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Information for the Independent Mercedes-Benz Service Professional

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One of the Star Points: Ignition

Sealing the Deal

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Mercedes-Benz

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

Mercedes-Benz wants to present the information you need to know to diagnose and repair Mercedes-Benz vehicles accurately, quickly and the first time; text, graphics, on-line and other technical sources combine to make this possible.

Feature articles, derived from approved company sources, focus on being useful and interesting.

Our digest of technical information can help you solve unanticipated problems quickly and expertly.

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

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IN THIS ISSUE

One of the Star Points: Ignition

To run properly, any gasoline-burning engine requires three elements to work together in perfect harmony: compression, fuel, and, our subject here, spark. Maintaining this harmony insures the legendary power and performance of Mercedes-Benz vehicles.

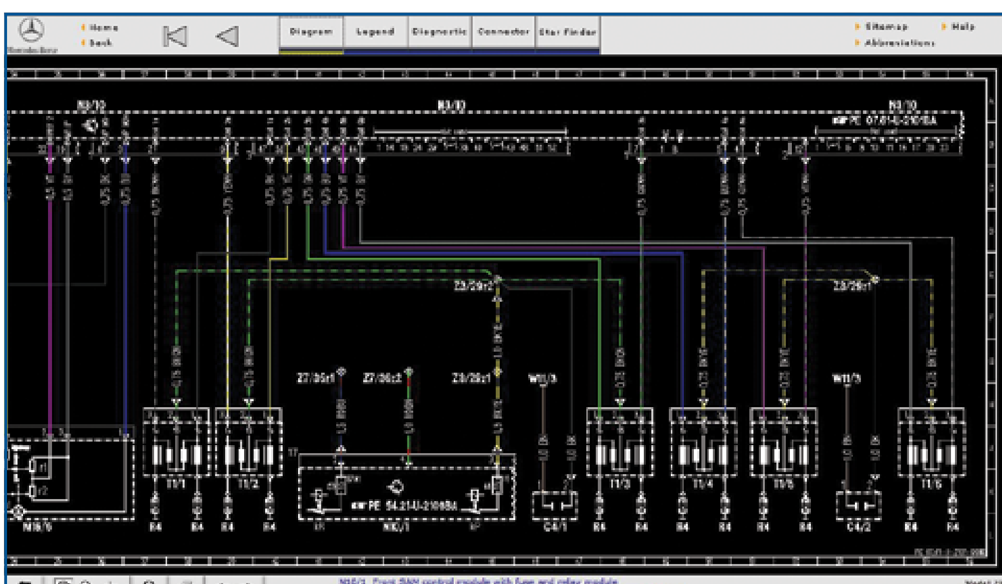
In any team sport, players need to work together to achieve a goal. The same applies to the internal combustion engine. The basic engine is engineered to take in and compress quantities of air. The fuel system combines a flammable liquid hydrocarbon with this air at the optimal ratio to provide a clean-burning mixture. In a diesel engine, ignition occurs naturally, so when that happens is determined by the timing of the injection event. In a gasoline engine, on the other hand, the mixture is compressed to a point where it is ready to burn, then the ignition system provides the high-voltage, low-amperage spark that ignites it. If this spark were to occur at the wrong time in the engine's cycle, harmful emissions would increase, fuel mileage would fall, and performance would be reduced. Internal engine damage is another possibility. In the old days, we were able to adjust spark timing by twisting the distributor, or changing the gap of the ignition points. Now, of course, the computer provides vastly more precise adjustments throughout the rpm range.

The Ignition System

To properly diagnose ignition systems, you need to have an understanding of how they work and how they can affect drivability. The system is divided into two parts. primary and secondary. The primary side controls when spark occurs, and is sometimes referred to as the triggering mechanism. The secondary side does the actual work of igniting the mixture. It all starts in the ignition coil, which is fed voltage through the vehicle's power distribution system. An ME (Motor Electronics) control unit, or a dedicated ignition module controls the ground side of the coil. When the coil is grounded, a magnetic field is created in and around the primary windings. The secondary windings contain many more wraps of fine wire than the primary does. When the module or computer "un-grounds" the coil, the circuit is broken and the magnetic field collapses into the secondary windings, and the result is high voltage. The ignition systems found on older vehicles before the mid-'90s had coils with single secondary towers. The spark out of this tower would be sent to a distributor cap and rotor, which would then distribute the spark to each cylinder in its turn timed to coincide with its piston approaching TDC (Top Dead Center).

How We Get kV from Just V

The induction phenomenon that generates many tens of thousands of volts at the spark plug gap from mere battery voltage is both interesting and subtle, but it's not our purpose here to provide a detailed physics lesson. Suffice it to say that the ignition coil is actually a voltage step-up transformer. Like all transformers, it only transforms voltage from its primary windings to its secondary windings when the current flow changes. Since



Using startekinfo.com you can pull up a wiring diagram of the ignition system, such as this one for the CLK 320. You can see that the center pin (#2) is the voltage supply to the coil. You can check the resistance of the coil windings between this pin and the outer two.

we're dealing with DC, that means when the primary circuit is broken by releasing the ground. The primary has only a few windings (and thus a relatively low resistance), while the secondary has many more windings (and a higher resistance).

While the coil primary circuit is grounded (called "dwell"), the current flowing sets up a powerful magnetic field inside and around the coil. When the ground is released – changing the current flow – the energy in the magnetic field is released in the form of a higher voltage through the coil secondary. When this voltage reaches a certain level, an electrically-conductive spark forms across the spark plug electrodes. Because the spark is conductive, the voltage drops somewhat and remains relatively constant until the energy stored in the coil's magnetic field is exhausted.

Traditionally, this has been described as "collapsing lines of flux" (meaning the primary's electro-magnetic field) inducing high voltage in the secondary windings.

The secondary voltage must be kept high as it passes through the coil wire, distributor cap, distributor rotor, back through individual spark plug wires and finally across the spark plug gap. This high voltage, like any electrical current, is looking for the easiest path to ground. So, it will "leak out" of any component that has cracks, cuts, or carbon tracks. This means the "electromotive force" will not make it to the spark plug to ignite the mixture. The cylinder will not produce power and raw fuel will pass into the exhaust stream.

This total lack of, or incomplete, combustion is called a "misfire." On '96 and later models, OBD II regulations require that misfires be monitored, and, if one occurs, that the MIL (Malfunction Indicator Lamp, also called the CEL for "Check Engine Light") must flash on and off. This warning is emphasized because of the fear that unburned gasoline will overheat the catalytic converter.

Of course, for many years Mercedes-Benz has been using "COP" (Coil Over Plug) ignition, wherein there's a small separate coil for each spark plug. This eliminates the distributor cap, rotor, and plug wires, so there is never a problem with those components. The coils themselves or their control circuitry can still fail, however.

The Basics Of Ignition Timing

It is important to know that spark does not occur at TDC. This would be too late. The piston would already be on the way down by the time the expanding gases started pushing on it. So, the air/fuel mixture is ignited just before the piston reaches the top of the compression stroke, and how much before is calculated electronically to achieve the

On 104 and 111 engines, the waste spark ignition system is used. A single coil serves the plugs of two cylinders, one under compression the other during the exhaust stroke. You can see here that the resistance of the secondary winding is 7,370 ohms. The primary resistance is about .25 ohm. These readings will change slightly with temperature.

best combination of fuel efficiency, power, and low emissions. In the past, this "advance curve" was determined on the basis of rpm by means of centrifugal weights, and engine vacuum by means of a diaphragm and lever mechanism.

Problems with Ignition

As we said, if the spark occurs too late the piston will already be on the way down and power output will be reduced. If the mixture ignites too early, on the other hand, the flame front will hammer the rising piston. This will also reduce power output because what's wanted is a smooth push, not an explosion, but it can also cause serious engine damage. This condition is known as pre-ignition, detonation, or "pinging" from the distinctive sound it makes, and it can have multiple causes. Cheap, low-octane fuel may ignite at lower combustion chamber temperatures before the spark occurs. Higher-octane fuels are more resistant to pre-ignition from heat and therefore will not ignite until the spark arrives. Also, inexpensive fuels may not burn completely leaving carbon deposits behind inside the combustion chamber. These may retain the heat of combustion and "glow," which can ignite the incoming charge before the carefully-timed spark occurs.

Since preignition can slow down the speed of the crankshaft, it can have the same effect as misfiring in turning on the OBD II MIL, and may also cause failure of a state or local emissions test. Also, undue stress is put on the pistons, rings, connecting rods, and bearings. Multiply this by millions of revolutions and you can understand how catastrophic engine failure happens. So, the timing of the spark and the actual spark output need to be verified during the testing of any drivability problem.

Who is in Control of Timing?

When it comes to ignition timing, you need to understand that it is all computer-controlled; therefore it is difficult to test manually, and that is probably not necessary anyway. Basic ignition timing is set by a calculation of the ME control unit based on the crankshaft and camshaft position sensor signals. On earlier model engines, you may only have one crank and one cam position sensor even through you have a V8 with two banks. V12 engines usually have two six-cylinder systems mated together as System 1 and System 2. Later-model, more sophisticated engines have a position sensor for each camshaft, particularly if they also have variable valve timing. The combination of crankshaft and multiple cam sensors allows the ME unit to

On a 119 engine, you should see a coil primary resistance of about .5 ohm between the two outer pins of the three-pin connector. The middle pin is wired to ground and is attached to the secondary windings. Verify the ground connection for the secondary windings.

control ignition timing per cylinder, accurately detect misfiring cylinders, and also to test the operation of the variable valve timing system. As a result, any problem with cam and crank timing will be identified by the self-diagnostics. Other tests, such as that for engine compression, can be performed, of course.

The next largest influence on the timing calculation is that of the load sensor. Since the early '90s, Mercedes-Benz has used a Mass Airflow Sensor (MAF) almost exclusively to measure engine load (it is a requirement of OBD II). If the MAF changes ignition timing enough to affect drivability, you can identify the cause of the symptoms with additional testing. The additive and multiplicative fuel trim readings would also indicate there may be a problem with the MAF.

Testing The Primary

What you will need to do to accurately diagnose a MIL-on or drivability issue is to test and verify, or eliminate, the ignition system as the source of the problem. Also, ignition can be used as a tool to identify problems present in other systems. You might perform static testing first, which is typically a matter of checking the electrical characteristics of the components. Measuring the resistance of a spark plug wire is a static test. Dynamic testing usually involves measuring the kV and amp draw of the components as you would with an ignition oscilloscope. Starting with static testing, you should always verify that you have battery voltage at the coil's positive terminal. A quick look at a wiring diagram on **www.startekinfo.com** will help you identify the coil's voltage source. Next, you can test the coil's primary winding resistance. You could have readings from a few other coils to compare, but ideally you would use WIS (accessible through startekinfo.com) to get specifications.

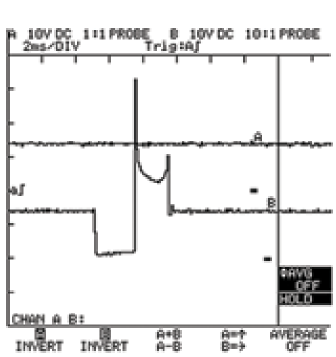
Typically, Mercedes-Benz powers the coils by means of drivers in the ME control unit. You can scope the primary trigger of the coil. The way the voltage that results in the spark passes through the secondary windings affects the electrical signal of the primary, so you will see the conventional firing

This coil is really two coils mounted in one housing. Therefore, there are two secondary windings. Short spark plug wires are used with this dual-plug system, but they still need to be checked. You don't want to see much more than 2k ohms, or replacement is necessary.

line, burn time, and coil oscillations. With a low-current probe, you can monitor each coil's amp draw. The ME control unit will increase dwell with rpm, but draw is typically limited to one amp. The critical part of the signal to watch is the rate at which the amperage slopes upward. You can use other cylinders that are not misfiring as a guideline.

Testing The Secondary

The coil primary windings are only half of the equation. The resistance should be checked on the secondary side also. To do this, you will have to know how the coil is constructed. In the past twenty years, Mercedes-Benz has mainly used three designs for its ignition systems. On the older in-line four 111 engine and six-cylinder 104 engines, a coil-over-one-plug design is used with an additional coil wire going to another cylinder, which is referred to as a "waste spark" system. This coil's secondary windings fire at both ends, one positive and one negative. There is no longer a direct connection with the positive side of the coil. Spark travels from the ground side of one spark plug electrode to the center electrode, then passes through the coil and onto the companion spark plug. In the case of the 112 and 113 engines, a single coil fires two plugs. On a 113, this happens in a single cylinder as each one has two plugs. The design is essentially two coils in one housing, sharing the same power supply. The plugs can be fired individually and are staggered to help completely burn the mixture in the cylinder. You can check secondary resistance by measuring



What you are looking at is the primary waveform of a 119 engine. The pattern starts off with voltage to the coil, which is then pulled to ground during the dwell period. When the ground is released, the spark line followed by a normal burn time (usually between .8 and 1.8ms) are shown. There are minimal coil oscillations from a single coil for a single cylinder.

from the output tower to its ME-controlled ground. Finally, there are engines like the 1997 119 that have one coil wire per cylinder. The secondary winding runs from the spark plug through the coil to ground, which is the center pin (brown wire) so you can check resistance across those two points.

Using the Ignition System for Troubleshooting

Monitoring the coils' secondary output kV is very important when evaluating the ignition system. You can tell exactly what is going on in that cylinder under multiple conditions. You will need an oscilloscope with an adapter for the various coil designs Mercedes-Benz uses. The first part of the pattern you will come across is the dwell, or ground time. This is when the primary circuit is complete. The next change you will see is often referred to as the firing line. This is the initial arc across the spark plug gap. A high firing line generally means the spark plug electrodes have eroded leaving a gap that is too wide, but a bad plug wire, or a lean condition can also be the cause. A relatively low firing line means the plug gap is too small, probably from physical damage, or perhaps a rich condition is present. After the firing line comes what is sometimes called "burn time." This is the condition of the spark while the mixture is being ignited. You would like to see a smooth, flat, even line that would indicate ideal combustion. The final part of the pattern is the coil's oscillations. These tell you if the coil is up to its task. You should see minimal oscillations with a normal coil as the excess energy in the primary winding of the coil dissipates. No oscillations can mean a shorted coil or loose connections.

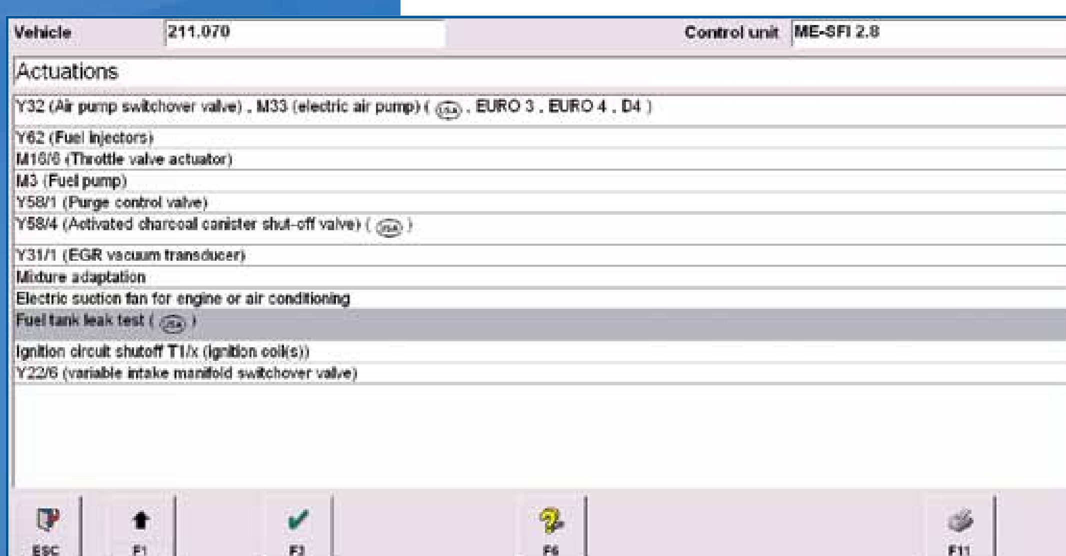
Taking the few steps outlined here should help you confirm whether or not the ignition system is working properly, and isolate problems. Also, looking into the secondary ignition system is an excellent way to diagnose other troubles with either the fuel system or the basic engine mechanicals. An accurate, informed diagnosis is why your customers choose to come to you, and what's better than that?

Sealing the Deal

Evaporative emissions have been tested and monitored by the ME since the beginning of OBD II regs in 1996. This system has been one of the more difficult air pollution-reduction systems to diagnose and verify. SDS software has made the job easier.

Believe it or not, evaporative emissions controls have been around for over four decades. For most of that time, they were relatively simple, comprising a liquid/vapor separator in the tank, a charcoal canister with a vacuum-operated purge valve, a special gas cap that didn't vent pressure unless it exceeded maybe two psi, or vacuum until it reached several inches, and related plumbing (many of you won't remember that there was even a hose from the carburetor bowl vent). When the engine was started and run above idle speed, ported vacuum opened the purge valve, the stored vapors were drawn through a hose into the intake stream, and fresh air entered the canister through a filter. These systems not only reduced a vehicle's hydrocarbon emissions by up to 20%, they also saved a little gasoline. And they were pretty much trouble-free.

With the advent of OBD II regulations, EVAP had to go high-tech with the PCM actually performing tests to make sure the tank and hoses were vapor-tight. If not, commonly because the gas cap has been left loose after a fillup, there'll be a MIL-on situation and you'll get a visit from the customer. If a loose cap were the only potential problem, there'd be no need for this article. But sometimes you'll be presented with a diagnostic mystery.



This is a good example of why investing in an SDS will make you a true Mercedes-Benz specialty shop. Under the heading "Actuations," you'll find various tests you can perform on the EVAP system, including activating the purge solenoid, shut-off solenoid, and EVAP leak test.

Overview

Just as in the past, gasoline vapors that form in the fuel tank are directed to a charcoal canister for storage, then routed to the combustion chambers to be burned. What's different today is the control of canister purging. In old systems, this was accomplished by the simple expedient of ported vacuum either drawing off the stored fuel vapor directly, or opening a valve that allowed manifold vacuum to do the job. Now, of course, mixture management is much more crucial, and only the ME (or PCM) can provide the precision needed.

So, the purge solenoid, sometimes referred to as the regeneration valve, is under the command of the ME. It is pulsed as necessary to allow manifold vacuum to reach the charcoal.

Under OBD II, if there's a leak in the EVAP system the ME control unit needs to be able to detect it. If it's less than the air that would be lost from .020-in. hole, it's acceptable. If the leak is larger than that, but lower than that of a .040-in. hole the ME sets a small-leak code. Anything larger than that results in a large-leak code. If any individual part of the EVAP system fails, the ME detects it.

Measuring EVAP Leaks

Two strategies may be used to allow OBD II to test EVAP to see if everything is sealed properly. One uses pressure decay, and the other vacuum decay. In the former, pressure is applied to the EVAP system and measured. If the pressure drops too quickly, a leak must be present. In the latter, vacuum is generated in the system and any drop is also measured.

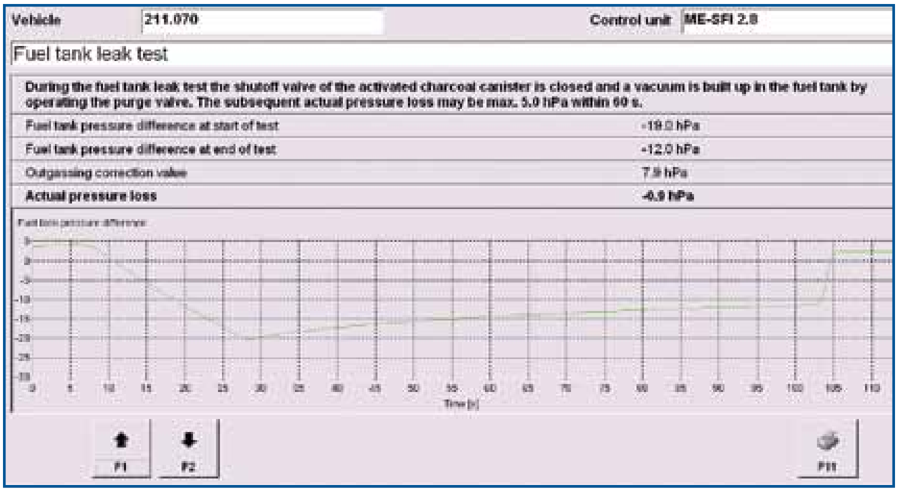
In either case, measurement can't be accomplished unless the normal channels are sealed. This is the job of the canister close valve. Remember, fresh air needs to be taken into the canister to allow the vapors out. This air comes through the close valve, which is normally open. During the testing, the computer energizes the valve, closing it.

Here we are adding smoke and we have closed the cut-off solenoid. If you look closely, you can see a small amount of smoke coming from the vent. Is this enough to cause our leak code? We wanted to be sure.

Mercedes-Benz uses the vacuum decay method to determine if there are EVAP system leaks. The regeneration valve, or purge solenoid, is pulsed open to draw the system into a vacuum. The fuel tank pressure sensor (FTP) measures the drop in pressure just as a MAP sensor measures the pressure drop in an intake manifold. When the FTP signal reaches a predetermined level, the purge solenoid is closed. With the canister close valve energized and the purge solenoid de-energized, the EVAP system is completely sealed. The vacuum should hold and the FTP signal voltage should remain steady. If the voltage changes, vacuum is being lost, so there must be a leak.

Okay, How are We Going to Test it?

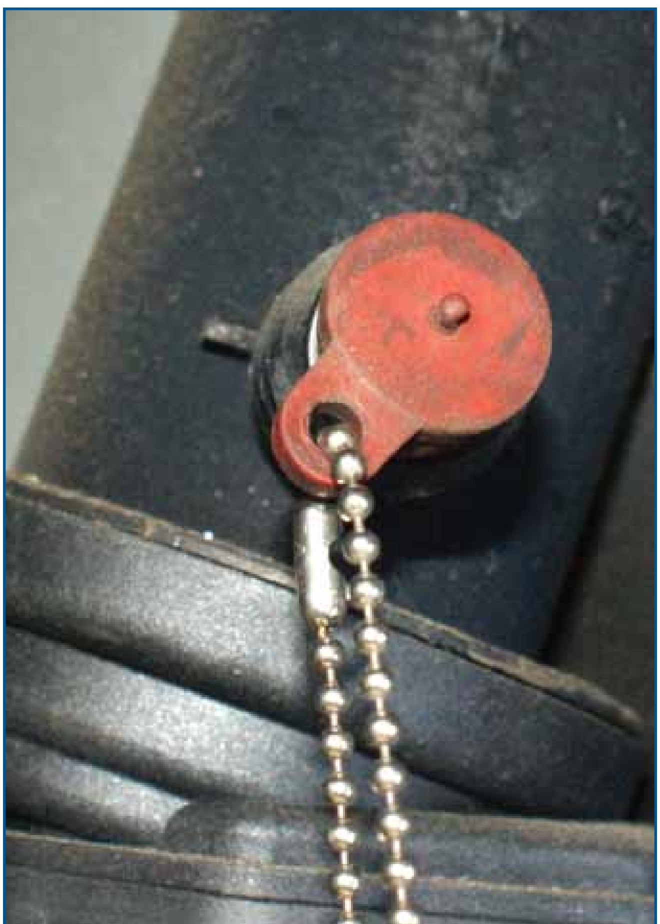
You could manually close the canister close valve and open the purge solenoid. You could then watch the signal voltage of the FTP and allow the purge solenoid to close while seeing if the FTP signal voltage changes. You need to know what a good FTP signal is without any pressure or vacuum in the fuel tank to verify that the FTP is reliable. You also have to know the change in vacuum by how it affected the FTP signal.



Using the Fuel Tank Leak Test, you can watch the pressure in the fuel tank in hectopascals (hPa). Here, the pressure increased by eight hPa over 60 seconds. The outgassing factor was because the gas cap was removed and reinstalled before the test.

Another way you can check for leaks is to "smoke it." An EVAP-compliant smoke machine generates a small amount of pressure and blows smoke into the EVAP system. You still need to close the canister close valve to seal the system, but you don't need to run the engine.

Obviously, wherever you see smoke is where your leak is. You will have to expose the plumbing to isolate the source, which can be time-consuming depending on the model you're working on. Also, if the purge solenoid is the source of the leak you will not see the smoke since it will enter the intake manifold first before exiting the air filter housing. Once you find the source and repair it, you will then have to drive the vehicle to verify your repair. The EVAP monitor is one of the more difficult monitors to run. Variations in outside temperature, fuel temperature, fuel level, atmospheric pressure, etc. all have an effect on whether or not the monitor actually runs, so this can take a lot of time. Using conventional methods will make it difficult to verify your repair. Is there a way around this dilemma?



To verify that the cut-off solenoid was closing, the vent port was blocked. There should be no difference whether the cut-off solenoid is closed and the vent port is blocked since they both seal the system. However, there is a difference in the results of the leak test.

SDS to The Rescue

SDS offers advanced testing of this system. Not only will it allow you to verify your repair, but it can also be used in the diagnostic process to help determine the source of the problem. When accessing the ME control unit, you will probably look for DTCs first. Once you determine they are EVAP leak codes, you can start testing. Under the heading "Actuations," you will be shown a list of various components on the car that you can activate through SDS software. This also lets you know the computer is capable of grounding solenoids and is not the ultimate source of the problem. One of the actuations you can do is that of the canister close solenoid. This can be useful if you are smoke testing. If you apply smoke to an open

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MODEL YEAR	VEHICLE MODEL	REMAN PART NUMBER
1984-1992	190D2.2	A000230121180
1984-2002	260E, 190D2.5, 300TD, 300D, 300CE, SL500	A000230241180
1986-1991	420SEL, 560SEC/SEL, 560SL	A000230251180
1986-1995	190/300 series, E300D	A000230111180
1986-2002	300E, 300CE, 600SL, SL600	A000230051180
1990-2002	500SL, SL500	A000230061180
1992-1993	500SEL	A119230111180
1992-1995	400SE, 400SEL, 500SEC, S420, S500	A119230001180
1992-1999	600SEL, S320, S600, 300SEL	A000230171180
1992-1999	300SE, 600SEC, S600, S320, CL600	A000230221180
1992-2004	CL500, 300/400/500 series, S/SLK/C/CLK/E-Class	A000230701180
1994-2000	C220, C280, C36 AMG	A000230131180
1998-2005	ML320, ML430, ML55 AMG	A000230681180
1998-2010	ML500, ML350	A001230281180
1998-2010	ML350, ML500, E500, SL500, C/CL/S/G-Class	A000230901180
2000-2006	CL600, CL65 AMG, S65 AMG, S600	A001230011180
2000-2009	E320, S350	A000230911180
2002-2007	C32 AMG	A000230781180
2002-2007	C230 CL 1.8	A000230971180
2002-2010	CLK-Class, C55 AMG, SLK55 AMG	A001230191180
2003-2009	CLK500	A001230161180
2003-2010	SL55 AMG	A001230021180
2003-2010	E55 AMG, E320, E500, CLS500	A001230121180
2003-2010	E-Class, CLS55 AMG, CLS550	A001230141180
2003-2010	SL550	A001230551180
2005-2010	SLK280, SLK300, SLK350	A001230541180
2006-2010	R350, R500, ML350, ML500, ML550, GL450, GL550	A001230871180
2006-2010	R350, R500, ML350, ML500, ML550, GL450, GL550	A002230521180
2009-2010	C300, C350	A001230501180
2010	GLK350	A002230311180
2010	E350, E550	A002230381180

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DENSO

Available only through your local Mercedes-Benz Dealer system you will simply see smoke coming out of the canister vent. You can now close the vent solenoid and see if smoke comes out anywhere else.

If it still comes out of the close solenoid, then you simply have a bad cut-off solenoid. You may want to verify that the solenoid is being grounded by the ME. It may be difficult to see if smoke is still coming out of the cut-off solenoid.

The SDS software can also perform the entire EVAP test on newer chassis like the 211. This is a significant time-saver. When you are done with your repairs, you can test the system to verify that it will pass the monitor. The engine must be running for the test since you need engine vacuum to draw down the EVAP system. The automated test grounds the close solenoid and opens the purge solenoid.

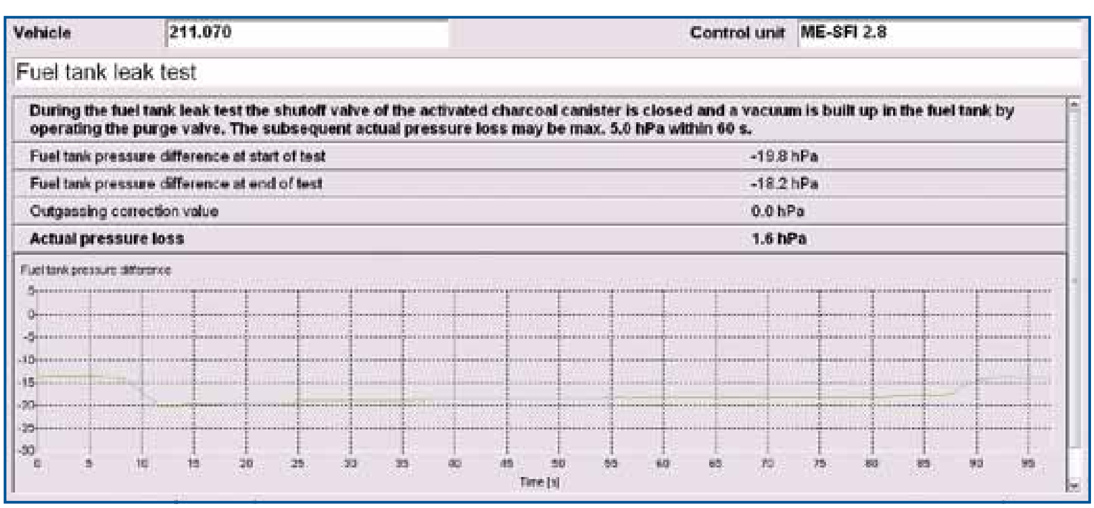
Monitoring the Situation

You'll see the FTP signal displayed in hPa instead of a signal voltage on a graph. You'll also see the drop in pressure (relative vacuum) as the purge solenoid is opened and the cut-off solenoid is closed. Watch the FTP reading over time as the purge solenoid is allowed to close. Observe the graph as the 60-second test is run. The parameters are also given in the test screen. In the case of the 211 chassis, the SDS does not want the FTP reading to increase by five hPa over 60 seconds. On our test subject, this test has failed. To isolate the leak, you can remove and block off various hoses, and re-run the test. If it now passes, you now know the leak must be in the part of the system you blocked off.

Keep in mind that much of the EVAP system has hard plastic lines, which you shouldn't crimp as they will probably break, creating more leaks. The safer way is to remove the line at a flexible hose and plug it. In our test vehicle (211 chassis), we temporarily blocked off the vent of the canister close solenoid and ran the test again. During the test, the close solenoid should be closed anyway, so blocking off the vent port should not have had an effect on our test – but it did. The EVAP system passed the test with the vent port plugged. This told us that the close solenoid wasn't completely sealed and allowed the vacuum to drop in the system. On the 211, the canister close valve is incorporated into the charcoal canister assembly, therefore the entire canister had to be replaced.

Verification

Once the new replacement canister is installed, you should run the EVAP system test again. You should see the FTP reading stay stable after the regeneration solenoid is closed. If the system passes now, you can return the vehicle to the customer without the worry of he or she returning multiple times for the same problem.



After installing the new canister cut-off solenoid assembly, the leak test was run one more time. The pressure difference is less than two hPa. This means the EVAP system has passed the leak test and should pass the monitor as the vehicle is driven.

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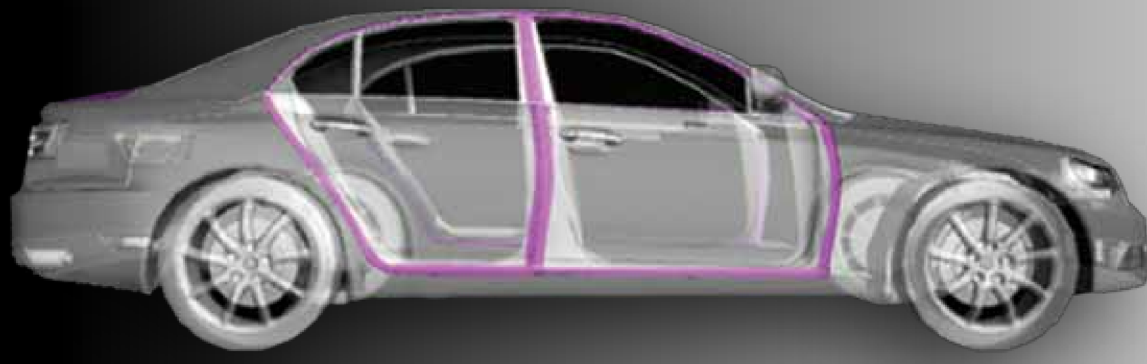
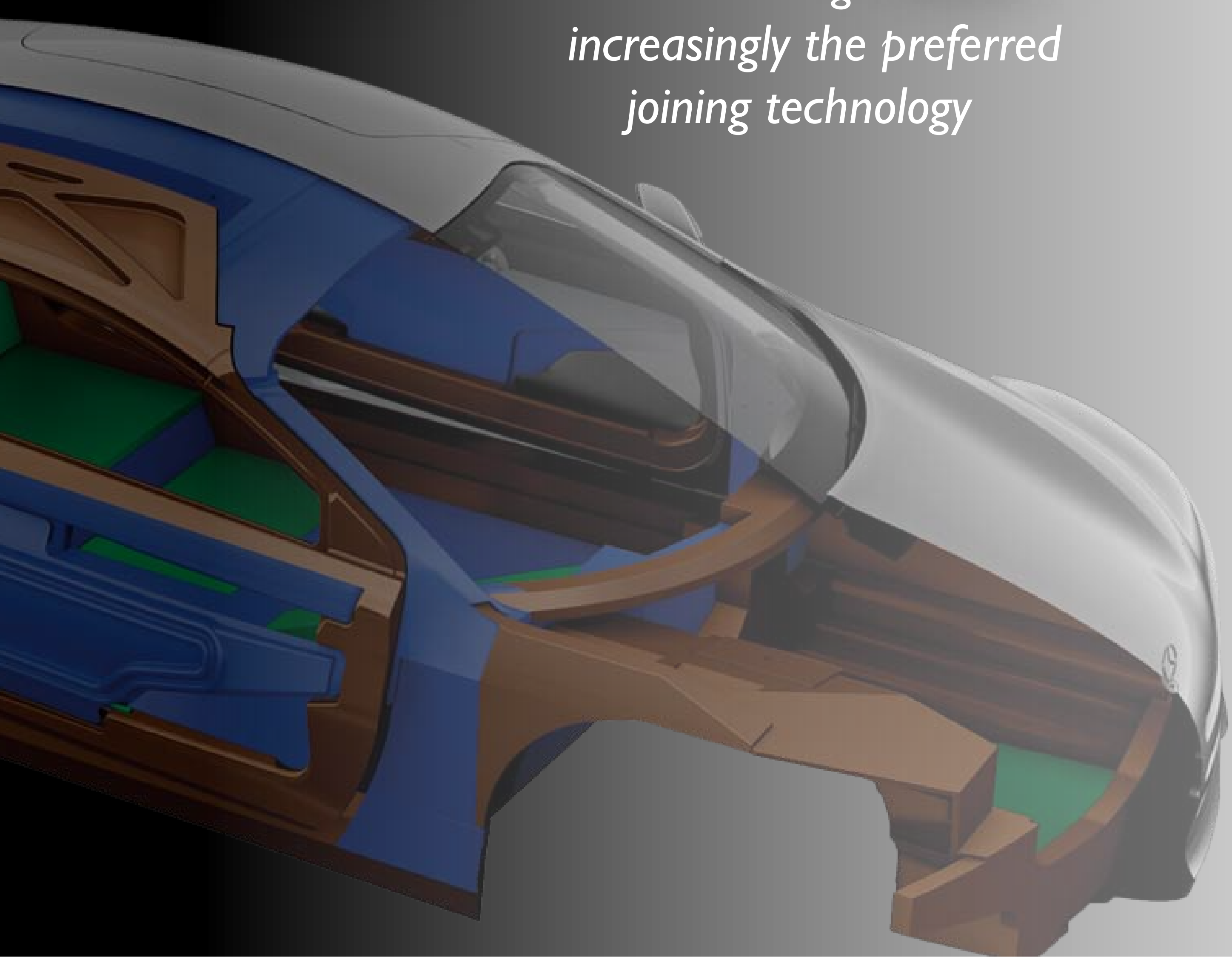
As Good As New



Chemical bonding is increasingly the preferred joining technology



Chemical bonding through the use of structural adhesives is not new to the collision industry, but the need for repair professionals to keep pace with advanced adhesive materials, equipment, and procedures is now on the front burner. Going forward, the repair of Mercedes-Benz body panels and other components demands a commitment to continuing learning about bonding techniques and practices. It's also an opportunity.

Advanced adhesive formulations are now available

Structural adhesives are not new; they've been used for more than 25 years in the automobile industry. Early adhesives were of the single-component variety, which at that time was sufficient for some repairs involving conventional mild-strength steels. These yielded to two-component adhesive formulations that provided improved bonding properties and allowed more working time.

That was fine until the materials that vehicles were manufactured with began to change in response to demands for lighter weight, more rigidity, better driving and environmental performance, improved safety, and lower manufacturing costs. To stop the ever-increasing mass spiral without penalizing safety and comfort, automakers have transitioned from using mild tensile-strength steels to lighter weight, but stronger materials, such as higher-strength steels, other metals (aluminum, magnesium, titanium, etc.), thermoplastics, carbon fiber-reinforced plastics, and other composites.

This ongoing evolution is driving the increased use of chemical bonding (using structural adhesives) as the preferred and recommended joining method, rather than welding, riveting, or other practices. Body panel repair instructions, for example, commonly prescribe chemical bonding procedures that use adhesives.

But challenges exist for adhesives (as they do for other technologies). The reason: High-strength steels, alloys, and plastics come in different grades, which impacts how each material performs under various stresses during normal operation and during a collision. Automakers are now aware that the mix of material choices used to manufacture a vehicle requires adhesives that were formulated to match the materials being repaired.

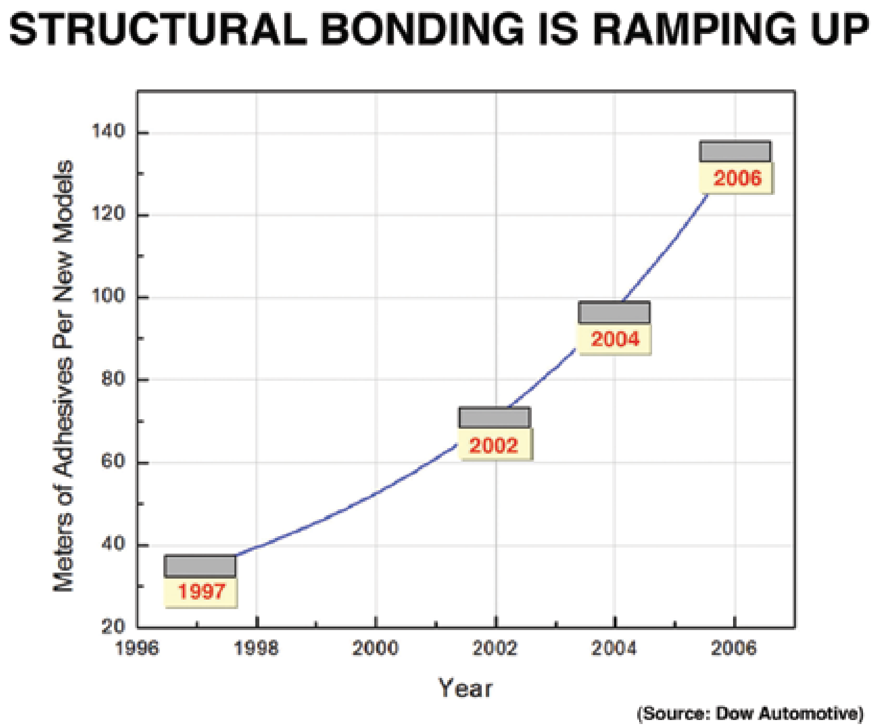
Modern adhesives are more crash resistant

Applying adhesive is a more complicated process than just slathering on some glue and clamping the parts together. Modern automotive structural adhesives are made from chemicals called epoxies, which typically come with two parts, a resin and a catalyst that are kept separate until used. When combined during a repair, the catalyst initiates a chemical reaction in the resin. Expect to feel the bonded parts heating up as the resin develops its bonding properties and the mixture cures.

The two-stage structural adhesives in use today include polyurethane epoxies, glassy matrix epoxies (which have glass beads embedded in the resin), and rubber-based epoxies. Glassy matrix epoxies are extremely strong and rigid, and they resist shearing stress – the lateral separation of the bonded parts – at very high force levels. Polyurethane epoxies are more flexible and provide a better fit for some components, but they break under shearing forces at much lower force levels than glassy matrix epoxies. Newer rubber-based adhesives contain additives that allow synergistic rubber toughening of adhesives to provide high-strength epoxies with greater flexibility – a hybrid of earlier formulations.

The curing ability is built in to the adhesive, but it requires a lot of testing and some impressive chemistry to meet an automaker's specifications. In some cases, curing may be aided by baking or some other procedure involving applied heat. Some epoxies even cure with the application of ultraviolet light. Note that the curing times for various adhesives can range from just a few minutes to a day or even longer. Automakers know their vehicles, so following their collision repair procedures and using the approved resources ensures that technicians have adequate working time to effect a safe, complete repair.

For example, some repairs may only require a two-stage adhesive, while others may require the use of adhesives and rivets – a process known as rivet-bonding – or the combination of spotwelding. Technicians should note that repairs involving aluminum should use aluminum rivets, those involving steel should use steel rivets, and that a coating of zinc dust to prevent corrosion may be required. Be sure to use the number of rivets specified in Mercedes-Benz service information.



Beginning in the mid-1990s, structural adhesives usage began to accelerate. In 1996, for example, approximately 35 meters of adhesives could be found in a new Mercedes-Benz S-Class model. By 2006, the S-Class had over 135 meters present. It's continued to grow since and this trend is prevalent in other Mercedes-Benz classes. (Image — Dow Automotive Systems)

Chemical bonding provides stronger and more durable repairs

While based on earlier two-component structural adhesives, newer adhesives also include advanced special polymers, epoxy resins, adhesion promoters, and other additives that improve bonding, manage stress more effectively, provide better mechanical properties and resist corrosion when compared to alternative joining technologies.

According to several industry sources, these newer adhesives provide a number of advantages. Dow Automotive Systems and 3M note that using the new two-part adhesives and procedures recommended by Mercedes-Benz for chemical bonding repairs:

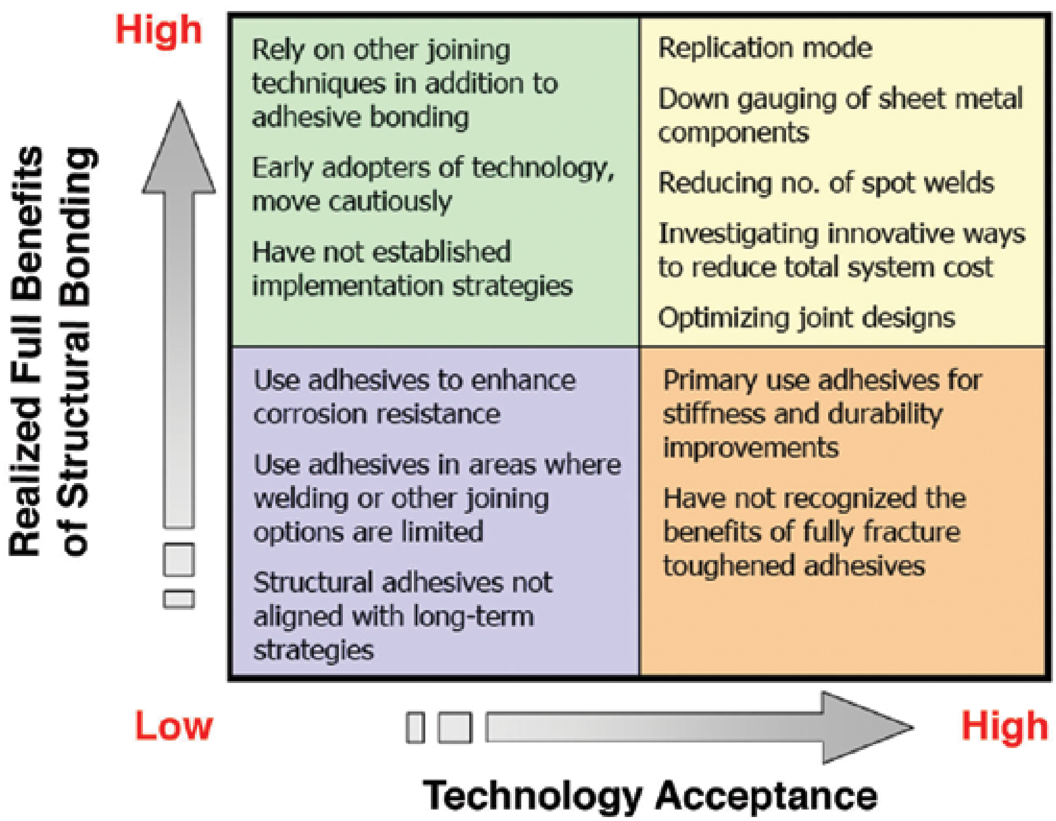
Provides more durable and stronger repairs with less corrosion risk than welds alone. In fact, adhesives usually form a bond stronger than the materials they're bonding together. In the future, as carbon composites are increasingly used, adhesives might be the only way to bond them, as carbon fiber panels cannot be welded together.

Reduces the number of welds that would have otherwise been required. For example, Mercedes-Benz requires OEM rivets and OEM structural adhesive to be used in areas that squeeze-type resistance spot welding (STRSW) arms cannot access, or when replacing USIBOR (boron) components. Adhesive bonding is also a well-known complement to help resolve problems with cracks around spot welds occurring as a result of fatigue loads.

Allows the various stresses during vehicle operation or a collision to be more evenly distributed across a region that is joined with adhesives compared to those joined only by welds, rivets, or other joining methods.

Enables the flow of energy force transferred in an accident to remain truer to the automaker's design intent.

STRUCTURAL BONDING BENEFITS



(Source: Dow Automotive)

The shift in the acceptance of chemical bonding technologies by automakers is leading to the realization of many benefits, some of them unexpected surprises, such as the opportunity to use thinner body panels without sacrificing performance or safety. (Image — Dow Automotive Systems)

—Facilitates the down-gauging of metals (e.g. thinner and lighter body panels, less steel reinforcement) for lightweight, optimized vehicle construction.

—Replacing otherwise necessary sealant materials with adhesive not only seals out water, it also improves noise, vibration, and harshness (NVH) by dampening airborne noise distribution and minimizing body vibrations.

—Improves the structural integrity during side-impact IIHS tests.

—Empowers the introduction of lighter-weight carbon fiber roofs and other non-steel and non-alloy components without compromising strength, safety or durability.

—Adhesives also enable hybrid sandwich construction to be employed in manufacturing. For instance, the front flexural and supporting structure in some models (e.g. CL) is a load-bearing assembly made of carbon fiber-reinforced plastic sandwiched between aluminum sheets.

—It is important that adhesives not be the weakest link when joining adherent surfaces or components. Modern bonding adhesives provide acceptable or improved elasticity and flexibility, in addition to better tensile and shear stress strength than the materials being bonded. Be cognizant that Mercedes-Benz employs different mixes of construction materials than other automakers during manufacture. In addition, just like different grades of new and emerging steel can be used, repairers should be aware that there are also different grades of aluminum and other metal alloys, plastics, and even carbon fiber. Mercedes-Benz collaborates with adhesive manufacturers, such as Dow Automotive Systems and 3M, to develop structural adhesives that are best suited to their specific models and repair applications. These may or may not be the same ones required by other automakers.

MBUSA also has a number of position statements pertaining to body panels and chemical bonding adhesives. For instance:

MBUSA does not support the use of critical recycled parts and assemblies, especially parts and assemblies that are welded, riveted or bonded to the vehicle structure during the assembly/ manufacturing process. Replacement of structural body panels/members/assemblies (clipping or partial clipping) with recycled parts is unacceptable and not approved by MBUSA.

Malfunctions caused by body repairs not performed in accordance with Mercedes-Benz specified repair procedures or otherwise not properly performed are not covered by the Mercedes-Benz New Vehicle Limited Warranty and may cause the car to not perform as originally designed in a subsequent collision to the repaired area.

Consequently, it is critical that repairers know and use repair procedures developed by Mercedes-Benz, along with lists of approved supplies, tools and equipment. Hence, it is crucial that technicians refer to Mercedes-Benz collision repair resources

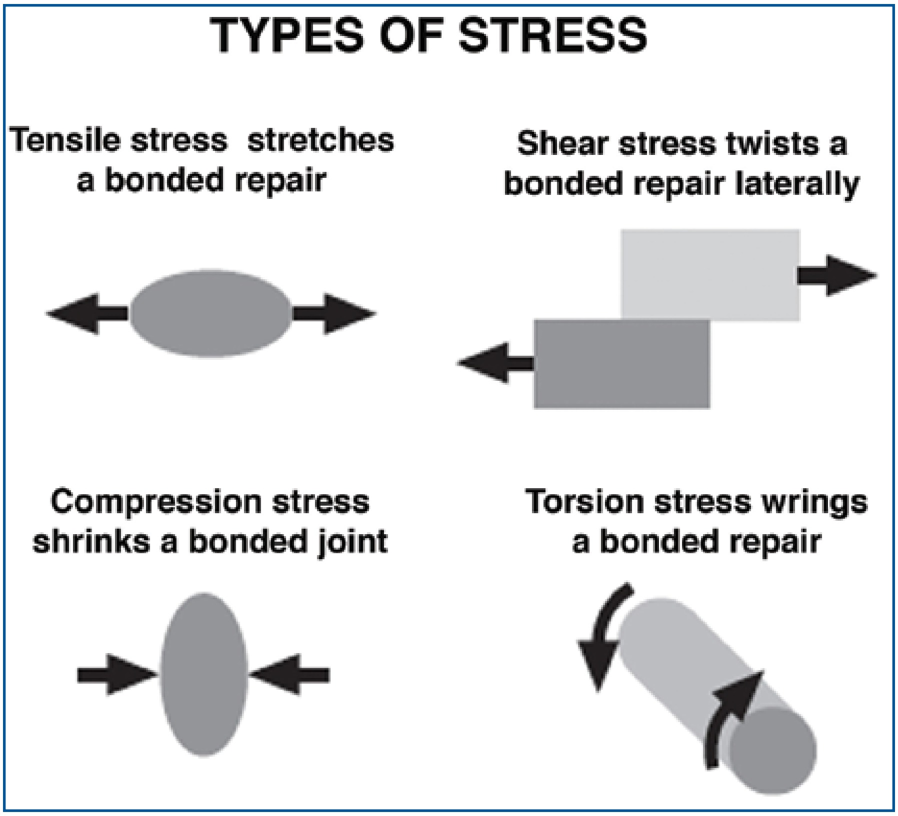
Need More Info About Using Adhesives?

For access to Mercedes-Benz' service information, technical bulletins, Workshop Information Systems (WIS) and more, visit http://www.startekinfo.com, a subscription-based website.

www.mbcollisioncenters.com/pages/publicindex.aspx is accessible to Mercedes-Benz' Certified Collision centers. This website arms repairers in advance of what the composition of any part is before it is cut into – whether mild steel, high-strength steels and other metals, plastics, carbon fiber, or other materials.

Finally, Mercedes-Benz provides access to archived StarTuned Magazine articles to collision professionals at www.mbwholesaleparts.com/wholesale-parts/section/startuned/archives, a website that allows repairers to search by year and date. For more information, use this link to access two earlier articles pertaining to the use of adhesives in collision repair — When Welding Won't Do (May 2010) and Taking Stock in Bonds (December 2008).

(Images —Mercedes-Benz USA)



Chemical bonding using MBUSA-approved structural adhesives, tools and procedures enables body panel repairs to better handle various type of stress compared to other joining technologies. The best place to use a structural adhesive is in a location where the primary forces are either compression (where the joined pieces are pushed together), or shear, where the force tries to slide the joined surfaces against one another, like pressing your hands together and trying to slide them apart. Structural adhesives are typically not good to use if the force acting on the joint would pull the two pieces apart as most adhesives have poor peel strength. Another poor location for a structural adhesive would be one where there are forces that would bend the joint, which could allow the joint to cleave and then peel. In these latter two cases, repair procedures may specify that adhesives be used with rivets (rivet-bonding) or in conjunction with certain welding techniques. (Image — Dow Automotive Systems)

noted in the Need More Info? sidebar. Otherwise, a repair that looks fine cosmetically may in fact have durability and corrosion-related concerns, as well as less occupant safety should another accident occur in the future.

An adhesive repair example: Rivet-bonding

New vehicle construction techniques mean new procedures in collision repair to maintain the integrity of a vehicle in the case of any following accidents. Specific year/model repair instructions can be found at the subscription-based StarTekInfo.com website. Be sure to refer to it and other MBUSA resources before beginning any repair.

For example, the new aluminum-body CL-Class uses aluminum panels as part of its load bearing structure. Outer body panels are constructed from aluminum, magnesium, and composite compounds. Aluminum is used for the roof, outer door panels, rear quarter panel, hood, and more. These new materials, such as load-bearing aluminum body panels, offer advantages. However, in many cases, standard welding methods cannot be used to join materials. Where welding is not approved for the repair, chemical bonding provides a viable alternative. In some cases, Mercedes-Benz requires a combination of riveting and bonding agents to maintain chassis strength.

Let's consider a repair example where rivet-bonding is required. Here are some key considerations when making the repair:

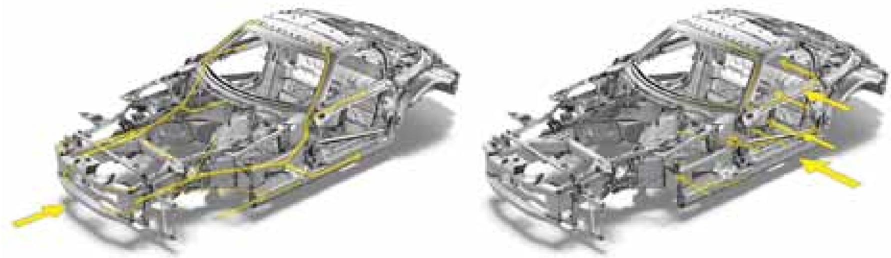
Know the composition — Technicians must be aware of what they are going to cut into before doing so. MBcollisioncenters.com provides critical information regarding the construction of vehicle parts and components. For example, various body panels on new models – roof, hood, quarter, door, etc. – may be constructed of magnesium, aluminum, high-strength steels, and even carbon fiber composites.

Use the approved attachment methods, be it replacement, welding of some type, or chemical bonding with adhesives — Attaching vehicle parts that are of two different materials should only be done if approved by Mercedes-Benz using the repair procedures the automaker specifies. The StarTekInfo.com website is the best resource for specific information, especially the procedures laid out in the Workshop Information Systems (WIS). Different grades of carbon fiber material require different chemical bonding procedures and/or agents. In addition, should dissimilar metals such as steel and aluminum be joined, it is critical that repairers avoid any cross contamination by working on the separate metals in different areas and with different tools. In addition, repair procedures such as rivet-bonding may be required rather than welding, as the latter could deform the metals and the interaction between the metals may lead to premature corrosion beneath repainted finishes.

Source quality parts, fasteners and adhesives — When fastening body panels together, the use of proper fasteners is paramount. To rivet-bond aluminum, be sure to utilize aluminum rivets; to fasten steel panels, use steel rivets. Also, ensure that the rivet gun being used is strong enough for the job. Body panels, other parts, rivets and adhesives are available from Mercedes-Benz or aftermarket suppliers. Because aftermarket suppliers may not be as thoroughly versed in Mercedes-Benz vehicles — remember, it's your responsibility to make the full, correct repair — be sure to ask what the specific steel grades of the rivets and body panels are, and also whether or not any adhesives or other supplies you purchase meet MBUSA requirements.

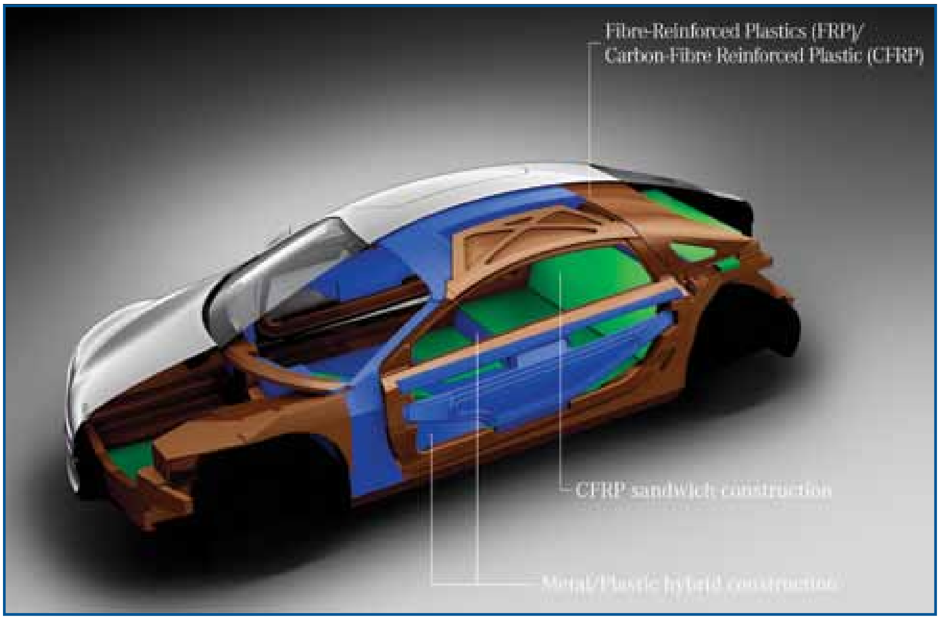
Cleanliness is essential — Clean surfaces are required for proper bonding, just as they are for welding. It is also important that bare metal be bonded to bare metal and not painted surfaces. Repairers may need to grind a body panel down to bare metal by removing enough of the corrosion inhibitor layer to expose sufficient bare metal to assure a thorough bonding. Finally,

ADHESIVES MAKE VEHICLES SAFER



Chemical bonding using adhesives (illustrated in the SLS AMG diagrams above) helps keep the absorption of energy forces during a crash truer to designed load paths. The basic principle is to ensure that the joining of adherents, at manufacture or after a collision repair, remains stronger than the adherents themselves, so that the latter absorbs most of the unwanted crash energy, while the adhesive itself only absorbs a very small portion of this energy. *(Image — MBUSA)*

The adhesive kit Betamate 2096 from Dow Automotive Systems is now available (Part # A 009 989 36 71) and must be used for the repair procedures described in all WIS which require body adhesive. The structural adhesive must also be applied using the adhesive dispensing/metering gun for 2-component adhesives (Part # W 220 589 03 63 00). In some cases, Zinc Dust Paint (Part # A 000 986 36 42) may be required tp prevent corrosion. *(Image — MBUSA)*



Mercedes-Benz says that 14 percent of all new developments relate to lightweight construction materials and production processes, such as new uses of carbon fiber-reinforced plastics, lightweight steels and metal alloys as well as other materials and processes. The automaker's new F125 concept employs many of these innovations, which result in a 40 percent reduction in bodyshell weight, compared to current series production models. For example, the front flexural and supporting structure is a load-bearing assembly of hybrid aluminum-carbon fiber reinforced plastic sandwich construction. (Image — MBUSA)

if rivet-bonding is to be employed, be sure to bevel the drill holes so that panels can be compressed snugly together.

Be cautious during adhesive application final assembly — Use only MBUSA-approved adhesive kit formulations that have been matched to the automaker's materials, so that collision repairs can meet the original safety specifications. Repairers should ensure that they understand application instructions before using the adhesive, so that the limited available working time is not wasted. Once the application is complete, clamp the body panel(s) into proper position.

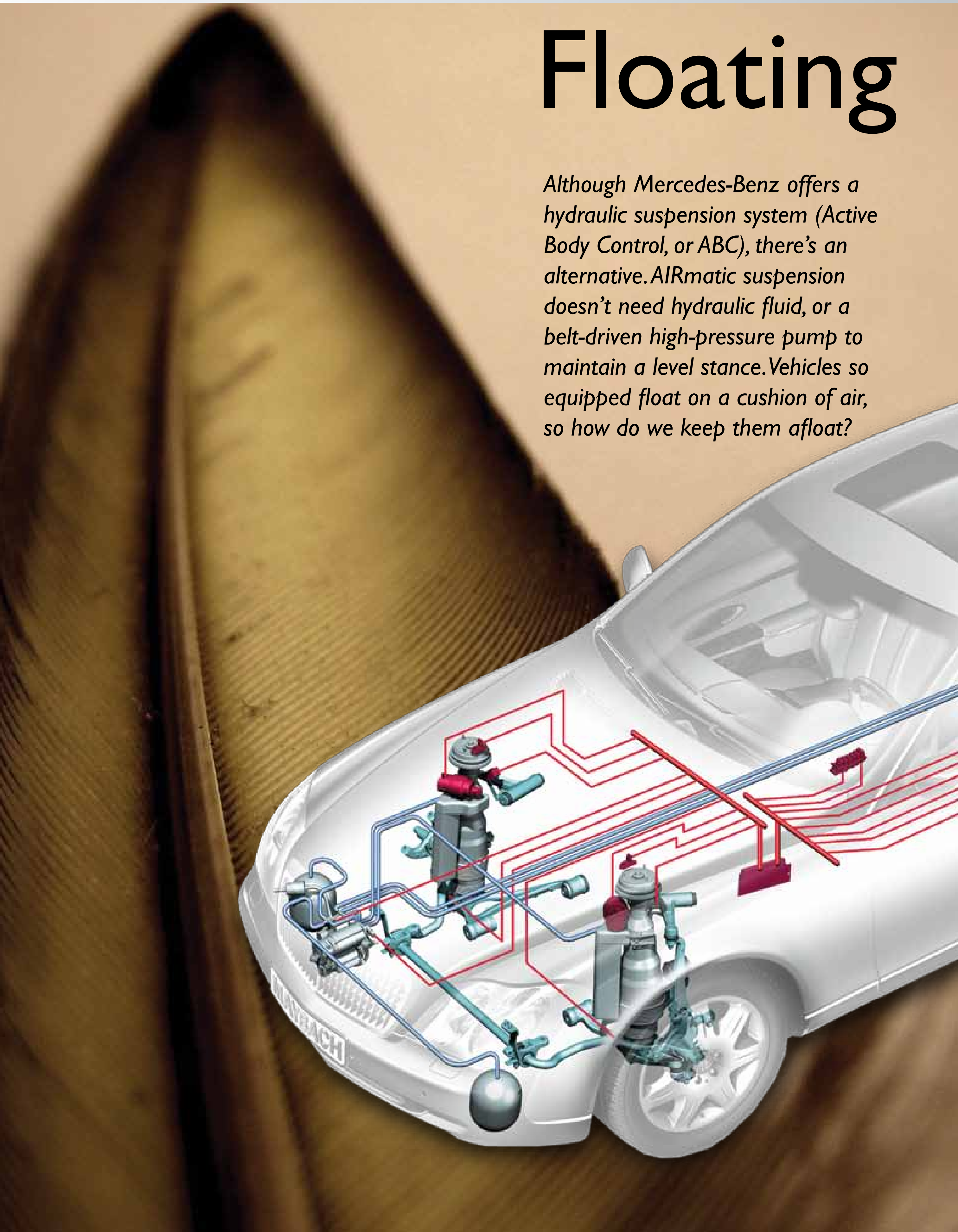
Complete final assembly — Before the final assembly, ensure that the new panel aligns properly to where it will be attached. In addition, check for gaps. Mercedes-Benz says that if a panel needs to be repositioned, repairers should slide the panel into proper position rather than lift it. Lifting the panel separates the bonding material and allows the intrusion of air bubbles into the bonding material, which can compromise the quality of the repair. Once the panel is in its final position, remove any excess material visible to the eye. Refer to the adhesive kit's instructions for curing time, which can range from one to 24 hours. Once cured, install the proper rivets and ensure they are fully covered. At this point, the rivet bonding process is complete. The repair is then ready for undercoating and painting.

Chemical bonding adhesives are ideally suited to modern vehicle bodywork repairs when high-strength metals, plastics, carbon fiber, and emerging composites are present. When compared to alternative joining technologies for current lightweight materials, modern two-component adhesive formulations and repair procedures allow all the properties of the body panel components to be returned almost, if not exactly, to their original state – namely improved surface bonding, more effective management of stresses, better mechanical properties and more corrosion-resistance.

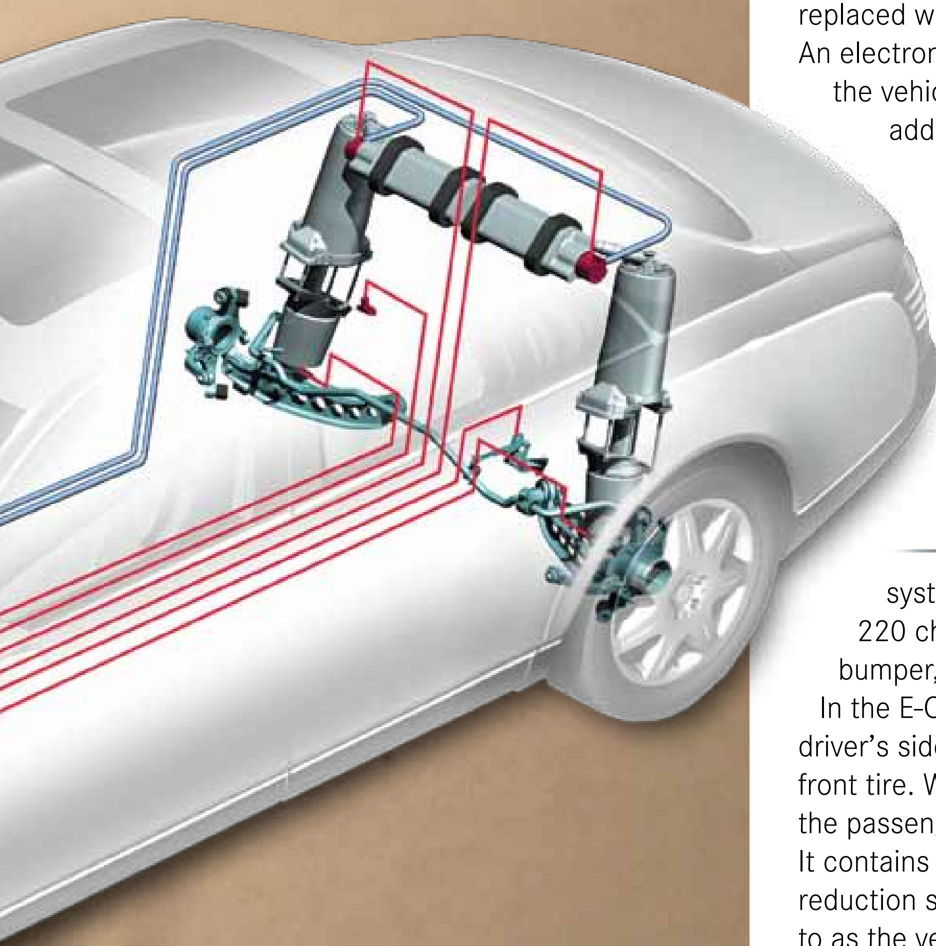
The quest for safer, lighter, and more efficient vehicles will continue to spark the introduction of innovative materials. Expect future improvements in adhesives to have an increasingly important role for this joining technology, during both manufacture and post-collision repair.

Floating

Although Mercedes-Benz offers a hydraulic suspension system (Active Body Control, or ABC), there's an alternative. AIRmatic suspension doesn't need hydraulic fluid, or a belt-driven high-pressure pump to maintain a level stance. Vehicles so equipped float on a cushion of air, so how do we keep them afloat?



On Air



Ride comfort is one of the many sterling traits Mercedes-Benz is known for, especially on its flagship models such as the E-Class, S-Class, and Maybach. As touring vehicles, they can be driven on winding country roads, or on long Interstate trips with equal aplomb. Being five-passenger sedans or coupes with enough trunk space for a golf outing, the load may vary quite a bit. Conventional suspension systems either sag from the additional weight, or are sprung so stiffly that they give a harsh ride when lightly loaded. To have the best of both worlds, a suspension system that can automatically adapt to changing loads is necessary, and this is what AIRmatic offers. Steel springs have been replaced with air bellows in the strut assemblies. An electronic system measures the ride height of the vehicle and determines if air needs to be added or removed from the struts to change the height. AIRmatic comes with ADS (Active Dampening System) and also controls suspension compliance with air pressure. It accomplishes these tasks with a series of pumps, valves and lines. But what do we do in the event something goes wrong?

The Heart

The heart of the AIRmatic suspension system is the pneumatic pump. On a 220 chassis it is usually located behind the bumper, under the car, on the passenger side. In the E-Class, it's usually mounted behind the driver's side of the front bumper, ahead of the front tire. With an R-Class model, it is in front of the passenger side front tire, behind the bumper. It contains the pneumatic pump and a pressure-reduction solenoid, which is sometimes referred to as the vent solenoid. The pump is capable of producing over 200 psi. Your SDS will display the pressure in Bar – just remember one Bar equals 14.7 psi of air pressure. One of the tests offered in the SDS software is to run the pump for 40 seconds and verify that it can produce 205 psi. The draw of these pumps can soar to about 100 amps at start-up, and stays at around 40 while running. They are typically protected by a 40-amp fuse. In the R- and the S-Classes, the driver's side fuse box houses the fuse and the relay for the compressor. In the E-Class, the relay is mounted separately from the fuse box, but still in the electronics housing. If you replace a compressor, it is always a good idea to change the relay since voltage drop across the contacts will increase the amp draw of the pump.

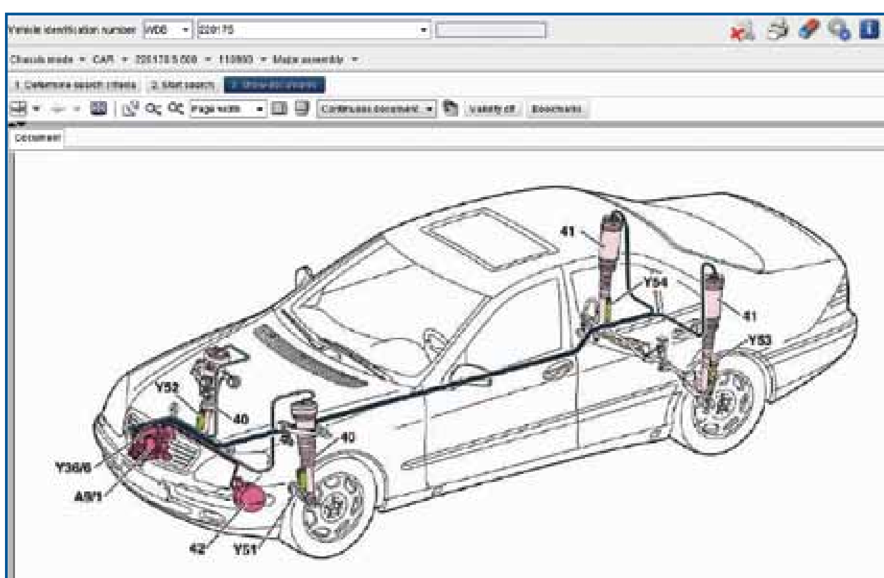
The pressure reduction solenoid (a.k.a. vent) is normally closed. This allows the pump to build up pressure and lift the vehicle. When the vehicle needs to be lowered after it is unloaded, this solenoid (as well as the individual shock solenoids for each corner) is commanded open to relieve the excess air pressure in the suspension. If the vent solenoid gets stuck closed, the suspension will never drop and compression dampening will get very stiff, giving the customer a harsh ride. If the vent solenoid gets stuck open, the pressure will never build up and the vehicle will not lift, so it is important to verify that it closes. You can activate the solenoid manually using the SDS or equivalent. You should see about 15 ohms on the solenoid windings and overall amperage draw of around one amp when the solenoid is activated (open to relieve pressure).

Other solenoids in the system are the air dampening valve units. These are typically mounted on the individual shock or strut. They do not affect ride height, but they do control the dampening, or shock-absorbing, characteristics. Each shock assembly has two solenoids. One handles compression dampening and the other rebound dampening. Other solenoids are used to allow air into and out of the air bellows of the strut/shock assemblies. In the case of the the early 220 chassis, each shock has a single chamber to fill. On later 220 and 211 chassis, dual chamber assemblies are used (more on that later).

Air Storage And Distribution

Once pressure is created, it is collected in a central reservoir, so extra air pressure is available if needed. The charge valve controls the pressure

The heart of the AIRmatic system is the air pump. It includes the pressure relief solenoid, which vents overall system pressure to lower the vehicle. If you have a case of no lift, verify that the solenoid is not stuck in the open position.



Using WIS, you can see a layout of the system. This helps isolate where you have to look for a problem. Also, safety procedures and detailed instructions are given to insure the safety of the technician.

into and out of the reservoir from and to the rest of the system. A test is available in the SDS software for this solenoid. It drops the pressure in the overall system by opening the vent solenoid, then closes it. It then opens the charge solenoid and the excess pressure is expected to increase the pressure in the system. The four corners are controlled independently, but there are some slight differences among the different chassis. On the 220 and 251 chassis, the pump and reservoir feed a valve block that distributes the air pressure to the individual strut assemblies. From there, flexible lines carry the high-psi air to each strut. A leak in any of these lines will allow each corner to drop, as will a leak in the air bellows of a strut. The 211 chassis is piped slightly differently. A manifold distributes the air through flexible lines, but each strut has its own individual solenoid to allow air in and out of the bellows. A leak in a strut here usually means a solenoid problem, or that the actual strut is leaking. Applying soapy water will allow you to pinpoint a leak, but the SDS has such good control and sensor information that it is usually not necessary.

The Brains of The Operation

An AIRmatic control unit is in charge of both the level and dampening of all four corners. This is not to be confused with Mercedes-Benz's rear level control systems with ADS, which only maintain the rear ride height and rear dampening. On the 220 chassis, you will find the control unit under the hood in the driver's side electrical housing. With a 211 chassis, it is mounted in the passenger's side foot-well next to the automatic transmission control unit. On a 251 chassis, it resides under the carpet in front of the passenger's side seat. The control unit can supply power and/or ground to each of the solenoids that allow air into or out of the shock assemblies, but how does it know when to add air and when to bleed some off? For ride height correction, there are three height sensors, one for each front axle on the 220 and 211 chassis, and a single sensor for the rear axle. The sensors are of the typical three-wire Hall-effect type with a five-volt reference, signal, and ground. On the 220 and 211 chassis, four-wire sensors are used. These have an additional signal wire that shares the same five-volt reference and ground. Two body acceleration sensors are placed in the front of the vehicle, and one sensor is placed in the rear, on the right side of the vehicle, that cooperate to supply the control unit with the information it needs to manage dampening characteristics.

When you see this solenoid block you'll know the air pressure sensor is incorporated into the unit. On other models, the pressure sensor is mounted in the air distribution manifold. You can see the pressure read by the sensor by using your SDS.

The body acceleration sensors are just like the yaw rate and G sensors found in ESP systems. They are three-wire sensors that also have five-volt reference, signal, and ground wiring. The signal wire of the sensor puts out just under 2.5 volts when not in motion. Depending on the sensor's location, the signal voltage moves above and below 2.5 volts as the body pitches to the left and right during turns. Using these readings, the AIRmatic control unit can determine which dampening solenoid to activate for compression and rebound adjustments.

The only other sensor input is that of the AIRmatic pressure sensor, which reports on the overall pressure in the system. It is also a three-wire sensor with a five-volt reference, signal wire, and ground. In the 211 chassis, this is mounted in the manifold that connects the high-pressure air and the reservoir. On the 220 chassis, it is found in the valve block that controls the air flow to the strut assemblies. On the 251 chassis, it is incorporated into the valve block that directs the air to each corner's shock. All of these sensor readings can be evaluated with the SDS software, as well as testing for each solenoid. After any work is performed on the system, the ride height will have to be recalibrated. On the SDS, look under control unit adaptations. Once you have corrected the ride height of each corner, you can recalibrate the system with the new readings.

Here's a front shock assembly on a 220 chassis that has separated and allowed air to leak out of a system. This can happen from letting a leaking system go unrepaired for some time. You can also prematurely burn out the air pump from constantly trying to fill an empty system.

Vehicle	220.075	Control unit	AIRmatic
Actuation of level valves			
Signal 1 of component B22/8 (Left front level sensor)			3.65 V
Signal 1 of component B22/9 (Right front level sensor)			0.84 V
Signal 1 of component B22/3 (Rear axle level sensor)			1.12 V
Set values for front axle: inclination angle 4.8° - 5.5° (Romess inclination measuring instrument) Set values for rear axle: inclination angle (-1.9)° - (-1.4)° (Romess inclination measuring instrument)			
F3: Lift front left.			
F4: Lower front left.			
F5: Lift front right.			
F6: Lower front right.			
F7: Lift rear.			
F8: Lower rear.			

You can use your SDS to activate specific solenoids and raise and lower the vehicle. You can use the height sensor data to level the vehicle and compare ride height of each corner to that of the others.

Air Bellows

If you see a comfort/sport switch on the dash, two-chamber air struts are present in the front suspension. A pair of solenoids controls each strut. One handles the pressure in and out, and the other controls the split between the two chambers. When both chambers are open to system pressure, the ride is softer due to a larger volume of air being compressed. By closing off the second chamber, the ride becomes stiffer since there is a smaller volume of air to compress. The comfort/sport switch is wired to the lower control panel and instructions are sent through CAN B. This is also how the system is awakened. If you operate a door or trunk switch, the AIRmatic system wakes up and tries to correct the vehicle level. This can be a problem if you have the system apart for repairs, so disconnect the battery after bleeding off the system.

Some Do's And Don'ts

Before attempting any repair work, vent the entire system. This should bring system pressure below three psi and make it safe to open air lines. Keep in mind when a corner of the vehicle is on the ground other parts of the system may be holding high air pressure. When repairing damaged lines, you must replace the line completely. Only the rear lines can be repaired with kits available from your Mercedes-Benz parts supplier. The rear lines must be cut if you have to remove the air spring assembly. When towing the vehicle, there are special blocks that need to be temporarily installed to support the suspension. Otherwise, the suspension may lose pressure while on the bed of the truck and allow slack in the safety straps. If you have the proper straps, anchor the wheels to the tow bed.

Knowledge of how AIRmatic works and following all of these precautions should allow you to diagnose and repair the vehicle in a manner that is safe for both the technician and the customer.

THE NET

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- Downloadable Remanufactured Parts Catalog and Reman Parts policies.
- User friendly links to tools such as STAR Tekinfo and WIS.
- WebParts online ordering information and how-to video tutorial.
- Search feature to find archived StarTuned Magazine articles & information.

www.mbwholesaleparts.com

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