the bimmer pub®
February 2018 Volume 6 Number 1

Technical Knowledge for Independent BMW Service Professionals

Parasitic Draw | Network | Paint | Murphy's Law | Welding

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Welcome

the bimmer pub is sponsored by your local BMW wholesaling dealer parts department, and is dedicated specifically to independent technicians who service BMW vehicles.

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.

With a driving combination of the proper repair procedures and the correct Original BMW Replacement Parts, you can expect to fix that BMW right the first time, on time, every time.

Included in this effort is the development of a highly informative and user-friendly web site that will be home to article archives and more. Log on to thebimmerpub.com and let us know what additional material you would like to see us include that would be helpful to your business.

We want to make the bimmer pub the most useful and interesting technical magazine you receive, and you can help us do that. Please email our publisher at: cayers@thebimmerpub.com and let us know what topics you would like to see covered in upcoming issues. Your suggestions and comments are welcome, and with your involvement, this publication can become one of your most important tools.

Thanks for your continued interest.

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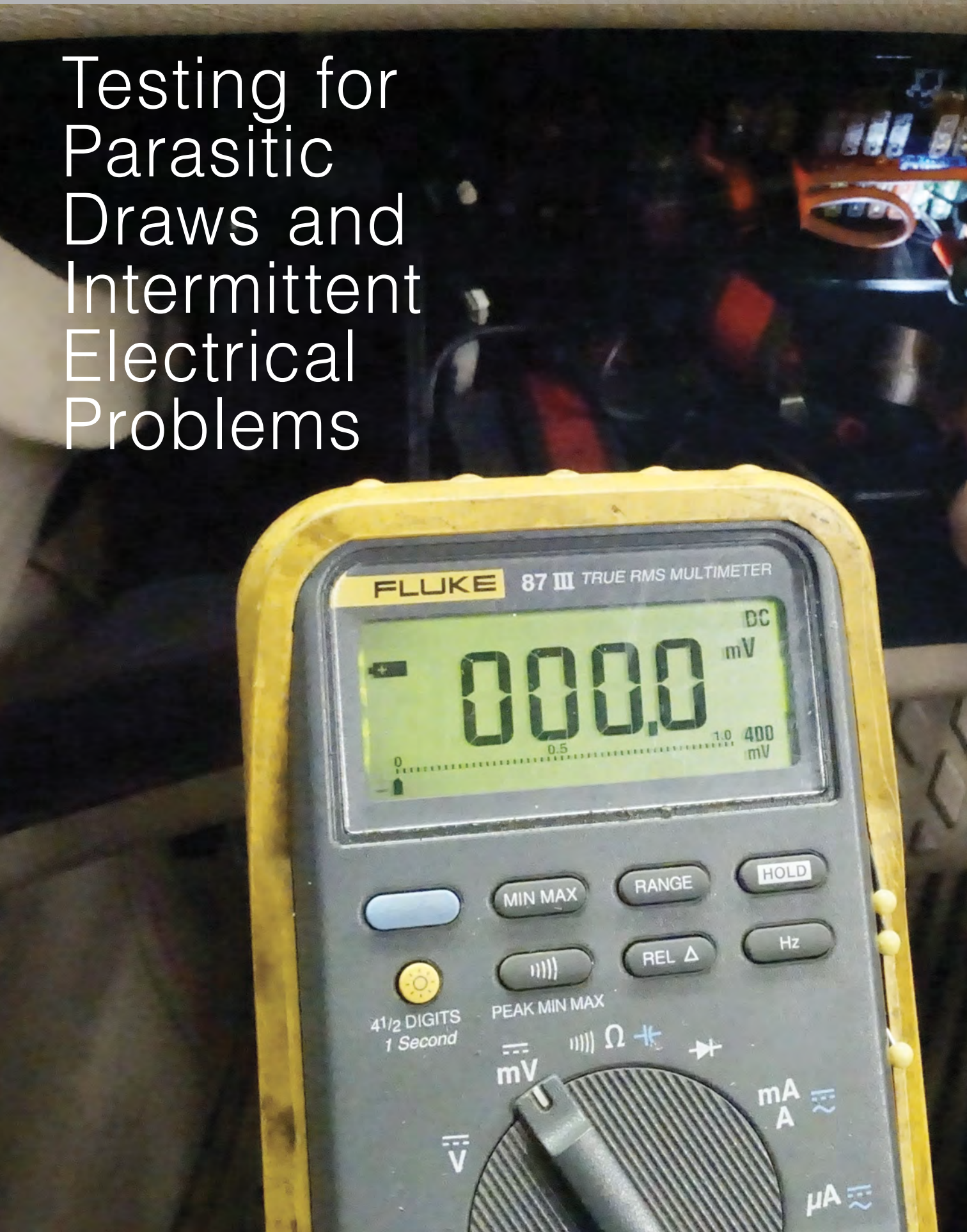
Contents

Testing for Parasitic Draws and Intermittent Electrical Problems



This test with 000.0mV across the fuse shows a good fuse and no amp draw.

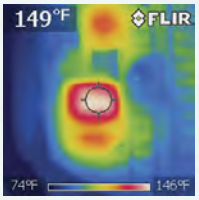
Parasitic draws can be the most challenging automotive problems to diagnose. So it's best to have a game plan before you start. Before you even break out wiring diagrams or test equipment, it's a good idea to ask the customer under what circumstances the problem occurs. For example, does it only happen when ambient temperature is hot? Or cold? Only when the engine is hot? Or cold? Things like that can help you save time. It's also a good idea to always check for TSBs before you dive into a problem.

The most important tool you have is not in your toolbox, it's your senses and your brain. Obviously tasting isn't a great idea, but your other senses are a good place to start. All diagnostics should start with a thorough visual and audible inspection. For example, don't waste a lot of time looking for an electrical problem when the floor mats are soaked or there's aftermarket equipment that might be causing the problem. You may have to pursue that first.

Sometimes the best "second step" is to call the customer and explain the condition. If they don't want to address underlying issues, you're done with almost no investment in time. Make sure you are authorized for your time before you start. It's best to log and document every step you take to justify the bill. Take pictures. Print wiring diagrams from bmwtechinfo.com and write your notes on them. Print scan tool results. Besides helping to justify the bill, documentation makes it easier to return to where you were if you are interrupted.

It's a "best practice" to perform a "charge/start system test" as part of initial testing. The test includes a battery test, alternator DC and AC voltage tests, alternator loaded output along with the starter current draw test. Any basic electrical system problems need to be repaired before going further. There have been times when computer related problems are actually caused by excessive AC leakage in the charging system corrupting the memories of the computers.

The same is true for induced signals inside a harness, especially a harness that has been modified. Always look for "previous work" and damaged wiring or



This is a FLIR image of a relay that stayed on. Note it's 149 degrees F!

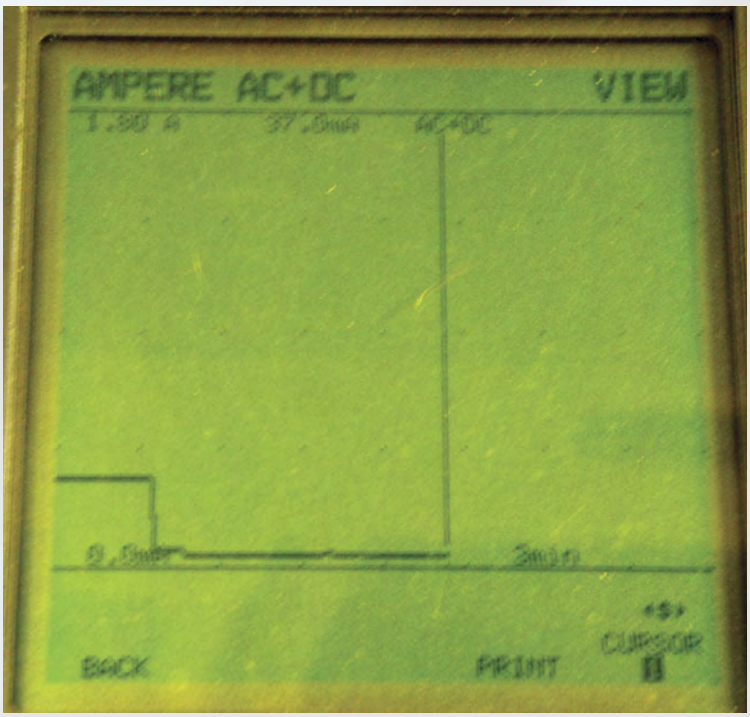
connections. Maybe it has corrosion or broken wires that affect all or part of the electrical system. Sometimes that is the cause of the parasitic draw and the diagnosis is done. Also, current only flows when a circuit or system is "on" and under load. So testing only voltage available with the system off can cause you to believe everything is good when it is, in fact, breaking down under load. When testing voltage drop to powers and grounds, go to the load first. When testing computers, test at the computer plug.

The other area to address before actually getting to the "problem" is codes and residual problems. Connect a factory level (GT1 on the older cars, ICOM through bmwtechinfo.com or Autologic are typical) scan tool and perform a "short test." As with the "charge/start system test," problems here need to be addressed before continuing.

A classic example is an E90 328i that comes in with a lot of problems. The "short test" reveals 20 network, defective module (checksum) and voltage codes in 14 modules. Use the "short test" and those codes as a direction finder for how to progress. Does it have a new aftermarket battery? Is it programmed/coded as the correct type (lead acid or AGM) and the correct amp hour rating? Has it been registered?

Typically in a case like this, the "new" battery has already been cooked (it is often the wrong one anyway) and this has to be fixed first. Use BMW batteries because modern BMWs are sensitive to power quality. In a case like this perform a "software reset" while the old battery is out. This is done by disconnecting the battery and connecting

The setup screen on the Fluke 98, shown here, matches the switch position on the low amp probe. Now it will be on the correct scale.



The amp probe can be on the positive or negative cable since the current is the same throughout the circuit. Negative cables are usually easier to reach.

the positive and negative cables together through a 10 ohm resistor for 15 minutes. Theoretically all stored power should release in milliseconds, but BMW recommends 15 minutes so any "latched" or controlled systems will draw down to zero. Also networks need "signal silence" for 15 minutes to reset.

To start discussing parasitic draw testing you need to understand the different types of test equipment, their strengths and weaknesses. Now it's time to begin the actual testing. There are different ways of measuring current draw. The direct way is to use a digital multi-meter (DMM or DVOM) in series between either the positive or negative battery cable and its battery post. Typically these meters have a 10 amp slow blow fuse which is quite expensive. At very low amperage numbers however these meters are the most accurate and reliable way to measure current draw.

The indirect way of measuring current draw is with an inductive amp clamp. Inductive current probes take advantage of the unique relationship between current flow and magnetism. Electrical current produces a magnetic field in proportion to the current flow. Conversely, a magnetic field sweeping over an electrical conductor will induce current flow. That is the principle behind how generators and motors work. It's important to understand this relationship to be able to correctly diagnose electrical issues. Most amp clamps are not very accurate below 50mA and they're also sensitive to EMI (electromagnetic interference), so you have to keep things like drop lights and power cords away from them while you're testing. Also, it's important to zero the clamp when it's positioned close to the actual wire which will be measured to cancel the interference.

The advantage of inductive current probes is that you can measure current draw without having to first disconnect anything from the circuit. The act of opening the circuit might make the draw disappear due to the "unlatching" of a computer driver or relay. The sophisticated way to measure current draw is to use a scope in flight record mode with an inductive amp clamp.

Different current probes have different voltage output for the same amperage readings (they measure

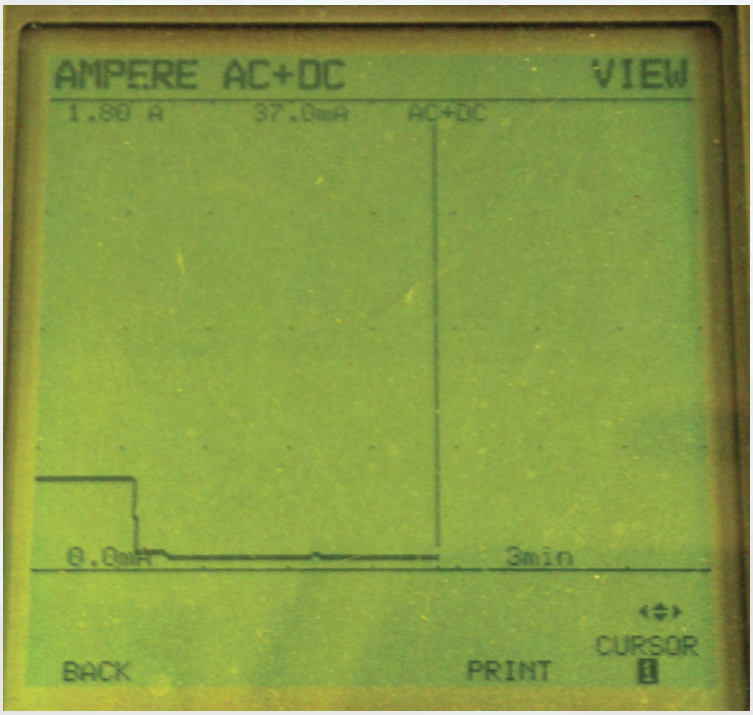
current, and output a voltage to the DVOM or scope in proportion to the current reading). Always make sure that you know exactly which scale you are on. For example, a 20mA rating which is a good number might look like a 200mA reading which would be excessive, and the reverse could also be true. Many scopes will have a setup feature that allows you to tell it which amp probe scale you are using so that the milliamp number on the scope is accurate.

Before you start actual "electrical" testing there is one other step you can take -- a quick scan of the car with an IR (infrared) gun or FLIR (infrared imager). All current consumed has to produce "something" -- light, noise, motion or heat. A quick scan might save tremendous time by locating the heat. Infrared imagers are dropping in price, but shop carefully. There is a wide range of features and accuracies in these tools.

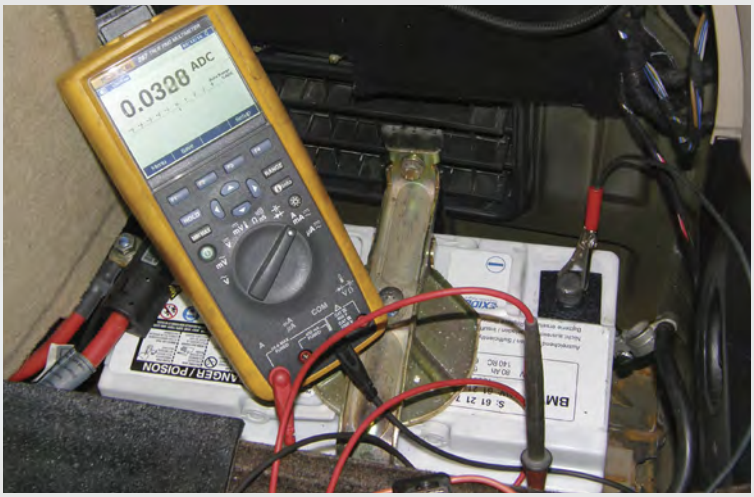
The limitations of using infrared are related to access. If the FLIR can't "see" the heat source, there won't be an image. Also any other heat source or heat drain can be misleading so make sure the car isn't in direct sunlight, over a heat source or subject to any type of external heating or cooling. Conventional FLIR images don't look like "visual spectrum" images so there is a learning curve with an infrared imager. Some newer imagers overlay the infrared over a conventional picture to make component identification easier.

OK, there are no codes, the charge/start system is perfect, there are no visible heat sources and it's time to start testing. To test with a DVOM, install an in-line fuse holder with a 7 1/2 amp fuse in series between the meter and the battery cable. That way if the load exceeds the fuse rating, only the cheap fuse blows instead of the expensive one inside the meter.

Next hook up a jump pack to the jumpstart points under the hood. Open the doors, hood and the trunk but close all the latches so the car "thinks" the doors and trunk are all closed. This way you have total access to the car but it can be asleep. Place a shop rag in each closed latch as a reminder to prevent damage from someone closing the door or trunk lid on a closed latch. Depending on the symptoms, you may have to remove under dash or other covers for easy access to suspected components.



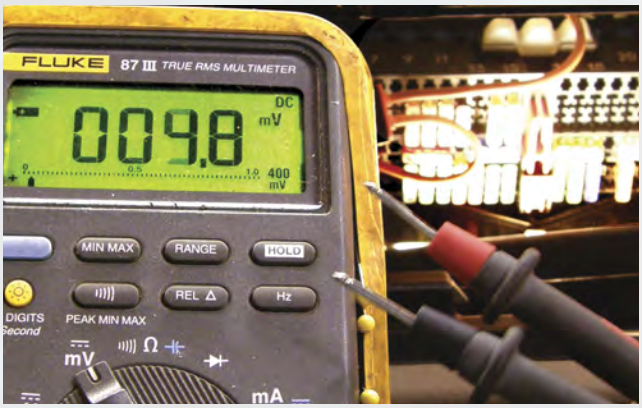
This "flight record" screen shows that the car went to sleep in less than 3 minutes and is now at 37mA draw.



Note the meter is hooked up between the negative battery post and ground.

Use an inductive amp clamp to make sure it's asleep so you don't blow the fuse right away. If you use a graphing meter or scope in flight record or min/max trend plot modes, the process of "going to sleep" will be clearly outlined. Be patient. Some parasitic drain problems are from modules being "pinged" repeatedly. That way, while the car is going to sleep you can be doing something else and see a record of how fast things were shutting down. This will also allow you to see if something is cycling the car back awake again periodically, a valuable bit of information. The training PDFs at the bmwtechinfo.com website (BMW Training) are an often overlooked source of information on network structure and system operation.

Once you are sure that the current draw is low enough to use direct measurements, start the setup procedure. Disconnect, typically, the negative battery cable and install your DVOM in series between the cable and the battery post. Now disconnect the jump



Note the test leads are disconnected and the voltage is wavering.

With the leads shorted together the readout is 000.0mV.

pack. The car is asleep on its own battery but the current is running through the DVOM.

Place your meter on the high amperage setting (10 amps max) with the leads in the amp plug (by the way, always remove the leads from that socket immediately upon completing the test so you don't blow that fuse when you go to check voltage the next time you use the meter). If the amperage draw is low, say 40mA, you have an acceptable drain and it's time to figure out what changed. If there is an unacceptable drain now, start the tougher part of the diagnosis.

Here's the part where you have to make up your mind. What kind of testing are you going to do? If it's a fairly large draw you can start by using a FLIR thermal imaging device or IR gun (Raytek etc.) to see if any of the fuses or modules are warm.

Unlike the first FLIR/IR gun quick check, this time remove cover panels for maximum viewing of heat sources. Be sure the vehicle is in an enclosed garage with no extra heat sources, wind, or other disruptions to the temperature. Covers have to be removed first as the FLIR or IR gun is only looking at the temperature of the surface directly in front of it. If you don't find something quickly then go to doing voltage drop tests across the fuses with a second DMM so the first one can stay in place. This is done using the millivolt scale on a voltmeter and looking for extremely low numbers of voltage drop across the two terminals on the back of the fuse. First hold the leads in the air and you should see "ghost voltage."

This shows up on the meter as a low level, rapidly changing voltage number. It can be used to show an open circuit. Check your meter by touching the positive and negative leads together - you should see 000.0mV.

Once you connect the two leads to the fuse pins you should see a number, either 0.000 (just like the leads touching each other) for no current flow or some very low millivolt number that indicates a voltage drop across the fuse and therefore a drain on that circuit. If you still see ghost voltage when connected to the back of the fuse then the fuse is blown since there is no reading to indicate a complete circuit.

Not all circuits have fuses which are readily accessible, so if you still don't find anything then it's time to study the wiring diagram and figure out where the hidden stuff is. If you find a circuit that has a draw, look up what devices are on that circuit and generally use the strategy of looking for the easy stuff first. If it's a tough one, then go to the wiring diagram again for locations of splice packs or other access points so that you can split the system and figure out which sub-circuit is affected. By disconnecting one terminal at a time from the splice pack it's easy to find the offending circuit and then the faulty component or shorted wire.

Some of the hardest faults are intermittent problems. The first question that comes to mind with an intermittent problem is "are there any codes?" The second thing to consider is "under what circumstances does the intermittent problem occur?" If you can't duplicate the circumstances it will be extremely difficult to diagnose the problem as it may never appear for you.

Sometimes, if it's very intermittent, the cheapest diagnostic procedure is to replace a part. The problem with that diagnostic process is there's an investment made with no idea of when or whether you will have a confirmation of the repair. This is a hard thing to sell to customers and can make the shop look unprofessional or incompetent. Also, on modern BMWs, modules may be VIN identified so they can't be switched from one car to another for test purposes. In those cases you can't just put it in the car, test it, and then put it back on the shelf or back into the donor vehicle.

If you suspect the module due to a trouble code or some other symptom, the first thing to test is powers and grounds to that module. Any problem in power or ground must be addressed before other problems can be taken care of. Test for voltage only with the module/circuit under load. Standard specs are no more than 200mV drop on powers, 100mV on grounds and 50mV on signals. Heavy loads will normally be higher. Healthy circuits will be much less.

Often times the power/ground is the problem. If not, there are two possible causes. The usual suspect is a bad control unit, but the other cause is some condition that keeps a control unit awake when it should be

This test shows 000.6mV across the fuse which means there is an amp draw.

asleep. Those are the ones that can eat our lunch as an industry. So before condemning a control unit for staying awake, put a scope on any data buss that is tied to that computer and look for "communication," which is a square wave or regular high/low waveform. Ring shaped busses will stop working when a control unit is removed, so the normal strategy is to remove the suspect unit from the buss and see if the parasitic draw is still there.

If the draw is still there, the controller is at fault. If the draw disappears, some other device on the buss is sending the signal. This is an area where you really need to read the system operation information in the training PDFs at bmwtechinfo.com. This may be the only source for this information, so make a habit of downloading and reading them whenever you are on the website. Star or hub and spoke busses can often have individual modules removed without crashing the buss. In those cases, the standard strategy is to disconnect one computer at a time until the problem stops. However you have to be careful. Only disconnect modules with the ignition off, and be careful not to damage electronics with static discharge. Wear a static strap when testing low voltage circuits. In CIP cars you may have to program or code other modules besides the "broken" one. When running a test plan always follow every step.

When you have found and repaired the problem you're not done until you clear codes, drive the car and re-scan to confirm no other problems are lurking to bite you later. •

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PPG

The BMW Network

Marriage of Convenience

CASE STUDY

Feedback we received from our recent survey showed an interest in seeing articles that are based on case studies - actual vehicles with a specific drivability problem that arrive at a shop's doorstep. So this issue includes not one, but two case studies as experienced by our "tag-team" tech gurus, Augie Ferron and Eric Dibner. Read on and then let us know what you think.

One part of this article and investigation began as "is this how it really works?" The second part was an attempt to keep it simple. The vehicle being tested and interrogated is a 2007 BMW X3 3.0i. The curiosity in the beginning was "What can I see at the data link we are all so familiar with?"

My interest and initial curiosity was to see how the scan tool functions at the DLC. If the homework wasn't completed, some mistakes and incorrect assumptions can be created when there is a lack of understanding of this BMW network and its "marriage by convenience." The best place to start is with a detailed schematic and grasping the interconnectivity within this network and with this specific model. In this article (Part 1) we will view the inter-relationship between the scan tool and the network. As for Part 2, using a CAN and or K analyzer will offer a deeper insight.

Keep it simple - or at least try

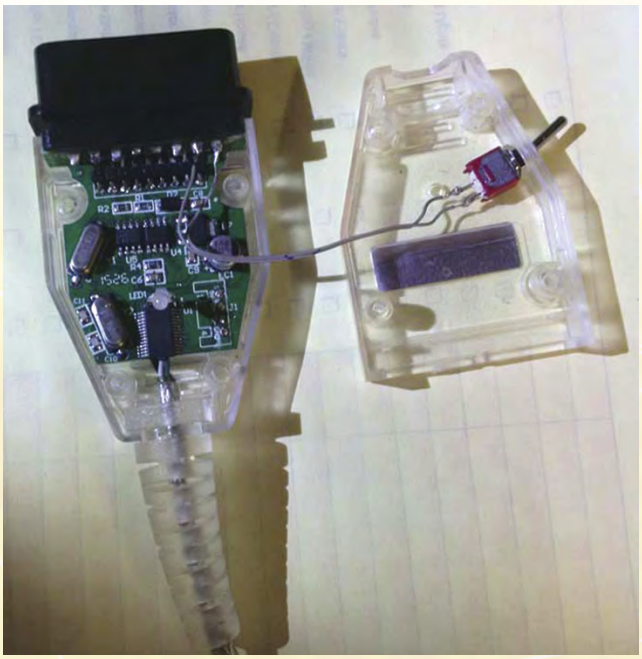
This BMW had no real issues to speak of, no problems so we decided to look at this vehicle with the simplest and most portable tools possible. Everything was accomplished without creating any faults or damage.

Tools used - Keeping it simple and having choices

- Tested with BMW Rheingold with K + DCAN Cable (Laptop)
- Tested with Launch EasyDiag (Android Tablet with BMW Application)
- AR Oscilloscope (2 channel Bluetooth with Android Tablet or Laptop)
- OTC DLC breakout box
- 90 amp floating power supply
- A current and specific Data Lines schematic

One word of caution: Any and all KOEO diagnostics MUST have a clean low A/C ripple power supply attached to the electrical system to maintain the required voltage (current) supply, keeping the vehicle alive and stable.

Rather than "jump" pins 7 and 8 with banana plugs on the break-out box, a switch is preferred to switch diagnosis pins from the new to older models that require pin 8. Closing the switch now makes pins 7 and 8 parallel.



The mini switch used can be purchased at any electronics outlet. Solder the two wires to pins 7 and 8, then the switch and mark it.

Connectivity and how this was done

I will assume many of us will use a 4 to 8 channel oscilloscope to view the "K," "CAN," or "LIN" BUS signals as they pass throughout the network. The choice was more of an experiment to use a miniature 2 channel battery-operated and Bluetooth-connected oscilloscope module. The requirements were to be: uncomplicated, quick, and effective, with a simplified setup. Another requirement was that the oscilloscope must work with either an Android or a laptop connection. Step 1 was to gather an entire scan.

The EasyDiag was the first scan tool used because of portability, and it worked flawlessly. Rheingold was used because of the network viewing layout within the software. Both software platforms and the Autel Pro tablet offered similar results.

The K + DCAN Cable that was used is the one with the green circuit board. The white ones don't seem work within this specific application. With this simple cable however, a switch was added to connect pins 7 and 8 together on the DLC.

In the view with the DLC breakout, there is a banana plug attached to pin 4 and used as the oscilloscope ground. Pin 8 is connected for the K-BUS and this connection will measure the K-BUS activity on the oscilloscope during diagnosis.

Things you should know and what you're looking at

This specific BMW has three separate networks. All three are operating at different protocols, different levels of speed, and different data sharing abilities. These three networks also operate independently or are co-dependent of each other. This is a marriage of protocol and language within three separate systems. All of those systems do get along with no complaints and no conflicts.

Note: The network not visible is the LIN network.

So what does all this mean?

Read the schematic and view the scan tool. We need to know what the networks are and how they behave. It's when we have a problem with a controller(s), that this article will help when there is "no connectivity" and also what the messages look like when the scan tool is connected to the controller and/or the network. When there is a connectivity problem or issue, a data line schematic and understanding how the controllers are connected will aid in a proper diagnosis.

Types of data busses:

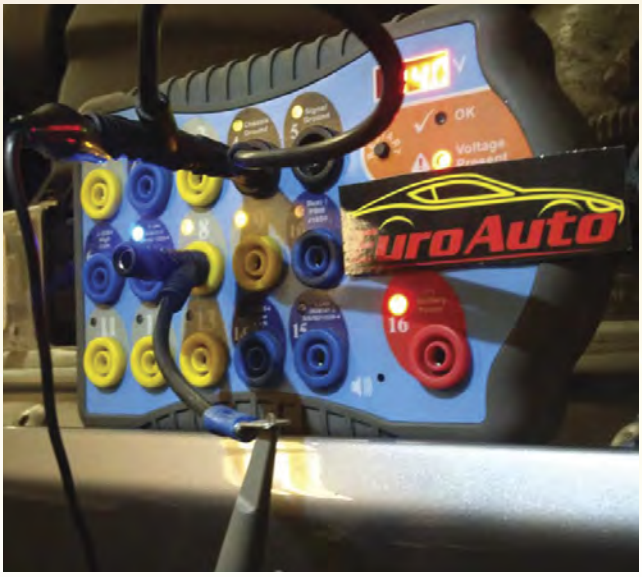
The K-BUS is a method of bi-directional control that will also display the current state of a data group. The K-BUS can also interconnect with other controllers and share information as required by the program written into the controller processor.

The K-BUS is a single wire connection with a data transfer speed of approximately 9.6 kbps. The only activity that should be seen is when the scan tool accesses the K-BUS and connects to a controller. The K-BUS only operates at nominal battery voltage, therefore the battery must be in good condition utilizing a clean power supply at all times.

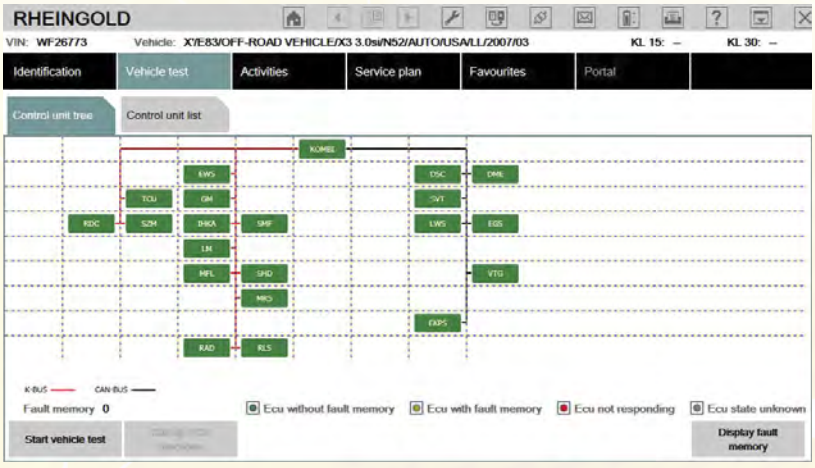
HINT 1: It only takes one K-BUS, CAN-BUS, or LIN-BUS controller or connection that is "BUS Damaged" via short to ground, short to positive, or suffering internal controller damage, to take the entire BUS down with no possible diagnosis.

HINT 2: In the glove box area are the K-BUS terminating connections, and opening one BUS connection at a time will help narrow the "culprit" via scan tool or multi-meter. Read the schematic and remember that this model at pin 8 is a White/Violet (K-BUS) wire to specific controllers BUT splits the connections at the instrument cluster as White/Red/Yellow. The instrument cluster becomes the gateway for the K-BUS and CAN-BUS.

The CAN-BUS network operates far differently from the K-BUS. This network shares data between the connected controllers with a twisted pair of wires at speeds up to 100 kbps. The CAN-BUS network transmits data within the entire structure, but only the controllers that require that data will accept the data. The rest is rejected.



To view the actual network activity, a break-out box is used in between the DLC and diagnostic cable. Pay close attention to the LEDs when a diagnosis is performed on the entire vehicle or on a specific controller. My interest was pin 8 (K-BUS) and pins 6 and 14 (CAN-BUS).



With the vehicle connected via USB cable, this image describes the entire network this vehicle was designed with, including connectivity and faults.

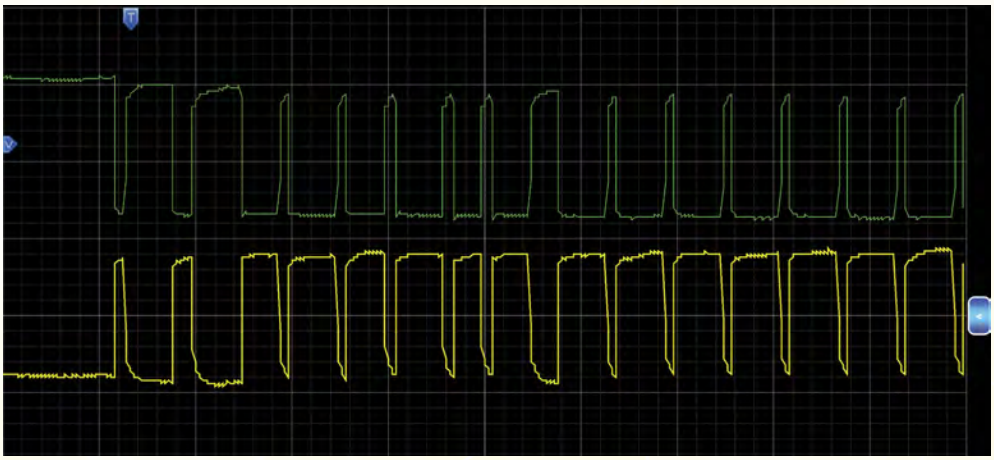
Following the schematic and this image clearly indicates the multiple connections that are easy to find and opened one at a time for testing or measured with a meter/oscilloscope.

This network also is a method of bi-directional control and will display the current state of a controller. It is no different than the K-BUS network, but it is possible to diagnose IF the connected K-BUS is still operational within a controller that uses the K-BUS for diagnosis.

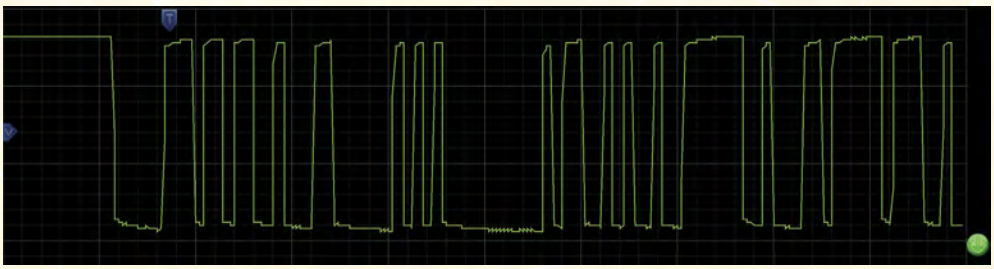
The LIN BUS (Local Interconnect Network) is a low cost network that reduces the BUS load of the CAN network. The LIN BUS is a low-speed, single-wire serial data BUS. This network can be called a "slave" network that operates, controls, and maintains functions of non-safety, non-critical control units such as mirrors, heater motors, wiper motors, etc. via the CAN "Master" network. In this model, LIN is connected to both mirrors and the Driver Door Module via General Module.

So what do the BUS connections look like?

Using the schematic and looking at the images, we can now see the layout and colored wiring found just above the fuse panel that resides behind the glove box.



The "chatter" produced between the scan tool and either DME or EGS will be in view and will change when operating the scan tool. The CAN-BUS message will also change when engine or transmission parameters change.



When diagnosing other controllers that are NOT using the CAN-BUS, this time pin 8 will be active. The same message changes will occur on the K-BUS or LIN-BUS with scan tool activity or controller parameter changes.

Repeating these steps with a scan or direct to the DME and EGS while attached to pins 6 and 14, the oscilloscope reads the CAN data produced by the connection to either DME or EGS.

The link provided offers a full view of the schematic used and a short video with Rheingold. The video will offer an identification of the controller addresses BWM uses during the scan process. •

Waterborne Paint

The Throughput Hero

Better coverage, shorter cycle time, excellent match to OEM colors – the benefits of water-based paint systems go far beyond helping improve air quality.

Portable air blowers are great for drying small areas, and for helping create horizontal air flow in the booth to create the turbulence that can speed overall drying.

It's been seventeen years since the U.S. EPA set strict limits on the amount of volatile organic compounds (VOCs) allowed in automotive coatings, and water-based paints have come a long way. Not only is water-based paint a proven performer in color match and panel blending, it is now accepted by collision repair facility operators as more cost-effective than solvent-borne coatings. Water-based paint saves labor time, energy costs, and materials expense. High-volume shops point to an increased number of paint jobs and repairs completed per week, but even small shops appreciate the faster throughput, which translates to both higher profit margins and the ability to put customers back into their vehicles sooner.

Pretty Green

VOCs contribute to ground-level ozone, a major component of the smog in high car-count cities. We reduce the VOC content of paints because it is harmful to our lungs and immune system.

Waterborne paints have come down from approximately 75 percent solvent in conventional basecoats to only 10 percent solvent in waterborne basecoats, and have reduced solvent by up to 60 percent in clearcoats. That's pretty green.

Yes, We Can

BMW became the first OEM to use waterborne paints in the U.S when, in 2010, we began using the technology in our factory in Spartanburg, South Carolina. Independent collision shops are more vulnerable to local weather conditions than climate-controlled factories, and don't have factory-like robotics technology. And because they typically paint only a part of the vehicle body, they face color match challenges that the factory doesn't have.

So the question arises, can aftermarket collision repair facilities achieve similar waterborne cost reduction benefits as big factories while maintaining excellent color match?

With BMW-approved Glasurit 90 Line, the answer is emphatically yes. 90 Line is a water-based paint system that provides a factory-like finish with greater

coverage per coat than with conventional solvent, shorter drying times, excellent color match, high gloss, and UV protection for durability.

Better Coverage

Waterborne basecoats contain 20 percent pigment in their metallic or pearlescent formulations, one-third more than the 15 percent pigment content in solvent-borne basecoats. Having one-third more of the solids that remain after solvent evaporates means that, with water-based paints, you get the same coverage while spraying less paint. Using 90 Line basecoat, you'll mix less, spray less, and save material cost and labor.

One basecoat spray may not give full coverage. Your objective is just to get an even, wet coat and a good blend-in. Here's where skill matters. If you spray a coat and get good coverage, but weren't careful enough to get a good blend, an additional make-up coat is going to eat up any cost savings you could have booked. So careful planning and execution are essential to achieving excellent color match the first time.

Shorter Cycle Time

With the proper air flow, water evaporates faster than solvent, so you get shorter flash times. Faster flashover and better coverage leads to shorter cycle time and more throughput.

Excellent Color Match

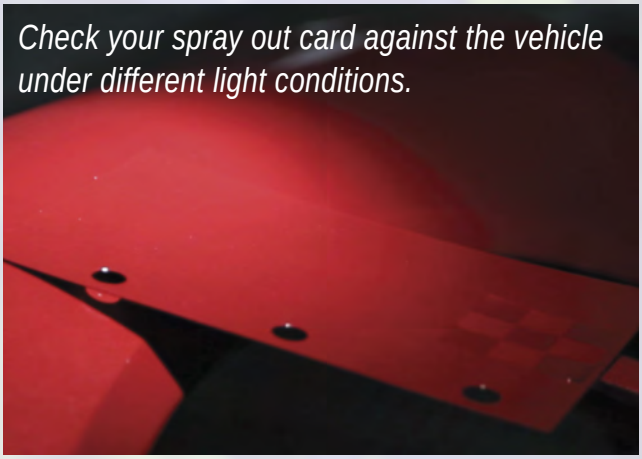
The vast majority of new cars sold in the U.S. are now painted using water-based products. That gives body shops using water-based paint systems the ability to achieve precise color match to OEM finishes.

Its uniform evaporation rate means that water-based paint dries at a more even pace than solvent-based paint. This helps metallic pigments to all flop to almost the same angle in the film, resulting in a relatively uniform color reflection. When painters praise water-based paint's "better control of metallics" to match the existing vehicle color, it is thanks to this even evaporation rate throughout the film. Simply spray the film thickness recommended by the paint manufacturer.

Additionally the pigments in water-based paints are half the thickness of solvent-borne pigments. Think of water-based and solvent pigments as two pots of marbles. Because there are more, smaller marbles in the water-based pot, they are packed closer together than those in the solvent pot. This more densely packed film offers greater opacity, which allows coverage with fewer coats. You can spray your first basecoat medium wet, then spray additional light coats, achieving blend-in using fewer coats than with solvent-based paint.

Water-based paints, when dry, are cleaner and brighter than their equivalent solvent-borne products. The OEM color
formula matching, uniform evaporation rate for better flop control, greater opacity for thinner and fewer coats, and cleaner, brighter final appearance together

Use tape and masking paper that is water resistant. If waterborne paint soaks through the tape or paper, it will adhere to vehicle surfaces underneath.



Check your spray out card against the vehicle under different light conditions.

all help make water-based paint easier to blend without halo effects, mottling or color shifts.

Water-based paint has a different color appearance when wet than after drying. Even experienced painters can't match water-based colors by eye when wet. You must prepare a spray out card, including basecoat and clear, and check it against the vehicle to ensure a match before you begin painting.

Computerized paint formula retrieval makes color match easy.

Unlike a solvent resin which, if clumped together, will re-dissolve in the presence of more solvent, a clump of waterborne paint that has dried will not re-dissolve. Make sure to filter your paint after mixing, in addition to any mesh filtration that is built into your gun.

You'll mix toners by weight, not volume, and computer software tells you the exact amount to add. If you overpour a toner, the software will adjust the other color components to re-balance the formula. It's a lot like your GPS when the voice says "Recalculating," and then tells you how to recover from your errant driving choices.

Smooth as a Baby's Bottom

Water-based coatings are thinner than solvent-based paints. They settle into sanding scratches rather than smoothing over them as solvents did. Paint angled into the scratch grooves will reflect light differently than the surrounding coating, making the scratches stand out. It will take more than one extra coat to level out scratches, making that not very cost-effective. The paint manufacturer's tech data sheets will likely recommend instead that you prep surfaces for water-based base coat by using a finer sanding grit than you would with solvent-based paints.

A related advantage is that you won't worry about whether or not you can re-coat over a repair substrate. The absence of solvent means water-based coatings don't cause the sanded edges of a repair to swell or deform.

Because waterborne is a thinner paint film than solvent products, it tends to lay down in cracks or any other flaws in the surface, changing the light refraction. Sanding with a finer grit – 800 or finer – is critical to getting the surface smoothness needed for painting.

Got Air Flow?

To dry waterborne coatings evenly and efficiently, you have to create air turbulence to ensure that air flow reaches all sprayed surfaces.

You'll use the same laminar (downdraft) air flow at 120 – 400 fpm as occurred during spraying, and add horizontal air flow at 200 – 600 fpm. Check your 90 Line documentation for cfm recommendations for the specific paint you are using.

The combination of two flow directions creates crosswinds, or turbulence, that breaks the envelope of air formed around the vehicle by the laminar air, and results in increased evaporation. It also helps speed drying of side panels, which otherwise can take longer than horizontal surfaces to reach the proper temperature for maximum evaporation. With proper air flow turbulence setup, painters routinely experience a 20 to 30 percent faster drying time.

The 90 Line paint guidelines offer recommendations on viscosity, gun distance from the surface, nozzle/fluid tip size, pressure settings, spray overlap, and how soon after spraying to start using extra air flow to flash the paint. Study the 90 Line guidelines, pick the recommendations that best match ambient temperature and humidity conditions in your booth, and follow them closely.

Durable Finish

As they dry, the latex particles bind together chemically, and that gives water-based paint a superior chip resistance and durability. •

Thanks to BASF for information about its Glasurit 90 Line coating systems and procedures, and to Nalley Collision Center in Doraville, Georgia for repair photos.

Use separate guns for waterborne base coat versus clear coat. Each requires a different nozzle size to accommodate the differing viscosities of clear versus base coat.

Waterborne Spray Adjustments for Temperature and Humidity

Ambient Conditions	High Temp and High Humidity (100°+ / =50% R.H.)	High Temp and Medium Humidity (100°+ / =30% - 50% R.H.)	High Temp and Low Humidity (100°+ / =30% R.H.)
Result	Dries Too Slowly	Dries Faster than Desired	Dries Extremely Fast

Possible Spray Adjustments

Material per coat	Apply less material per coat	Apply more material per coat	Apply more material per coat
Air pressure	Increase pressure – for finer atomization	Decrease pressure – for larger/wetter particles	Decrease pressure – for larger/wetter particles
Gun distance / overlap	Increase gun distance / less overlap	Decrease gun distance or increase overlap	Decrease gun distance or increase overlap
Fluid tip size	Consider slightly smaller fluid tip	Consider slightly larger fluid tip	Change to larger fluid tip
Viscosity	Lower viscosity – for thinner application	Higher viscosity – for wetter application	Higher viscosity – for wetter application

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Photo by Michael Furman

CASE STUDY

Impaired Automotive

2002 BMW X5 4.4i and Murphy's Law

History

Where do we start with this one? It was supposed to be an estimate on an oil leak and suspension noise. The X5 is owned by a customer we know and has a professional trust in us. We looked at the oil leak and suspension. It was later we learned that this vehicle had been "touched" by another shop.

Currently

As usual, a system scan was performed and saved. The saved data was placed in a folder and all the fault codes were deleted. The suspension work was estimated, lower engine covers were removed and the engine bay and engine were cleaned. Time was an issue so we gave the X5 back and expressed to the customer, "Drive it for the weekend and we'll look at it again at the beginning of the week when the suspension parts arrive." How simple could it be?

Tools used

- BMW INPA with a "K" plus D CAN cable or ADS cable.
- Launch with the BMW software.
- 90 amp clean and stable power supply.
- A quality grease cleaner, water hose and compressed air.

Experience

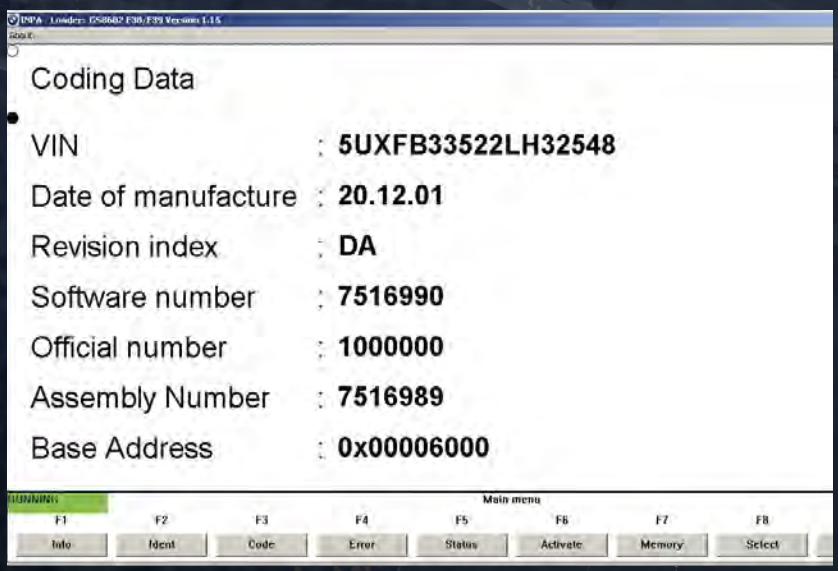
INPA is a ridiculously quick and somewhat adjustable tool if you have the patience to translate the German language to English code. Software is required to accomplish this task but this article doesn't discuss the changes made within the software. Many pieces can be found and added into the structure of INPA. For older models, this is our "go to tool." The Launch Tablet version is surprisingly well made and the layout is quick and clean to use. There is no bi-directional control in this simple tablet version but the data is identical to INPA.

Method to test 1

The first issues addressed included the leaks found and suspension noise identified. In the service bay, one ball joint and a CV boot required attention on the passenger's side. One leak was the transmission cooler and, while inspecting this, we also noticed an odd noise and found that

The water pump and one idler pulley required attention as well.

The remaining leak was yet to be discovered but for certain, the oil pan drain plug should have been sealed with a new gasket, not the mangled version



still attached to the original plug. Oil sweating was also noticed at the timing chain covers. Quickly all this was noticed after a reasonably effective cleaning of the entire engine and undercarriage assembly.

One shop rule is; when a vehicle is in the service bay and the key in the vehicle, the driver's window must always be in the open condition.

This proved to be a good rule, and when the window was closed in the parking lot, the window clip for the track broke and the glass became jammed.

The customer was notified and did comment "this happened at the rear windows," and we did order new clips. Now we needed to get the window up and disable the window motor temporarily so we could return the car to the customer for the weekend.

Next shop rule; perform a road test, just to be sure and it was tested, ready to deliver for the weekend. That was a Friday, close to shop closing time. The next morning a call was received on my personal cell phone from the customer complaining about a lack of power and his "feeling unsure" about its drivability.

We met and one fault was found; this X5 did not behave like the day before. There were no recorded faults for the DME the first time it was looked at, and that included the previous day. I asked questions as to what the sensation was, his answer being "lack of power and seemed to run rough."

So what were the chances that someone removed the cover over the coils and plugs, not ensuring that the seal in that cover was installed correctly and allowing leaking water into that one cylinder? 100 percent! Especially after we degreased and washed the engine. This seemed to work and, knowing full well this X5 did not arrive in this condition, it was checked, and double checked again, and the customer took the X5. Lucky for both of us, the X5 drove away and we watched it, very slowly down the street, and quickly returned with what would appear as higher idle. We heard the idle in this condition.

Next shop rule; Gather more information, and the customer was not happy because "it didn't do this till you touched it."

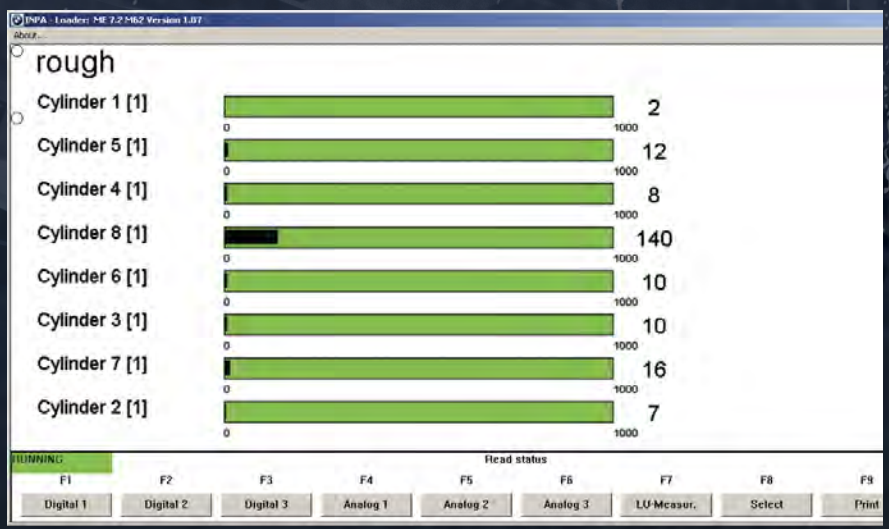
Then the customer said "see, look" as the throttle was pushed, no RPM increase and the customer turned off the key. We were horrified! Why was the key switched off in that condition, and would we be able to repeat it?

Yes it did recur, and we immediately heard something odd when the key was cycled to the ON position, then started the engine.

Method to test 1

We idled this X5 into the bay and got the customer back home. We got INPA ready while the fault was still affecting the X5. We looked for faults and recorded, then deleted, the codes.

An opera has structure; it has rules and is tuned to the music of the universe. It is an expression of the human condition through the eyes and



heart of a genius. Thinking about this vehicle we realized the BMW wasn't following any rules.

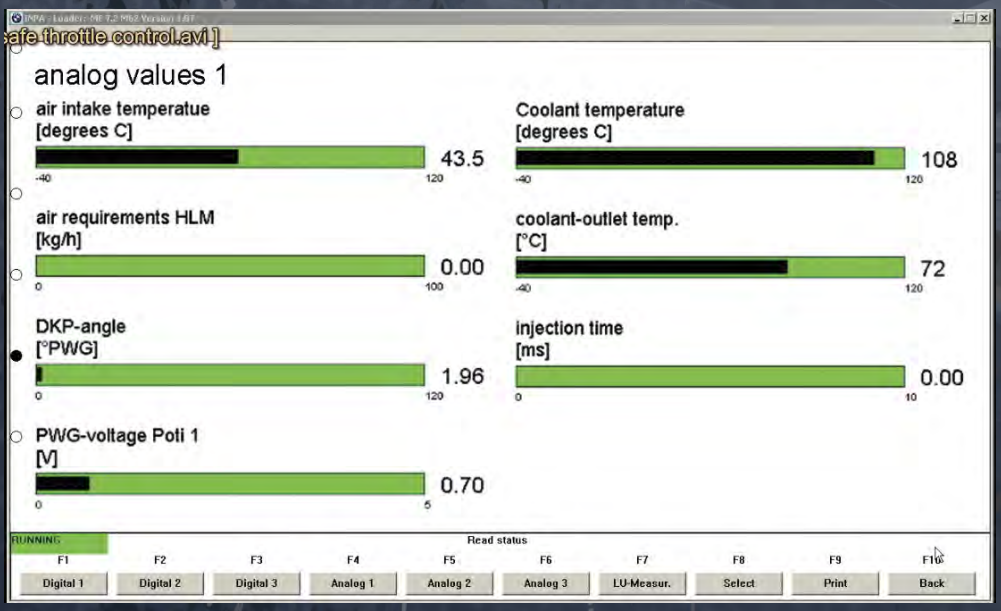
In the bay, there was no throttle control at all. With INPA running, that fault code was deleted, and we noticed that engine harmonics and RPM did change and we did feel the throttle react until the key was cycled again.

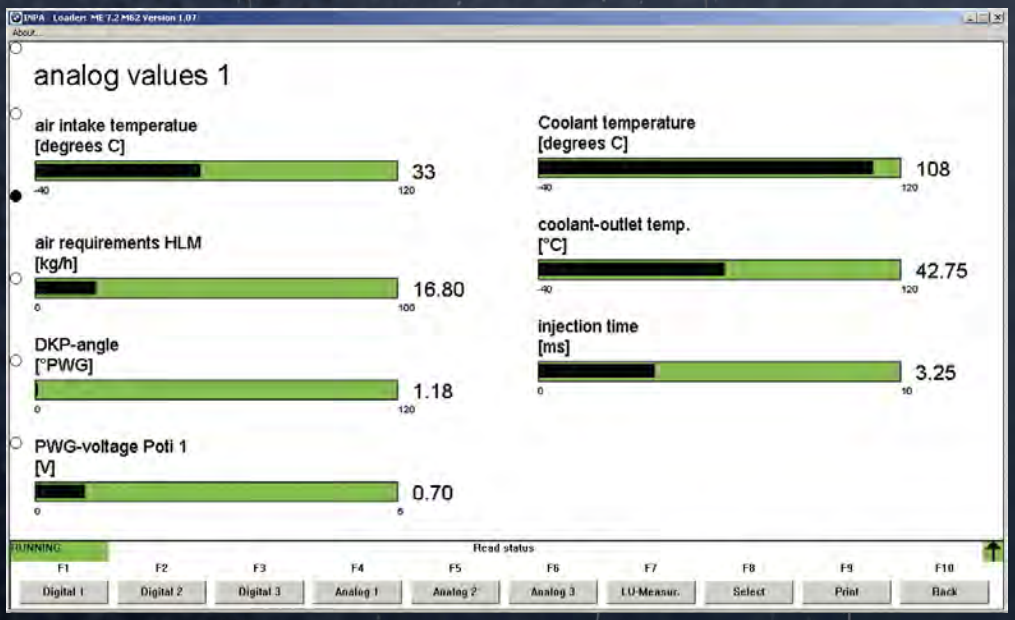
Second, we tried one more time and the fault returned with no throttle control until the fault was reset again. This time the scan tool software recorded the actual values and recorded the changes over time.

Recordings were screen images and a movie recording of INPA in use.

What we found

First, and because we had washed the engine, the drive by wire throttle control needed to be checked physically. The harness was inspected and no debris or water was found. To ensure a perfect connection, we used Stabilant-22 on the harness connection. Look it up, this is magic in a bottle and the scientific term would be "a long-chain organic block polymer that switches to a conductive state." This is expensive and NOT to be used as a "mechanic in a spray can." Do the research, it's impressive.





Third, we inspected the throttle blades because that noise appeared to be coming from the throttle control module.

When the air inlet and rubber seal were removed for inspection from the throttle body, the mystery of what happened was clear.

The clamp had to have been loose for some time. The clamp was loose enough to allow particles of dirt to enter between the hose and seal. With engine torque and movement, that small amount of dirt and debris would "grind" itself into the rubber seal.

When we washed and air dried the engine, we pushed whatever dirt was present through that loose seal, and that very small amount of dirt jammed near the shaft sides or the throttle. It took multiple tries and two more road tests to clean the throttle body to the point where throttle movement was perfect.

The values

During the recording KOEO, there was a value of interest:

- DKP-angle would toggle between 1.57 degrees and 1.96 degrees PWG for no valid reason.
- WOT throttle worked to 100 degrees PWG when floored.
- At closed throttle, 1.57 degrees and 1.96 degrees PWG toggling resumed.
- This we considered in safe mode. The next image is a screen capture from a movie. 1.57 to 1.96 KOEO is not correct!

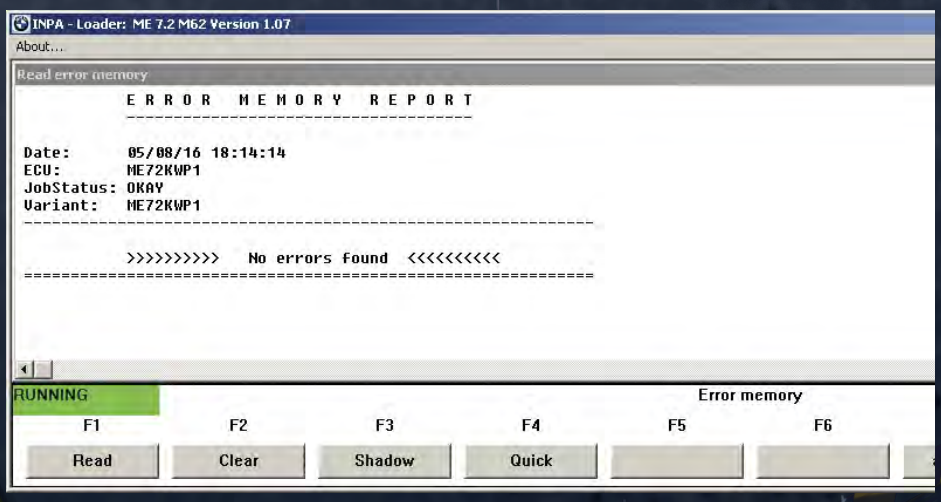
In the normal and cleaned operation, closed throttle is set to 1.18 degrees PWG with no load. That value remained stable.

If A/C was enabled, the setting would increase to 1.96 degrees PWG. If the rear defogger was enabled, the throttle degree increased to 2.35 degrees PWG. When consumers were turned off, the throttle returned to 1.18 degrees PWG.

The following image is a normal value/operation with no faults.

Note: These are values specific to this model at normal operating temperature and relative barometric pressure.

Once the cleaning was accomplished and the air inlet, air box and seals correctly assembled with a proper road test, the results were no faults, and the customer still maintains their trust in us. The image above is at normal temperature and idle.



So what was learned?

(a) Trust no one in Yoga pants that works on BMW models trying to imitate Pavarotti.

(b) Request to the customer that the local lube shop is just so.

(c) Murphy's Law is 100 percent reliable. •

Feel the Burn

Welding Basics Prevent Corrosion

Welding basics are critical to ensuring corrosion resistance after collision repairs. We explore the corrosion implications of various welding settings including voltage, wire feed speed, stick-out, travel speed and other welding parameters.

A corrosion-free repair is a beautiful - and durable - thing.

Corrosion prevention begins with clean mating surfaces

Attempting to apply welding or adhesive bonding techniques to metal surfaces on which there is dirt, oil, wax, rust, and (in the case of aluminum) oxide film creates a high risk of joint problems. This can include development of cracks, incomplete fusion, porosity and inclusion of contaminants. Each of these problems can lead to corrosion formation and weaken the welded joint.

Dirt, paint or other coating material not adequately cleaned off prior to welding can release corrosion-causing moisture when exposed to welding heat. These contaminants may also react with elements in the base metal to release hydrogen or other corrosive byproducts of such a chemical reaction.

If panels are adhesive bonded instead of welded, the adhesive acts as a sealer to keep corrosion-inducing moisture out of the joint. By preventing metal-to-metal contact, adhesives also reduce vibration and flex-caused stress cracks that can allow corrosion to start.

Before welding or adhesive bonding, remove old weld material, dirt, adhesive or other coatings from the existing part to prepare it for joining to the new replacement component.

Aluminum Oxide

Aluminum reacts with the oxygen in the air to form aluminum oxide, a thin film that covers the aluminum surface. The oxide layer can divert heat and prevent arc penetration to the root. This can result in a joint that, instead of achieving proper fusion or bonding, may have gaps and micro-fissures that allow corrosion to form. Additionally, oxide particles can become trapped on metal surfaces under the adhesive, or in the weld puddle as it solidifies. This can cause corrosion pitting, stress fractures, and ultimately lead to cracks and metal fatigue.

BMW recommends removing oxide film with a stainless steel wire brush or special sandpaper made specifically for aluminum. The stainless steel brush is

preferred because it does not leave behind impurities that can become trapped in the solidifying weld puddle, where they can lead to crack formation or can release corrosion-causing moisture.

If you use special sanding or grinding material made for aluminum, do not grind too quickly, as that may cause smearing of the oxide rather than removal. Smeared material may interfere with welding penetration, and should be filed off prior to beginning the welding process. Make sure to clean off all remaining sanding grit or dust.

The replacement component may have residue on it from lubricants used in manufacturing, or coatings applied for protection during shipping and warehousing. The hydrocarbons in lubricants and some coatings can break down during welding and release hydrogen into the molten weld puddle. As the weld solidifies, this hydrogen comes out of solution and coalesces into bubbles, leading to porosity and potential entry points for corrosion.

Clean the mating surfaces with BMW cleaning agent R1. Do not use compressed air to clean off sanding or grinding grit. Compressed air lines contain moisture and oil that can contaminate the surface.

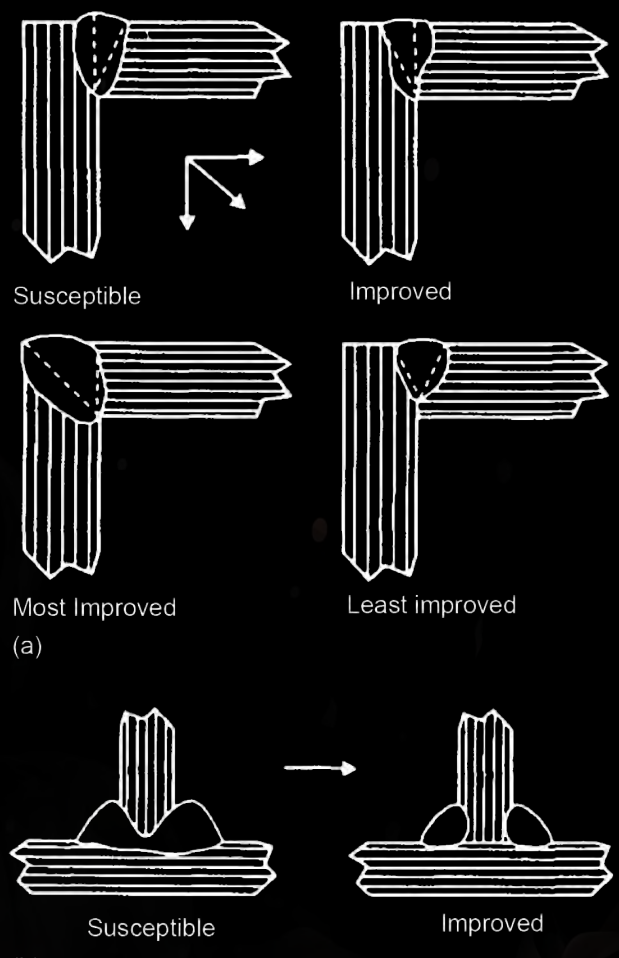
MIG/MAG Weld Only Over Bare Metal

In an area of at least 30mm around the weld seam or spot on the metal surfaces to be joined, clear off any paint, wax, grease, rust, dirt or other contaminants. Remove zinc (e-coat) if performing MIG/MAG welding, but not if resistance spot (STRSW) welding.

Also remove coatings from the reverse side of the weld area. If this is not done, contaminants could enter the weld puddle via the root during MIG/MAG welding. Similarly, paint or other coatings on the back side of a spot weld area could reduce electron flow, preventing an optimal spot weld.

Welding, or Weld-bonding?

In the narrow range of temperatures tolerated by aluminum and thin steels, welding requirements become more stringent. Some aluminum alloys or thin steel panels may not be able to accept welding heat without warping or altering their internal microstructure, and thus weakening the joint. Depending on the aluminum alloy, or the thickness of a steel flange or panel, welding may not be an option at all. Refer to the BMW repair information for guidelines on which joining method is best for a given aluminum alloy or thin steel panel.



BMW welding training teaches the best bead design for a given weld joint. The weld design must take into account a variety of factors, including plate thickness, electrode diameter, joint spacing, welding position, recommended number of weld passes to fill the gap, joint edge preparation, and other variables. In this image, arrows indicate the typical direction of stress on the joint.

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Follow OEM Welding Parameter Guidelines

There are four main variables that control welding penetration and bead formation in the GMAW (MIG) process: welding current (amperage, determined on some equipment by wire feed speed), distance from welding tip to the end of the wire electrode (stickout), voltage (heat), and arc travel speed. To get the desired thickness and depth of penetration of the weld bead, you need to create the proper balance of these and other variables.

Because they've been validated by extensive engineering testing for the part and vehicle model being repaired, the OEM parameter recommendations are your best starting point for welding equipment settings.

Welding Current (Wire Feed Speed)

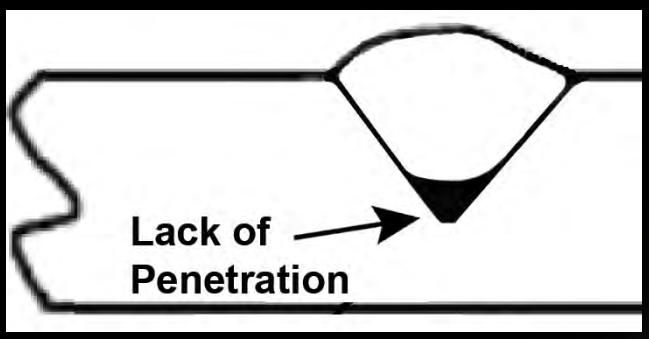
As you increase or decrease the wire feed speed (WFS) setting on your MIG welding machine, internal circuitry simultaneously increases or decreases the electrical amperage, or current. A combination of this current and voltage establishes the electric arc that connects the molten electrode (wire) to the base metal being welded.

There is a welding current (amperage) range that gives the ideal thermal profile to melt the base metal and deposit molten wire to fill the weld gap. Outside of this range, the filler wire behaves in ways that can harm weld performance.

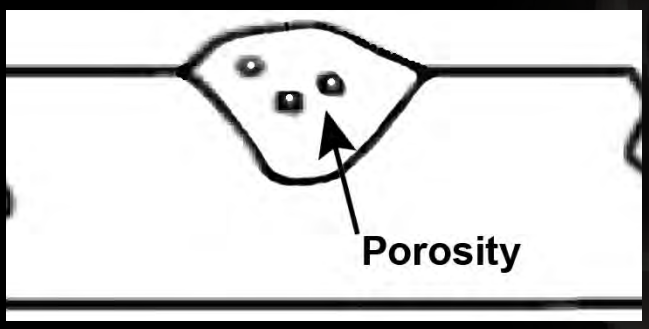
Setting the wire feed speed (current/amperage) too high can result in excess heat that can distort and burn through the base metal. The burn-through risk is higher for aluminum, due to its lower melting point and high heat conductivity, and for thin sheet steels.

Excess heat caused by high wire feed speed can also result in distortion of the base metal in the surrounding heat affect zone (HAZ). Even slight distortion in the shape of the metal can alter its response to the load it was designed to handle, leading over time to stress fractures in the joint. Even if no collision or other excess load occurs to cause weld failure at these stress points, the fractures allow moisture to settle in the joint and become the starting point for corrosion.

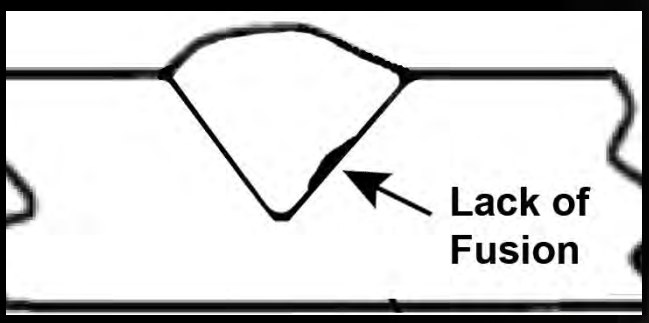
Too low a wire feed speed may cause a failure of the arc to penetrate to the base, or root, of the weld joint. The result is inadequate fusion, or tie-in, of the filler wire to the base metal. Any gaps in fusion can allow corrosion to take hold.



Welding current has a major impact on the depth of penetration and fusion with the base metal.



Contaminants in the weld puddle release vapors when heated, causing porosity when bubbles are trapped in the weld.



Incomplete fusion leaves gaps or grooves between the weld bead and the base metal. The grooves may be at the sides, and may or may not be visible from the surface.

Wire Extension (Stickout)

In the MIG process, the collar at the end of the wire feed tube is what transmits welding current to the wire as it exits the tube. Stickout is the distance between the collar (contact tip) and the end of the wire electrode. As this stickout, or wire length, increases, amperage is reduced.

Fast travel speed (more on that later) and long stickout are great when using short-circuit transfer or inverter pulse welding on aluminum or thin steels. The current stays low enough to minimize the risks of too much penetration (burn-through) and/or heat warping of the base plate.

Too long a stickout results in wire being deposited with low arc heat. The wire will not be heated enough by the low arc temperature to tie-in, or fuse, with the base metal.

Instead, the molten wire will pile up on top of itself. It will absorb heat that the arc should be using to penetrate to the root or tie into the sides of the weld gap. Bead height will increase faster than width. The edges of the tall, narrow bead will roll over on one or both sides rather than fuse with the base metal. Again, the resulting gaps will allow an entry for corrosion.

Stickout is specified as a range based on the wire thickness and welding application. Less stickout generally results in a more stable arc, for better control over where in the joint the energy is being deposited so the desired fusion can occur. The shortest stickout within the specified range for the application will generate good fusion under low voltage operating conditions.

Additionally, too much stickout may stretch the shielding gas envelope so much that it thins out and loses ability to prevent atmospheric contaminants from entering the weld pool. This causes porosity and contaminant inclusion in the weld, both of which lead to corrosion.

Stickout plus arc length equals tip-to-work distance. Maintaining a relatively constant contact tip-to-work distance (CTWD) is important. If you change the tip-to-

work distance, arc length (arc voltage) will change, and that will alter weld bead shape and performance. This is determined by Ohm's Law, which says that if current (set by wire feed speed) is held steady, an increase in voltage causes an increase in resistance, making the arc hotter. So, lengthening the arc increases heat and leads to a wider, flatter bead. Shortening the arc results in a narrower, taller bead.

Be careful not to use too short a tip-to-work distance. Some wires are shipped with lubricant residues left over from manufacturing, or coatings that are intended to protect the wire during shipping and warehousing. With shorter stickout, less resistive heating is available to evaporate these residues, and they can enter and contaminate the weld pool, increasing corrosion risk.

Voltage

The voltage setting on MIG welding equipment influences the shape (height and width) of the weld bead. Insufficient heat causes failure of the filler metal to fuse completely with the base metal.

Grooves may form beneath the surface, where the heat failed to penetrate deeply enough to fuse the bead to the desired depth into the base metal, or even to a previous weld pass. Called "undercut grooves," they create a place where moisture may settle in the weld, leading to corrosion.

Too much voltage (heat) can also cause undercutting. When voltage is too high, the arc spreads the molten weld pool, resulting in reduced heat transfer to any one area. The outer edges of the weld puddle cool faster and remain separated from the base metal rather than fusing with it. Rather than a smooth transition of the outer edges of the weld bead to the adjacent base metal, you may see areas in which the weld metal shows a lip, or overlap of the base metal. In addition to being a weak joint, this undercut groove offers an area for corrosion to set in. Additionally, too much heat causes excessive spatter and a misshapen weld bead, which at the least requires additional rework to improve finished weld appearance.

Dancing Together

Voltage, Wire Feed Speed and Arc Length

Boiled down to the simplest explanations, voltage influences weld bead shape (height and width change independently of each other), wire feed speed controls bead size (height and width can grow or shrink by the same percentage), and arc length impacts weld fusion.

If the weld bead is tall and narrow, increase voltage. If there are gaps (undercutting) between the bead and base metal, decrease voltage.

If the bead is too small, or if there is inadequate weld penetration, increase wire feed speed. If the bead is too large and, instead of fusing with the sides of the weld gap (or with a previous bead if you are doing a multi-pass weld), overlaps the gap edges, decrease wire feed speed.

For welding thicker plates or wider gaps, increase arc distance from the base metal. You'll get a hotter arc which, if travel speed is not too fast, results in greater penetration and a wider, flatter bead. Shorten the arc to get less heat and a narrower bead with greater metal accumulation

For a weld that has uniform thickness from start to end, voltage, wire feed speed and tip-to-work distance should all be kept at the same relative values to create a durable and attractive weld. You should do test welds to determine the best settings for each of the parameters for which your welding equipment allows adjustments.

Travel Speed

As you travel the arc along the joint you are welding, the heat needs to reach down to the root of the weld gap. If you move the arc too quickly the heat does not penetrate deeply enough to fuse the panels together completely. They may be fused at the top, but have a gap or only a weak blending together at the bottom.

A gap provides an entry for moisture and corrosion. A weak joint is a risk factor in the event of a future collision.

What you will see if you travel too quickly is a narrow weld bead with a pointed crown that is taller than the bead is wide. You should instead see ridges that are gently curved and leaning on each other, like a stack of coins laying on its side.

Travel too slowly and you also end up with incomplete fusion. Not traveling quickly enough allows some of the molten wire to pile up in front of, and to the sides of, the arc. This excess molten wire absorbs some of the heat of the arc, preventing the ability of the weld puddle to fuse at the toes (sides), or at the root of the joint.

What you will see is sharp edges on one or both sides of the weld, rather than the desired smooth transition from weld to base metal. If you crosscut the weld, you will see gaps and microscopic fissures where the filler wire did not fuse with the base metal.

Walking the Puddle

Training your dog to walk slightly behind you establishes your control. Keeping the arc on the leading edge of the weld puddle as you move forward allows heat focus for maximum weld penetration. If you need only a narrow bead, move straight ahead while keeping the arc in front of the puddle.

If you need to fill a wider gap, move forward in an upside down "V" pattern. Starting on one side, move up and toward the center of the gap, then back down and to the opposite side. Move further forward, repeating the pattern in the opposite direction. Keep the narrow end of the "V" in the center of the gap. Pointing the "V" in the direction you are welding creates the familiar "stacked dimes" appearance of a successful weld fillet. Pause briefly at each side to allow fusion to occur.

Reversing the pattern so the arc moves with the open end of the "V" facing forward focuses heat on the outside edges, or legs, of the joint. Not enough heat makes it to the center of the joint to penetrate to the root. You can see the effects of this in a cross-section of the finished joint. There may be fusion at the outside edges, or toes, but a gap at the root, where the arc failed to bite into the base.

In the event of a future collision, this gap could be a weak point that causes a larger failure. Just one failed weld could prevent a crumple zone from performing as intended. Even without a collision, this gap could allow moisture to seep into the weld, leading to the formation of corrosion.

Choose the Right Shielding Gas

Shielding gas, along with current and voltage, provides major influence over the behavior of the heated filler wire and, ultimately, the shape and strength of the weld bead. Shielding gas prevents the entry of oxygen, nitrogen, and hydrogen from the atmosphere into the molten weld puddle. These atmospheric elements can cause a variety of problems that limit the strength and durability of your weld.

For example, nitrogen in a steel weld can cause microscopic cracking that, in addition to reducing the impact resistance of the repair, creates an opening for corrosion-causing moisture to settle in the joint.

Too much oxygen absorbed into a steel weld combines with other elements in the metal and alters the weld microstructure in ways that weaken the repaired area. The excess oxygen can combine with carbon to form carbon monoxide, a gas that will leave pinholes in the metal as it bubbles out of the cooling weld puddle. In many cases, this porosity can extend from the surface all the way down to the root, making it easy for corrosion to set in and quickly damage the weld.

Hydrogen, extracted from water vapor in the air by the welding heat, can combine with the iron in steel and cause microscopic cracking to occur in the interior of the weld bead. Hydrogen can cause microscopic cracking in aluminum, too.

Three main gases: argon, helium, and carbon dioxide, sometimes in combination with small amounts of oxygen or other gases, are used to shield the weld puddle from atmospheric contaminants. Different shielding gas formulations are used with various

electrode wire types and metal transfer methods (short arc, globular transfer, or spray arc/pulsed spray arc welding).

OEM-recommended gas and wire duets

The shielding gas used must be matched to the electrode (filler wire) and base metal. If you do not use shielding gas that is compatible with the required filler wire, porosity and microscopic cracking may weaken the weld and open the door to corrosion.

For MIG welding mild steel using solid wire, the recommended shielding gas is often a 98 percent argon/2 percent oxygen formulation, while for aluminum, it is 100 percent argon. When welding mild steel using flux-cored wire, an approximately 80 percent argon/20 percent CO_2 shielding gas produces a more stable arc with less spatter, for a better quality weld.

Your BMW repair procedures information will specify the correct filler wire type and shielding gas combination for the base materials being welded.

For example, when MAG welding steel components on the 535i, BMW specifies one of two types of steel welding wire: G3Si1 (SG2) or G4Si1 (SG3), along with shielding gas composed of 82 percent argon, 18 percent CO_2. The addition of CO_2, which has a minor chemical reaction with the molten weld puddle, makes this a MAG (active) welding process. The CO_2 produces a more stable arc, making it easier to control weld penetration and avoid incomplete fusion and gaps that allow corrosion to get a toehold in the weld.

Match Filler Wire to Base Metal

In addition to making sure the wire and shielding gas are compatible, you must match the filler wire to the base metal being welded. If the filler wire and base metal are significantly different, even when properly welded together, they can form a galvanic reaction that leads to corrosion within the welded joint. Vehicle manufacturers recommend specific combinations of filler wire and base metal based on extensive testing that assures that the completed weld will not only meet strength and durability requirements, but will also resist corrosion.

TIP: Store filler wire in sealed containers in a dry place until you are ready to use it. Some wires can absorb atmospheric moisture into their coating. Welding heat then helps to vaporize and release the moisture. Because the wire is inside the shielding gas envelope, any moisture vapor or other released gases can enter the molten weld pool. Some of these vapor bubbles may make it to the surface of the weld pool before it solidifies, while others remain trapped inside. It may turn your weld bead into something resembling swiss cheese, with microscopic holes in the interior and pinholes on the surface. Each hole creates an opportunity for corrosion to begin.

Done with the proper welding and bonding materials and techniques, you'll be able to replicate, as closely as possible, the strength and durability of the original structure. And, at the same time, you'll be joining components in a way that will, in the future, resist rust and corrosion and will allow your customers to continue to enjoy the reliability they've come to expect from their BMW. •

Different shielding gas types are required depending on whether you are welding steel or aluminum, the plate thickness, the type of wire electrode you are using, and other variables.

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