BMW
TechDrive
Magazine

For independent
BMW service
professionals

The Ultimate
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TechDrive

Volume 6 Number 1 December 2009

Coming soon, www.techdrive.com

Original BMW Parts

To our readers,

What could be more useful to independent service technicians who work on BMWs than a publication dedicated specifically to them?

That's the idea behind the magazine you're holding, *TechDrive.* BMW of North America both sponsors the publication and provides much of the information that's included. A big part of the rationale behind *TechDrive.* is the belief that if you are able to diagnose, repair and maintain BMW vehicles properly and efficiently, your reputation and ours will be enhanced.

TechDrive's combination of feature service articles (written from both BMW tech information and interviews with successful independent BMW specialists), new technical developments, systems evolution, as well as the correct BMW replacement part, and service bulletins are intended to help you fix that BMW right the first time, on time. Our list of BMW dealers will assist you in finding Original BMW Parts.

There's more to this effort, including highly-informative and user-friendly web sites, which we'll explain in future issues.

We want to make *TechDrive* the most useful and interesting technical magazine you receive, and you can help us do that. Please email us at editor@techdrivemag.com and let us know what topics you'd like to see covered, and provide any other comments you might have. With your involvement, this publication can evolve into one of your most important tools.

Thanks for your continued interest.

For more information please email us at: editor@techdrivemag.com

Cover Photo:
The air/fuel ratio sensor is the keystone of electronic engine management.

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Production assembly of wiring harness

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A publication for the independent BMW service professional

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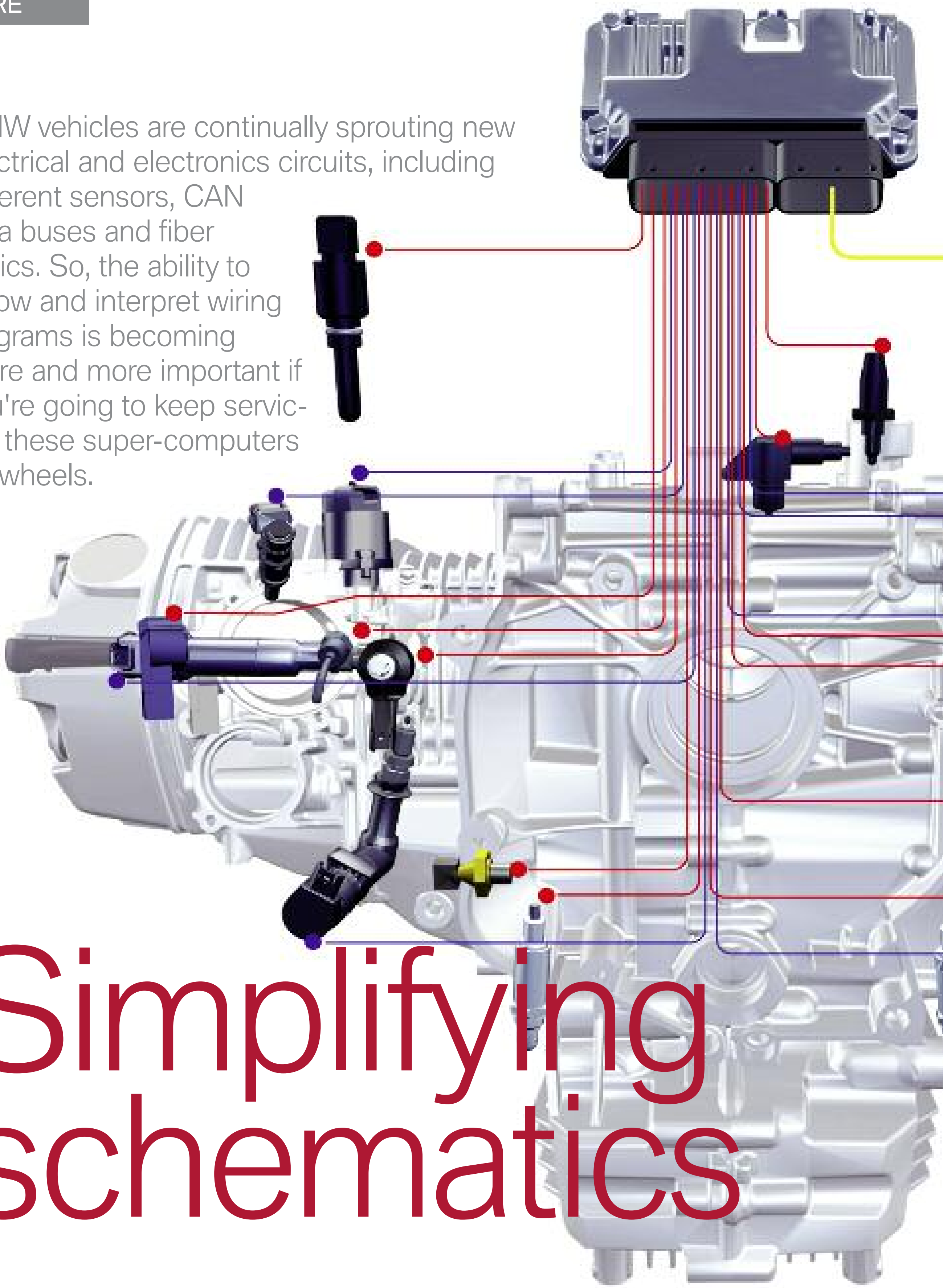
Original BMW Parts

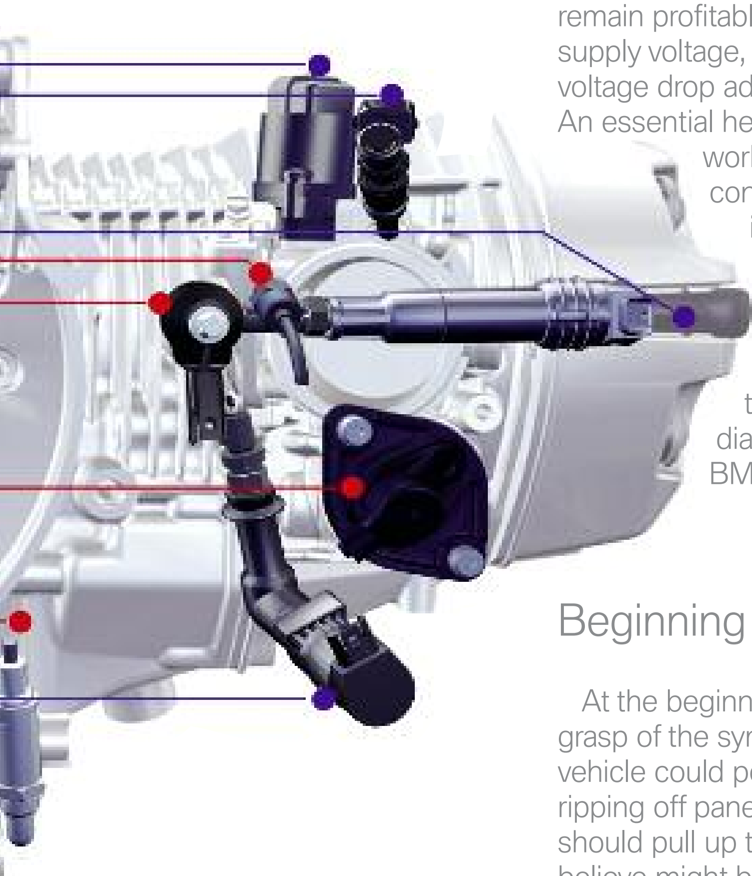
BMW vehicles are continually sprouting new electrical and electronics circuits, including different sensors, CAN data buses and fiber optics. So, the ability to follow and interpret wiring diagrams is becoming more and more important if you're going to keep servicing these super-computers on wheels.



Simplifying schematics

As every technician knows, one of the most challenging tasks in the automotive field is electrical diagnosis. This is compounded by ever more complex vehicles. Whether it is for efficiency in manufacturing, or for more integrated features, electronic control units are being asked to handle almost every aspect of motorized transportation. While this does lead to a reduction in wiring, it also makes factory self-diagnostic software essential to diagnosing problems in these integrated computer networks.

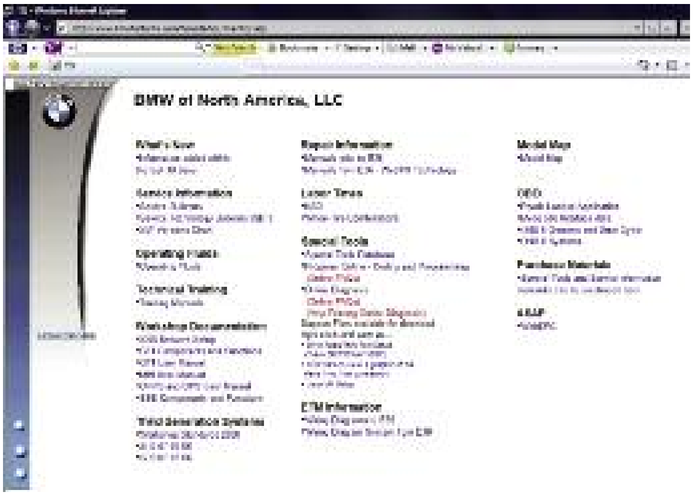
Regardless of all the new complexity, you still need to come up with a diagnostic plan that will find problems efficiently and effectively, thus allowing your shop to remain profitable. With electrical problems, inadequate supply voltage, component current draw and excessive voltage drop add up to troubleshooting complications. An essential here is understanding how the circuit works, but this is one aspect we are in control of. Knowing how to read and interpret BMW wiring diagrams accurately is half the battle (the other half is actually testing voltages, resistances and amperages).



Here, we are going to review navigating the BMW website for the proper wiring diagrams, and some of the benefits of BMW factory wiring.

Beginning

At the beginning of any diagnosis, you need a firm grasp of the symptoms and what systems on the vehicle could possibly cause them. Before you start ripping off panels and covers to access wiring, you should pull up the wiring diagrams for the circuits you believe might be at fault. With your paid subscription www.bmwtechinfo.com, you will have access to accurate factory diagrams. This is especially valuable when it comes to the variants of the model -- not only the various options, but also any changes that may have occurred from one production run to another. This vehicle-specific information is not always available from the aftermarket information sources you may currently be using.



Your paid subscription to www.bmwtechinfo.com gets you access to factory service information. Under "Wiring Diagrams," select “Wiring Diagram Systems from E38” and you will be directed to installing WDS wiring.

Once WDS is started and the plug-in is installed, you will see the main navigation screen. Select “Complete Vehicle” and pull-down menus will start to appear just as they do in Windows Explorer on your PC.

On the homepage under the heading “Wiring Diagrams,” you will see two options. The first is for selecting the E36 chassis or earlier vehicles. These are PDFs (Portable Document Files), so you will need to have Adobe Acrobat Reader on your computer to view them. They are scanned images of factory paper manuals. You navigate through the various pages by scrolling with the bar on your right and at the bottom just as you do with any file folder in Windows or MAC Explorer. All the information is there, you just have to move the screen around to see it because these pages were not intended to be PC-based. Your other selection is for BMWs built after the E36 chassis, which are probably most of the vehicles you work on. These diagrams were constructed with PC navigation in mind, so all of the variations are laid out like the folders in Windows Explorer, but more on that later.

After selecting post-E38 diagrams, you are directed to the next page where you will select BMW wiring diagrams and the language you would like them displayed in. You are then directed to another page called WDS BMW Wiring Diagram System. If you are using WDS for the first time, you will need to install a plug-in that is available within the WDS website itself. You can do a system test to verify if your PC is capable of running WDS. This test is found on the lower left-hand corner of the installation page. On the right side of the page you'll see where to download and install the SVG plug-in.

With all this complete, the WDS home page is displayed with large picture icons of BMW models by chassis number and model series. There are variations in production dates, so be sure to accurately select the vehicle you are working on. Once you have selected a chassis/model, the next page is split in two. The left side of the page is for navigation, and the right side is where the diagram is displayed. If you're familiar with Windows Explorer navigation you should have no problem here. When you click on the “+” symbol to the left of the heading “Complete Vehicle” once, or double-click on the heading itself, a pull down menu with three more selections is displayed. Your options are “Drive,” “Chassis” and “Body”. Select the field for which you want to view all the available diagrams.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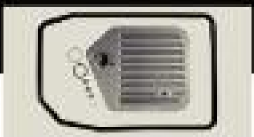


Here is where you need to pay close attention to your selection. Very often in a single chassis there are variants that are the result of modifications or developments during the vehicle's lifespan. One chassis can have several variations in any of its systems. For instance, the E46 chassis has seven different variations for the engine management (DME) system and five for the transmission (AGS). One of the easier ways to determine what system is in the vehicle is to plug in your scan tool and actually look at the initial screen once you have communicated with the control unit. If the system ID is not displayed here then select “Control Unit ID” and your next page will illustrate what type of system is used, and hardware, software, index and coding ID numbers. Back in WDS, select the system that matches. Also, watch for production date cut-offs, country produced for, options (ASC or DSC, for example). etc.

This is where technicians might get into trouble. By not selecting the correct diagram, you may end up finding wiring that does not match the vehicle, or looking for wiring that is not there.

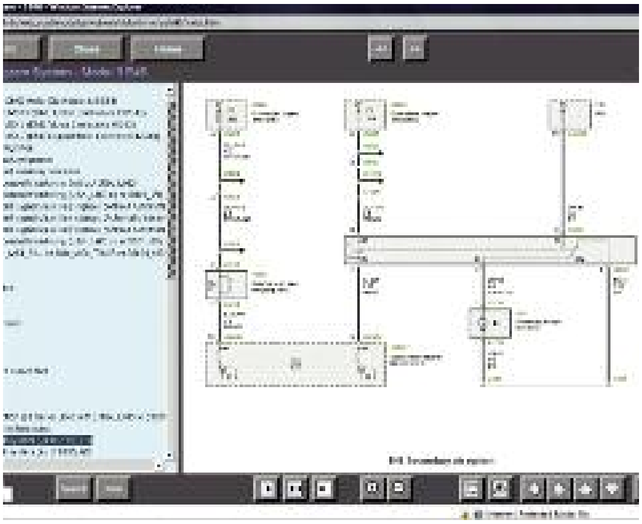
The first critical step is selecting the correct wiring diagram. You will need to choose among all the different variants of the vehicle. This can include production dates, options (ASC or DSC, for example), body style, left/right hand drive, version level, etc.

For example, if you need to know if the vehicle has ASC or DSC, with the ignition key on look for either a DSC on/off switch mounted near the center console, or use your factory software to scan for all modules. On factory software, this is referred to as a “Short Test,” or on later releases a “Quick Brief Test”. Here the ZCS coding is read off the vehicle and all possible modules for that model are displayed. Unless there is a communication problem with one of the various bus systems, this is the best way to identify the variants.

The Easy Part

Once you have selected vehicle options, another pull-down menu will be displayed. You will see a combination of diagrams listed at the top, and just below these are more sub-folders to choose from. The diagrams displayed at this level are system simplified schematics. They show the entire system in one diagram. Details such as wiring colors and connectors are omitted, but you can print the diagram and get an overall view of what wiring is involved in this system's power supply, electrical consumer, switch/sensor inputs, output controls and grounds. If you look below these diagrams, you will see more pull-down menu folders. By selecting these choices, you will display a menu of specific sub-systems within the system you selected. There may be more variants to choose from, so once again production dates, included options, system version and body style may all affect your selection. These diagrams are very specific and only include wiring pertinent to the sub-system.

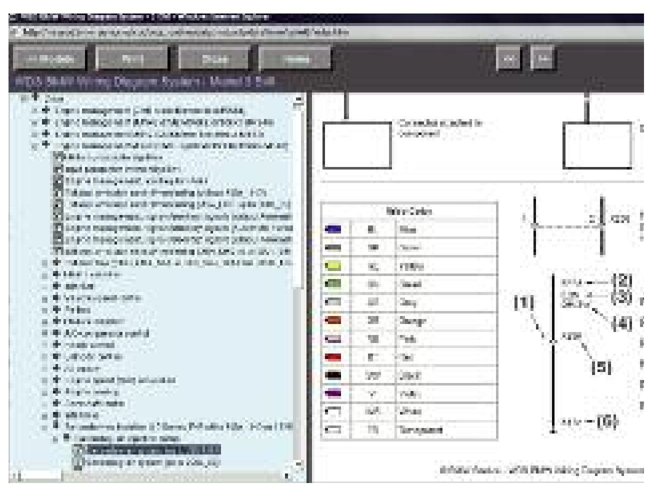
Now that you are in an actual wiring diagram, you will notice more specific details of the circuits involved. You will see connector details, wiring colors, components, etc. Generally, a component is boxed in with either dotted lines or solid lines. The dotted lines indicate that this individual circuit is part of a larger component and you are only being shown the portion of it involved in the sub-system you are investigating. The boxes made up of solid lines indicate that the whole component is displayed in the diagram and that you are seeing all of the wiring going to it.



Now that you have a diagram up, you can follow the wiring. You should be able to determine which wires supply power, what the component does this power, and how the components are grounded. Your testing of these factors is next.

Within each component you'll see the circuitry of each wire entering it. From this you can tell if the wiring is power supply, switched power, switched ground, or ground. This is helpful in determining how a circuit functions and what voltage/amperage controls you can expect to see. For instance, looking at a relay you see which wires are for the control coil and which are for the switched circuit. You can put a multimeter across a control coil and see if it is being activated. You can also install a jumper wire between switched circuits and bypass the relay to test if the component functions. Within control units, you will see the symbol for a power transistor usually connected to ground. This indicates that the wire should get pulled to ground when the computer commands it, such as with a purge solenoid or injector. If monitoring this wire with an oscilloscope, you will see voltage on it get toggled to ground.

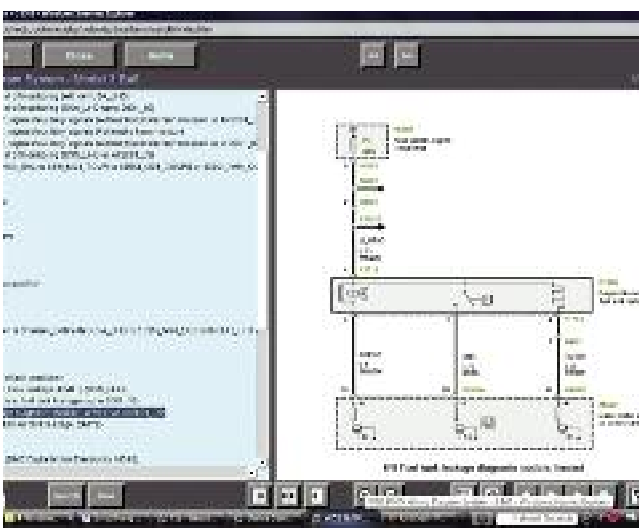
Each wire has its own identification tag with symbols that represent what the wire does. The top line of the description is an abbreviation of the function. This can be letters and/or numbers. For instance, while looking at the diagram for Diagnostic Module Tank Leakage, you will see the abbreviation DMTLH with the wire connected to the symbol for a heater element in the DMTL component. This indicates that the wire grounds the heater (the power supply is the same one as for the DMTL pump). The numbers follow DIN standards, so if you see "30" you know the wire is a constant power supply. The number 15 would indicate ignition-on power, Number 31 would be a ground, and so on. Of course, the wire size is indicated in millimeters, and the color markings are there. If there is some question about a symbol or wire color used in the diagram, you can select the “?” in the lower right hand corner of the toolbar. This link takes you to a page with the legend for the diagram, which breaks down the wiring symbols and colors for you. When applicable, you will notice a “text” box below the diagrams on the right side of the screen. This displays a description of system operation. It gives a written account of the



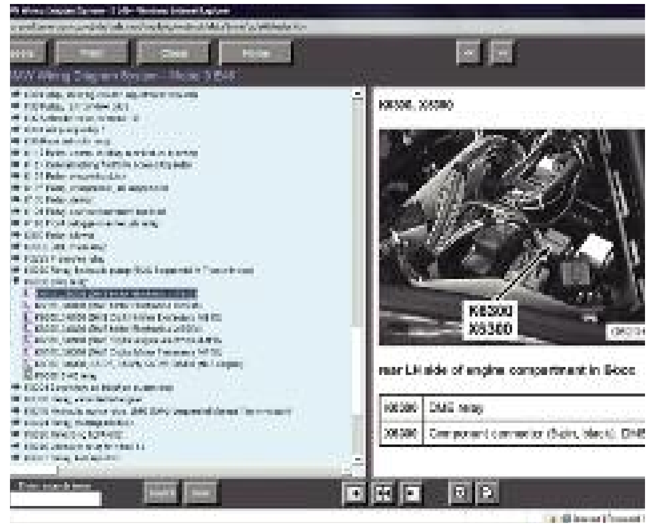
Selecting the “?” box in the lower left gives you a legend of the wiring diagram. Here you can find unfamiliar wire colors and a breakdown of how wiring is to be identified. Also, connector names and pin locations are described.

circuit's operation and the overall function of the system. This is helpful on systems you may not have previous experience with.

Another feature is the “quick link.” These are the green alpha-numeric designations of component and connector locations. These quick links are found in both the simplified schematics and the more detailed wiring diagrams. Of course, the more detailed diagrams have the quick links for the connectors and splices included. The quick links found in the simplified schematics mainly direct you to component locations. This can prove extremely helpful when locating a fuse within a fuse box, as well as other components. Once you have clicked on a quick link, you will see the navigation page move toward the bottom of the folders where more wiring and component locations are stored. At the top of the list you will see more images.



Looking at this wiring diagram of a DMTL system, you see that the black wire with the red tracer has the designation DMTLH. This is the ground for the EVAP system heater. The power transistor inside the DME indicates that this wire is grounded for activation.



By selecting one of the green links inside the wiring diagram, you will be directed to a pull-down menu in the navigation bar. After selecting the particular variant, you will see the component location of the link you selected. This can make finding fuses, relays and splices easy.

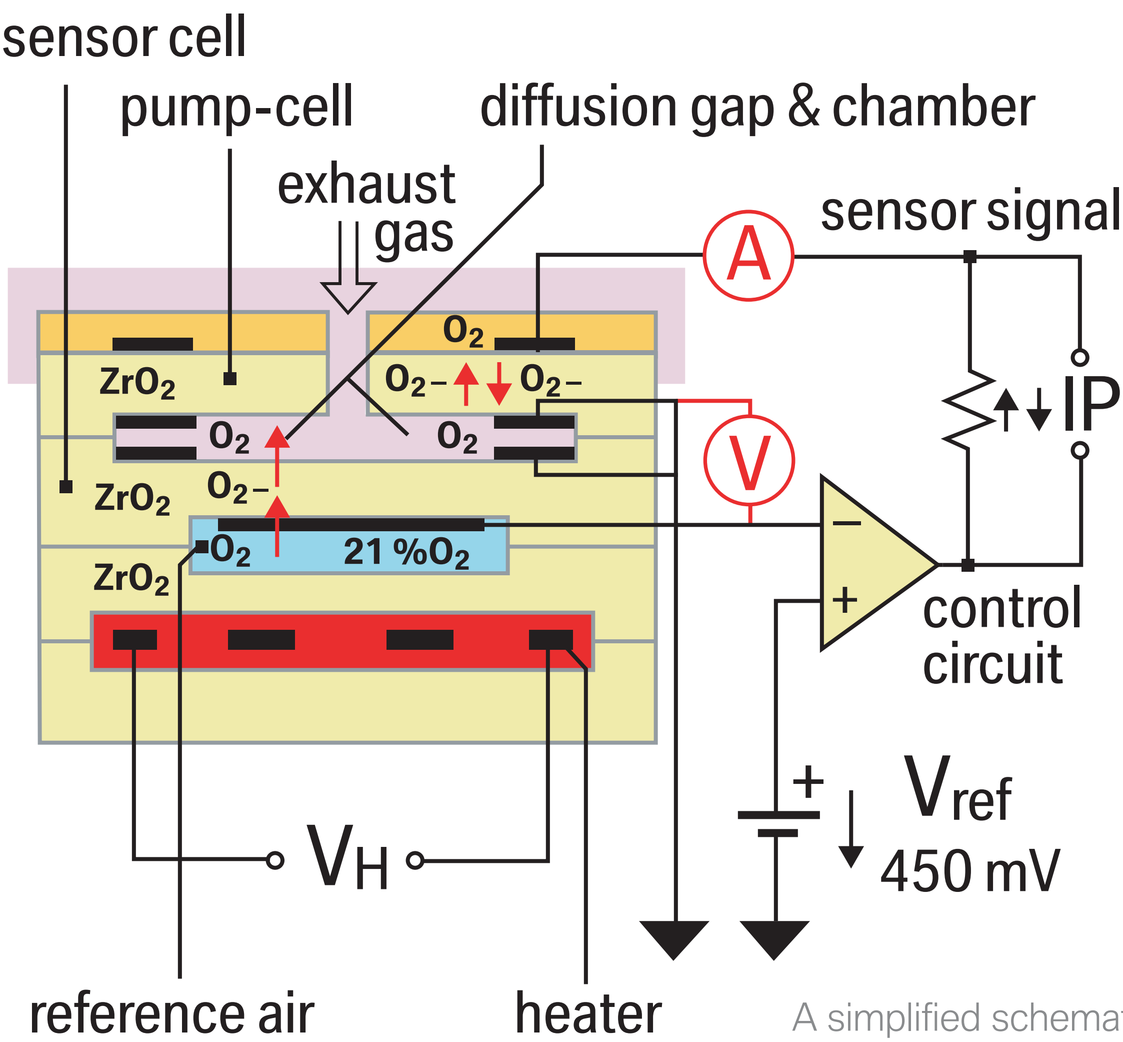
These pictures display all of the wiring of the component you’ve selected. This way you can follow the wiring diagram of the splice you have just selected. Below these links are blue colored links that take you to photos of component location of the splice you have selected.

In Summation

Taking a look at the proper wiring diagram before the vehicle even gets to the shop will allow you to plan your diagnostic strategy. You'll also be able to determine which wires should have voltage, what consumers they supply and how these consumers are ground controlled. A good game plan will lead you to an accurate diagnosis, and that's good for business. □

Let us give you some feedback

We were always taught 14.7:1 was the perfect ratio of air to fuel. Well, with the need to improve fuel economy and decrease harmful emissions, leaner air/fuel ratios are required. How is the PCM going to determine how lean is lean?



A simplified schematic of an air/fuel ratio sensor.

We all want clean air. We thrive in it. We breathe it in, turn it into power and exhale it. Our vehicles do exactly the same thing. The process of internal combustion is not 100 percent efficient, however. Not all the fuel is burned, and some is only partially burned. Totally unburned fuel is measured as hydrocarbons (HC), and partially burned fuel is measured as carbon monoxide (CO). If gas temperatures are high, say from a lean mixture, other gases that are produced as a by-product of combustion are oxides of nitrogen (NOx). These gases are all hazardous in their own way, and they are emitted from any vehicle's tailpipe (O2 and CO2 are emitted with them, but only the latter has possible long-term environmental effects). Maximizing the efficiency of the combustion process will not only reduce air pollution, but also increase fuel mileage.

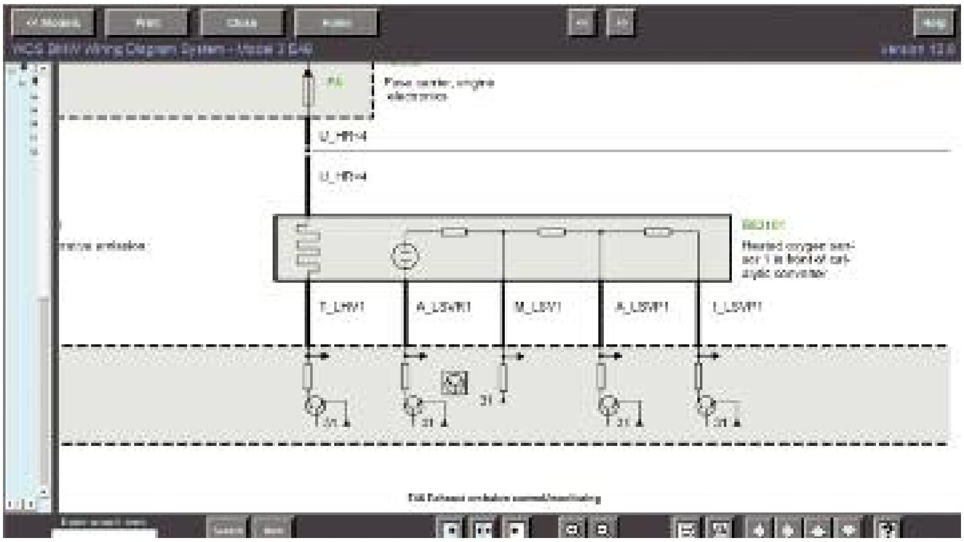
The Path to Enlightenment

One way to accurately control combustion is to monitor the contents of the exhaust and adjust fuel quantity and ignition timing accordingly. Monitoring the exhaust is now a time-honored tradition -- we have been doing it since the mid-1970s. Within those 30+ years, the technology used has evolved. We started the journey with the single-wire zirconium dioxide O2 sensor (also known as a Lambda sensor or probe). The concept this sensor was based on is called the Nernst principle. Basically, this sensor generates its own signal voltage the strength of which depends on the oxygen content in the exhaust stream compared to that in ambient air. The signal is relatively high -- 600 to 900 millivolts -- in a mixture richer than the stoichiometric 14.7:1. The signal is less than 400 millivolts when the mixture is leaner than 14.7:1. The stoichiometric ratio theoretically yields the best optimization of combustion gases that allows a catalytic converter to both oxidize HC and CO, and reduce NOx to harmless nitrogen and oxygen.

This original type of oxygen sensor can't generate a voltage signal until it reaches 350 deg. C. A typical engine does not produce this level of exhaust heat until it reaches normal operating temperature, or is run at high rpm. So, the electrically-heated version appeared in the early 1980s (sometimes referred to as a HEGO for Heated Exhaust Oxygen Sensor). The heater element brings the sensor up to 400 deg. C. rapidly, and keeps it there at idle so that closed-loop operation is assured.

The next development was the planar type, which uses micro-thin layers of galvanic material incorporated with the heating element to provide even faster

No longer are air/fuel ratio sensors mounted in the down pipe. They need over 750 deg. C. to function properly. Also notice how they are mounted straight up. This prevents condensation from getting trapped in the sensor, and it also makes service much easier.



Through www.bmwtechinfo.com you can view the wiring of the air/fuel ratio sensor. Notice that there are six wires in the diagram, but only five on the sensor itself. That's because you're seeing the harness side of the connector.

operation. BMW also used NGK "resistive jump" sensors that are similar to the Titanium type in that they require a reference voltage from the control unit of five volts that the sensor pulls to ground according to the O2 level. These sensors work the opposite of what we are used to. Sensor signal voltages above 2.5 volts (half the reference voltage) reflect lean mixtures, and those below 2.5 volts are indicate rich mixtures.

Further developments have occurred in the monitoring of exhaust gases. The United States and European governments have called for stricter and stricter regulations on reducing harmful emissions and increasing fuel economy, and rising fuel prices have put the issue of mpg right in the consumer's face. To accurately control combustion and improve efficiency monitoring O2 content needs to happen sooner after start-up, for the rich mixtures present during warm-up, and for the lean mixtures of deceleration. Previous O2 sensors are not accurate enough, nor fast enough to provide a precise signal for these extremes. So, in the late 1990s a new technology was introduced known as the "wide-band" O2 sensor. This is still based on the Nernst principle, but there is now an additional chamber. Also, there are new sophisticated electronics within the control unit that allow it to take a more active role in monitoring the oxygen content of the exhaust gas.

Air/Fuel Ratio Sensor Operation

The new air/fuel ratio sensor is still an oxygen sensor, but its new design allows it to start providing feedback after only 10 seconds! Not only is it fast, but it's also capable of reading extremely rich and lean mixtures. As mentioned earlier, the sensor has two chambers. One is open to the atmosphere. This is known as the reference air gap, and is adjacent to the reference cell. This reference is always held at 450mv (Lambda). The other chamber is known as the diffusion gap or measuring chamber. This is adjacent to what is known as the pump cell, and is exposed to exhaust gas. The DME wants to maintain a stoichiometric ratio in the diffusion or measuring gap. As exhaust gases enter this gap, they are either high in oxygen (lean), or low in oxygen (rich). The DME reacts to these mixtures in the measuring gap by modulating the current to the pump cell. This in turn either attracts more O2 ions into the measuring gap (diffusion chamber), or repels the O2 ions from the gap. If the exhaust gas is lean the DME adds current to repel the O2 ions in the lean mixture out of the measuring gap. If the exhaust gas is rich the DME subtracts or pulls current to attract O2 ions into the measuring gap.

How does the DME know if the mixture is rich or lean? Remember, the DME monitors the reference

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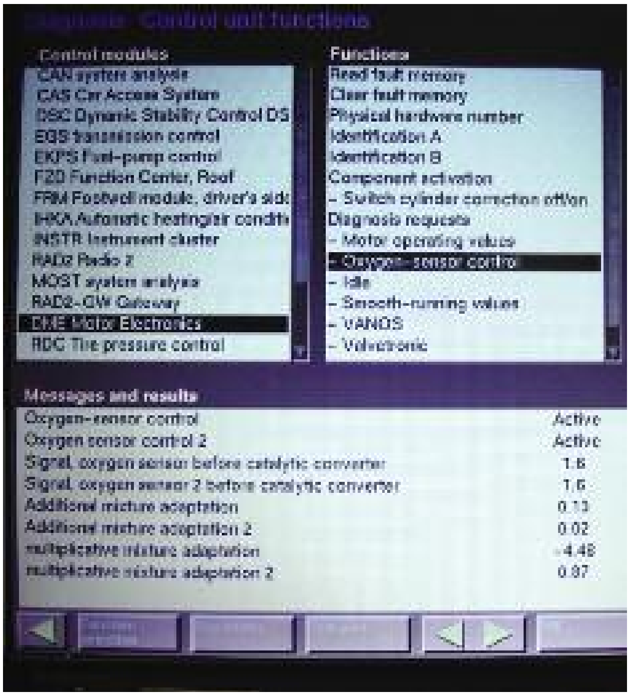
Homologation: BMW E60 E61 (series 5)
E63 E64 (series 6)



When using your scan tool, you may be tempted to watch the air/fuel ratio sensor voltage and make a determination from that. Here you see that both AFR sensors are reading 1.6 volts after opening the throttle, which you will not see on any wire at the sensor. This show activity but not much else.

cell and compares it to the exhaust in the measuring gap. The DME does not directly measure the difference between the O2 content in the exhaust and that in the reference cell. Instead, the DME monitors the amount of current it needs to add or subtract to the pump cell. The more current it adds, the leaner the mixture. The more current it subtracts, the richer the mixture is. The DME can add or subtract current very quickly to keep the ratiobetween the measuring gap and reference gap at the stoichiometric ideal. This translates into fast reaction time and the ability to monitor a broad range of mixtures.

The principle is similar to a Mass Air Flow sensor wherein the DME does not measure the temperature drop as air flows across the hot wire or film element. It monitors the current it adds to keep the wire at a specified temperature.

Symptoms?

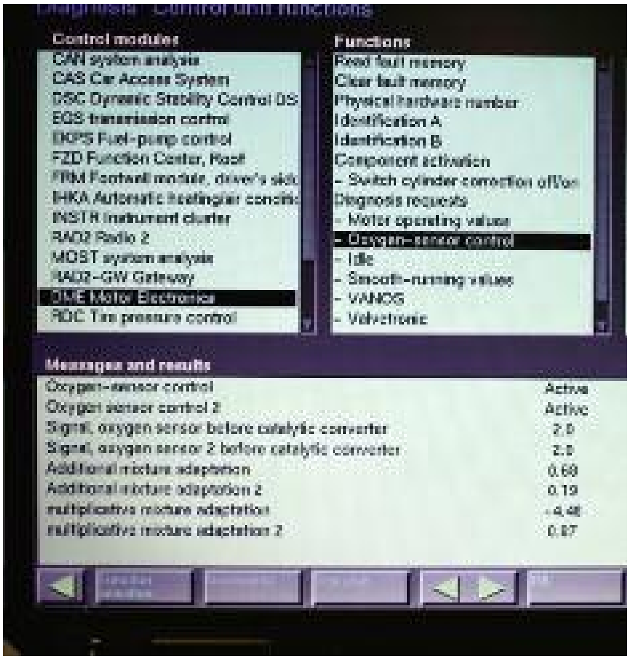
You might think that its operating principles would make the air/fuel ratio sensor difficult to test. But like much of the new technology in today's vehicles, there is more than on way to evaluate the sensor. You can still measure the voltages from the sensor and watch how it reacts, but you can also directly monitor current to the pump cell. Of course, you can also use data from your GT1 scan tool, or factory software equivalent.

Whether the problem is a drivability complaint, a MIL on, or a failed emissions test, at some point you may need to test this new bit of technology. Before we get to actual procedures, we should mention some items of interest you should be aware of. First, the reference cell must be exposed to the atmosphere. The outside air is supplied through the sensor connector and the harness. Any damage or contamination will result in the sensor not working properly, so be careful when using cleaning solutions and tell your customer to be aware of the potential problems engine compartments detailing can cause.

Next, these sensors only operate within a specific temperature range -- approximately 750 deg. C is their working temperature. This is one reason they are mounted on the exhaust manifold where it is easier to maintain that level of heat. The sensors are almost always mounted straight up, too, which is necessary to allow condensation that would affect the sensor's operation to evaporate out of the sensor body.

Another factor to consider is backpressure. These sensors are pressure-sensitive, which means a restricted exhaust system from a clogged catalytic converter will change the way the sensor responds. The flip side of this is the potential for improper operation presented by high-performance exhaust systems installed by a "tuner" customer. Changing exhaust volume, flow and backpressure characteristics can affect the way the sensor operates, so make sure you are not chasing your tail on this one.

As far as symptoms are concerned, you should know that the air/fuel ratio sensor has significant authority over the mixture, more than conventional O2 sensors had. They can certainly cause a drivability symptom as well as an illuminated MIL. Off-idle stumble, hesitation and surging can all have multiple causes, but the air/fuel ratio sensor is certainly a prominent suspect.



Testing

Testing these sensors can be challenging. Remember, they add and subtract current to change the polarity of the pump cell. To accurately read the mixture directly you must measure the current passing to and from the pump cell. If you remember "Basic Electricity 101," you know that amperage is measured in series, which means you are going to have to open the circuit and connect your test leads to both sides of the pump cell circuit. The polarity of the leads also makes a difference. If you connect the positive lead of your meter to the harness side of the wire and the black lead to the sensor side of the wire, and the current is flowing from the DME unit to the sensor, you will register positive current. This would mean the computer is adding current to the pump cell as a reaction to a lean condition. If you reverse the polarity of your test leads, you would see the reverse and might mistake the negative current as indicative of a rich condition.

To indirectly test the activity of the sensor, you can monitor the voltage of the pump cell. You will not be able to tell if the mixture is rich or lean, but you will be able to see if the sensor is switching from rich to lean. This requires some advanced electrical testing. First, you need to connect the red test lead to the pump cell wire (the easiest access point is the sensor connector). You will notice that the sensor side of the connector has five wires in it, but the harness side has six! That is because the pump cell wire is spliced through a trimming resistor (mounted in the sensor side connector) into two wires. One continues on to the DME, and the other passes through the resistor and then goes to the DME. On the sensor side of the connector, monitor the voltage at pin #5 (the pump cell). This can be done with a graphing multimeter or an oscilloscope. You should see just under 3.0 volts if you connect your ground directly to the battery. You can also use the sensor's relative ground pin #2, which has about 2.5 volts on it. Since pin #5 has just about 2.9 volts on it, and the relative ground has 2.5 volts on it, you should see just under .5 volts on your meter. You will see a voltage swing plus or minus .25 volts if the sensor is reacting to changes in the mixture. As mentioned earlier, you are not directly measuring a rich or lean condition. You are only verifying that the sensor is reacting.

At a stable idle, you see 2.0 volts on the sensor, but this will not help you diagnose the problem. Look at "Additive Fuel Trim" and you see that the reading for Bank 1 is more than triple that of Bank 2. The multiplicative numbers show us Bank 1 is almost 5 times that of Bank 2. If injectors and coils are working properly, suspect the AFR sensor for Bank 2 as the source of the problem.

Another way that is a little less complicated is using additive and multiplicative fuel adaptation readings from scan data. Look at the additive numbers at idle. They should both read as close to zero as possible. If the value for one bank is different from the other, you can assume it is not a vacuum leak since that should affect both banks. Looking at the Multiplicative numbers, if you see that one of the percentages is not zero, but a few percentage points off, you can conclude that the problem is with one bank. This should also indicate that the trouble is relegated to one bank, and is not a problem with the MAF since that should affect both banks.

Knowing how air/fuel sensors work will allow you to accurately diagnose them. As with any new technology, aftermarket replacements are often reverse-engineered, which may take some time to get right. Genuine BMW original-equipment replacement air/fuel ratio sensors have the same strict quality control parameters as those that came with the car when new, and will go a long way in preventing comebacks. □

Environmental Impact

Being in the luxury segment means BMW vehicles provide great creature comforts as well as high performance. So, keeping their climate control systems functioning properly should be a high priority for you.

With cold weather closing in upon us, your customer’s attention may turn toward comfortable warmth. The days are getting shorter, children have returned to school, and on cold mornings they'd better have heat in their BMW's! Inform your customers that even in this hectic life we live they should still take the time to properly warm up their vehicles, which will extend engine life. After a short warm-up they will not want to be feeling cold. BMW has advanced its climate-control systems to address the driver’s concerns, such as quickly defrosting the windshield and sufficient heat provided quickly.

In previous issues of TechDrive, the air conditioning portion of the overall HVAC system was covered in depth. IHKS, IHKR and IHKA were reviewed, leaning toward A/C compressor operation and engine management system integration. Now, let's turn our attention toward keeping our customers warm.

Controlling the blower motor speed is obviously important, and has advanced from simple parallel circuits with a matrix of resistors of different values to a more sophisticated solid-state module capable of many more speeds, and which can respond to changes in demand automatically.

This single heater control valve is mounted behind the auxiliary coolant pump. It determines how much coolant makes it to the heater core, and the auxiliary coolant pump assists flow when heating demand is high.

(Continued on Page 22)

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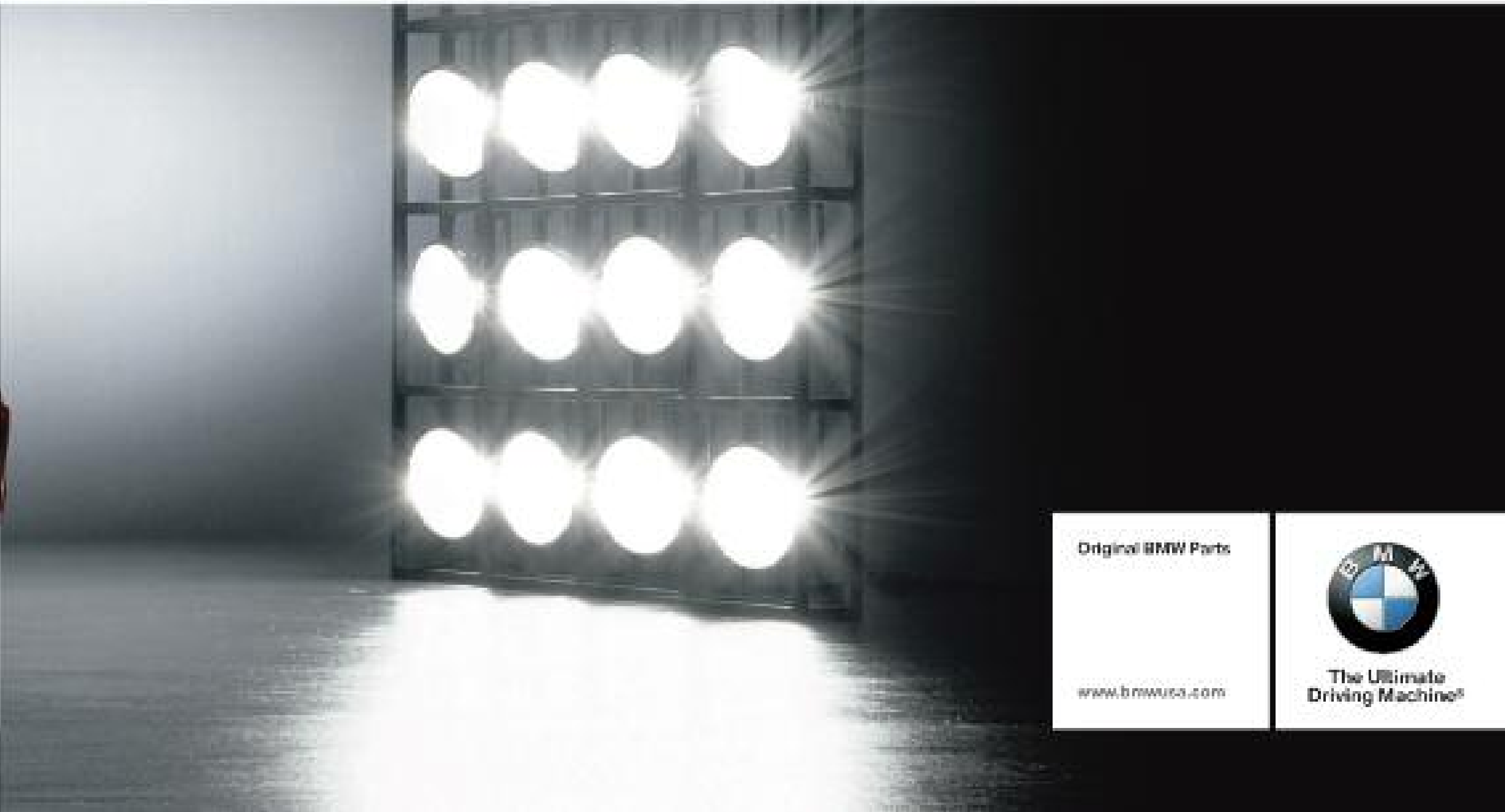
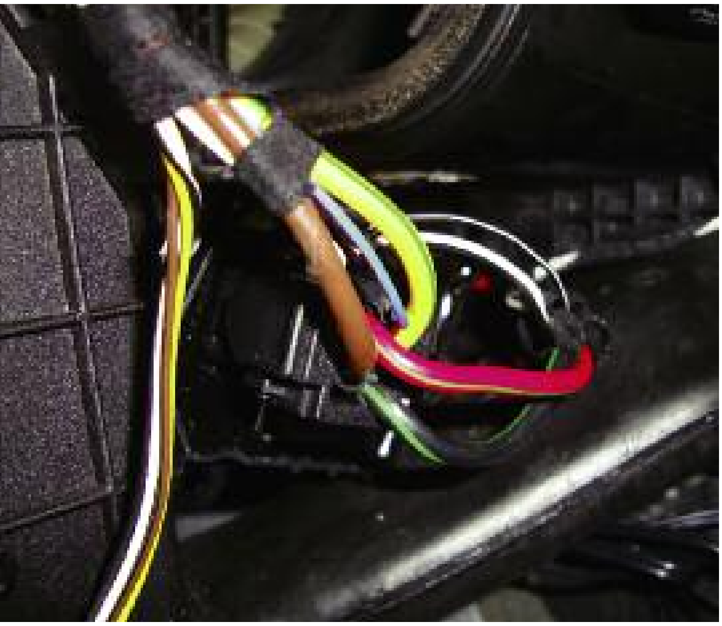
Original BMW Parts





The final stage unit is usually located behind the glove box. The yellow wire with a green tracer is the power supply from the heater relay, the brown wire is ground, and the red wire with a green tracer is the power supply. The black wire with a green tracer is the ground supply to the blower motor, and, finally, the blue wire with a red tracer is the control wire from the IHKR or IHKA control units.

It's Getting Hot In Here

While the conventional thermostat and heater core have been supplying heat for passengers for decades, over the past 20 years BMW has improved its systems with the addition of an auxiliary water pump. With added heater cores for dual- and multiple-zone systems, coolant plumbing has become more complex. With this additional piping and sharper angles, coolant flow is often compromised.

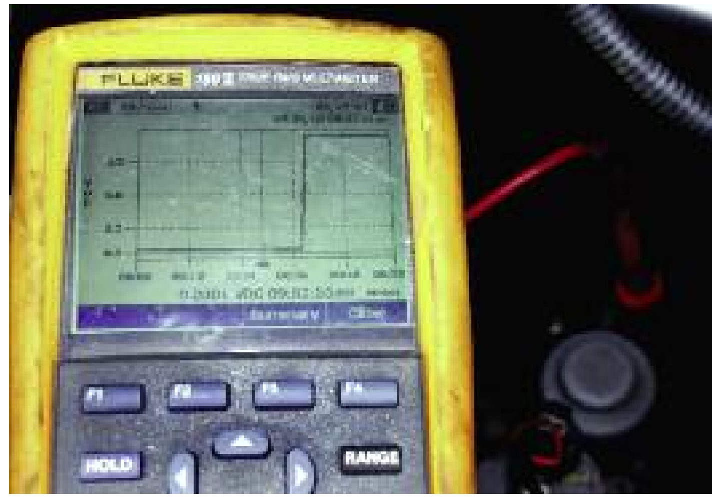
To help maintain flow, the auxiliary coolant pump is used to maintain flow through the additional hoses whether the thermostat is open or closed. Also, it allows the coolant that is heated by the engine after start-up to quickly get circulated through the vehicle's heater core(s). The auxiliary coolant pump is only activated when heating demand is high. The IHKS, IHKR, and IHKA control unit manages the operation of the pump when the interior temperature is approximately five deg. F. colder than the selected temperature. The pump is typically mounted on the coolant return side of the heater core(s), sending coolant back to the water pump. This allows even coolant flow through each heater core even on multiple-zone temperature-controlled systems.
The pump works in conjunction with a heater control valve.

The heater control valve has been used by BMW for approximately three decades. It manages the flow of heated fluid into the vehicle's cabin. Instead of using a cable or vacuum control to open and close the valve, BMW opted for electronics. The IHKS (R, A) control unit uses a pulse with modulated signal to open and close the valve depending on the selected temperature. This valve controls the heated coolant flow even if the auxiliary coolant pump is not operating. The heater control valve is often mounted near or with the auxiliary coolant pump on the return side of flow. Single temperature controlled systems only use one heater control valve, whereas on dual-zone systems a "duo" valve is used. It's simply two separate heater control valves sharing the same housing and return line. Each valve controls coolant flow to its respective heater core. Now that we have heat inside the vehicle, how do we circulate it throughout the cabin

The job of the blower motor is to move air around the cabin. It takes the temperature-controlled air from the HVAC housing and distributes it. To accommodate passenger comfort, the rate of air flow can be changed with fan speed. The task of controlling fan speed is now handled by a solid state device known as the blower motor control unit. Yes, it has achieved "control unit" status.

In most applications, the blower motor control unit, (aka "final stage unit, or "transistor output

Look at the voltage command of the heater control valve and you see that at the beginning of the graph the voltage is low. This is the valve commanded closed for A/C operation. As you increase the temperature in the cabin, you eventually see the valve being "ungrounded" toward the end of the trace and therefore opening for maximum heat.



stage") is fed power through a relay. The relay supplies power providing the ignition switch activates the relay. Once activated, the final stage controls both the power supply and ground to the blower motor. It can vary the ground potential of the blower motor to increase or decrease fan speed. The command to increase and decrease blower speed is also supplied by the IHKR (A) control unit to the final stage unit.

Who Pulls Whose Chain?

By now, you should have determined that the central control of the heating system is the IHKS, IHKR, or IHKA unit. IHKS is a manual system that still uses electronic controls to set temperature and blower speed, but does not provide feedback as temperature conditions change. Mode door control is manual. IHKS can be identified by three round dials for temperature, mode door, and blower speed, but it only has a switch panel with a remote-mounted control unit. It also uses a resistor pack to vary blower motor speed, not a final stage unit. The IHKR system does provide feedback for changes in temperature and blower speed, but mode door control is still manually controlled. It also has three dials, but the control unit is incorporated into the switch assembly. Finally, IHKA systems are electronically controlled, and in "Auto" mode can automatically change mode doors, temperature compensation and blower speed. Once again, the switch unit is also the control unit.

Testing One, Two, Three

Whether the complaint is insufficient heat, or no blower operation, you now have won half the battle by knowing what the various components are and what is involved in supplying heat. If you are going to diagnose this problem, you're going to need some testing procedures. Some of the symptoms you have to contend with are inadequate heat, lack of heater control, the inability to control each dual/multiple temperature zone, no blower motor control, or the blower is stuck at one speed.

How are we going to approach these various problems? Let's start by looking at the heat situation. The electronically controlled heater valve, or duo valve, depending on the application, is normally open. That is, it passes coolant when not energized. This gives maximum flow and therefore maximum heat when there is no power to the system. When there is a failure in the system, at least the vehicle still has heat for defrosting purposes, etc. You can use this operational strategy to your advantage by simply unplugging the valve and seeing if the input and output hoses read the same temperature with a non-contact infrared thermometer. If yes, then

With the temperature set above 80 deg. F., you should see the auxiliary coolant pump activated. It should draw about one amp at full speed, but it's normal for a cold engine to increase that draw to about 1.3 amps.

the valve is open. If not, the valve may be stuck closed. The same operational characteristics apply to the duo-valve. When you have a vehicle without independent control of temperature settings you may have one of the channels of the duo-valve stuck closed.

With the valve(s) wide open, you should get maximum heat. In order to reduce heat and increase cooling during the summer months, the circuit(s) of the water valve are energized or grounded. This closes the valve and reduces the heat inside the HVAC control assembly under the dashboard. With the heat reduced, the A/C system can work more efficiently. If you notice the A/C system is a little warmer than normal, but the refrigerant high- and low-side pressures read normal for your ambient temperature, the water valve(s) may be stuck open. The water valve(s) is controlled by the IHKS (R, A) control unit. You can monitor the voltage sent to the water valve to close the valve as well as checking resistance between the solenoid(s) of the system you are working on. In some cases, the water valve solenoids are grounded and the control unit supplies power to close them. In other cases, the valve is supplied with a fused power supply and the control unit grounds the solenoid to move it to the closed position. Obviously, check the wiring diagram of the variant you are working on so you know what signals you should be testing for. The voltage control does pulse on and off, but very slowly. You will see a square wave if the time frame on your scope or graphing multi-meter is very slow. These signals can easily be monitored by a conventional DMM. You can supply your own power and ground to manipulate the heater valve, but do not test for too long as current is no longer controlled and excessive current can damage the valve. It takes under a minute to open and close the heater control valve(s).

Auxiliary coolant pumps typically draw about one amp, but can go up to 1.3 amps on a cold motor. If the draw is too low, you probably have a weak pump that's not sending sufficient coolant to the heater cores. If the amp draw is high, you may have a blockage in the system. This could be from corrosion, as well as a from a stuck-closed heater valve.

Solid State For Solid Performance

With blower motor controls, you should do some digging before you condemn a component, and after you have checked the basics, such as a blown fuse. The blower motor fuse is typically located in the main fuse panel either

Here we are measuring the amperage draw of the pump with an inductive amp probe while monitoring the command to the power stage with a graphing multi-meter. As you can see, at maximum speed the analog voltage signal is about eight volts, and the blower draw is about 30 amps.

under the hood in the E box, or behind the glove box. In most cases, to gain access to the blower motor final stage you need to remove the glove box from the vehicle anyway. Now, you can access the final stage connector to perform testing. Being a solid state device, you will see an ignition-on power supply from the heater relay, a direct ground wire, the two power and ground supplies directly to the blower motor itself, and, finally, the control wire from the IHKR (A) control unit. With no blower or fixed speed operation, you should check the voltages at the final stage unit. Since the heater relay supplies battery voltage to the final stage unit, there is the possibility of voltage drop across the contacts of the heater relay. This would supply a low voltage to the final stage for it to operate properly. The final stage also needs a constant ground supply. This ground it typically mounted underneath the driver's side or passenger's side seats on a bus bar ground. You can unplug the final stage connector and jump the power supply and ground wires directly to the blower motor wiring to verify that the blower motor is operational. Check the blower motor amp draw to make sure it is not going to damage another final stage unit if replaced. A typical blower motor will draw about 30 amps at full speed. Anything higher than that may overwork a new final stage unit and cause premature failure.

Once the power/ground supply and the blower motor have been checked, you can evaluate the control signal from the IHKR (A) control unit. This can be done with a voltmeter, or scope. The voltage control signal is analog, not digital. Simply monitor the analog voltage signal as you manipulate the blower motor speed control button. With a low-voltage signal, you should have low blower speed. With a higher voltage signal you should notice blower speed increase. In the "Auto" mode, you may notice the signal voltage to the final stage reducing as the interior temperature reaches the selected value. If you use a aftermarket scan tool to monitor this voltage, some of the programming may be incorrect. The voltage signal does not vary between zero and five volts as indicated. The voltage actually increases from just about zero volts with the system off to around eight volts with the control unit commanding maximum blower speed. If the signal is changing between zero and eight volts, you know the control unit is doing its end of the work. If you have a blower speed problem at this point, your problems is with the final stage unit.

In Conclusion

BMW vehicles are technological marvels on multiple levels, but something as simple as insufficient heat or no blower motor can leave your customers out in the cold. By diagnosing and repairing their vehicles with BMW genuine parts you can be sure they'll ride in the comfort they are entitled to expect. Job well done. □

Collision corner: Working with aluminum panels

BMW's quest to make vehicles stronger, lighter and more fuel -efficient is never ending. In order to achieve these goals, new ways of thinking and new materials are necessary. That translates into new repair procedures.

Aluminum panels purchased from your BMW parts supplier come already primed. After cleaning, they are ready to paint with BMW Colorsystems. A typical fender replacement may be more profitable than straightening.

In an effort to both clean up the air we breathe and reduce petroleum consumption, government regulations require lower emissions and improved fuel economy. You may think this is a job for the engineers who build engines and powertrain management system. You would be right, but this is only part of the equation.

Engineers design these systems to work with a specific load. The weight of the vehicle and its aerodynamics affect this both under acceleration and at speed. If you can lighten the load, you will take stress off of components, increase fuel economy and reduce overall emissions.

So, the weight of a vehicle is as important as any other engineering criterion in improving a vehicle's overall performance. One of the efforts made by manufacturers to reduce weight is the increased use of aluminum.

This light-weight metal can replace steel without sacrificing structural integrity and passenger safety. Of course, different construction techniques are required to maximize aluminum's characteristics, and with these come new repair procedures. In order to provide your customers with the same safe body structure they had before any crash damage, you need to adhere to the proper repair techniques specified for aluminum.

Aluminum 101

You may wonder what has driven the change to aluminum. First, aluminum is about one-third the mass of steel. But that doesn't mean you can save two-thirds of the weight. First, aluminum is not strong enough by itself for automotive applications. It needs to be alloyed with other metals to exploit its characteristics. Also, if we want to maintain the same strength as steel we need to use more of this alloy. As a result of the need to be an alloy, aluminum has multiple manufacturing benefits. The most common form is sheets, but it can be cast or extruded to form sub-structures. Different alloy blends will highlight different characteristics and these are identified by the series number. For example, a 2000 series alloy has relatively more copper in it. This makes for a fairly strong, workable panel that can be easily stamped. A 3000 series alloy has manganese, which makes for a stronger panel.
A 4000 series alloy will melt at a lower temperature, so is used in welding wire. In the 5000 series, aluminum is blended with magnesium, so in addition to being stronger it is also corrosion-resistant. This series is also strong enough to be used in sub-structures. By adding silicon to the 5000 series, you get a 6000 series alloy that is stronger yet. Adding zinc to the mix yields the 7000 series, which is both strong and corrosion resistant. This alloy is strong enough to be used in bumpers and their reinforcements. Whatever the alloy and depending on its application, on average the overall weight savings ends up around 40% over steel.

Another benefit of aluminum is its ability to conduct electricity. It is an excellent ground path for electrical systems. By the way, as more aluminum is used in manufacturing, its cost-effectiveness increases.

Various aluminum alloys react differently to heat-treating. The 3000, 4000 and 5000 series are not heat treatable. That's why some of these are used for welding wire. This means they will not strengthen with heat, but they will strengthen by working the metal. To a small degree, you can anneal them, but be careful. These alloys do not show warning signs of excessive heat, so you can easily damage the panel. Use heat-reactive crayons or tape to keep track of the panel temperature if annealing is necessary. Try not to put the metal through too many heat cycles, which can actually make the panel weaker.

On the other hand, 2000, 6000 and 7000 series alloys will strengthen with both work-hardening and heat. You still need to be careful of the temperature as you can do more harm than good by overheating. This is important. Remember that whenever you repair a dent in a panel the damaged area is work hardened. When attempting to remove the dent, the surrounding metal may warp since it is not work hardened. Heating the damaged area softens the metal making it easier to work with. In the "heat-shrinking" process, you apply heat around the dent. This forces the metal to return somewhat to its original shape, which translates into less working of the panel. With more severe accident damage, the panel may not be worth repairing and may call for replacement. Heat can also be used to soften bonding agents between adjoining panels that cannot be welded together. With BMW using more aluminum in its vehicles and mating this metal with steel structures, new bonding methods and materials need to be learned.

Preparation

When an aluminum panel is initially stamped it has either a water-soluble dry-type film, or a water-free dry-type lubricant. These lubricants protect the metal during stamping and must be removed before any welding or painting takes place. Any contaminants on the aluminum during welding can result in porosity in the weld. This happens when hydrogen gas stays in suspension with the molten aluminum. As the aluminum cools, the hydrogen escapes leaving behind a porous weld. In addition to cleaning off

Although currently BMW does not recommend straightening aluminum, some day it may approve aluminum-to-aluminum welding. Be prepared to tool up with an inverter-type welder, which pulses current across the welding tip to keep metal temperatures down.

metal-forming lubricants, you will also need to clean off the oxide layer that naturally forms on bare aluminum, which requires special solvents. If you purchase a genuine BMW replacement panel, it comes already primed so there is no need to perform all this additional work, something to think about since time is a big factor in profitability.

It is as important for the work area to be clean as it is for the panel to be clean. While prep work is often relegated to the apprentice, here it is one of the most important parts of the repair. Any cross-contamination from other jobs going on in the shop can have an adverse affect, especially on painting when it is often too late. Steel and aluminum chemically react with one another over time. If steel particles from sanding or grinding were to end up on an aluminum panel, the reaction would cause “fisheye” within the paint layer. To avoid steel contamination, the section of the shop working on aluminum must be protected from the rest of the shop with dividers. It is strongly recommended that you maintain a separate set of body tools made of aluminum to be used only on aluminum panel repairs. Even the cart the tools are stored on should be aluminum and clean of any outside debris. If you were to use your steel tools, you

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It's All In the Process

Remanufacturing Process (Original BMW)

1. Dismantle core and clean all components.
2. Replace key components 100% with new OE part.
3. Test all other critical components.
4. Replace components that do not meet specs.
5. Assemble, test and box.

Rebuilt Process (Typical Aftermarket)

1. Identify damaged part or parts.
2. Replace damaged part with non-OE part and clean.
3. Re-assemble, test and box.

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Although to repair this damage is time-consuming relative to the surface area involved, these aluminum panels should be repaired. The general rule with aluminum is to start from the outer most portion of the damage and work inward toward the middle.

would have to thoroughly clean them of any ferrous particles, which is next to impossible considering how dust can hide in a tool's cracks and crevices. If contamination were to occur, you would have to take the panel back down to bare metal and repaint. This is a waste of time that can take the profit right out of a repair.

Keeping your employees safe is another concern. Aluminum chips are combustible, so welding or the heat source for annealing can ignite them. It is imperative that you have a vacuum evacuation system to extract contaminates and dust away from the work area. In addition, the entire vehicle should be covered with a plastic drop cover except for the damaged portion.

Before and after any aluminum panel work is performed, you must inspect for cracks. You can coat the panel with colored dyes that will fill channels and highlight cracks. Use a magnifying glass to inspect the surface. Cracks that are too small to be seen by the naked eye can cause blemishes during the painting process. Vibration and stress can increase the size of the crack over time, and require further bodywork in the near future. It is also important clean any dye out of the crack before it dries as this type of contamination can interfere with welding and painting -- have a solvent ready.

Panel Straightening

If accident damage is no too severe, you can attempt to straighten the panel instead of replacing it. Locate the highest and lowest points of the dent as you do with steel, but unlike steel you should you should start straightening in the middle of the dent and gradually work your way outward. Just as with “paintless” dent repairs, you should start by pressing out the dent using wood, plastic or aluminum hammers. Avoid using any tool with too sharp an edge as it is easy to do more harm than good. Do not “stretch” an aluminum panel. The more you stretch, the weaker it will become.

When the dent has been straightened out as much as possible, it is time to “draw in” the aluminum. Once again, first clean the panel surface of all contaminants. With a neutral welding flame, heat the area in and around the dent. Keep the flame between 300 and 350 deg. F. With heat crayon or tape you can modulate the heat to stay between these two temperatures. Try to cool off the panel quickly and the panel should try to resume its original contours. Heating the panel softens the metal and cooling it allows the outer undamaged areas to pull the dent out.

If more extensive work is needed to straighten out the panel try to keep the metal temperature between 475 and 575 deg. F. This will keep the metal soft enough for you to strike with your wood, plastic or aluminum hammers. Without this heat, the panel becomes “springy” and tries to resume its damaged state. If you apply too much heat, the metal will distort the damaged and undamaged areas as well. Remember to gradually raise the metal temperature and work the panel. If you can, avoid heating the panel a second and third time as this will make the metal weaker overall. After all "tin knocking" is done, re-check for cracks and repair accordingly.

Chemical Bonding

As seen on the 2004 BMW 5 series, the entire nose section is aluminum. The rest of the body is a steel structure. These two dissimilar metals cannot be welded. In order to join these two sections you need to thoroughly clean and treat the contact surfaces with a Pyrosil kit. Through your BMW parts supplier, you should be able to order the Dow adhesive BMW recommends for chemical bonding. When using a static mixer or mixing tip on your applicator, equalize the mixture by squeezing out one inch before applying the tip, and ½ inch with the tip installed. Apply a sufficient bead to coat the joining surface and, using a chassis jig, join the nose section to the body. You will have to rent the Celette chassis jig for this big job if you do not have one.

As you can see, the bonding agent is not evenly dispersed in the mixing tube. This chemical bond will not dry or adhere properly. Equalize the mix by squeezing out an inch of material before and after installing the mixture tube.

On 2004 and later 5 Series, the entire front clip is aluminum, including the firewall. The unit is bonded and riveted to the body. Be sure to add the ground strap to prevent any electrical problem. Look through you archives of TechDrive for a previous article on grounds.

Next, install the mechanical fasteners, which is this case are rivets. Use only rivets supplied by BMW (the same goes for any mounting bolts). The rivets are made of a special non-corrosive/reactive metal to protect the attachment seam. For this structural repair, BMW forbids any pulling of the front structure or heating/welding. Mounting screws need to be of the Electro Magnetic Conductivity type (EMC) so they do not adversely react with the aluminum components.

It is this attention to detail that will allow you to provide a safely and responsibly repaired vehicle, and tht will give you peace of mind about guaranteeing your work.

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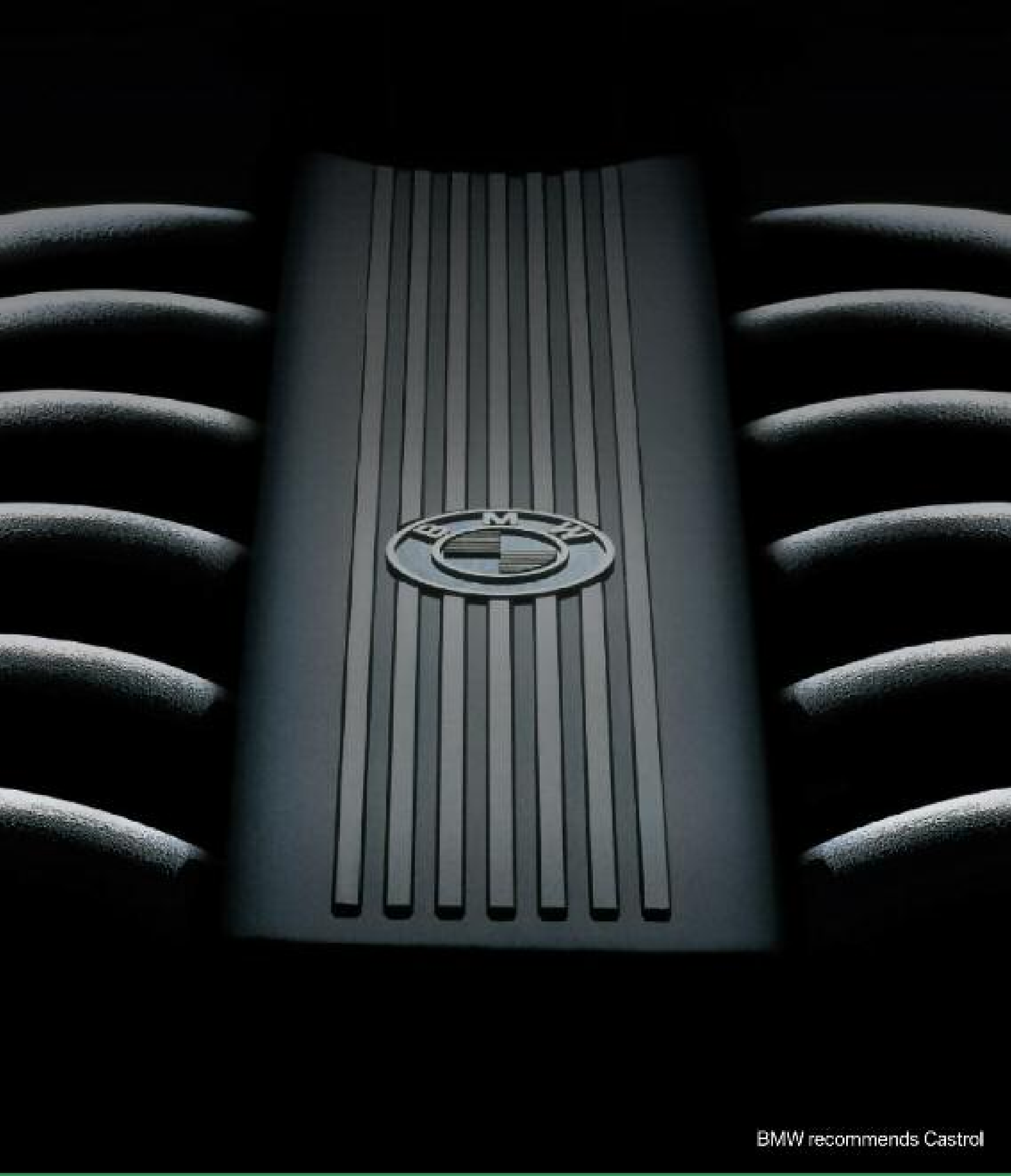

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