


One of the more recurrent questions motorists raise is: “Why do my wheels keep getting dusty, even though I clean them so often? The rest of the car doesn’t collect dirt like that. Can you do something to stop all this dust from settling on my wheels?”

The right answer should be, ‘Can, but won’t.’ And the rest of the right answer is ‘What’s more, doing anything to reduce the formation of that dust would be a mistake. Just keep cleaning the rims if it bothers you.’ Here’s an explanation we hope will be useful and interesting for your customers as well as for you in the shop.

The dust on the wheels is residue from the brake pads and rotors, worn off as the brakes stop the car. It includes some ordinary road grit and tire rubber, too, because the braking system draws air from the underside of the car and blows it toward the outside, carrying whatever road and tire dust it sweeps along. As you can see from the color-coded, virtual smoketrails in the computer ‘windtunnel’ graphic, the air adjacent to the wheelrim is, somewhat surprisingly, the slowest moving air around the car, so that’s where the dust settles.

So why not just trick the car out with solid wheels, after the fashion of ‘moon disks’ from the 1950’s? A chopped and channeled, candy-apple red



In this computer graphic, you can see by the color-coding the relative speed of the air passing around and through the wheel through different paths. Dust will settle where the windspeed is slowest. That’s also where the brakes generate all the dust and heat



Brakes are machines for extracting energy to slow a vehicle. They're designed to produce and remove heat and deliver it to the outside air, but if they absorb more heat than they can dissipate, as in this experiment, the temperature of the pads, rotor and eventually caliper just increase. The only thing cooling brakes is the air drawn through them and blown out the wheels, and that air channel must stay open if the brakes are to function safely. With no air-dissipation limit to the heat buildup, either brake fade from boiling brake fluid or mechanical failure can occur. You can imagine what this kind of heat, sustained even a little while, would do to wheel bearings and grease seals as well as to the caliper rubber. Enough heat could even set a cast-iron brake rotor on fire.

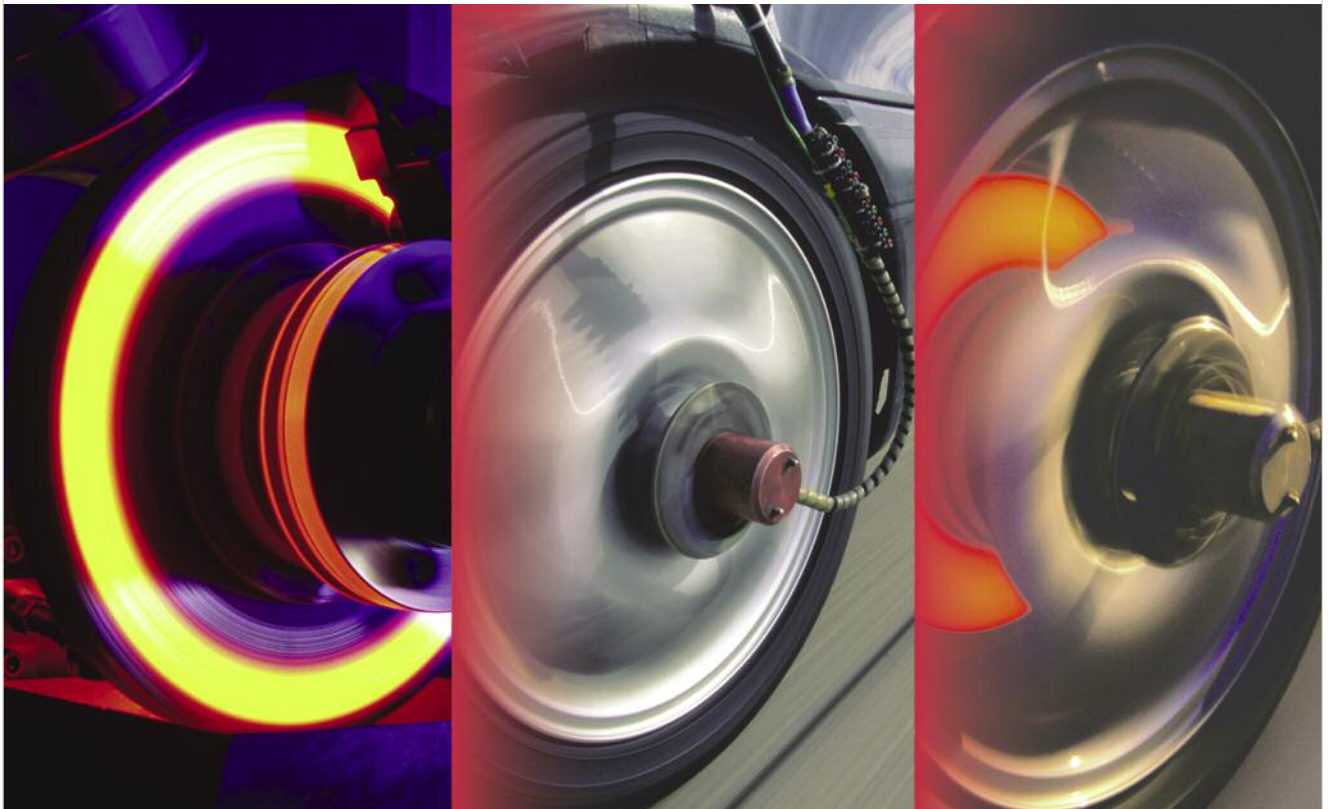
bathtub Hudson Hornet won't show dust on its wheels. A manhole-cover, slab hubcap would certainly stop the flow of air and the dust it carries along. And the smooth surface would allow a faster perimeter airblast, preventing most of the dust from collecting on the wheels.

Of course, so would removing the brakes altogether. No brakes, no friction, no dust. Nobody would be so rash, surely, as to consider that option. The 'manhole/moon-disk' option, however, is just a once-removed version of that preposterous suggestion. Let's see why.

Consider what brakes do. A moving car is, besides a transportation vehicle, a climate-control chamber, a portable private space and all the various other automotive things we think of, besides all that, it is fundamentally a kinetic object, carrying momentum in a particular direction. We know from basic automotive physics that a car driving at a steady speed-limit cruise along a flat, straight highway may only require 15 or 20 horsepower to

maintain its movement, and much of that goes to power lights, air conditioning, power steering and other accessories.

But that's not the total power stored as kinetic energy in the moving car. The total momentum is the torque required to raise the vehicle speed from a standstill to highway cruise. For most cars – perhaps not those with the most powerful engines – that requires, let's say, 30 seconds of the better part of the engine's power output. Once up to speed, all that engine power it took to get there remains stored as the momentum of the moving car. To bring the car to a halt requires absorbing and dissipating the same total amount of energy – and sometimes in much less time than it took the engine to build it up. The brakes on any modern car can bring it to a stop from a given speed much more quickly than the engine – than any engine – can raise the speed up to the initial velocity. A conservative estimate is that most cars' brakes can generate deceleration roughly equivalent to 1500-2000 horsepower.



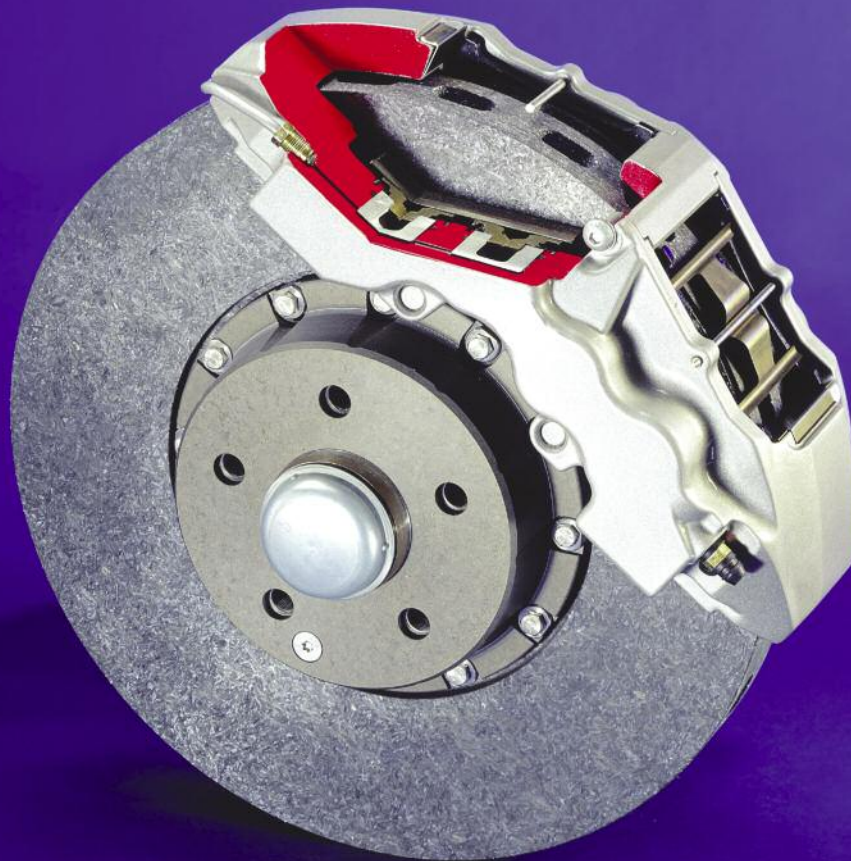
Brake testing is one of the most extensive projects for a car manufacturer. Test cars, festooned with dozens, even hundreds of sensors, record temperature and other changes in many places over any kind of condition the vehicle may encounter. These tests are repeated many times to determine the best combination of design, materials and function. Changing something as critical as the flow of cooling air through the wheel, as in an attempt to stop brake dust, for instance, can adversely affect brake performance and safety. Changing something as critical as the wheel design, particularly for nothing beyond cosmetic reasons, could be a very imprudent amateur modification. It isn't that form follows function; it's that long, careful testing has determined the best form for the function.

All of that power, 100 percent of it, has to take the form of heat transferred to the air. The energy transmission path is not obvious, though: The momentum of the moving car is the average kinetic energy of all the molecules constituting it. They vibrate at all sorts of speeds in every direction, but if the car is moving down the road at 60 mph, their average speed is 60 mph forward down the road. What the brakes must do in a stop is to change this average, change it so the molecules of the car still move in every possible direction and speed, but their average balances out to zero relative to the road surface. That means the brakes have to increase the average speed of (let's suppose the car weighs 4000 pounds) two tons of surrounding and bypassed air by 60 mph, or one ton by 120 mph, and so on.

The heat of any object is the average speed of its constituent molecules, plain and simple, whatever the material, cast iron, engine coolant or air or anything else. The brake system includes all the vehicle

components that convert movement into heat at the friction surfaces, the pads and rotors, and from them into the air. Each of the vented rotors includes vanes between the surfaces that function just like the impeller in a water pump, flinging air at the center of the hub outward through the disk and drawing fresh air from the underside of the car to the center of the hub. Heat dissipation occurs, then, by conduction into the adjacent metal parts, and by radiation into space, but mostly by convection (and forced convection) into the air. As a car slows, it blows whirling plumes of hot air through each of its wheels, air drawn from under the car, forced through and around the disks and out to the sides.

Brakes don't just slow cars from cruise speed, however. Perhaps the hardest stress on a brake system comes as a car descends a long, steep mountain. The driver doesn't stop the car but uses the service brakes (hopefully in conjunction with engine braking) to govern the descent speed. In this case, the amount of energy is not just what the



Brake development continues. In this proposed carbon-ceramic brake, both pad and rotor are made from the black, fibrous material. Carbon is remarkably strong and heat resistant, but the manufacturing techniques took a long time to perfect. Its major advantage over a steel rotor is weight: The carbon-ceramic disk weighs only about a third what the traditional brake disk does. That allows many suspension improvements, because that mass comes entirely out of unsprung weight, smoothing the ride and improving the traction.

engine produced to bring the speed up to cruise, but all the power that went into lifting the car up the other side of the mountain. All of that energy must flow through the brake system, translated by friction from kinetic energy to heat in the ambient air. This extraction of stored energy by gravity is the same source that spins turbines in hydroelectric dams or accelerates a roller-coaster downhill, except (until we start using hybrid gas/electric cars with electric regenerative braking) the car must just dissipate that power.

For effective brake design and materials selection, a carmaker must make very extensive tests, varying the dimensions and geometry of the mechanical and hydraulic components, experimenting with different pad compositions and rotor surface qualities. This can be tedious work, since there are so many variables to test. There are more objectives than just braking power, considerations

like the mechanical strength of the components, the durability of the friction surfaces, noise attenuation, the consistent increase of friction with greater hydraulic pressure. Few brake-test experiments involve white-knuckled emergency stops from high speeds; many record nothing beyond the gradual buildup of brake heat over a measured series of modest brake applications to determine just how fast the brakes can dissipate heat in ordinary driving conditions.

But in all of the completed brake systems, the free circulation of air through and around the disks and through the wheels is critical. Yes, the car could make a single emergency stop even if the brakes simply retained all the heat they generated. But it couldn't make another stop in any reasonable time after the first, and it could not control a long downhill speed with the brakes.

Finding a Classic is Rare. Finding Its Parts Shouldn't Be.



Relive the good ol' days. Mercedes-Benz makes it easier to find classic car parts. Call 1-866-MBCLASSIC, and Mercedes works to track down the genuine Mercedes-Benz classic part you need. So you can be sure of one thing: they really do still make 'em like they used to. Visit MBUSA.com/classic. **Genuine Mercedes-Benz Parts**



Mercedes-Benz

ESP

SENSING THE UNSEEN, BALANCING THE FORCES, HOLDING THE COURSE



Grabbing for traction when there isn't much to grab.

Shazam in a séance! The marketing acronym for this Mercedes-Benz traction-control system puns against the once-fashionable notion of 'extra-sensory perception,' a collection of now-discredited delusions of semi-magical knowledge ('parapsychology' and its related pseudo-sciences). On Mercedes-Benz cars, however, *ESP* refers to the Electronic Stability Program, standard to begin with on 12-cylinder cars, optional on 8-cylinders and later on others, available perhaps on most Benz carmodels eventually.

The system is 'extra-sensory' only in the removed (but entirely accurate) meaning that it has additional – that is to say, extra – sensors and microprocessors, extra components other traction control systems don't. Its functional operation, however, certainly does seem magical – until we remember Arthur C. Clarke's observation (he wrote *2001, A Space Odyssey*) that every technological advance seems like magic, until later, once we understand how it works. Or you may recall the scene in *The Wizard of Oz...* "Pay no attention to that man behind the curtain!" The Wizard's Emerald-City hocus-pocus evaporated completely, the moment the Yellow-brick-roaders saw inside the contraptions of his wizardry.



The unique components for ESP include a yaw sensor, a lateral acceleration sensor and a steering wheel angle sensor. The system shares the wheelspeed sensors as well as hydraulic and electrical control units with ASR and ABS. But the entire ESP traction control encompasses the entire car.

Well, here at *StarTuned*, we want to pull back all the curtains, so you can watch all the 'little-men-within-the-machinery,' busy at their digital and hydraulic work. We want to replace the illusion of magic traction in Mercedes-Benz' ESP with a clear understanding of the system's strategy and tactics, of its interrelated sensors, of its control units and actuators. This issue, we'll cover the overall system and its sensors, along with a few interesting oddments. Next time, we'll talk about the actuators, review some diagnostic procedures and conduct several thought-experiments.

More practically, of course, we also want to explain how to repair the ESP system should you find problems. Your customers may suppose you're a mechanical mystic or a digital dervish, but you'll know better. With ESP as with all serious automotive work, you must solve and correct real, objective problems – not fanciful, imaginary ones. There may be vehicular hypochondria on the part of some motorists, but there's no placebo-effect with the machine, itself, so a car requires a knowledgeable mechanic and not a prestidigital marketing magician. And development of that objective technical knowledge, of course, has been our objective since our first issue.

ESP Underway

While the system relies on very rapid hydraulic/mechanical and near-instantaneous electrical functions rather than on occult powers, if you push the car to its traction limits, it certainly does seem mysterious, the way the system retains or recovers control under circumstances where all your previous driving says you'll lose it and slide or spin.



I tested a Mercedes-Benz with ESP on an empty parking lot in a snowy New England harbor, erratically mottled with blobs of partially frozen but still very slippery seaweed from an unusually high winter tide. An ocean-churning Nor'easter had uprooted the stuff from the seafloor the day before, and the high water left little slimy tufts stranded around the salt-damp blacktop. Then the snow fell, making a perfect erratic surface for a traction-test. A buttered glass road with scattered handfuls of marbles could not have been more unpredictably slippery.

After accelerating, braking and cranking the steering wheel from right bump stop to left and back, I had to spin the test car through a 180 using only the parking brake. Could there be something peculiar in the tires, in the seaweed or on the snowy asphalt to make the wheels follow the intended track so closely? I knew how ABS controls a braking stop and how ASR keeps the drivewheels from spinning under acceleration, but even understanding those systems, I was astonished how effectively ESP kept the vehicle on course in the erratic poor traction.

The car shuddered and shivered as I spun the wheel right and left. But it went where I aimed— not perfectly smoothly, not any more than a full-pedal ABS emergency stop is perfectly smooth — but it always held the course I chose, up to the very edges of traction, even through the intermittent slimy globs of beached seaweed. Just as ABS and ASR pulse brakes off, ESP pulses specific brakes on, to control steering.

You probably recall how impressive it was the first time you pushed a vehicle's brakes into an ABS-brake pulse or floored an ASR throttle on an uneven, slippery roadway. In the absence of an empty, snowy, slippery parking lot, it's harder to test the ESP system. But if you get the chance, you'll find ESP's traction control in turns is as surprising, and as enlightening, as your first ABS-pulsed stop. We learn things, I guess, through the seat of our pants as well as through the top of our heads. But working here with words and pictures on flat paper, we must take the second course.

What Does ESP Do?

ESP boasts a long pedigree from earlier Mercedes-Benz traction-control systems. ABS sets out to prevent skids and slips from a driver's excessive pressure on the brake pedal for the available traction, ASR from a driver's excessive pressure on the accelerator under similar conditions. ESP expands that objective to include slips and skids when a driver turns the steering wheel beyond what ordinary traction allows in the circumstances.

The parking-brake spin resolved my 'what's-up-their-sleeve?' suspicions of traction tricks, but the amazing part was the actual ESP operation, itself. Just as ABS pulses individual brake caliper pressures down or off to prevent lockup during slow-down, just as ASR feathers the throttle, spark and individual drivewheel brakes to prevent drivewheel spin during acceleration, ESP applies individual wheel brakes to prevent sideslip in a turn. It applies a brake on the axle that is not slipping, to correct the car's yaw resulting from the axle that is.

'Engage the Caterpillar'

It's somehow perversely fascinating that a very subtle, complex system like ESP includes something amazingly simple and direct at its functional core. Rowboats, bulldozers and sidepaddle steamboats steer by directly acting on the rotation of the vehicle. Want to turn your bulldozer right? Stop the right track, and the 'dozer pivots right. Turn your rowboat by pulling on one oar as you push on the other. Ditto with your sidepaddles on a Mississippi River steamboat.



It's the simplest of all steering systems: Stop one side, and the 'dozer grinds in a circle around it.

Ever operate a bulldozer? Know how to throw one into a turn? Or have you at least watched the tracked action? None of the alignment complications of caster, camber, toe or SAI. No concerns about toe-out in turns or suspension travel. The 'dozer just moves one track faster than the other and pivots — it yaws — toward the slower side, grinding the dirt beneath. Nothing complex or subtle about it.

Proof-of-Concept Cars



Mercedes-Benz is famous not only for its luxury cars, for its durable sedans, for its high-tech sports cars and for its long line of world championship racing cars, but also for its concept cars, cars intended as research vehicles rather than production prototypes. Among them was the F300 LifeJet. Like other concept vehicles, this one has served its purpose and probably won't be appearing in a showroom near you anytime soon. The F300 LifeJet has even more elegant successors, the F400 and F500, incorporating its variable camber, but they'll be our subjects another time.



The F300 is interesting in a discussion of ESP specifically because of its amazing ability to take a fast corner. It was not built as a particularly fast or powerful vehicle, using the engine from a small Benz sold in Europe and connected to its single rear drivewheel by a toothed drivebelt (shades of Milwaukee iron!). Seating two people in fore-and-aft tandem like an enclosed motorcycle, it is, however, very far from a bike.



If you've ever driven a three-wheeled motorcycle, you know the cornering drill: Stop, or almost stop, and then turn very slowly and accelerate again. This is even true for such near-threewheel-motorcycles as the Isetta from the 1950's (it had four wheels, but the rear drivewheels were only inches apart, just enough to clear the drivechain between them). A three-wheeled vehicle, in general, has much less inherent cornering capacity than one with four wheels, specifically because there's no good way to design in a low center of gravity.

Not so the LifeJet, by any means. On-board computers factor vehicle speed, steering wheel position, engine conditions and no doubt most other available data to calculate how much to angle each front wheel's camber. This allows the vehicle to lean into turns, but not just like a two-wheel motorcycle. This camber shift, as you can see, also shifts the vehicle's center of gravity toward the inside of the turn while increasing the track width toward the outside.



Special asymmetrical tires pivot to an area with a different rubber compound and tread for the really tight turns. With all the curve-carving 'magic,' the F300 can reportedly take a turn at over 1.6-G's. It is extremely rare for any ordinary car to take a turn at even 1 G. Since its maximum bank angle is 30 degrees, however, the driver and passenger don't have the same sense of the curve you would have in a four-wheeled car going around the same curve at anything like the same speed.

You might find it curious that even in such a radically different vehicle as the F 300 LifeJet retains so much of the look and feel of a familiar Mercedes-Benz sedan. The driver's view out the windshield, while narrower than from an S-class, carries many of the same ergonomic features and styling cues. The steering wheel, while trimmed like an aircraft's, still affords clear view of all the instruments. The designers have worked these characteristics out over many years and many more experiments, and they're not about to drop them just because the vehicle structure is so different.

In principle, that's what ESP does. If one axle starts to slip to the outside of a turn, the system applies a brake on the other axle to pivot the car's centerline back parallel with the direction of travel. How the system does this is a good deal less simple than how the output works, but the basic function is just as simple as that. We'll get to the non-simplifications shortly.

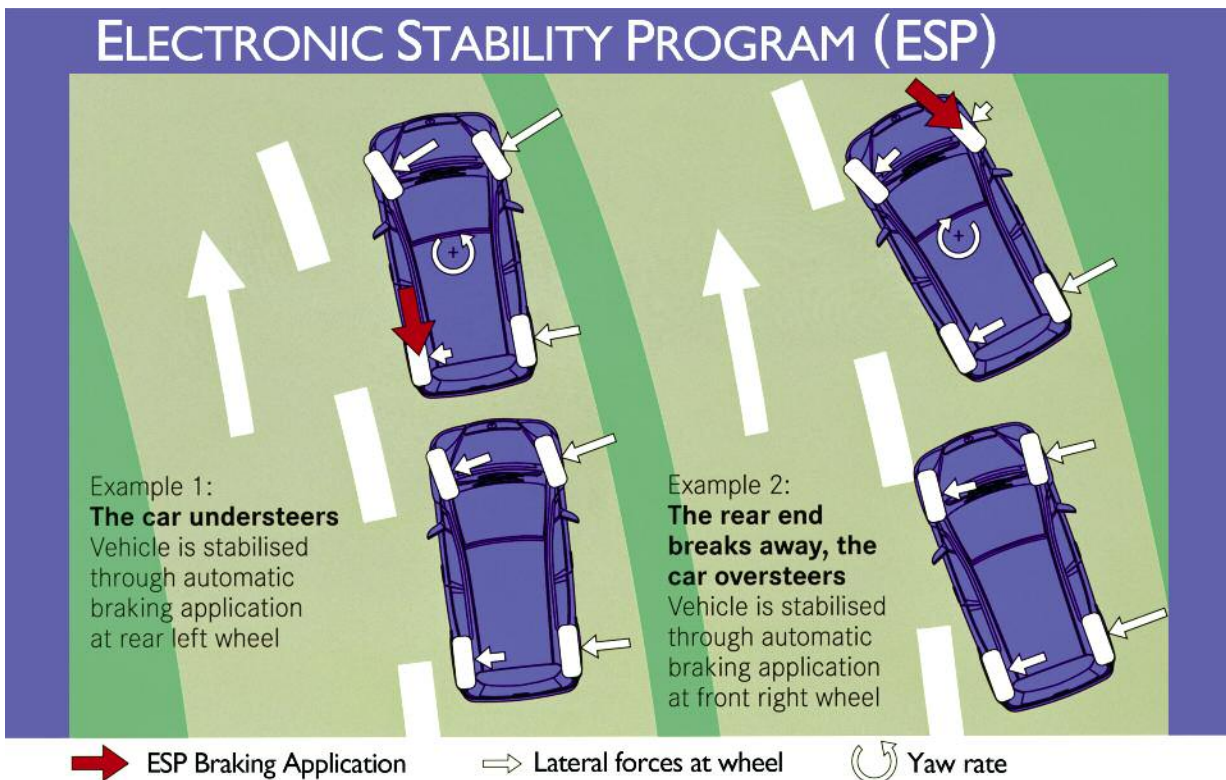
Right away, of course, the complications begin. First, on the ESP car, there's not one 'axle-bulldozer,' but two, one in the front and one in the rear. Activate the correct brake, and you correct the slip, but the system has to know which one to apply. Activate the wrong one, and you improve nothing, because the wheels on that axle were already sliding.

Understeer and Oversteer

Hold a car in a constant-radius turn and increase the speed around the circle, and eventually one of three things occurs: If there's enough traction (or if

the center of gravity were high enough), the car rolls over. If there's more traction at the rear wheels than at the fronts, the front tires can start to slide outward, and the curve opens its radius up. This is usually called "understeer." If there's more traction at the fronts than at the rears, the rears can slide outward, the curve suddenly tightens, and the car can spin around sideways or even backwards. That's called "oversteer." NASCAR fans, their conversations speaking from the traditions of oval-track racing, with the car frequently on the edge of lateral traction, favor calling the first "push" and the latter "pull."

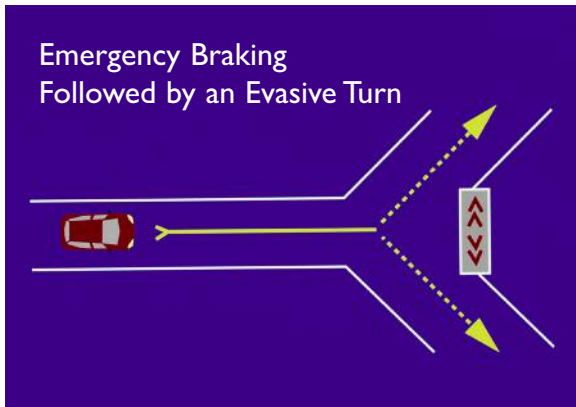
Since traction could never be exactly equal on each axle (or exactly proportionate to the load), every car must either oversteer or understeer. Which axle will lose lateral traction first? There's no way to tell across the board, of course, but for safety and by design most cars understeer rather than oversteer. Understeer is self-limiting in the sense that, once the front wheels start to slide outboard in a turn, the turn becomes less steep, the centrifugal force



How do you control wheel sideslip at one axle? With a single brake on the other axle, the one that's not slipping. This requires instantaneous data interpretation and brake actuation by the system. If the front wheels start to slip toward the outside of the turn, ESP activates the inside rear brake to yaw the car back into the correct direction. If the rears are the first to slip, the system applies the outside front wheel brake instead, for the same yaw correction. This graphic is perhaps misleading in one respect: Once sideslip begins, the sideforce at that axle reduces substantially. We should consider the sideforce arrows as flagging the force that was there a split-second before.

declines and with it the sideforce. Of course, there might be an immovable obstacle or a steep hillside on the side of the road, so stability is not an end in itself. It's also much easier for most drivers to recover from understeer by a combination of slowing and tightening the steering wheel angle.

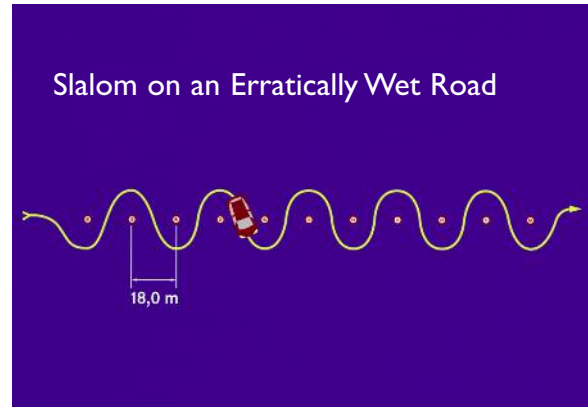
Oversteer is self-worsening. Once the rear wheels start to slide outboard in a turn, the turn becomes immediately steeper, and centrifugal force and sideslip increase. The slide gets faster very quickly.



How does ESP deal with this? You come upon an unexpected sudden barrier with insufficient time and insufficient space to stop and turn. Here's what happens: ESP usually includes Brake Assist, so the system detects your foot quickly depressing the brake pedal. BA immediately goes to full brake boost, and the ABS part of the system prevents the brakes from locking any wheel. ASR may employ the engine braking control and crack the throttle open to prevent drivewheel slide by the decelerating engine (whether this happens depends on how slippery the pavement is, what gear the car is in and so on). Since by hypothesis there's still insufficient space to stop, you rapidly turn right or left to avoid colliding with the obstacle. A good driver will simultaneously release the brake, but ABS can pitch in to release individual brakes if the driver is not experienced enough. ESP comes into play at the precise moment the car turns most sharply. If the car understeers, that is, the front wheels can't get enough traction to pull the nose of the car in the direction the driver chooses, ESP will activate the inside rear wheel brake to pivot the car around, just like the bulldozer track we saw earlier. If the car oversteers, if the rear wheels don't have enough traction to resist sliding toward the obstacle, ESP pulses the outside front brake to nudge the car back into the desired path.

It's much harder to recover from oversteer unless you have quick reactions, experience driving on ice and the presence of mind not to touch the brakes or reduce the throttle when it occurs.

You could make most cars oversteer, I suppose, by piling the trunk full with sacks of concrete or by using worn tires or sagged inflation. But under normal circumstances, most cars lose front wheel traction first, and nose to the right off the road or left across the lanes, depending on the direction of the turn.



How does ESP deal with this? The car drives through a uniformly spaced slalom course, but the pavement does not provide consistent traction. There could be patches of water, ice, loose gravel or other friction variations. Since the driver doesn't touch the brakes, ABS is just along for the ride. ASR might get to work if he's on the throttle hard enough to start to spin an inside drivewheel, but let's suppose not, let's suppose he holds steady throttle. Again, the car will either understeer or oversteer, and that should be inherent in that car all the time. The only way I can think of it could switch from one to the other would be if someone were tossing sacks of sand from the trunk while the car drove the course. If the car understeers, the fronts start to slide outward at each curve with insufficient traction. In that case, ESP pulses the inside rear brake just as it detects sideslip, correcting the yaw. If the car oversteers, the rears start to slide at the same points on the curves. Then ESP pulses the outside front brake to correct the yaw. The laws of physics apply throughout, naturally, so if the driver enters the slalom course at too high a speed or if the pavement is extremely slippery, neither ESP nor any other traction-control system can keep the car on his chosen path.

– ESP Article Continued on page 18

The Genuine Mercedes-Benz will blow

Mercedes-Benz Quality and Reliability at a Great Value.

The quality, reliability and value of the Genuine Mercedes-Benz Remanufactured A/C Compressor wasn't meant to be taken lightly. The A/C Compressor is not only an exact replacement for the original unit, it's also re-manufactured and tested to meet the same strict specifications as the original, so it performs just as well. And like all remanufactured parts, it's covered by the Mercedes-Benz limited parts warranty.* In fact, the only detectable difference you'll find between a Genuine Remanufactured A/C Compressor and a new one, is the price. Which we're sure you'll find quite refreshing.

Remanufactured for Mercedes-Benz using the same factory standards as new parts.

- Fits like new parts
- Performs like new parts
- Meets original specifications
- Backed by same warranty as new parts

Remanufactured to Genuine New Specifications

Cylinder Block & Front/Rear Housing

Cleaned, inspected, gauged, and honed to OEM specifications or replaced with new components as needed.

Discharge Reed Valve

Cleaned, polished, and inspected.
Replaced with new components as needed.

Steel Gasket

Replaced 100% with new components.

Oil

Replaced 100% with R134a-compatible oil.

O-Rings & Seals

Replaced 100% with O-Rings compatible with both R12 & R134a refrigerant.

Pistons

Cleaned and inspected. Replaced with new, if the treated surface is scratched.

Shaft & Swash Plate

Cleaned, polished, and inspected.
Replaced with new components as needed.

Shaft Keys

Replaced 100% with new components.

Shoes

Sized, cleaned, polished, & inspected.
Replaced with new components as needed.

Snap Rings

Replaced 100% with new components.

Suction Reed Valve

Cleaned, polished, and inspected.
Replaced with new components as needed.

Thrust Bearing

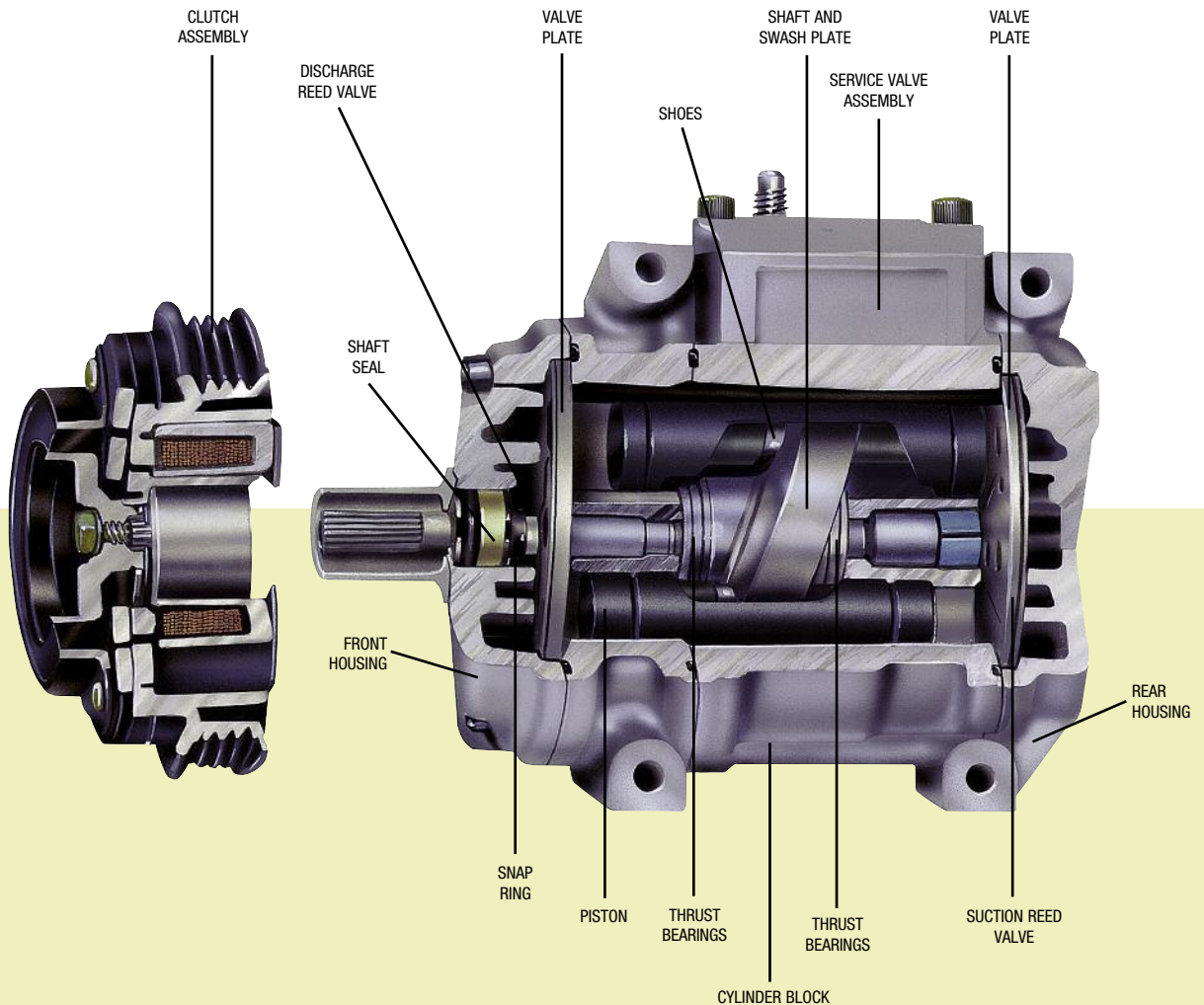
Cleaned, polished, and inspected.
Replaced with new components as needed.

Valve Plates

Cleaned, polished, and inspected.
Replaced with new components as needed.

Remanufactured A/C Compressor you away.

Genuine Mercedes-Benz Remanufactured A/C Compressor



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

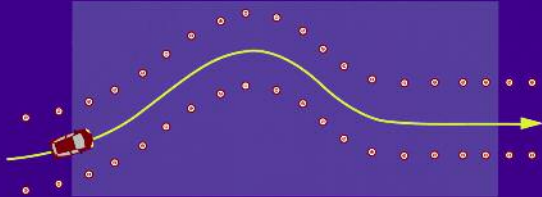


Mercedes-Benz Genuine Remanufactured Parts

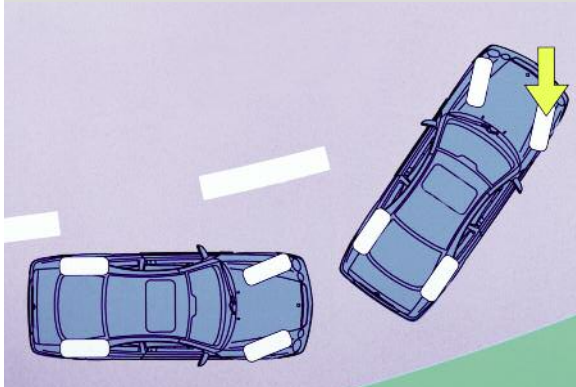
DENSO

Remanufactured for Mercedes-Benz by DENSO

Steady Speed Through a Compound Curve on a Slippery Road



How does ESP deal with this? A consistent speed through real-world turns on slippery pavement (snow, black ice, wet leaves). There are three steering changes, but we don't know the traction at any of them. As long as there's enough traction, ESP sits back counting wheel-speed sensor pulses and reading signals from its various other sensors. If the control unit calculates there is sideslip at one axle or the other, it triggers yaw correction using the other axle's corresponding brake.



Let's suppose the car understeers, but that the road is just too slick to recover traction. The front wheels slide outward in a turn, and the system applies the inside rear brake to pivot the car into line. It can't apply much braking force, naturally, because ABS reduces pressure at the first lockup wheel twitch. An understeering car, thus, widens the turn even with a properly functioning ESP if traction conditions are bad enough. But let's suppose the car oversteers. As the rears pivot outside, the system applies the outside front brake (yellow arrow). But now, there's a geometric point-of-no-return, after which no brake application corrects spin. If the inside rear wheel slides outboard of the outside front, the system can't recover. It's traction physics, not magic.

Roman Roads

Why design and build such a complex system as ESP? Part of the reason is that accident avoidance is a kind of automotive grail the best vehicle engineers pursue. Part of the motivation comes from the most extreme roads in Europe. Most of us in the USA live where the world really is flat, where most of our roads are north-south or east-west, with gentle curves where needed. When we have mountains, the roads are steeper, but still designed for the traffic speeds we expect. Most of Germany is as flat as Michigan, with hills, small outcroppings like the Harz Mountains and some large river valleys here and there. But south lie the Alps, and any German car must be able to drive through the Alps in safety and under control.



Why have ESP? For just such roads as this, circling through and around steep mountaintops, in and out of sunlight, under traction conditions that change abruptly and often. A system that improves traction use on such challenging roads means a substantial margin of safety for ordinary roads.

The Alps are somewhat higher than the Rockies, but what makes them unique is the dramatic height difference from peak to valley, a consequence of the particularly hard, crystalline rock and the specific erosion, mostly by glacier rather than by rain or wind. Glaciers excavate a valley floor deeper but have no effect on high peaks. What this means is that the Alps are very steep. On a trip to Germany, driving south from the Black Forest, I thought, 'What a wide, incredibly sharp-edged storm is coming.' As I drove closer, I saw more clearly. It wasn't a cloud; it was stone, covered with permanent snow in August. The 'storm' was the north face of the Alps.



Roman roadbuilders built straight, flat roads, like the Via Appia here, wherever they wanted across the warm and graceful plains of Italy. But inflexible geology determined where they built roads through the Alps, the same inflexible geology that makes modern roads follow the Roman routes.

Because the Alps are so high, so steep and so cold, the roads through them are difficult to drive. Rain, fog, glare ice and snow can occur in rapid succession on any day of the year. Traction can be perfect where the pavement is in the bright sun and nonexistent once you drive behind the shadow of a rise.

The Romans laid out the major roads over two millennia ago, and they didn't concern themselves with banking turns or highway safety. No road was too steep or too narrow as long as two long columns of armed men could walk it at a thousand paces an hour. A glance over the precipice was enough to encourage the legionnaires to stay away from the edge. What the Romans wanted from a road was structural stability: They paved the road using huge buried stones, too heavy for the locals to pry up and vandalize whenever the Romans turned their backs.

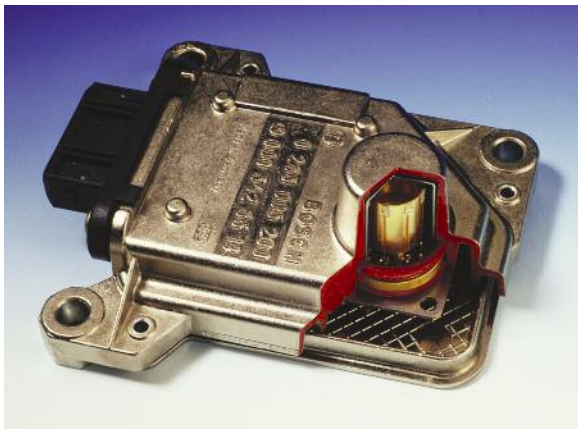
We think of roads as avenues of travel and commerce; the Romans thought of them in military terms. If the Germanic colonial subjects on the far side of the Alps got restless under the various exactions imposed and looked likely to start a dustup, those indestructible roads meant the Roman Army could be anywhere in the Empire within about two weeks, to lend their muscular powers of persuasion to the feebler eloquence of the tax collectors.

That's all ancient history, literally, but many of the Roman roads through the Alps are still there. Not usually the original Roman pavement, of course, but their routes and roadmaps. The mountains, you see, stayed put, and our roadbuilders can no more ignore them than the Romans could. Not only would it be impractical and uneconomic to re-route most roads, in most cases there aren't alternative routes anyway,

without blasting impossibly expensive long tunnels. Some of the Transalpine roads may technically be unlimited-speed Autobahns (or the Austrian, Swiss, French or Italian equivalents), but the hairpin turns, steep slopes and near-constant ice provide a speed enforcement that issues no warning tickets. Go over the barrier on some of these roads, and it won't matter whether you wore your seatbelt or have airbags in your car. An ejection seat and parachute might help, but they're not in the accessory catalog.



No speed limits here, and no need for any. In the very center of Western Europe are roads nobody speeds on twice. Even with the most advanced traction controls, a driver is apt to sit up a little straighter and drive with increased attention around these curves.



Electronic Slide Perception -- Sensors

So that's how the system uses the bulldozer principle to nudge the car back into the path of the curve. But how does it know sideslip has begun? And how can it tell which axle is slipping, so it can activate the correct brake on the other axle?

There's no 'sideslip sensor,' you see, never mind one for each axle. The system has to quickly infer sideslip from the incoming sensor information. Of course, there's no braking-skid or acceleration-spin sensor for ABS and ASR, either. In each case, the computer infers the traction loss by comparing input sensor data with its stored, read-only memory parameters to distinguish circumstances incompatible with continued traction. But that comparison is much more complex with ESP. Here's our best understanding of what goes on.

Wheelspeed

Our old ABS/ASR pals, the wheelspeed sensors, are just as important to ESP as to the earlier traction controls. These sensors function in the same inductive, tooth-counting way we've discussed earlier.

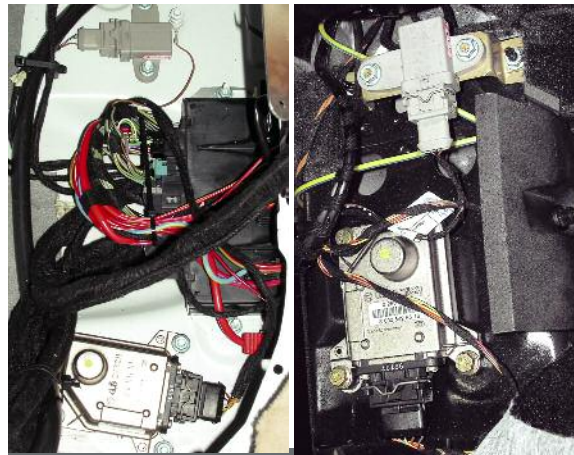
The major sensors providing information input are these: the wheelspeed sensors for the vehicle speed, a steering wheel angle sensor for the driver's directional intentions, a yaw sensor for rotation around the vertical axis and a lateral acceleration sensor for sideforce in the middle of the car. From the wheelspeed and the steering wheel angle, the computer can calculate what the range of the sideforce should be under ideal conditions. The road could tilt one way or the other, however, so this is not yet enough.

Yaw and Direction

Most interesting of the lot is the yaw sensor. This detects rotation of the vehicle around its vertical

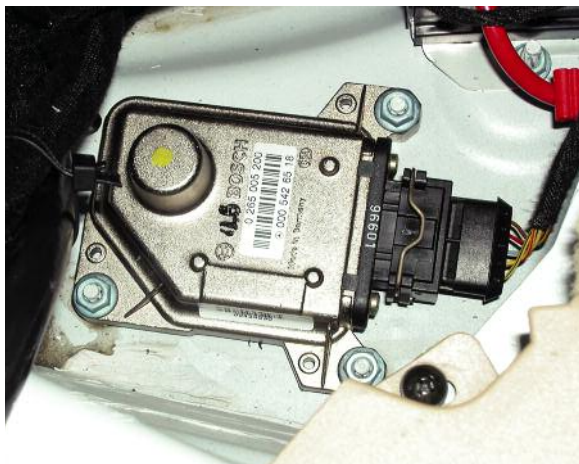


All of the intertwined traction controls, from ABS, through ASR to ESP, depend critically on the wheelspeed-pulse information from each wheel. These induction sensors provide the fundamental data on vehicle speed and on variations at each wheel. If a single one of them stops working, the whole interconnected set of traction-control systems turns off; the car drives as a normal car without traction control; the warning lights turn on as a DTC takes up residence in memory.



The major sensors unique to ESP are the yaw sensor (shown in cutaway at the beginning of this section) and the lateral acceleration or lateral-G sensor. They are close to one another, but in different places for different models. In most sedans, they're under the rear seat. In the 129 on the right, they are atop the rear tunnel just below the carpeted covers. Both sensors include internal microprocessors, special-purpose mini-computers, to convert the raw detector signal to an information signal, a very precise voltage, relayed back to the electronic control unit.

axis. The sensor works by multiple piezoelectric actuator/sensors responding to the Coriolis effect. Coriolis makes hurricanes and tornados turn counterclockwise in the northern hemisphere and clockwise in the southern. It's what makes water draining from a sink usually turn in the same direction. When air or water closer to the equator moves toward the North Pole, it will tend to move farther eastward because it was moving faster eastward at its original latitude. Correspondingly, air or water to the north moves westward as it moves south, since it was originally moving more slowly eastward. If you've ever tried to walk in a straight line from the outside perimeter of a moving merry-go-round to the center, or vice-versa, you noticed how your path was not only thrown to the outside by centrifugal force, but also ahead of or behind the merry-go-round depending on whether you tried to walk radially inward or outward. Obviously, it also depends on which way the merry-go-round rotates.



Sustaining a continuing standing wave atop a small cylinder in an evacuated chamber, the yaw sensor (also shown in cutaway on page 20) provides accurate information to the control unit about any change of direction the vehicle makes.

Things happen similarly in the yaw sensor of the car. In the earlier, cylindrical-element sensor, there are eight piezoelectric actuator/sensors around the circumference of the top edge of the calibrated cylinder, oscillating in its little evacuated chamber. Every other actuator/sensor, four in all, actively pulses at a precise frequency to introduce a standing ellipsoidal wave along the rim of the cylinder. The alternating four unpulsed actuator/sensors also move in and outward radially in phase with the wave.

As long as the vehicle does not turn, they report no yaw. When the vehicle rotates around its vertical axis, that is, when it turns, the passive actuator/sensors vary slightly in their electrical capacitance, in

response to the Coriolis effect, because they also try to move in the direction they were moving in as the turn began. The wave wants to stand still, not rotate, so it imparts some of the rim momentum to the sensor elements. A later, still smaller version of the yaw sensor uses what amounts to two interleaved combs. As the vehicle turns, they shift slightly relative to one another, changing their joint electrical capacitance.

There are, kindly, befuddled teachers in school used to tell me, no stupid questions. Well, OK, but as I learned later in the Automotive School of Hard Knocks, there are still stupid people, people who ask dumb questions, a role that's often been mine. So I asked an M-B engineer whether they needed a mirror-image yaw sensor for the Southern Hemisphere,

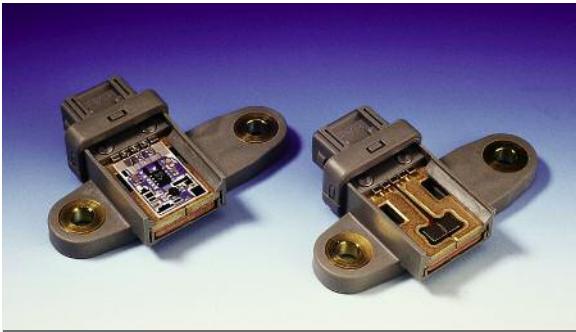


where hurricanes and water draining from sinks rotates the other way, clockwise. Nope, he answered, politely stifling a guffaw, it's the Coriolis effect of the yawing car involved here, not of the rotating planet. Then I remembered, it's also the Coriolis effect an ice-skater uses to increase the speed of a spin by drawing her arms and legs inward. Her total rotational energy remains the same even though the spin increases,

because the average radius of the spun mass is less, but the rotational momentum stays constant.

This effect on the piezoelectric sensors must be incredibly small and the changes in the electrical signal must be incredibly minute as well. But that's enough for the electronics housed in the sensor to translate the information into a yaw-rate millivolt signal and send that to the control unit. The yaw sensor can detect and report rotation much slower than once per hour, a most leisurely turn, but a sensitivity affording substantial overcapacity for detecting rotational change.

This information tells the control unit the vehicle's change of direction. But it needs more pieces of information to determine whether the vehicle is slipping sideways or not: what is the side force and what direction is the driver trying to achieve with the steering wheel? How fast is the vehicle going, from the wheelspeed sensors' signals? What about the engine speed and torque output, the transmission gear, the brake application status? On to the other sensors....



Mounted as close as is practical to the very center of the car, the lateral acceleration sensor detects lateral acceleration and sends quantified information about that in the form of a millivolt signal to the control unit. The sensor itself is Hall-effect, but the internal microprocessor translates the data into a scalable signal.

Sideforce – Lateral G

The lateral acceleration sensor uses a pair of minutely swinging weights within a Hall-effect sensor, responding to the lateral G-force the car is under. Even more than the yaw sensor, it must be positioned close to the center of the car. If it were too close to one axle or the other, after all, it could report a false reading if the nearer axle slipped more than the farther or vice-versa.

The sensor has a range of about 1.4 G's in either direction (more sideforce than tires can usually support), while it is sensitive enough to report the later-



The lateral acceleration sensor is relatively delicate, about like the bulb in an incandescent troublelight, though it can sustain the bumps and shocks of the moving car. If you remove it for test or replace one, however, be careful not to drop it on the floor or smack it against a workbench or hard parts of the car. The exclamatory red label on it reports (in German) that it's sensitive to impact damage.



The system not only has to detect sideslip, it also has to factor in what the driver wants the car to do, the direction he wants to steer. Reporting that information is the job of the steering wheel position sensor

al acceleration resulting if you rock the car gently back and forth. We'll cover how to test this sensor and the other components next issue.

Reading the Driver's Mind

The steering wheel position sensor, the device reporting what direction the driver wants the car to head in (whether possible or not), consists of an array of nine LED's and light receptors, optical sensors, in other words, separated by a plastic wheel



Alternating slots, LED's and light receptors form a cluster of sensors to report the position of the steering wheel to an accuracy of 2.5 degrees. This sensor is similar to but not interchangeable with the steering wheel position sensor used with 4MATIC and ASD.

with variously spaced slots. The spacing of both LED's and slots are so arranged that each position of the steering wheel corresponds to a unique combination of light-sensor communications. This means the control unit can detect exactly where the steering wheel is at all times.

The steering wheel position sensor must be 'initialized' anytime it's ungrounded or replaced. You initialize the sensor by either turning it slowly from lock to lock (engine running) or by driving straight ahead at a speed above 12 mph. This process enables the system to recalibrate the straight-ahead position.



The steering wheel position sensor can only fit over the splines and onto the column in one position, but the internal 'clock' spring could be wound beyond the correct position with the sensor on the bench. Then the spring could snap when the steering wheel turns to the tight extreme. To prevent this accidentally happening, leave one of the attachment screws in the sensor to keep the rotating part lined up with the stationary plate.

The system also needs information from the engine control system, the transmission controls (to tell what gear it's in and whether a shift is imminent, and thus what the effect of a throttle change will be on torque at the wheel) and various other sensors, including the ESP-off switch (which actually only turns off ASR engine torque control).

Doing the Fast Math

As mentioned earlier, there is no sideslip sensor. The system has to noodle that out from all the information streaming into the control unit. But we know what information is available and what kinds of traction controls the system can use, so we can understand the intervening steps, at least in principle.



The information from all the sensors we've described in detail, as well as data from the engine and transmission controls, flows into the ESP control unit, here unplugged and visible from the side. All the read-only memory for allowable thresholds, all the calculations to determine what the car's situation is and what steps, if any, to take for correction, as well as the output signals to the traction control actuators, center here.

First, let's have the problems clear: Longitudinal and transverse slip can be independent. That is, a car may continue in a straight line, parallel to the tire tread, if you lock the wheel with the brakes or spin the drivewheels with engine power. Or the wheels could continue turning at a speed perfectly coinciding with vehicle longitudinal movement (parallel to its centerline), even though one or both axles are sliding sideways and the car is out of control. The control unit must necessarily infer the need for traction control, and what measure to take.

There are several hard inference problems here: How can you tell a wheel is slipping from excessive force on the brakes or spinning from excessive accelerator travel (the problem sorted out by the ABS and ASR systems) or how can you tell a wheel is side-slipping from an excessive steering wheel angle for the available traction (the ESP problem). You could have a loss of traction in the direction of travel independently of a loss of traction sideways, or you could have both simultaneously. Then, with that first set of questions answered, you need the answer to one more: which axle's wheels are sliding to the side? You need to know this to tell whether to engage the front outside or the rear inside brake to correct the slide.

Let's turn to ABS/ASR for a start. Each of those systems relies mostly on the wheelspeed sensors' signals to identify vehicle speed and, more importantly, on the rate of change of vehicle speed at each

individual wheel. The control-unit computer includes in its read-only memory a maximum change of wheelspeed compatible with even the best possible traction. This rate of change is the engagement threshold for the ABS or ASR traction control measures.

No carmaker blurts that precise number out, because it cost so much time and money to discover and develop through multiple brake system experiments and redesigns. Nonetheless, here at *StarTuned*, we're privately inclined to suspect the ABS/ASR acceleration/deceleration maximum threshold is roughly 1.5-1.6 G's for most Mercedes-Benz models. If a wheel slows or accelerates more quickly than the G-force threshold, more quickly than is compatible with a rotation speed change under the best possible traction conditions, that wheel's sliding or slipping, so the system applies its countermeasures. It's interesting that the ESP lateral acceleration sensor has a maximum range of 1.4 G's, and it's reasonable to conjecture that's because the engineers doubt such a lateral force will ever be exceeded without sideslip.

From the yaw sensor, the computer determines the direction and speed of the rotation of the vehicle around its vertical centerline, its rate of turn, in other words. As we'll discuss next issue, the sensor generates a different voltage output for right turns compared to left turns even at the same rate, enabling the control unit to distinguish both the rate and direction of the turn from different magnitudes of the same information signal.

From the wheelspeed, the steering angle sensor and the yaw, the computer can calculate an expected lateral force, however. No doubt there's a certain range to factor in more or less grippy tires, tilted roadways, high sidewinds and the like, but the computer can almost instantaneously determine a plausible value and compare that to the lateral acceleration sensor signal. That still doesn't tell whether the wheels are sideslipping, however.

If the fronts slip, there'd be less yaw than predicted; if the rears slip, there'd be more. So we conjecture the real trigger for ESP activation comes from the lateral acceleration sensor. Probably not in the way you'd imagine, putting traction controls to work as the lateral acceleration reaches a threshold. Probably what the system does, instead, is to look for a sudden *reduction* in lateral force with no simultaneous change in wheelspeed or in steering wheel angle. You'll recall the quibbles we had with the conceptual drawing at the beginning of this article, that the sideforce must have just declined from its maximum. That unexpected reduction of sideforce could only be the direct result of sideslip. That reduction says wheelslip has just begun, and the yaw sensor simultaneously flags the slipping axle: Less yaw

means the fronts are breaking loose, more means the rears.

So now, the computer knows there's slip and knows where. Next issue, we'll see how it corrects the problem and regains traction, if it can.

Next Issue: ESP Actuators, Diagnosis and Thought Experiments

StarTuned thanks the students and instructors at the Chicago Area Mercedes-Benz Elite Training School, part of UTI. Their knowledge, enthusiasm and cooperation were very helpful, and we hope to drop in on them again.



Coming soon to a small screen
right in front of you....
From *StarTuned*, The Magazine...
StarTuned, The Website!

Besides every page in our current issue, the website will include all the articles in our past issues as well, going back to the very first.

Cut us some slack to hammer out a few digital dents, splice a few wires and quarantine a few viruses, and we'll let you know as soon as it's up and running.

Environmental Note: StarTuned.com is built entirely with recycled electrons. No new electrons were used in its manufacture.

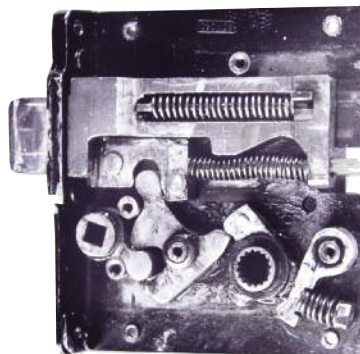
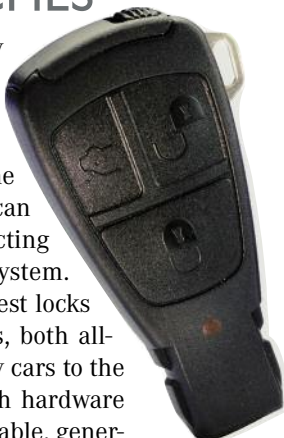


PARTS NEWS

LOCKS AND LATCHES

Security means more than the capacity of a car to protect its occupants in the event of an accident and to minimize damage to bystanders and other vehicles. It also means that an owner can lock the car and feel reasonably secure nobody can easily defeat the locks and latches protecting the doors, trunk and ignition system. Mercedes-Benz has built and used the best locks and latches obtainable for their vehicles, both all-mechanical bolts going back to very early cars to the latest infrared, keyless systems. All such hardware sustains a lot of use but must remain reliable, generally for the life of the car.

If a lock, latch or hinge was damaged after an accident, replacement with an original is the best way to restore the security of the car to what it originally was. Early locks install in obvious ways; electronic security devices come plain in the box, but detailed instructions to set them up properly are available.



EXPANDED CD TECHNICAL INFORMATION

The next Technical Information CD is ready, this one for Model 202. All the 202 service manuals, introduction books, electric troubleshooting manuals, engine manuals, owners manuals, climate control and chassis/body manuals, maintenance manuals and more are all encapsulated on this disk. The CD includes all the technical information there is for the 202.

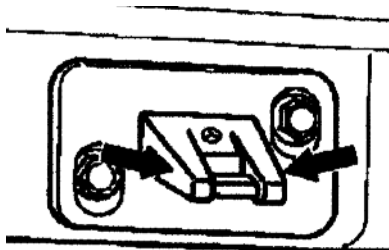
This title follows those for the 107, 114/115, 116, 123, 124, 126 and 201. Upcoming titles include Model 129 and Model 140, available in early spring of 2004. You'll need a computer running a current version of Windows (98 SE or higher) with relatively modest hardware resources.





FACTORY SERVICE BULLETINS

These suggestions and solutions for technical problems come from service bulletins and other technical sources at Mercedes-Benz. They are selected and rewritten for independent repair shops. Your genuine Mercedes-Benz Parts source can obtain almost any item designated by a part number. This issue of *Factory Service Bulletins* represents our first dip of the StarTuned toe into body-related information. If your shop does body work and mechanical work closely related to body repairs, please let us know what sorts of topics you'd like us to cover in future issues.

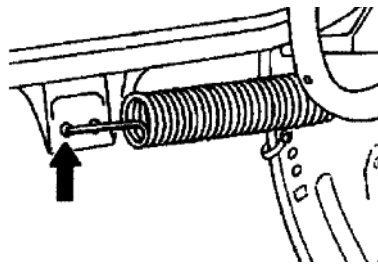


Most Mercedes-Benz trunk latches form wedges in several dimensions to center the trunk panel exactly in its opening. Sometimes that fit can be too tight, regardless of the adjustment.

Trunk Troubles 1 All Models

The trunk latch mechanism on Mercedes-Benz cars centers the trunk panel in the trunk opening, as long as the latch is properly adjusted with the bolts on either side of the latch. Even if you have that perfectly adjusted, however,

that can sometimes mean the trunk fits so tightly it does not pop open when you press the release. The mating parts are plastic, and we're inclined to suppose any such parts can work together invisibly, with no friction whatever. Nope. Sometimes even slick plastic surfaces are too sticky to let parts work freely. The cure? A dollop of grease at the mating surfaces. Don't worry, the lock will still work perfectly well. It doesn't depend on friction at the plastic surfaces.

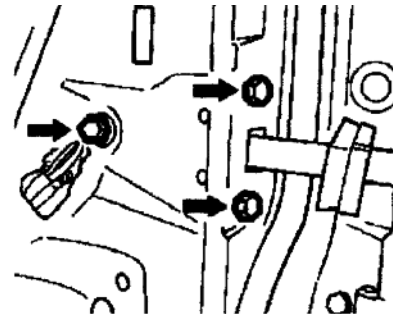


Spring tension determines the 'anti-gravity' lift of the trunk panel, and the position of the spring ends determines that tension. You're not locked into one hole rather than the other: Increase or reduce the tension as needed by shifting the hole.

Trunk Troubles 2 Models 124 and 201

If the trunk doesn't stick, it could still wallow, or possibly it could bang open with a snap. The rate at which the trunk opens once released is determined by the spring tension, and that is determined (in part) by the anchor hole in which it is hooked. There is more than one anchor hole, and each one of them is every bit as official a Mercedes-Benz spring

anchor hole as the others. If the tension is enough to raise the trunk panel to its full position, it's correct. If the tension doesn't open the trunk, doesn't open it up all the way, or opens it up too fast, shift the springs in their holes. They don't have to both be in the matching hole, so you really have three possible settings.



A strange clunk in a door, gradually growing louder over a long time. But don't take the door apart first, searching for something that's not there.

Mysterious Knock at the Door All Models

As long as we've covered the spookiness of ESP in our major article this issue, it only seems right to think about strange clunks in the door. Before you open the inside panel to see what is rolling around loose, check the bolts that hold the strap and bar limiting the opening span of the door. If these rattle loose, you could hear just such a sound from the fittings and bolts in the door. It might be a good idea to either replace the bolts with new ones or inoculate them with threadlocker.



GENUINE MERCEDES-BENZ PARTS... NEARBY

Alabama**Dothan**

Mike Schmitz Automotive
334-794-6716

Hoover

Crown Automobile
205-985-4200

Huntsville

Regal Auto Plaza
256-837-5752

Mobile

McConnell Automotive
251-472-3187

Montgomery

Jack Ingram Motors
334-277-5700

Tuscaloosa

Leigh Automotive
205-556-1111

Alaska**Anchorage**

Mercedes-Benz of Anchorage
907-277-3383

Fairbanks

Cook's Import
907-459-7070

Arizona**Chandler**

Mercedes-Benz of Chandler
480-403-3444

Phoenix

Phoenix Motor
602-264-4791

Scottsdale

Schumacher European
480-991-1155

Tucson

Mercedes-Benz of Tucson
520-886-1311

Arkansas**Fayetteville**

Jones Motorcars
479-521-7281

Little Rock

Riverside Motors
501-666-9457

California**Anaheim**

Caliber Motors
714-777-1900

Arcadia

Rusnak/Arcadia
626 447 1117

Bakersfield

Mercedes-Benz of Bakersfield
661-836-3737

Belmont

Autobahn Motors
650-637-2333

Beverly Hills

Beverly Hills
310-659-2980

Buena Park

House of Imports
714-562-1100

Calabasas

Calabasas Motorcars
818-591-2377

Carlsbad

Hoehn Motors
760-438-4454

Chico

Courtesy Motors Auto Center
530-893-1300

El Dorado Hills

Mercedes-Benz of Eldorado Hills
916-567-5100

Encino

Auto Stiegler
818-788-0234

Escondido

Mercedes-Benz of Escondido
760-745-5000

Fremont

Claridge's
510-623-1111

Fresno

Mercedes-Benz of Fresno
559-438-0300

Glendale

Calstar Motors
818-246-1800

Laguna Niguel

Mercedes-Benz of Laguna Niguel
949-347-3700

La Jolla

Heinz Gietz Autohaus
858-454-7137

Long Beach

Mercedes-Benz of Long Beach
562-988-8300

Los Angeles

Downtown L.A. Motors
213-748-8951

Modesto

Modesto European
209-522-8100

Monterey

Mercedes-Benz of Monterey
831-375-2456

Newport Beach

Fletcher Jones Motor Cars
949-718-3000

Oakland

Mercedes-Benz of Oakland
510-832-6030

Palm Springs

Mercedes-Benz of Palm Springs
760-328-6525

Palo Alto

Park Avenue Motors
650-494-0311

Pasadena

Rusnak Pasadena
626-792-0226

Pleasanton

Mercedes-Benz of Pleasanton
925-463-2525

Riverside

Walter's
909-688-3332

Rocklin

Von Housen Motors
916-924-8000

San Diego

Mercedes-Benz of San Diego
858-279-7202

San Francisco

Mercedes-Benz of San Francisco
415-673-2000

San Jose

Beshoff
408-239-2300

San Jose

Smythe European
408-983-5200

San Luis Obispo

Kimball Motor
805-543-5752

San Rafael

R.A.B. Motors
415-454-0582

Santa Barbara

Cutter Motors
805-682-2000

Santa Monica

W.I. Simonson
310-829-4511

Santa Rosa

Smothers European
707-542-4810

Stockton

Berberian European Motors
209-944-5511

Thousand Oaks

Silver Star A.G.
805-371-5400

Torrance

Mercedes-Benz of South Bay
310-303-3500

Van Nuys

Keyes European
818-461-3900

Walnut Creek

Stead Motors of Walnut Creek
925-937-1655

West Covina

Penske Motorcars
626-859-1200

Colorado**Colorado Springs**

Phil Long European Imports
719-575-7950

Denver

Murray Motor Imports
303-738-3400

Littleton

Mercedes-Benz of Littleton
303-738-7700

Connecticut**Danbury**

Mercedes-Benz of Danbury
203-778-6333

Fairfield

Mercedes-Benz of Fairfield
203-368-6725

Greenwich

Mercedes-Benz of Greenwich
203-869-2850

Hartford

New Country Motor Cars
866-346-2369

New London

Carriage House of New London
860-447-3361

North Haven

Mercedes-Benz of North Haven
203-239-1313

Delaware**Milford**

I.G. Burton
302-424-3042

Wilmington

Mercedes-Benz of Wilmington
800-800-1949

Florida**Clearwater**

Lokey Motor
727-530-1661

Coral Gables

Bill Ussery Motors
305-445-8593

Daytona Beach

Mercedes-Benz of Daytona Beach
386-274-4775

Ft. Lauderdale
Mercedes-Benz of Fort Lauderdale
954-462-4381

Ft. Pierce
Coggin Motor Mall
772-466-7000

Ft. Walton Beach
Quality Imports
850-863-2161

Gainesville
Kraft Motorcar
352-332-7571

Jacksonville
Brumos Motor Cars
904-724-1080

Lakeland
Central Florida Eurocars
863-688-8111

Maitland
Mercedes-Benz of Orlando
407-645-4222

Melbourne
Continental Motorcars
321-956-0600

Miami
Mercedes-Benz of Miami
305-919-8000

Naples
Mercedes-Benz of Naples
239-643-5006

Pensacola
Centennial Imports
850-432-9903

Pompano Beach
Autohaus Pompano
954-943-5000

Sarasota
Glauser
941-923-3441

St. Petersburg
Crown Eurocars
727-526-3738

Tallahassee
Capital Eurocars
850-574-3777

Tampa
Mercedes-Benz of Tampa
813-870-0010

West Palm Beach
Mercedes-Benz of Palm Beach
561-689-6363

Georgia

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
Theo Davies Euromotors
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

Highland
Terry Shaver Imports
219-924-2400

Indianapolis
World Wide Motors
317-580-6810

Lafayette
Mike Raisor Imports
765-448-4582

Mishawaka
Gurley-Leep Motorwerks
219-256-1500

Iowa

Davenport
Lujack's Northpark
563-388-8610

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

Iowa City
Chezik-Sayer Imports
319-337-6100

Kansas

Shawnee Mission
Aristocrat Motors
913-677-3300

Topeka
Sunflower Motors
785-266-8480

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
Audubon Imports
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
Performance Motors
207-781-3207

Maryland

Annapolis
Mercedes-Benz of Annapolis
410-268-2222

Bethesda
Euro Motorcars
301-986-8800

Cockeysville
Valley Motors
410-666-7777

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**

Black Forest Motors
231-938-2840

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
616-241-2671

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

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

Von Housen's Motors
916-924-8000

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
732-549-6600

Englewood

Benzel-Busch
201-567-1400

Fairfield

Globe
973-227-3600

Freehold

David Michael
888-362-8867

Lawrenceville

Mercedes-Benz of Princeton
609-771-8040

Little Silver

Contemporary Motor Cars
732-842-5353

Milville

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

Feduke Motors
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

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
716-424-4740

Rockville Centre

Lakeview
516-766-6900

Roslyn

Rallye Motors
516-625-1600

Smithtown

Competition Imports
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
610-984-9080

Columbus

Ed Potter
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

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
Crater Lake Motors
541-773-3673

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
605-362-9500

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
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
713-868-6800

Laredo
Powell Watson Motors
956-722-5182

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

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

Midlothian
Mercedes-Benz of Richmond
804-545-9600

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
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

To be a world-class shop, you need a world-class refinish system.



Glasurit® paints employ state-of-the-art European technology that gives you the ultimate blend of advantages: Speed. Ease of use. Color match. Durability. And the rich, liquid color and deep, brilliant gloss that define a world-class finish. A Glasurit finish.

The Glasurit brand has long been considered a worldwide standard for excellence—for years it has been approved for refinishing Mercedes-Benz vehicles.

For more information about Glasurit paint from BASF, contact the BASF Call Center at 800-825-3000, or visit us at www.basfrefinish.com.

Glasurit is a registered trademark of BASF.



HELPING MAKE PRODUCTS BETTER™

BASF

THERE'S NO BETTER PROTECTION
FOR YOUR REPUTATION.



There's nothing like trust to keep your customers coming back. Which is why Mercedes-Benz and AMG rely on Mobil 1. Now Mobil 1 features the SuperSyn™ anti-wear system. This patented technology represents the most advanced Mobil 1 engine protection ever. The more heat and friction threaten an engine, the more you can trust Mobil 1. So why give your customers anything less than Mobil 1? There's no better way to take care of a Mercedes-Benz. Or business.

For more information, call 1-800-ASK-MOBIL or log on to www.mobil1.com. Nothing outperforms Mobil 1.

**THE MORE YOU KNOW ABOUT MOBIL 1,
THE BETTER IT IS FOR YOU, AND YOUR CUSTOMER.**



© 2003 Exxon Mobil Corporation. Mobil, Mobil 1 and SuperSyn are trademarks of Exxon Mobil Corporation or one of its subsidiaries.

Mobil® Command Performance