the bimmer pub®

October 2012 Volume 1 Number 3

Technical Knowledge for Independent BMW Service Professionals

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Our position is simple. If you are able to repair and maintain BMW vehicles properly and efficiently, your reputation will be enhanced, as well as the reputation of BMW. To this end, feature articles are intended to provide hands-on diagnostic and repair procedures, service and maintenance techniques, with content sourced from both BMW and successful independent BMW repair specialists.

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Thanks for your continued interest.

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Mixing It Up

Now more than ever BMW owners are concerned about their fuel mileage as well as their impact on the environment. Part of BMW's "Efficient Dynamics" movement is reducing emissions and still providing a vehicle that is a driver's car. How are you going to keep your customers' vehicles running efficiently?

One of the many sterling characteristics of BMW vehicles is their fuel efficiency. Other European luxury manufacturers are only now following BMW's lead with engines that are both powerful and fuel efficient. Many BMW models already get close to 30 miles to the gallon with normal driving. In order to get the best mpg and still maintain performance and drivability, the DME control unit carefully meters the precise amount of fuel needed for conditions. When everything is working properly, the engines sip fuel and provide the necessary power when the need arises. However, as components wear and tear with normal driving gaskets will dry up, contaminated fuel will clog injector screens and dirty air filters will restrict airflow. All of these conditions and more can lead to mixture problems. The sophisticated electronics of the DME can pick up these mixture irregularities, flag a diagnostic trouble code (DTC) and turn on the check engine light (CEL). These fuel mixture related problems can lead to more severe symptoms such as misfires depending on the extent of the problem. The DME's sophisticated electronics will shut down misfiring injectors if it is determined it is a catalyst damaging misfire. We are going to need to learn how diagnose if the misfire is caused by a fuel mixture problem.

The Basics of Fuel Control

The basic combustion process starts with an optimal fuel mixture. This optimal mixture is determined by the various sensor inputs to the DME. The base pulse width is typically determined by the two important sensors, the engine position sensors and the engine load sensor. The DME gets the information on engine position from a combination of the crankshaft position sensor and cam position sensor(s). With modern sequentially grounded injectors cam position sensors can verify when the piston is coming up on the compression stroke or coming up on exhaust stroke. This is how the DME determines when the injector is fired. The DME determines how long the injector is opened using the load sensor. The Mass Airflow Sensor (MAF) is the load sensor and measures how much air is being drawn into the intake manifold. Current Catalytic Converters work best with a mixture ratio of 14.7:1 air to fuel. This allows the converter to store oxygen when the mixture is lean and release it when the mixture turns rich. It is the job of the oxygen sensor to sense the oxygen content of the exhaust gas and pass this information along to the DME. If the exhaust gas reads too lean the injector on time will be increased. If the mixture is too rich then the on time will be reduced.

Older BMWs use single wire and 4 wire O2 sensors. These are typical zirconia type sensors that have a two heater wires, one power and one ground, an O2 sensor ground and the signal wire. The signal wire can range between .01 of a volt to .5 of a volt to indicate a lean condition and .5 to 1.0 volt to indicate a rich condition. We can easily measure this with a voltmeter as well as observe the voltage change on our iComm scan tool with ISTA or equivalent. In later years

In order for any engine to run properly, it needs sufficient fuel pressure and volume. Here, we are reading approximately 50psi on a vehicle that performs well. Under hard acceleration, this reading must not drop. If it does, there's a problem with fuel volume. Check for a clogged filter before changing the fuel pump.

a slightly different NGK linear planar titania type sensor is used. This sensor works the same way as a conventional O2 sensor but a 5 volt reference is supplied by the PCM. The sensor toggles the 5 volt reference depending on the mixture in the exhaust. With this sensor 0 to 2.5 volts indicates a rich condition and 2.5 to 5.0 volts indicates a lean condition, which is the opposite of the zirconia type sensor. Instead of this type of sensor switching above and below .5 of a volt the titania sensor switches above and below 2.5 volts as it bounces between a lean and a rich condition.

Late model BMWs use the latest in oxygen sensor technology. The latest sensor is referred to as an air/fuel ratio sensor. Its operation is significantly different from the previous zirconia and titania type sensor in that the voltage no longer indicates a rich or lean condition. Sophisticated electronics use milliamps (ma) to indicate a rich or lean condition. The basic operation of the air/fuel ratio sensor is this. As the mixture passes by the sensor it is drawn into a chamber within the air/fuel ratio sensor. If it is a lean condition more current (ma) is pumped into the sensor through a pump cell from the DME to draw in a greater amount of the exhaust gas. The more current has to be pumped in the leaner the mixture. If the mixture is rich current is taken away from the pump cell by the DME. The greater the current is taken away the richer the mixture is. Although the sensor operation is complicated it is also capable of accurately reading mixtures as low as 22:1 air to fuel, something a zirconia or titania sensor cannot do accurately. These sensors do require greater heater control from the DME since they need to work at a much higher temperature but they can start working in closed loop much faster than older O2 sensor designs, usually within 30 seconds of starting the engine.

The Air/Fuel Ratio Sensor

This allows the mixture to be monitored and controlled during the engine warm up period and can reduce emissions significantly during this period. Since the sensor works by pumping milliamps back and forth between the sensor and the DME it is difficult to determine a rich or lean condition with a ammeter. The signal amperage may only toggle between -20 to +20ma. Also when measuring amperage you need to connect you meter in series. The measured current needs to pass through the meter. This means you will need to open the circuit to install your meter. This type of testing can be time consuming and is not cost effective. There are other ways of testing the air/fuel ratio sensor and diagnosing mixture related problems. The iComm/ISTA diagnostic system does allow you to monitor the activity of the air/fuel ratio sensor and all of the sensors that affect the desired fuel mixture. It can also provide this information throughout the entire rev range of the engine. This is significant because a mixture related problem at idle can have a totally different cause than a mixture related problem at 3000rpm. What tools are at our disposal to isolate the cause of the mixture problem?

An air intake leak can lead to symptoms similar to those of a traditional vacuum leak. Here, the intake manifold is not leaking, but a rip in the air intake duct is allowing air to enter the intake without being measured by the MAF (called "false air"). The low reading of the MAF will skew the amount of fuel injected into the engine downward, resulting in an overly lean condition. The motion of engine torque may open the crack wider making the problem worse.

We tend to have the bad habit of immediately pulling out our scan tool and start looking for electronic fuel injection problems when we have a drivability problem or DTCs. As with any automotive system the basics have to be checked first before we can go on to more sophisticated testing. With mixture related codes this is no different. Before an engine can function the way it is designed it needs to have proper engine timing, sufficient spark and the correct fuel supply. The BMW DME is a pretty smart computer and can watch the crankshaft and camshaft position sensors to determine if the valve timing is off. You can also put a lab scope on the crank and cam position sensors and compare the pattern you get with a known good running vehicle. If you suspect a spark problem first look at the spark plugs. If they are worn they usually lead to a slightly rich condition. Severe wear can lead to misfires. To be sure you are installing the correct plug it is a good idea to purchase them from your BMW dealer. The coils should fire and HEI spark tester. You can always evaluate the ignition pattern on your ignition scope if you have a suitable adapter for the ignition coil.

Mixture Adaptation

A greater concern with fuel mixture codes are the fuel and air supplies. These are the most common faults when it comes to mixture related codes that do not lead to a drivability problem. Plus or minus 10% on the mixture scale will set a code but may not necessarily to a drivability problem. These are often the harder problems to find since the fault is so subtle. For these problems our iComm/ISTA scan tool is ideal. It can read the data provided in real time by the DME. Most European manufacturers, BMW included, do not use the same long term/short term fuel trim scale that Domestic and Asian manufacturers do. You can retrieve this information using Generic OBD – II scan tool communication but long and short term fuel trims only tell you if the problem has been going on for a while. BMW data gives the mixture information in "Additive" and "Multiplicative" scales. These scales tell you in real time what the mixture is doing at the moment. The additive fuel scale tells you the fuel trim correction factor at idle and just above idle. The multiplicative fuel scale gives you the fuel trim correction factor above idle and in the higher rpm ranges. This is an excellent way to determine when the vehicle is having the problem and where you should test it.

If the problem shows up with high numbers on the additive fuel trim you should test the vehicle at idle and see what can affect the mixture under idle conditions. You should also look at the same time the multiplicative fuel trim and compare them to the additive readings. Look at the definition of the specific code you have. It will indicate if the problem is in the additive or multiplicative rpm ranges or both. The scales may be different for both readings. BMW generally gives the additive reading in milliseconds of injector pulse width or milligrams per stroke. A positive number means the vehicle is lean and trying to open the injector longer to add fuel. A negative number means the engine sees a rich condition and is reducing injector pulse. The increments are very small, but if you see a significant change compared to a

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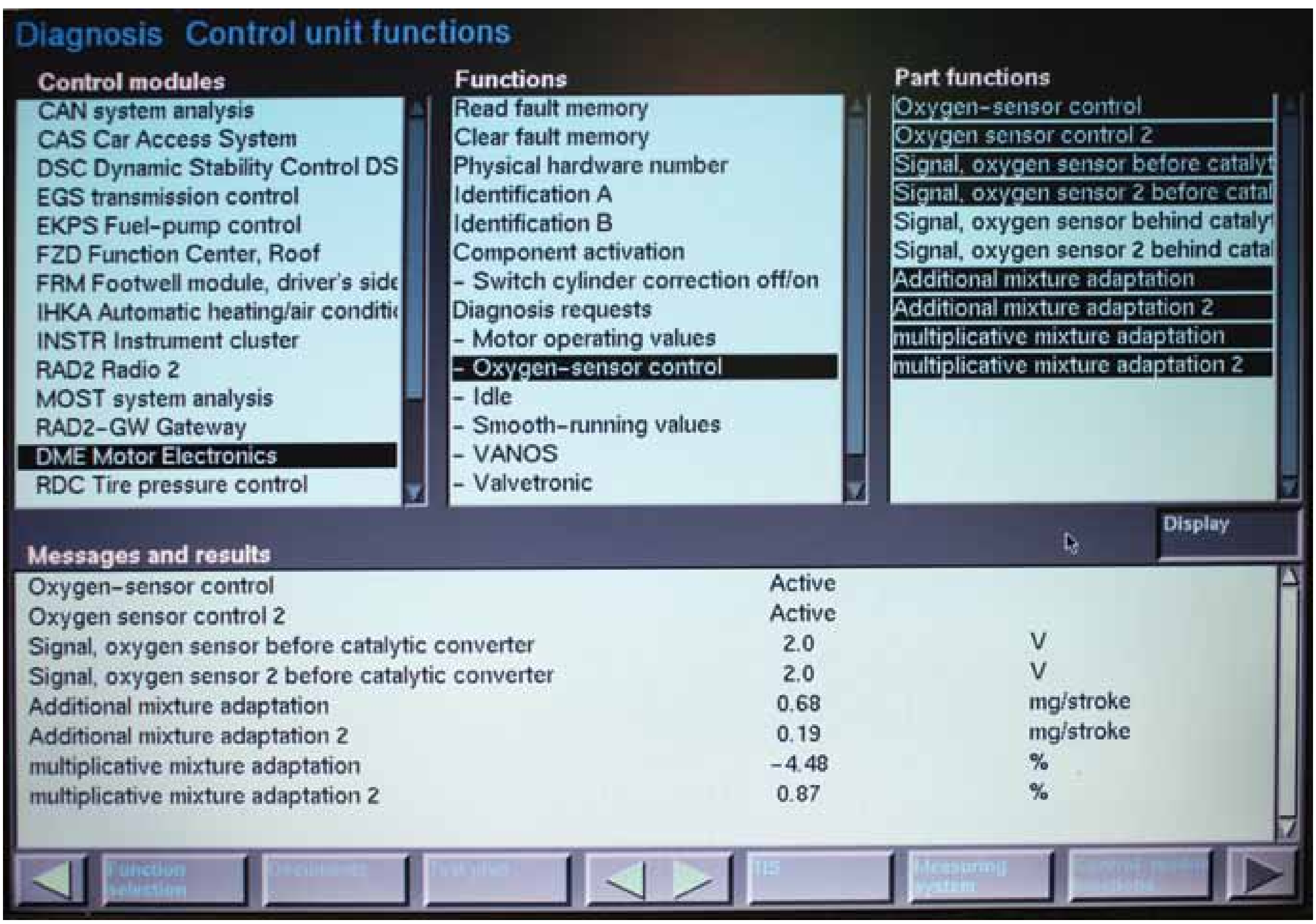
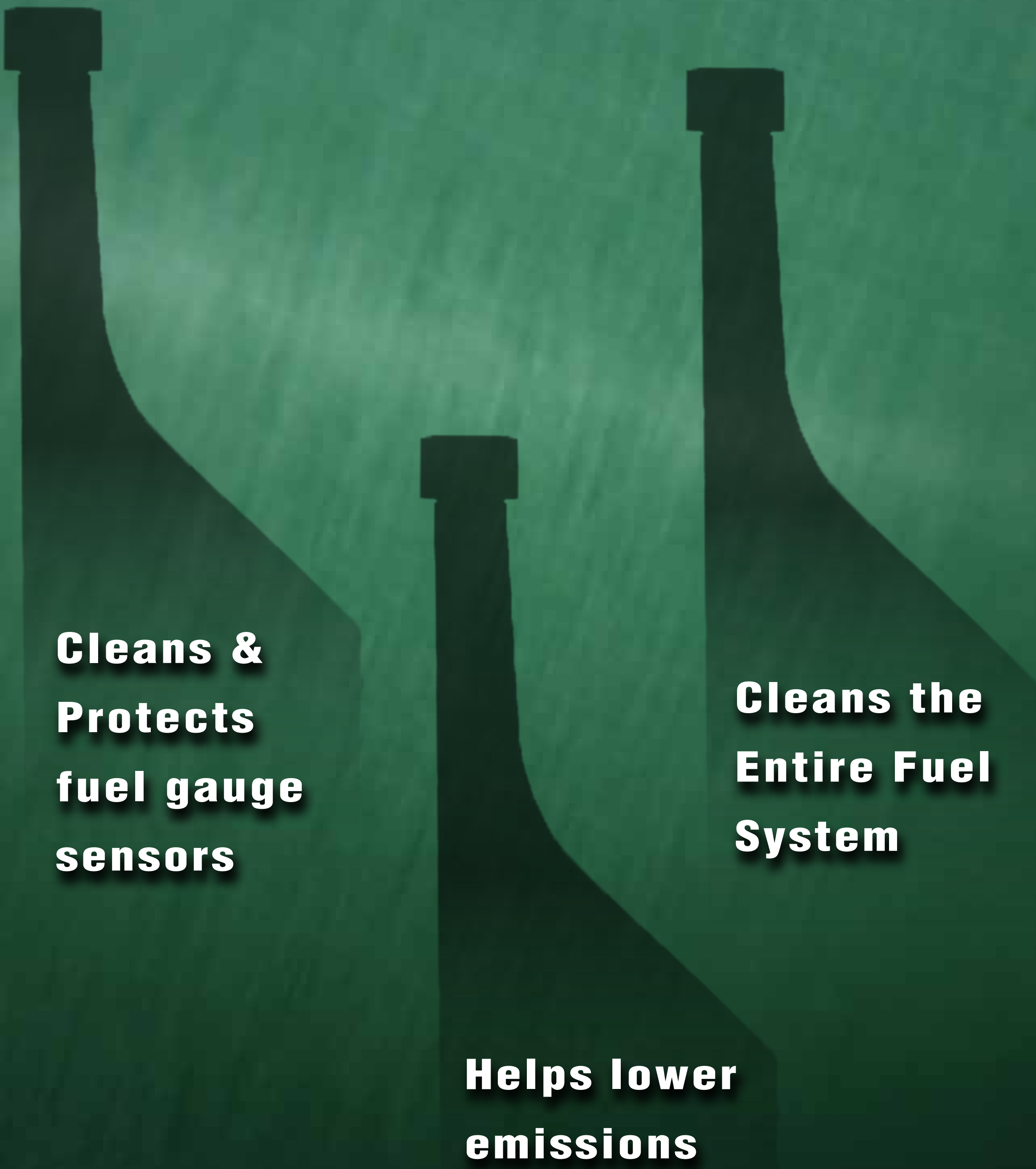


Using your GT1 software, you can see the additive and multiplicative readings in real time. As you can see here, Bank 1 has a severe problem with fuel mixture in both the additive and multiplicative rpm ranges. The .68 mg/stroke means it is adding fuel at idle. The negative multiplicative fuel trim reading of -4.48% means it is rich and subtracting fuel at part throttle.

BMW Group Fuel System Cleaner



good running vehicle, you've found out something. The same rules apply to the multiplicative scale except it is usually displayed in terms of "Lambda" or 100%. Above 1.00 (Lambda) or above 100% the engine is lean and the computer feels it needs to add fuel. Below 1.00 or 100% the DME sees a rich condition and is reducing injector on time. Carefully examining these numbers can lead you to the correct tests you should perform.

Looking For Clues

As an example if your additive correction factor is positive and relatively high but the multiplicative is normal your problem is a lean condition at idle. You should check the fuel pressure of the supply system and make sure fuel pressure is not too low. It probably isn't because if fuel pressure was low you would also have low fuel pressure at high rpm and flag a code for multiplicative fuel control as well. If the problem is only at idle then you either have too little fuel or too much air only at idle. Take a quick peak at the idle speed correction factor. If the DME is reading negative numbers then it is trying to close the idle speed motor. Many BMWs that have electronic throttle still retain the idle speed motor. This means there is extra air getting into the intake and keeping the idle speed too high. At this point connect your smoke machine and start looking for a vacuum leak leaning out the mixture at idle. A small vacuum leak may affect the fuel trim at idle but does not pass enough air to affect the fuel mixture at higher rpm ranges. What if the scenario is reversed?

What if the additive fuel trim is normal but the multiplicative fuel trim is high. On a scale of 1.00 the reading 1.10 would be equivalent to 10% fuel correction. This will flag a code. We can conclude it is probably not a vacuum leak since there is no problem at idle. But the mixture is being leaned out at part throttle. At higher rpm we have either too much air or not enough fuel. At higher rpm fuel pressure and volume need to be looked at. A fuel volume tester is the best way to insure proper volume with higher loads. Many newer BMWs have returnless fuel system where the fuel pressure regulator is incorporated in the fuel filter or in the fuel pump module assembly. In these cases we cannot block the return line to check the fuel pump's maximum output. You can watch fuel pressure under hard acceleration but you should have someone else drive the vehicle to maintain road safety. The fuel pressure should not drop under acceleration. If fuel volume is a problem it can lead to a lean condition and will flag a code in the multiplicative range. Pushing the button on your fuel pressure tester is a crude way to verifying sufficient fuel supply and you should refrain from doing so.

Pumping smoke into the intake is a great way to verify a vacuum leak. This one is at the front throttle plate adapter of a V8 engine and verifies that the gasket needs to be replaced. This type of leak will lead to higher additive trim readings, but will not have much of an effect on multiplicative readings.

The Usual Suspects

Another concern with lean multiplicative conditions is the MAF. As mentioned earlier the MAF or load sensor makes up the base pulse width. If oil or dirt contaminated MAF cannot measure the exact amount of air being drawn into the engine the DME will not open the injectors for the proper amount of time resulting in the lean condition. Less measured air means less measured fuel. If the fuel supply is sufficient you should then check the MAF sensors responsiveness. This can

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be done with a Digital Volt Ohm Meter (DVOM) either by measuring an analogue voltage or frequency. As an example older MAFs would read just about 4.0 volts under hard acceleration. Once again have someone else driving to maintain road safety. More modern MAFs as found on a E46 chassis with the 330i straight six can almost reach 4.5 volts on a snap throttle. A dirty MAF will read less than these so you can attempt to clean it and see if the readings changes. If it does replace the MAF as cleaning is only a temporary solution to the problem. Remember a MAF will affect the fuel trims on both banks. Even on a six cylinder the first three cylinders are considered bank 1 and 4 thru 6 are bank 2. If you only have mixture codes on one bank check for a specific vacuum leak, clogged injector(s) and/or a malfunctioning O2/air/fuel ratio sensor.

By mid-2000 and later model MAF's send out the signal as a frequency reading. This is a change from the earlier analog voltage reading in the past. With an analog MAF the voltage reading increases proportional to airflow. On the newer digital MAF the voltage and the duty cycle of the square-wave stay the same only the frequency (pulses per second) increases in proportion with airflow. You can still use additive and multiplicative readings to assist in the diagnosis of the mixture control problem. When dealing with fuel mixture codes you need to test all of the factors involved in correcting the mixture. Understand MAF and fuel pressure/volume problems will affect both bank equally. Intake runner vacuum leaks and oxygen sensor/air/fuel ratio sensors usually affect only the bank they are installed in. Use your additive and multiplicative readings to isolate the problem and verify the solution with component specific testing. Your customers will be happy the problem is completely repaired and your will be happy when they do not come back with the same problem. Good job guys. ●

You can measure MAF signal voltage directly with a DMM. Here, we see with the engine at idle that the MAF is putting out .6V. Using the MAX/MIN feature of the meter, we see the peak signal voltage reached is just about 4.3V under hard acceleration, not a terrible reading for a MAF.

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Any time you are evaluating a suspension problem you should first perform a visual inspection. Here we have removed the protective plastic boot to expose the strut shaft and look for possible oil leaks.

Earth Shocks

From early on, one of the main things that separated BMWs from other cars was the fun-to-drive quotient. A big part of that has always been due to great suspension designs that provide both agile handling and a compliant ride. Even in this age of computer controls, you can make sure your customers' vehicles retain these valuable qualities

It's been a couple of decades since BMW introduced its first full-time electronically-adjustable suspension system. Dubbed EDC (Electronic Damping Control), it appeared on the 7 Series and did exactly what its name implies -- changed the stiffness of the shock/strut units according to how the car was being driven by means of a valve that altered the size of the hydraulic orifices.

Fine, but today BMWs employ additional inputs to determine damping commands, which presents us with another whole level of sophistication and complication. So, when a customer comes to you complaining of a harsh ride, you'd better understand what you're dealing with.

What's what

First off, EDC is different from EHC (Electronic Height Control), which only addresses vehicle level as additional weight is carried. The tip-off to the presence of EHC is the large reservoir on the power-steering pump and the hydraulic lines running to the shocks/struts. As we said, EDC handles suspension stiffness, and offers the driver manual choices for either a soft, compliant ride, or a sportier, stiffer suspension feel. Through the years, this system has evolved to provide an increased range of comfort and additional vehicle control under various road conditions.

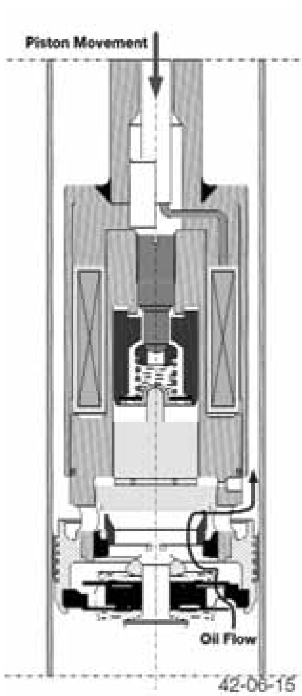
BMW has offered computer-controlled suspension systems as options on various models. EDC-K followed EDC I, II, and III. The K system is truly active, reading road conditions and reacting accordingly. BMW uses conventional gas-charged shock absorbers even in its computerized systems, but they have the addition of adjustable hydraulic restriction to control compression and rebound dampening. EDC logic commands internal valves that control the flow of hydraulic fluid from one chamber of the shock to another. When the valves are wide open, the fluid passes easily providing a softer, more comfortable ride. When the valves close down, flow is restricted increasing compression and rebound dampening. This makes for a stiffer ride and sporty, more precise control of the vehicle.

As with every other make, the hydraulic fluid level is not serviceable, so if a serious leak occurs unit replacement is required.

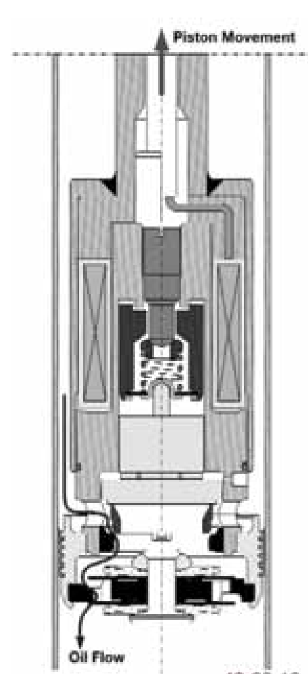
When Computers Take Over

The EDC control unit is continuously in charge of shock absorber compression and rebound dampening, and the shocks are infinitely adjustable from full-firm to full-soft. If there is a failure such as the loss of voltage supply, the shocks default to maximum compression and rebound dampening. In other words, the internal valves are in their most-closed position when they do not have electrical power. Again, don't confuse this with EHC -- when that fails, the suspension can drop the chassis to the ground. With EDC, on the other hand, a problem will only change the ride characteristics. Your customer may notice a very stiff ride and severe jolts over large bumps, as well as the EDC warning light coming on, indicating that the self-diagnostic system picked up a fault.

The EDC control unit has only one function: adjusting the dampening characteristics of the individual shock/strut assemblies. It receives signals from three sensors that indicate body direction and speed, which are called acceleration sensors. They are placed in only three corners of the vehicle because the direction and speed of the fourth corner can be determined by the readings of the other three. Locations can vary according to year, make, and model. For example, on a 2007 M5 the two front sensors are mounted in the rear of the front wheel houses and on the passenger's side of the trunk, or the right-rear corner. They are all three-wire sensors with a 5V reference, ground, and signal wire. The signal voltage should



Here's the flow of oil through the shock absorber during compression dampening. The control valve at the bottom opened with the application of current allowing easier oil flow and a softer ride.



The same principle applies to rebound dampening. A compressed spring returns to its normal shape so rapidly it can make for a rough ride. By slowing down the spring's return (rebound dampening), road feel is improved.

be very close to 2.5V for each sensor while the car is parked on a flat surface. The signal voltage on each sensor will rise from 2.5V in one direction of travel, and drop below 2.5V in the other direction. It is important that these sensors are installed properly, especially after accident damage.

So Who Pulls Whose Chain?

The driver is in control of the overall setting of the suspension. EDC-K has two settings, Comfort and Sport. This driver input goes directly to the Controller (Con) through the K-CAN and can be seen in the on-screen display. From here, messages are passed on to the Gateway (ZGM), and then on to the EDC control unit on the Powertrain (PT) CAN. This is not the only input coming in from the Gateway. The Steering Angle Sensor (LWS) sends a "Byteflight" fiber-optic signal (used to increase the speed of the steering angle input) to the Gateway control unit as well. This information tells the EDC control unit how much steering input is occurring so it can make the necessary adjustments to the suspension valves using pre-determined maps. Other inputs come in directly on the PT-CAN. The Dynamic Stability Control (DSC) unit has some say in how the EDC should react. Here, the relative speeds of the two front wheels are used to calculate the optimal suspension adjustment.

Not all inputs go directly to the EDC control unit. The steering angle sensor is built into the steering column module (SZL). The information is sent to the Gateway control unit and then passed on to the EDC through the PT-CAN.

The EDC control unit provides power and ground for the valves in the shock/strut assembly. It is a relatively low voltage supply because high currents are called for (more on this later). Remember, the shocks are normally in the firmest setting without power. Small amounts of current to the valves keep the suspension firm. The more current that is applied, the softer the suspension is going to be. That is limited to two amps to prevent damage to the solenoid and/or the driver in the EDC.

Several different failures can occur, but there are only two fail-safe modes. With minor faults, the system enters a "partial fail-safe," which keeps a static current to the solenoids for medium ride quality. Total failure defaults to the firmest settings as mentioned earlier. The solenoids are current-controlled, but BMW uses a pulse-width modulated (PWM) signal to average the amount of current the solenoids receive.

A Current Divided

The control unit can adjust each individual corner of the vehicle, but it has a unique way of controlling each pair of shocks on one axle. The EDC provides a 12V power supply to one of the front solenoids. In the case of the 2007 M5, this goes to the left solenoid, and the ground control of the left solenoid becomes the power supply to the right solenoid. This way, current is evenly split between the two solenoids on one axle. As mentioned earlier, the EDC controls the ground voltages at about 2.5V and maintains the overall current flow with PWM. You can use an oscilloscope to monitor these signals, but you will have to drive the vehicle. Current control of the solenoids stops below three mph.

Using your iComm/ISTA tool, you can diagnose problems with the system. The EDC control unit only sets faults for axles, so you have to individually test each shock. You are going to need a special tool available from your local BMW dealer's parts department, Part #90 88 6 372 050, to use Testplan to isolate which shock is at fault. If one is replaced, the "running time memory" in the EDC control unit must be reset. To put it another

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ORIGINAL BMW REMANUFAC

Series	Engine	Production Years	Models	Reman Part Number
E30	M42	Up to 04/1991	318i, 318is	64 52 8 385 916
E31	M62 M60	M60: 9/1993 - 11/19/95 M62: From 05/1995	840Ci, 840i	64 52 8 385 908
E32	M60	From 06/1992	740i, 740iL	64 52 8 385 908
E34	M60	From 01/1988	530i, 540i	64 52 8 385 908
E34	M50	Up to 07/1993	525i	64 52 8 385 915
E36	M50, M52, S52	Up to 09/1992	320i, 323i, 325i, 325is, 328i, M3	64 52 8 385 915
E36	S50	From 11/1993	M3	64 52 8 385 909
E38	M60, M62	Up to 09/1997	740i, 740iL	64 52 8 385 917
E38	M73, M73N	From 09/1997	750iL, 750iLP	64 52 6 911 348
E38	M73, M73N	04/1997 to 09/1997	750iL	64 52 2 147 456
E39	M52	Up to 09/1997	528i	64 52 8 385 919
E39	M62	Up to 09/1997	540i, 540iP	64 52 8 385 921
E46	M52, M54, M56, S54	M52, M54, M56: Up to 09/2002 S54: 09/1997 - 09/2002	320i, 323i, 323Ci, 325i, 325Ci, 325xi, 328i, 328Ci, 330i, 330xi, 330Ci, M3	64 52 6 911 340
E38, E39, E52	M62, S62	From 09/1997	740i, 740iL, 740iLP, 540i, 540iP, M5, ALPINA V8 Roadster, Z8 Roadster	64 52 6 911 342
E53	M62	From 10/1998	X5 4.4i / 4.6is	64 52 6 921 651
E53	M54	Up to 10/2002	X5 3.0i	64 52 6 921 650
E65, E66	N62, N62N, N73	Up to 4/2008	745i, 745iL, 750i, 750iL, 760i, 760iL	64 52 2 147 458
E60, E60N, E61	N52, N52N	Up to 9/2008	525i, 525xi, 528i, 528xi, 530i, 530xi	64 52 2 147 460
E46, E83	M54, M56, S54	From 09/2002	325i, 325Ci, 330Ci, M3, X3 2.5i / 3.0i	64 52 6 936 883
E60	M54	Up to 10/2005	525i, 525xi, 530i, 530xi	64 52 2 147 457
E60, E63, E64	N62, N62N	Up to 4/2008	545i, 550i, 645Ci, 650i	64 52 2 147 459
E82, E88	N51	Up to 3/2007	128i	64 52 2 151 495
E90, E90N, E91, E91N	N51, N52, N52N	Up to 10/2006	323i, 325i, 325xi, 328i, 328xi, 330i, 330xi	64 52 2 151 495
E92	N51, N52N	N51: Up to 3/2007 N52N: Up to 10/2006	328i, 328xi	64 52 2 151 495
E93	N51	Up to 3/2007	328i	64 52 2 151 495

CTURED A/C COMPRESSORS

Series	Engine	Production Years	Models	Reman Part Number
E82, E88	N54	From 11/2006	135i	64 52 2 151 496
E90	N54	From 3/2006	335i, 335xi	64 52 2 151 496
E90N	N54	From 04/2008	335i, 335xi	64 52 2 151 496
E92	N54	From 06/2005	335i, 335xi	64 52 2 151 496
E93	N54	From 10/2005	335i	64 52 2 151 496
E82	N51, N52N	N51: From 03/2007, N52N: From 10/2006	128i	64 52 2 153 227
E88	N51, N52N	N51: From 03/2007, N52N: From 10/2006	128i	64 52 2 153 227
E90	N51, N52, N52N	N51: From 03/2007 N52, N52N: From 10/2006	323i, 325i, 325xi, 328i, 328xi, 330i, 330xi	64 52 2 153 227
E90N	N51, N52N	N51: From 03/2007 N52N: From 10/2006	328i, 328xi	64 52 2 153 227
E91	N52, N52N	From 10/2006	325xi 328i	64 52 2 153 227
E91N	N52N	From 10/2006	328i, 328xi	64 52 2 153 227
E92	N51, N52N	N51: From 03/2007 N52N: From 10/2006	328i, 328xi	64 52 2 153 227
E93	N51, N52N	N51: From 03/2007 N52N: From 10/2006	328i	64 52 2 153 227

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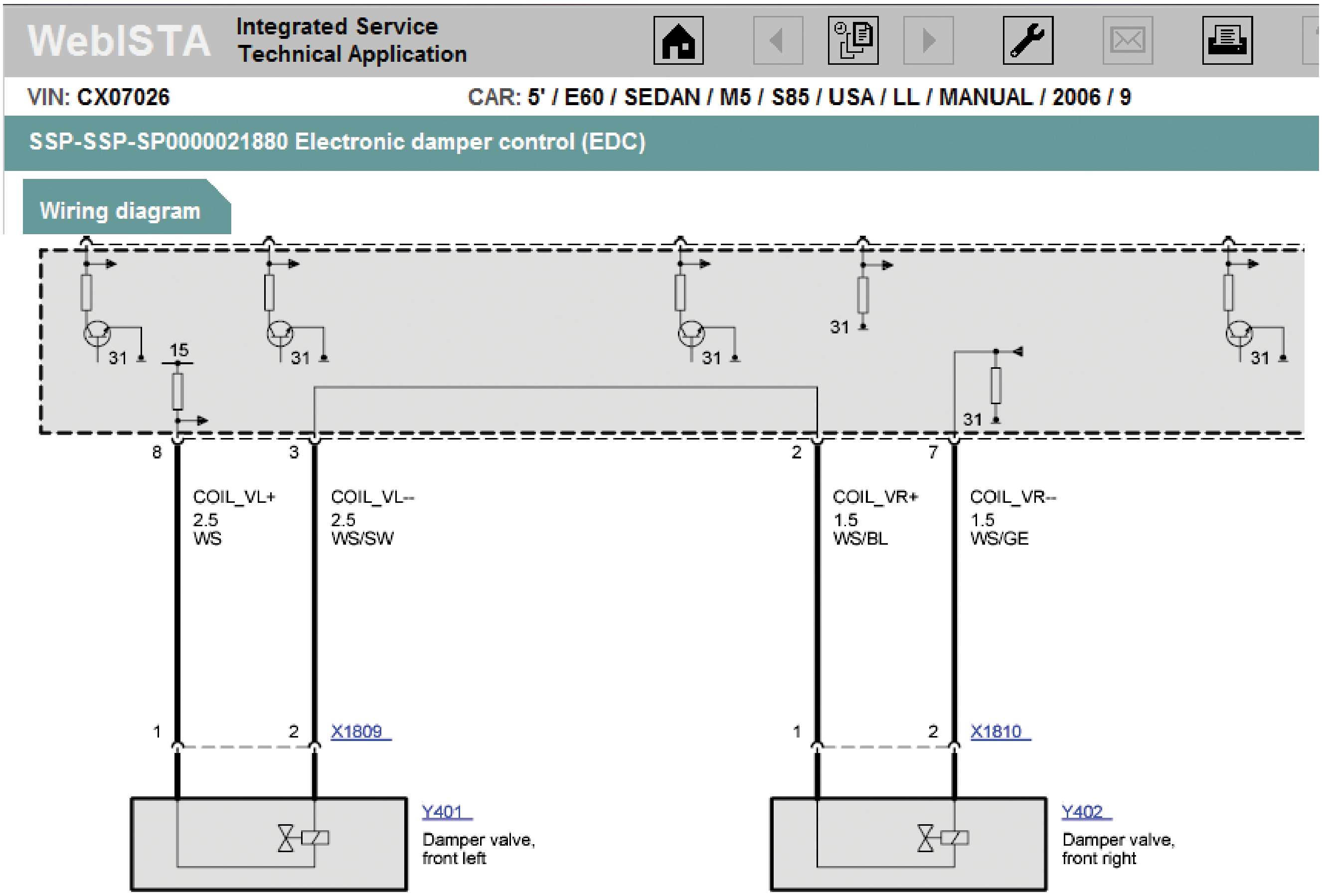
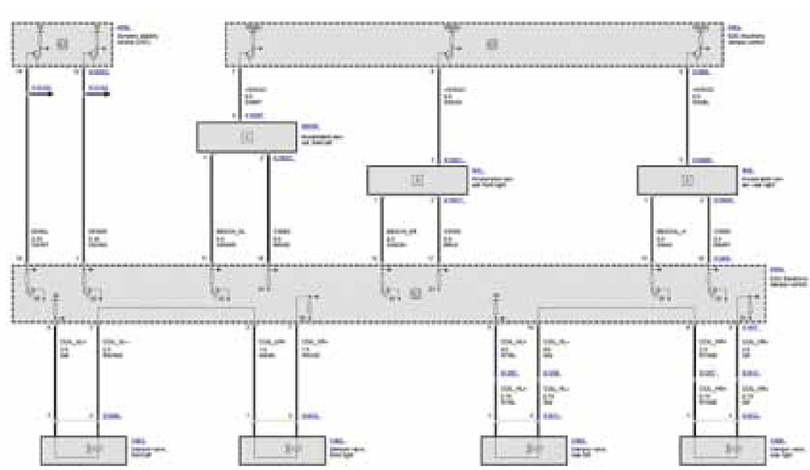


If you look closely at the oil control valve wiring, you'll see that the power supply is sent directly to the left damper valve. The ground of the left valve is the same as the power supply of the right valve. The ground of the right valve controls the overall current to both solenoids.

way, the EDC keeps tabs on the wear characteristics of each shock, so this learned pattern needs to be erased.

With a little knowledge of the system, a paid subscription to www.bmwtechinfo.com, and a good relationship with your BMW dealer's parts department, you should be able to provide your customers with the type of service they have come to expect. An accurate diagnosis, timely repair, and the use of genuine BMW parts ensures that your customers will keep coming back. Now that's a good business plan. ●



With a paid subscription to www.bmwtechinfo.com you can enter the last seven digits of the VIN and identify the vehicle you are working on. This is the EDC wiring diagram for a 5 Series E60 chassis. You can evaluate this data using an iComm/ISTA diagnostic tool.

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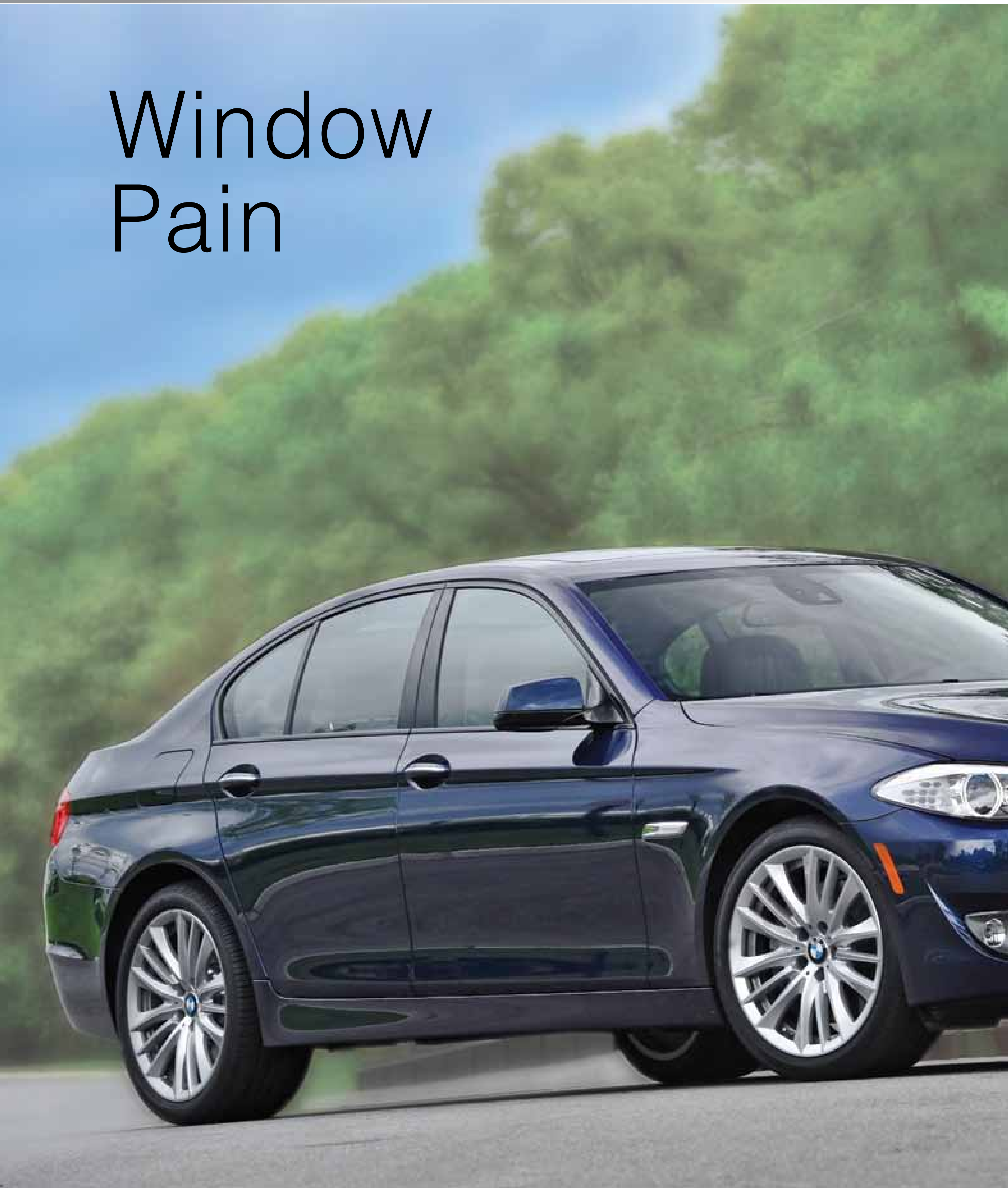
Window Pain

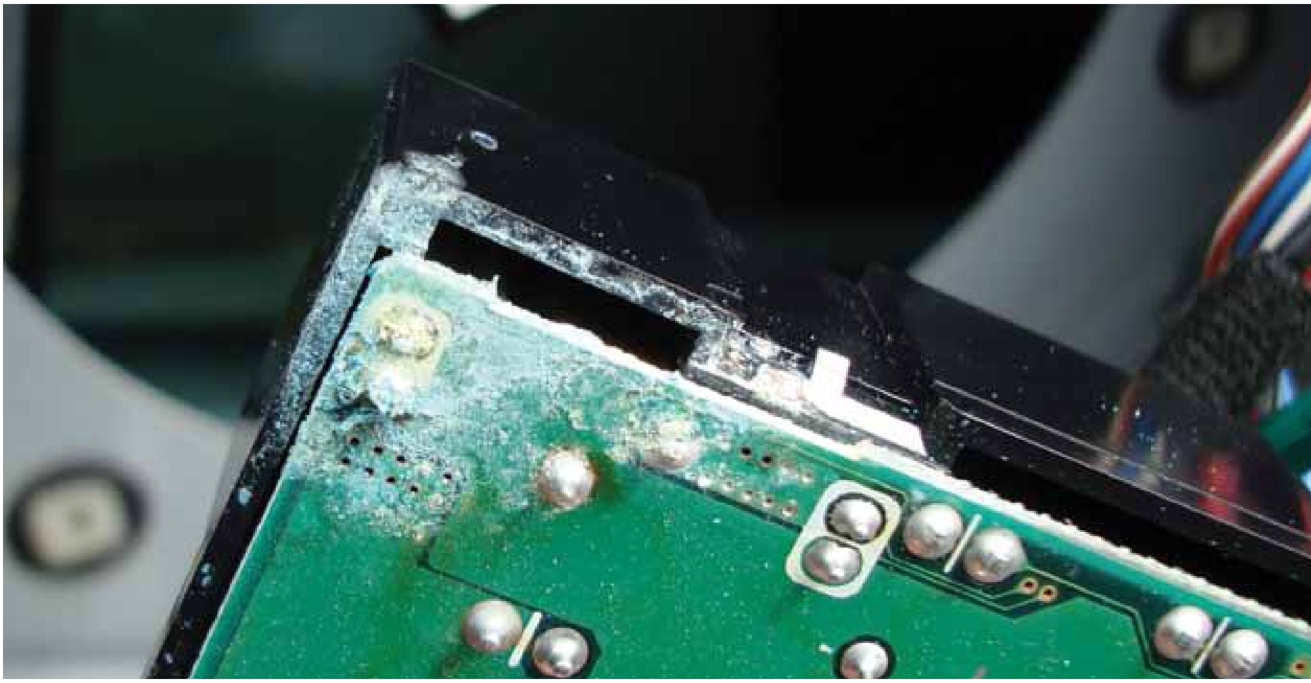


BMW provides sophisticated climate control systems, but sometimes you just want to open the windows and breathe in the fresh air.Or, how about paying tolls? For whatever reason, do you know how to prevent window pain?

One of the most frequently-used accessories on any vehicle is power windows. They are installed on virtually every car sold in the United States. Older, less complicated systems only had a simple switch to complete the circuit to the window motor. Now, we have modern features such as "one-touch" where with a simple push of a button the window will go all the way down by itself, which is especially convenient when approaching a toll booth. In later-model BMWs, we have the ultra-modern "convenience" feature. This allows you to automatically open or close all windows by operating the door lock system. Simply hold the key in the lock position and all of the windows (and sunroof) will close. This is great when one of the children has left a window open after you shut the car off. By holding the door lock cylinder in the unlock position you can open all the windows before you get it. In the summer, this is a great way to let the hot air out of the cabin. These modern conveniences come at the price of added complexity, however. But, an accurate and cost-effective diagnosis is still possible if you are familiar with the way the system is wired and how it works.

Way back

You can go back as far as the E32/2 chassis to see when BMW started to implement computer controls of the power windows. Starting as early as the 1988 BMW 7-Series, a computer called

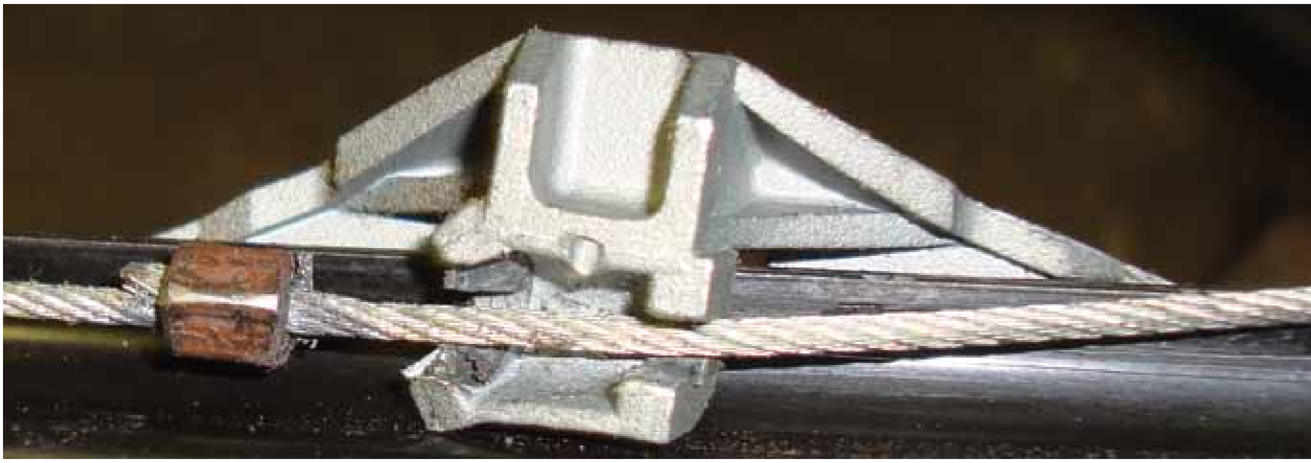

Because of their location, door modules are prone to water damage.

the General Module (GM) was in control of all power window functions. The system was slightly more complicated than what you are probably familiar with. As in any computerized system, the main control unit receives input and manipulates various outputs according to its programming. In this case, the E32/2 driver's door switch does not send power and ground directly to the window motor to move the window up or down. Each door switch provides a two-wire input to the GM. In the up position one wire is going to ground, and in the down position the second wire is going to ground. The GM sees which wire is commanded to ground and responds by opening or closing the appropriate window. It does this by operating a relay module, which is what actually provides the power and ground for each window motor.

Through the early '90s, the 5-Series had the same type of power window control with a GM, switch input, and a relay module, while models such as the E30 3-Series had different systems. Two-door models had individual control units in each door. A solid-state controller had built-in relays to handle the power and ground supply to the window motor. On four-door models, only the driver's door is computer-controlled (the others use manual switches). These is a rudimentary computer that is built into the window motor assembly. The door switch inputs are simply reference voltages that get toggled to ground to command the window open or closed. The door control modules also have Hall-effect sensors built into the motor so the control unit knows the window's position.

Although these systems had control units, they did not have scan tool diagnostic capability yet. For diagnostics, you have to go to each control unit and check voltage on each of the pins until you identified the problem. This, of course, would change in later years with more sophisticated systems.

In '94, the 3-Series received the same architecture as the earlier 5-Series with one notable exception: The rear windows are controlled by a relay module and only have one-touch operation in the down direction. With the front widows, one-touch operation tells the ZKE IV control unit to move the window all the way down, or all the way up. With conventional thinking up to this point, it would take at least five wires to make this happen. You would need at least one ground, and four different wires to indicate each option of up,



Damage such as this crack will raise havoc with power window operation.

down, one-touch up, and one-touch down. If you want to illuminate a switch, that would make for an additional wire. To reduce the number of wires, the ZKE IV uses switch logic to figure out the command. Using only two wires, it can determine which of the four different options the occupant wants performed. The way the switch is wired, if one wire goes to ground the window either opens or closes. If both wires go to ground, then one-touch operation is selected.

The ZKE IV control unit needs to know the position of the window motor at that moment in order to execute the correct command. With both wires going to ground at or near the same time how does the unit know in which direction to operate the window motor? If it knows the position of the motor, then it can figure out to close an open window and open a closed one. A three-wire Hall-effect sensor is built into each motor, and the ZKE IV uses their signals to determine window position. In the case of a disconnected battery or a replaced window motor, the control unit may "forget" or lose track of the window position, so a procedure needs to be followed to allow the ZKE IV to learn the window positions again. It is usually a simple procedure of moving the window all the way down and continue to hold the switch down for five seconds after the window has stopped. Then, you move the window to the up position and hold it again for five seconds after the window has stopped. You know you're successful when the one-touch operation starts working again. If it doesn't you may have a wiring problem or a malfunctioning Hall-effect sensor. How are you going to check that?

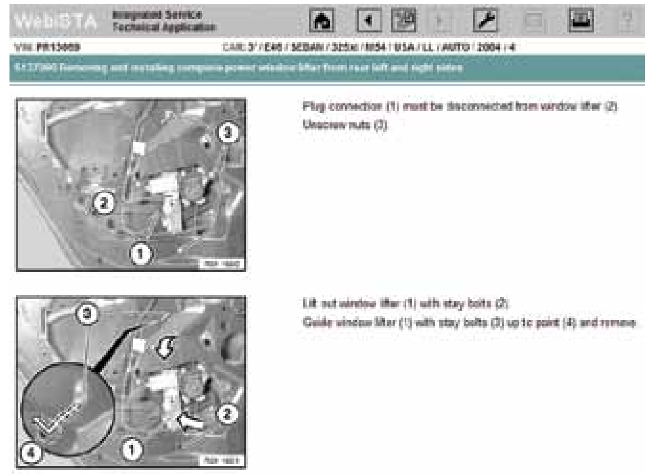
As with any computer system, you can test each signal voltage input directly to the control unit, however this can be very time-consuming. Going over several different circuits in a wiring diagram may not lead to a cost-effective diagnosis for you and your customer. With your GT1, iComm/ ISTA scan tool or equivalent, BMW integrated self-diagnostics will allow you to read all signal inputs as data to the ZKE IV. This is an incredible time saver when it comes to diagnosing problems in any computer-controlled system with self-diagnostics. Typically, you can retrieve the control unit's part number and software level, read codes, clear codes, look at data, and very often activate components. The results of this testing will be more accurate and less time-consuming. However, it is important to know the layout of the system you are working on. This is critical when evaluating a power window problem. As an example you should know the E38 chassis (7-Series) produced before September of '95 has a separate power window switch assembly and door control module. In those produced from October, '95 onward the door module is integrated with the control module. When choosing a variant, how do you know you have the right diagram?

As a regular practice, you should subscribe to www.bwmtechinfo.com and use the wiring diagrams provided in webISTA. To access these diagrams you will need to enter the last seven digits of the VIN. This insures that you pull up the diagram specific to the vehicle you are working on and the correct variant. Aside from looking at a wiring diagram, you can select links on the page to take you to additional information such as the component location and the connector view. In the mid-'90s and later years, controls units would be placed in each door controlling all of the functions of those doors, including power window operation.

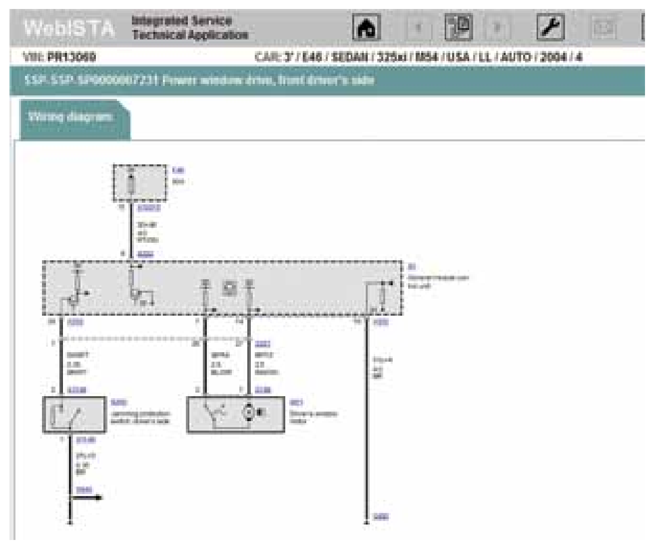
Starting in March of '94 up to September of '95, the driver's side power window switches sent commands to all of the door modules including the driver's side to open or close through a P-Bus. This network connects the GEM (ZKE IV), all power window switches, all door modules, sunroof module, and the driver's side/passenger's side seat control module with and without memory functions. The P-Bus can only be interpreted by scan tool diagnostics, but you can measure the voltage signals with an oscilloscope to verify the bus is up and communicating.

As you can tell by now, these systems have evolved through the years. Focusing on GM III, GM IV and GM V, you should know the differences among the applications. For example, GM III only uses individual door modules on the front two doors. Through the P-Bus, the door modules are wired into the GM. The GM directly receives rear door switch inputs and also controls the power window motors. In addition to power window control, a safety feature was added to prevent anything from getting pinched in the window when going up. A pinch-protection switch runs along the top of the window seal. If the door module reference voltage is grounded, this means something is pinched in the window. As a result, the window is sent down for one to two seconds. A 1.2kOhm resistor is wired between to the reference voltage and the ground to detect if there is an open circuit in the pinch-protection switch.

With a GM IV system, there are no individual door modules. The GM is receives all door



You're going to need specific repair information, such as this from WebISTA, to avoid comebacks.



With today's sophisticated power window systems, wiring diagrams are essential for diagnosis.

switch inputs and the anti-trap signal and directly controls the front window motors. The rear windows are controlled by a relay module, which the GM controls.

On GM V systems, the GM is in total control of each of the window motors directly. It receives all of the door switch inputs. With four-door sedans, all four windows have the one-touch feature in both directions and each window has and anti-trap switch built into the upper window seal. This is not true for convertible models. There is no anti-trap

This 3-Series has cable-driven window regulators. They're lighter and simpler to service than the scissors-type, but more sensitive to binding glass.

switch, so there is no one-touch operation in the up direction for the passenger door. The driver's side door still has the feature (for tolls, etc.), but window operation is limited to eight seconds by the GM V module since it is in direct control of all window motors. This is enough time to move the window all the way from fully open to fully closed. In the '04 model year, anti-trap switches were eliminated in convertibles, and a new type of indirect trap protection was employed. The GM used the window position (through the Hall-effect sensors), direction of travel, and current draw to determine if something was jammed in the window. Of course, the windows had to be initialized for this to work, and the window cannot bind in any direction as the increase in current will stop power window operation.

For instance, on the E46 chassis (3-Series) cable-driven window regulators move the windows up and down. They are lighter and simpler to service than bulky metal scissor-type regulators, and it is especially important that the windows are installed properly and the glass is not binding in the window tract -- high current draw will make window operation inconsistent. When servicing the windows, you should only apply a small amount of light grease to the sliding mechanism. Cables do not require lubrication, so do not apply grease to them. When separating the window from the regulator, you need to always replace the glass holder bushing. Do not over-tighten this nut and bolt as you will damage the holder and possibly the glass. Once again, the specific procedure for fitting components can be viewed in the REP pages within webISTA with a paid subscription to www.bmwtechinfo.com. Since the door panel needs to come off, it is probably a good idea to order the correct door panel clips while you are ordering the window regulator and/or motor for your repair. These are the details that lead to a trouble-free repair.

Understanding computer-controlled systems and their layout allows you to come up with a diagnostic plan using your GT1/iComm/ISTA, or equivalent, and back up your findings with electrical testing. In future issues, we will review the newer E90, E60, and F01 chassis, so keep an eye out for the Bimmer pub at your BMW dealer's parts department. ●

Second to None

BMW collision repair training leads the industry. Are you onboard yet?

All images courtesy of BMW of North America

The commitment to superior collision expertise is no idle claim. Planning, preparation, execution, and a thirst for continual improvement are essential ingredients for meeting that commitment. The Body & Paint Service Technician Education Program (STEP) developed by BMW of North America LLC (BMW) helps guide collision technicians to the lofty goal.

STEP is intended to help achieve several key objectives. These include:

- Providing BMW dealer network and dealer-associated independent body shops with highly skilled technicians.
- Using state-of-the-art training facilities to enable technicians to learn, practice, and refine BMW-specific skills and repair procedures.
- Enabling technicians to learn current and future repair competencies and processes.
- Supporting BMW's Certified Collision Repair Center (CCRC) program.

Not only does STEP work for BMW, it is also the best in the industry and is recognized as such by independent collision industry organizations, equipment and tools makers, and technicians who have completed it. Most importantly, it delivers the level of expertise that customers expect and deserve.

Organizations that collision repairers rely on respect STEP

the bimmer pub attends many key collision industry events, hosted by automakers, the Society of Automotive Engineers (SAE), the Inter-Industry Conference on Auto Collision Repair (I-CAR), and other industry associations and groups. At these get-togethers, the praise, respect and high regard that STEP receives from others impresses us. It's success is a story worth telling.

Consider the Equipment and Tool Institute (www.etools.org), which has a long association with

The Body & Paint STEP program is currently available at three of the six BMW training centers nationwide: Woodcliff Lake, N.J.; Greer, S.C.; and Oxnard, Calif. (left to right). Each facility houses classrooms, a body shop, and paint facilities.

BMW. ETI members include the manufacturers that develop and build the tools, equipment and other products required by automakers to perform collision and mechanical repair, as well as third-party aftermarket information and software providers. Note that the BMW-ETI connection is relevant, because BMW requires a number of specific products from ETI members be used by its CCRCs; for other body shops not in that network, those products are recommended.

ETI also hosts three annual industry events at which automakers, including BMW, meet and

BMW's Body & Paint STEP training is authentic. To help technicians advance their skill level to meet real-world needs, STEP training employs the same service information, tools, equipment, materials, repair, and safety procedures, and other resources that are required by bona fide BMW Certified Collision Repair Centers.

share information (e.g. scan tool data, wiring diagrams), emerging automotive technology that will require the development of new tools or equipment (e.g. carbon fiber, active safety, and electrified systems) and relevant collision repair/replacement procedures (e.g. specialized welding, new lightweight metals). Of note, BMW has even presented STEP training to industry attendees at these events.

BMW cooperates with all industry segments to improve reparability

After attending a STEP training session titled Bonding and Adhesives, we were prompted to speak with Tim Morgan, who serves ETI as chairman of the Collision Repair Group.

"The new designs, evolving material content of vehicles, and how they are built are making collision repair more difficult," Morgan said. "The biggest challenge I see in the industry today is getting the correct education to collision technicians — making them understand what the new vehicle content and repair processes are. Without authentic service information, training and the right equipment or tools, a safe, complete repair cannot be performed," "BMW is unique in that it provides collision repair training to technicians as well as suppliers like ETI members," he added. "Like every other segment of the collision industry, equipment and tool manufacturers also have a responsibility to stay abreast of emerging automotive technologies, handling new materials, or employing new repair procedures. That's a major reason we are involved with BMW and its Body & Paint STEP training."

More recently, at an I-CAR event, Technical Director Jason Bartanen described how OEM collision training varies across the industry. "How collision training is delivered to technicians differs from one automaker to another. Most OEMs require all training be delivered through a specific mix of I-CAR and OEM-approved providers. Some require all training to be provided by I-CAR. BMW is unique because it provides all collision (and mechanical) training to technicians.

"I-CAR works with all automakers," he continued. "It is clear to us that the BMW STEP collision training model is one that other automakers would do well to emulate." But here's the kicker: "Compared to other automakers, BMW STEP collision training is second to none."

STEP empowers technicians and facilities to seize expertise

It was at a recent ETI/I-CAR sponsored forum titled Collision Repair in the Aftermarket, that we first met Tom Brizuela, Body & Paint STEP technical team leader at BMW's Oxnard, Calif., training center. Brizuela was actively involved in developing the Body & Paint STEP curriculum; his expertise and experience intrigued us. We met with him briefly after the forum, and later visited with him after he returned to the training center.

"BMW Body & Paint STEP training is open to dealer technicians and independent technicians recommended by a BMW dealership," Brizuela said. Although not within the scope of this article,

Visit www.BMWstep.com for more information about the BMW STEP programs.

he added that STEP also is available to aspiring technicians in bona fide automotive education programs that meet NATEF/AYES requirements. "The same STEP training is provided to all participants, whether they are independents, dealers, or aspiring technicians"

"Every aspect of BMW-specific collision repair is learned and performed under the guidance of expert instructors." noted Brizuela, "In addition, each of the centers is fully tooled and equipped to the same standards that BMW requires of its Certified Collision Repair Centers (CCRCs). This allows us to prepare technicians to work in any collision facility — dealer or aftermarket — that is prepared to properly repair BMW vehicles."

Qualifying technicians who complete the Body & Paint STEP curriculum will have the following BMW-specific core collision repair competencies:

- Use of BMW Integrated Service Technical Application (ISTA)
- Removal and installation of body components.
- Structural and non-structural body repair.
- Welding techniques.
- Bonding and riveting procedures.

Each BMW STEP Body and Paint training center houses classrooms adjacent to real world body shop and paint shop facilities.

- Aluminum repair.
- Specialized BMW repair procedures.
- Paint preparation and application.
- Diagnosis and estimating.
- Entry-level paintless dent repair.
- Polishing and detailing.

In addition, Brizuela notes that the elite graduates from the foundation STEP Level I training are eligible to be selected to attend the brand-new Body & Paint STEP Level II program that BMW has just developed and deployed.

Making the grade

Brizuela said that it is important that collision professionals — whether dealer or independent — understand what is required to become a BMW CCRC. "BMW insists on rigorous standards when it comes to the repair of the vehicles it builds. This requires substantial investment and commitment to ongoing technician training, specialized tool and equipment technology, paint systems, materials, and other BMW criteria."

"BMW customers deserve every assurance that, whether service or collision repairs are performed, the competency of the technicians that work on their cars and quality of the materials and parts used is unparalleled and keeps pace with change. To retain their CCRC designation, BMW dealers must undergo an annual audit, similar to how hospitals and other standards-based organizations and businesses are reviewed."

The auditing firm retained by BMW is required to:

- Conduct onsite inspections of the facility's equipment, tools, paint, material and other physical resources.
- Review staff training requirements, repair procedures and processes.
- Help the facility update its action plan.
- Report observations and results to

BMW that then serve as the basis for continued certification.

The audit ensures compliance with the expectations of regulators and the automaker. It identifies and schedules BMW-credentialed continuing education and training to ensure that technician competencies keep pace with ever-increasing vehicle complexity. It also gives substance to the level of collision expertise that BMW and its customers expect from a CCRC.

"Of the 350 BMW dealerships nationwide, just 70 are BMW dealer-owned CCRCs," Brizuela said, based on his last review of available data. "Clearly, there is a lot of collision repair being done by independent aftermarket facilities. BMW recognizes this market reality by providing training across the technician and collision facility spectrum. For example, of the Body & Paint STEP participants who were already existing technicians, approximately 75 percent of attendees were from BMW dealers, while 25 percent were from independent shops."

"The independent collision shops that some BMW dealers choose to work with need to deliver the same capabilities and quality of repair as a CCRC. That's why dealers that don't own their own bodyshop will only work with

BMW Body & Paint training center body shops are fully equipped with the same equipment, tools, and materials that BMW requires of its CCRCs.

certain independent shops. It is also why they can confidently recommend certain independent collision technicians from those independent collision shops to attend Body & Paint STEP and other BMW training."

What do collision facilities say?

Bodyworks by Concours is a BMW CCCR located in Milwaukee, Wis. Tom Gillespie, manager of the collision facility, says that when he was hired by Bodyworks, he was tasked with transitioning Bodyworks to a BMW CCRC facility. Having worked previously for the first BMW dealer to become a CCRC, he knew the path ahead.

"Our technicians work on high-end, technology-enhanced BMW vehicles every day," he said. "Before a new BMW model even hits showroom floors, our BMW-trained technicians must know how to take it apart, make body adjustments to it, and be able to provide collision-related repairs to that vehicle. In addition, these complex vehicles must be diagnosed and reprogrammed after every collision."

He cited BMW CCRC criteria —tooling and equipping the body shop to CCRC standards, the use of BMW Clear System brand of waterborne paint and refinishing processes, and ongoing BMW-credentialed training for its working and entry-level technicians— as enablers for Bodyworks' successful transition.

Moritz Body Shop is located in Arlington, Texas. Owned by Moritz BMW/Mini, the bodyshop is not a BMW CCRC. According to the bodyshop's manager, Perry Newton, the bodyshop employs both collision and mechanical technicians. In addition, the facility meets all BMW criteria to be a CCRC except for its choice of paint supplier.

"Moritz Body Shop seeks to hire and train staff beyond minimum expectations," he said. "That's why we take advantage of other training that BMW makes available to our collision and mechanical technicians.

STEP
Service Technician Education Programs

Spraybooths in BMW Body & Paint training centers meet the same criteria required of BMW CCRCs.

"Every year, I've seen more applications and inquiries from technicians who have completed the STEP program, even though Arlington is 1,000 miles away from the nearest BMW training center. The new BMW training center being built in the Dallas area will help all of the shops that repair BMW vehicles in the region. There will be a greater number of entry-level technicians proficient in BMW service and repair locally."

"The Dallas area can have severe tornado seasons, such as this year, that can cause a lot of damage to vehicles," he continued. "That leads to shops like ours being booked solid for months. Having a BMW training center nearby will help Moritz and other bodyshops in the area to take advantage of local BMW training, even during a time we are very busy."

Training builds upon a foundation and resolves competency gaps

We then spoke with Michael Abernathy, a BMW/MINI master technician and team leader at Moritz. He shared that he had just returned from BMW's training center in Atlanta, Ga., where he had completed an advanced diagnostics course provided by BMW training staff.

BMW invites expert-level technicians to this training class, who receive new diagnostic training, then apply their diagnostic experience along with what they have learned in authentic service/repair diagnostic demonstrations. These end-of-course demonstrations are observed by training center evaluators who judge how technicians apply their enhanced diagnostic cognitive skills, practices, and procedures when using BMW resources to analyze problems, prioritize the order to follow in, efficiently and effectively completing diagnosis, and more.

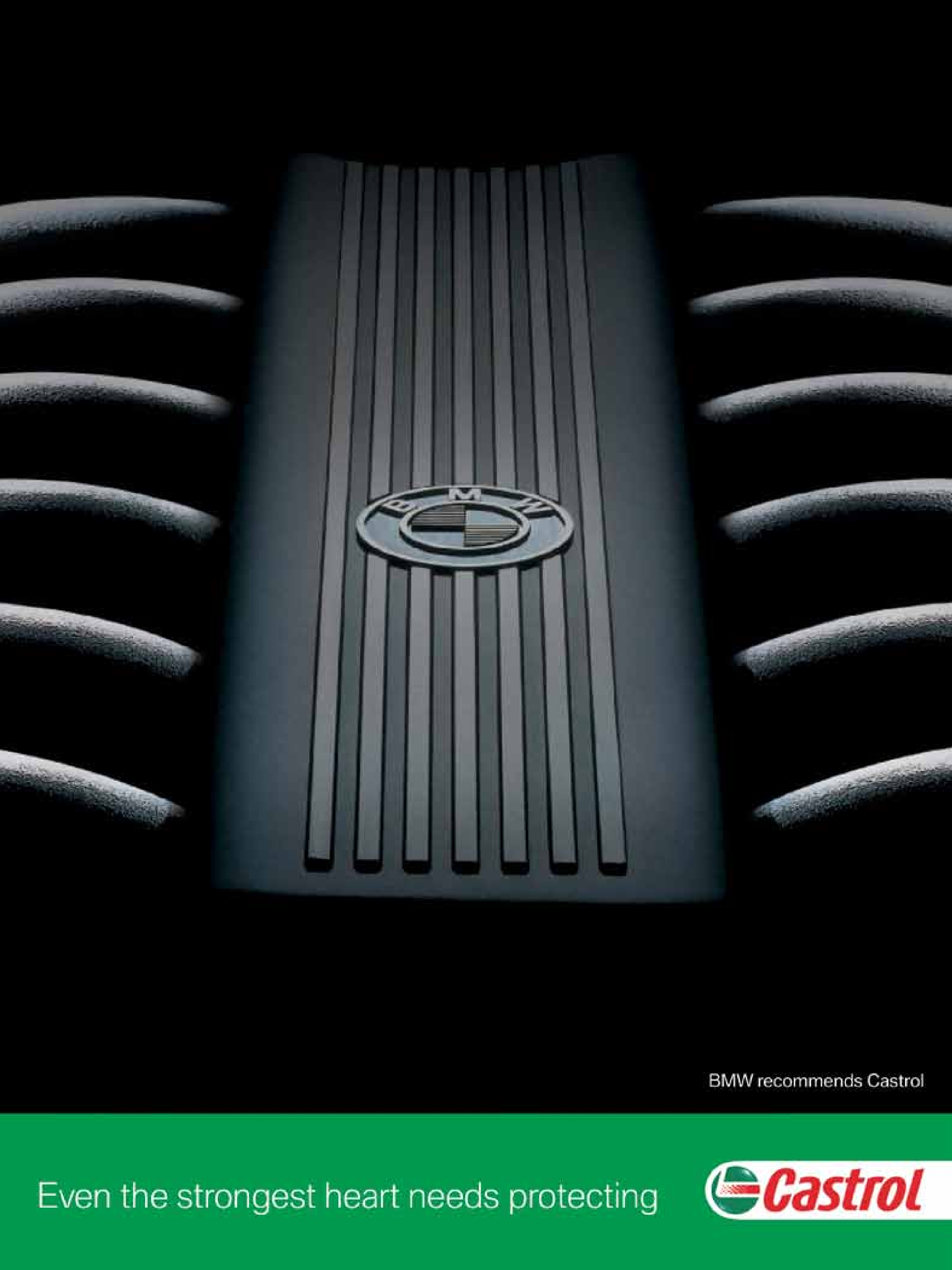
"At the end of the course, it came time to demonstrate the integration of what we already knew with what we had just learned," Abernathy explained. "We were given instructions and told what to expect before we entered the testing areas. We were tasked with individually diagnosing a unique series of different unknown problems at each of six stations in the shop/lab area of the center."

"Three of the stations had vehicles, one had engines, one had wheels and other assemblies, and one was used to complete a written test of diagnostic knowledge. Each station had two BMW training center evaluators present. They did not provide any guidance or feedback; rather, they observed and made notes regarding each technician's reasoning, performance, accuracy, efficiency, and other important diagnostic competencies."

"It was like being watched while inside a pressure cooker — just you and the cars — but it's hands-on and authentic," Abernathy added. "After the practical diagnostic evaluations were completed, each technician was advised whether the course had been successfully completed or not. Each technician was given feedback that identified individual diagnostic strengths and weaknesses."

"This personalized feedback is something I really like about BMW training. I want to know what I'm really good at, but I also want to know where I need to grow and how to improve. To help, the BMW course feedback identifies this and also provides follow-up resources and training that is customized to help each technician resolve any gaps in diagnostic expertise. That not only makes me feel good as an individual employee, it makes me a better technician for BMW customers."

We find that last comment interesting… for Brizuela had made the same point. And it is that commonality in BMW training, from STEP through continuing education, that impresses us the most. ●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