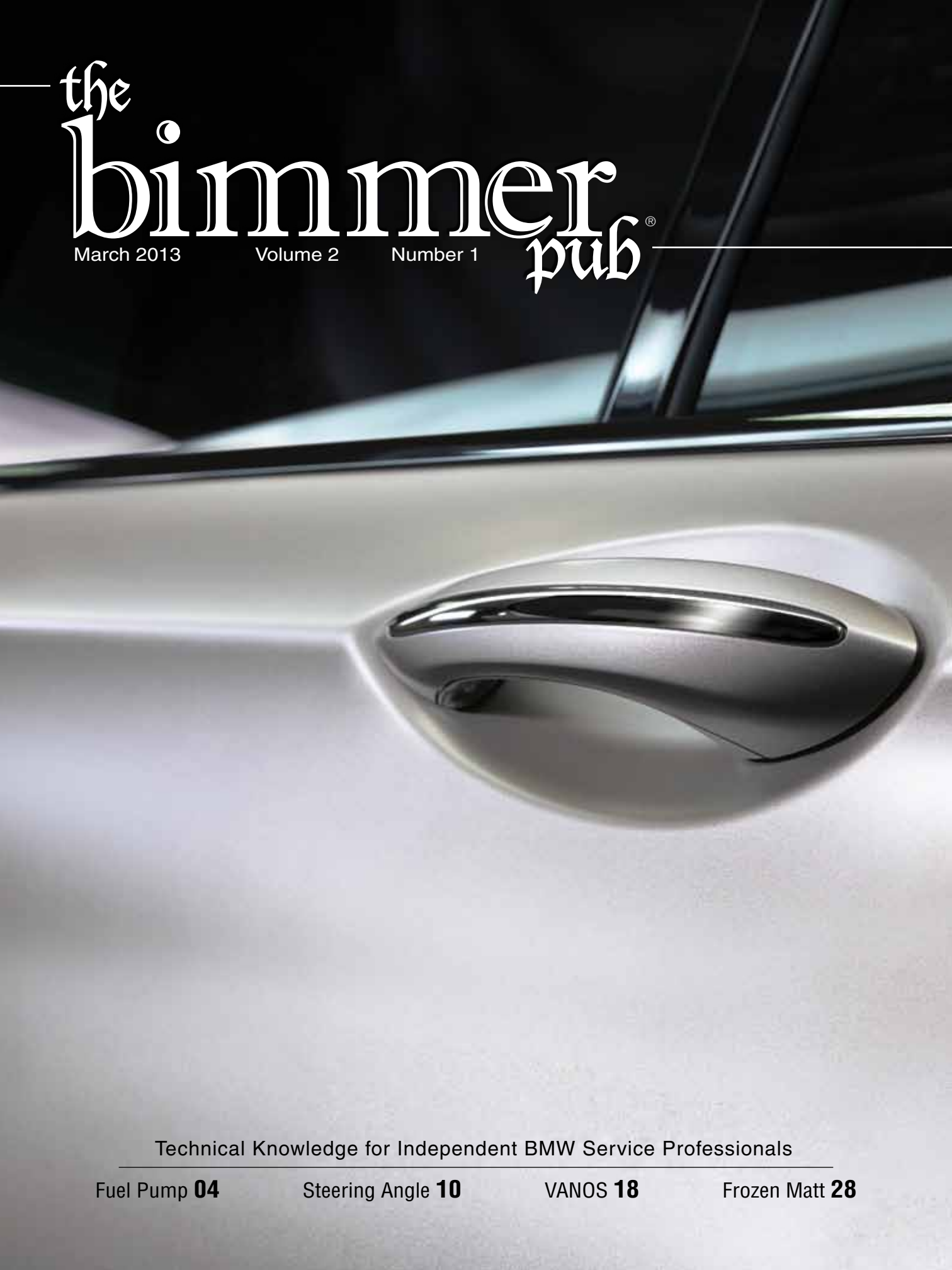

the bimmer pub®

March 2013 Volume 2 Number 1

Technical Knowledge for Independent BMW Service Professionals

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

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Thanks for your continued interest.

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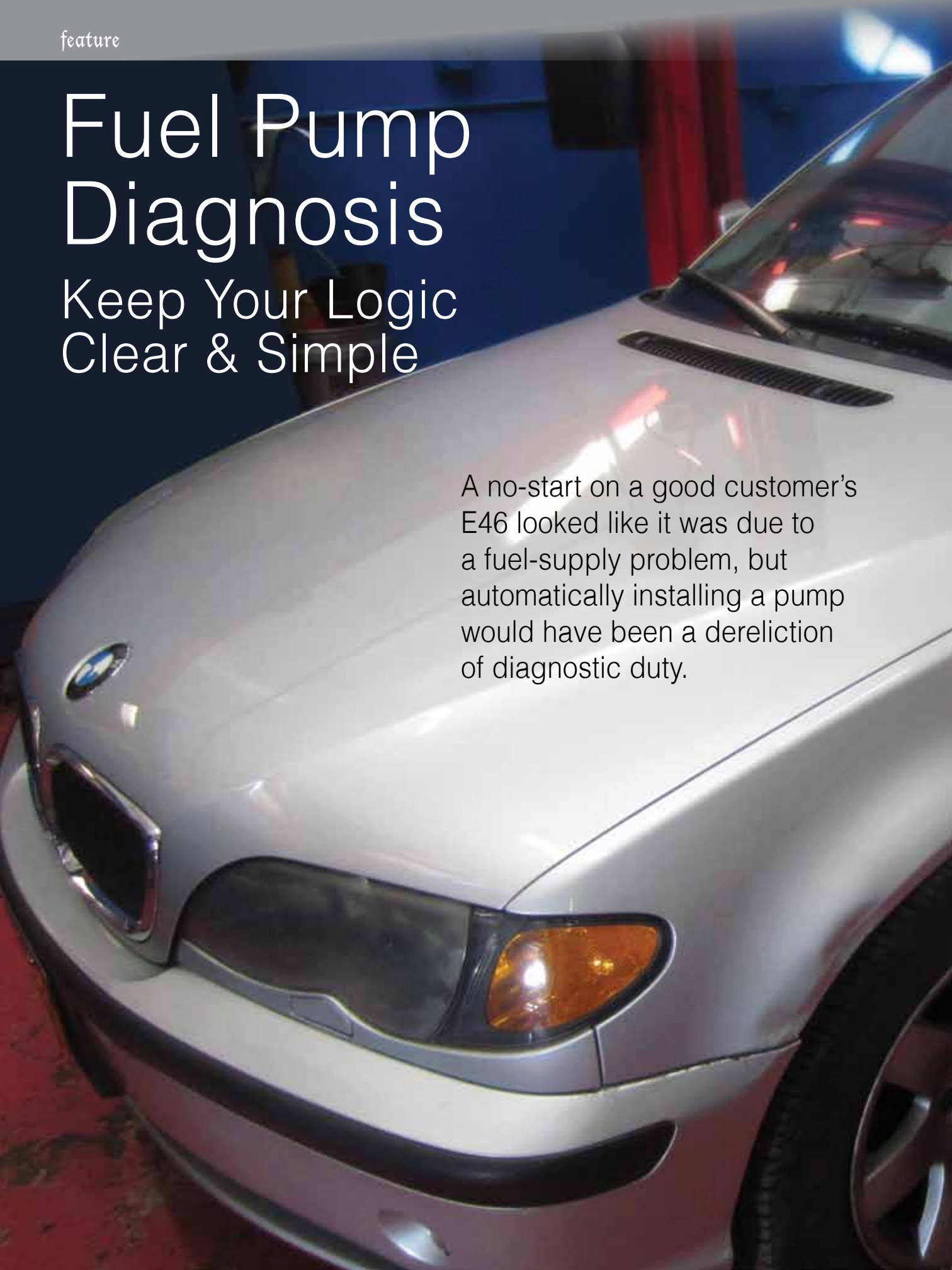
Fuel Pump Diagnosis

Keep Your Logic Clear & Simple



A no-start on a good customer's E46 looked like it was due to a fuel-supply problem, but automatically installing a pump would have been a dereliction of diagnostic duty.

We have the pleasure of working on a local judge's cars. His daughter had just turned 17 and he bought her a 2004 BMW 325 XI after having us check the vehicle out thoroughly. Before she took possession of the car, we did a tune-up, including the fuel filter, and replaced the fan clutch, which goes bad on almost all specimens of this model. The vehicle passed muster otherwise.

A few weeks later, the car was towed back to our shop because of a no-start condition. Whenever you get a no-start, check the basics first: battery, fuel, and spark (well, the internal engine parts that generate compression are traditional basics, too, but we saw no reason to suspect them at this point). The battery was good, the starter was engaging, and the engine had spark. Before we pulled out our trusty bottle of propane and attached it to the brake booster vacuum hose as we usually do to see if the engine would fire up with an artificial supply of hydrocarbons, we hit the key again and it started. That classified this situation as an intermittent.

Immediately, we theorized (but could not yet prove) that we had a fuel pump problem, simply because the KOEO (Key On Engine Off) turns were priming the pump, at least sometimes. However, Long Term Fuel Trim was not elevated and there were no codes that would tip us off that the fuel pump was on its way out. So, how could we make sure that the pump itself was the culprit before replacing it?

The Art of Diagnosing Fuel Problems

The first thing many BMW techs will check is the fuel pressure as read at the gauge port on the fuel rail. After all, this is the factory-recommended procedure. But is this really the best way to diagnose fuel problems on BMWs?

This clean 2004 BMW 325XI M54 checked out initially, but developed a no-start issue.

The company publishes two fuel system specifications for the E46 model. One is that fuel pressure should be 3.5 BAR both Key On Engine Off and Key On Engine Running, which is about 51 psi on the gauge. The other is that fuel volume should be 2.25L per minute, which is 0.59 gallons per minute on a fuel volume gauge. If you do not have a specification for fuel volume for a particular model, expect at an absolute minimum that volume should be above 0.45 gallons per minute on four-cylinder vehicles, and 0.55 gallons per minute on turbo-equipped fours, and six-cylinder and up engines.

The reason we want to check fuel volume as opposed to just fuel pressure at the fuel rail is twofold. First, if we merely checked fuel pressure at the rail, we cannot rule out that the fuel pressure regulator that is internal to the vehicle's fuel filter is defective. Being that we already replaced the fuel filter on the vehicle a few weeks previously, it would be nice to avoid a needless parts-changing routine before looking at the fuel pump. The other benefit to checking fuel volume is that sometimes fuel pressure is good, but overall fuel flow is insufficient. For example, some sort of restriction impeding fuel delivery would effectively cut volume, but maintain strong pressure.

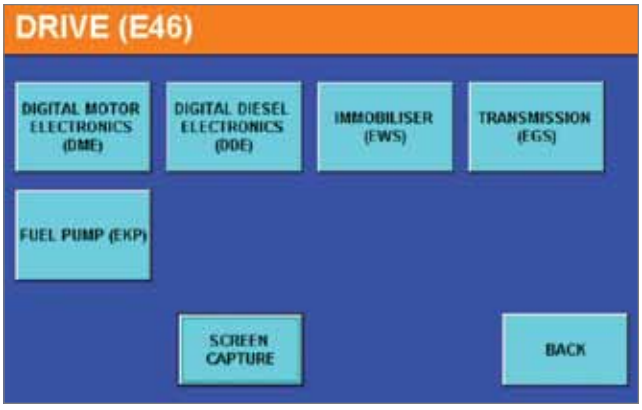
Hooking Up a Fuel Volume Gauge to an E46

Hooking up a fuel volume gauge is very easy. It only requires removing two covers with an 8mm socket and a Phillips screwdriver. Then, attach the volume gauge in series between the fuel hose and filter on the pump side so that your readings are not affected by the pressure regulator in the filter.

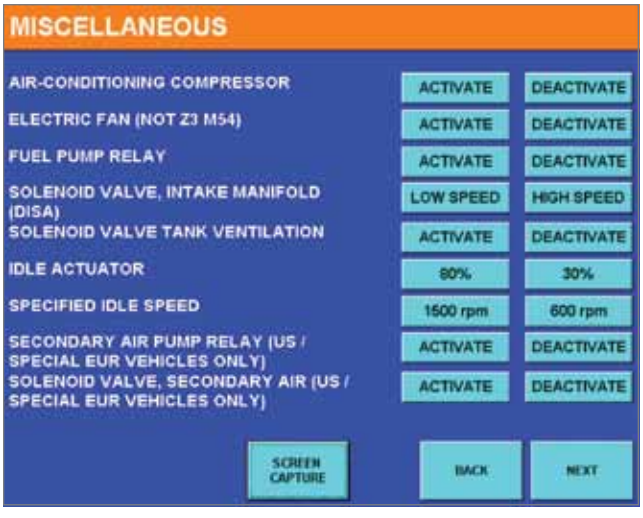
Next, command the fuel pump on using your scan tool. We use an Autologic with BMW software, but any scan tool with enhanced OEM capabilities can do this. On the E46, you need to go into the DME module in order to command the fuel pump on in the bi-directional controls menu.

With our fuel volume gauge hooked up we were able to read both fuel pressure and volume. Fuel pressure KOEO was far below specification at a little below 1.7 BAR/20 psi. Yet, when running

This is where the fuel filter is located on the E46. The fuel volume gauge is hooked up on the left (pump) side of the filter, not only because it is easier, but because it will also give us a more direct reading.



The Autologic lists a "Fuel Pump" module, but it will not communicate because on this model we simply interrogate the fuel pump by going into the DME.



We command the fuel pump on in the bi-directional menu simply by activating the fuel pump relay. On this particular model, activating the fuel pump relay does not engage the jet/ transfer pump, but merely the fuel pump.

A fuel pressure reading on an E46 suffering from fuel pump drain-back leak with the Key On Engine Off.

the vehicle had a strong fuel pressure of about 3.6 BAR/54 PSI. Was that because electrical system voltage is higher at idle than the battery alone can supply? If so, it would mean the brushes and commutator in the pump's motor should be suspect.

Fuel volume was above specification on this vehicle at about 0.66 gallons per minute, which is above 2.25L per minute.

Being Positive

Obviously, the vehicle needs a new fuel pump with a matter of perfect certainty. How did we rule out a bad fuel pressure regulator or a restriction in flow? If we had taken our measurements at the fuel rail, we could not be totally sure. However, we took our readings before the fuel filter with its internal regulator, confirming that the low KOEO pressure was not related to the filter assembly. Also, because we had strong fuel volume, there could not be a restriction, while if we were just checking fuel pressure readings, it is theoretically possible that the changes in fuel pressure could have been explained in that way.

The fuel pressure on the same E46 with the engine running. The fact that the fuel pressure is strong KOER as opposed to KOEO indicates we have an issue with the fuel pressure regulator or the pump itself.

Two other technicians were not too sure of our diagnosis, theorizing that the jet/transfer pump (which is merely a low-pressure pump that transfers fuel from one side of the saddle tank to the side where the high-pressure pump is mounted) might be bad, but we were totally confident that the E46's twin fuel pump system did not need to complicate our diagnosis. Of course, this may be splitting hairs a wee bit too much, but it is a matter worth addressing. First, we can go the "pattern failure" route of explaining it away. Fuel pumps regularly go bad on 3-Series BMWs, but not jet pumps, which, as we said, are only used to transfer gasoline from the other side of the saddle tank to the high-pressure pump side. A common symptom of a bad jet pump is engine stalling as if running out of gas when the dash gauge reads about 1/4 tank. This was not our symptom. There is a good reason why our supplier stocks three such fuel pumps on any given day. Second, thanks to using our Autologic to command on the fuel pump relay, with the E46 this function only powers up the fuel pump itself, not the jet pump. So, our readings only regarded the primary fuel pump alone, allowing us to condemn that single component.

As a side note, checking fuel volume and pressure before the regulator saves us time trying to current-ramp the fuel pump and do voltage-drop testing. Obviously, if the fuel pump runs fine once it starts up, there is not an issue with voltage drop. Furthermore, most BMWs do not have their fuel pump relays in accessible places. It takes much less time to just check fuel volume. Also, it is more accurate. BMW simply warns that the pump should not pull more than nine amps on "passenger cars." Otherwise, you are on your own to make a library of known-good fuel pump waveforms and draws. Most of the time, you can do a better job simply selling the customer on a new fuel filter and conducting a fuel volume test. It is not only better diagnostics, but it is better for business too.

So, we ordered the fuel pump and sealing ring for the job. We removed the rear seat, installed the new fuel pump and kept the old one long enough to take a snapshot of it.

Now the engine started and ran perfect, and the judge was happy. And, that's what's important, isn't it? ●

Here the fuel pump is apparently running strong with a fuel volume above specification.

The OE BMW fuel pump assembly including the sending unit, made by VDO.

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BMW

BMW E90 Steering Angle Sensor Diagnosis

A pattern failure may indeed point you to a bad component, but when the part is expensive you want to be very sure it's the culprit before you replace it.

A regular customer brought in his 2007 BMW 328XI E90 because the "lights" were illuminated. We asked which lights. He told us that the traction control, 4x4, and brake dashboard warning lamps were all on at the same time, but that they went out after the key was turned to the "Off" position. Obviously, some troubleshooting was in order.

As Murphy's Law would have predicted, when the car was started and driven straight into the back of the shop, none of those lights were on. Since BMWs store history codes, we concluded that a full system scan would be a logical first step. These days, the quick test is becoming a "must do" because there are so many modules connected to different networks that problems can be interrelated.

Very often, a quick test shows that some modules have issues or faults classified as "sporadic," meaning the errors do not happen all the time. The appearance of such codes may be a warning of an upcoming fault, but are often part of normal operation, meaning these codes exist on a permanent basis and do not reflect a problem. We like to call these "ghost codes."

Right turns only?

After we saved the code information, we cleared all the faults and drove the car to see if any hard codes would come back. It didn't take long to find out that if we made hard right turns, the Dynamic Stability Control (DSC) module showed three codes that were "stored." They were 5EBA Steering angle sensor plausibility, 94BB Steering angle sensor: internal fault, and 94B5 Steering column switching centre: internal fault. When most technicians working under the gun see these codes, they immediately condemn the steering angle sensor. This is not really such a terrible diagnosis because when a module sets an "internal fault" DTC, the usual cause is simply that, an internal fault. However, the wrong year sensor or connectivity issues can also set internal fault codes, though this is rare.

When we called the dealer and heard that he actually stocked the steering angle sensor and wouldn't have to order it, it became apparent to us that this represented a pattern failure on E90s. The part, however, costs $525. Do you want to take a $525 gamble? For those of you who aren't big gamblers, what we are going to cover here is how to be sure the culprit is really the steering angle sensor itself, and not some problem elsewhere in the system before you risk that considerable amount of money.

As always, basics first

As any successful technician will tell you, the first step should always be to cover the basics. Check the mechanical integrity of the vehicle. Inspect the front end for ripped bushings, look for bad control arms, and make sure different/wrong

When checking the steering angle PID on your scan tool, make sure that the steering wheel is arrow-straight. You should see 0 degrees.

tire sizes aren't present. Also, test the battery, look for ripple voltage from the alternator, and always check for TSBs through your subscription to BMW TIS -- aftermarket databases sometimes lack details and are commonly out-of-date. In this case, all the basics were good.

Keep in mind that if you have a weak battery, or any previous repairs that involved disconnecting the battery were recently done, you will have to perform a "steering angle sensor recalibration or relearn." This is where we started our diagnosis. It is recommended that you re-learn the steering angle sensor with a factory or BMW OEM-enhanced scan tool, such as the Autologic. When you go through the steps of the steering angle relearn, make sure that the steering wheel is as straight as an arrow. When you do this, the steering angle PID should be as close to 0 degrees

STEERING ANGLE SENSOR	
STEERING ANGLE AT STEERING WHEEL (°)	-1.98

With the steering wheel of this 328XI E90 perfectly straight, we were not reading 0 degrees. Relearning produced 0, but it went out again on the test drive.

After removing the air bag and steering wheel, the multi-tasking SZL switch cluster is almost ready to come out -- just four more fasteners.

(out of 360) as possible. As you can see, the PID for the steering angle here was at -1.98 degrees.

Still suspecting the part

The fact that we could not get the steering wheel very close to zero with the wheel straight ahead made me very suspicious because this is typical of a bad sensor. When we turned the wheel to get it to zero, it would obviously be off true straight-ahead. After the relearn, the steering angle sensor became 0 degrees. Nonetheless, after driving the vehicle and before coming back to the shop all the lights came back on with the same codes and the wrong steering angle.

Before making the assumption that there was a problem with a hard part, we tried coding the DSC module and recalibrating the sensor after the previous coding procedure, but, again, after my test drive (including a lot of hard right turns) the lights came back on.

Now what? Just change the $525 sensor? Wrong. In many similar cases, it's time to break out the labscope and check powers and grounds to the sensor. On newer BMWs, the wiring and connectors don't lend themselves to easy scoping, so we felt it was more time-efficient to physically inspect the steering angle sensor itself. Yet another approach is to look for intermittent drop offs in the steering angle PID when you turn the wheel as read on your scan tool, although we are not fans of this because sometimes the tool does not always graph quickly enough to pick up a drop-off, and the Autologic doesn't even have a graphing function.

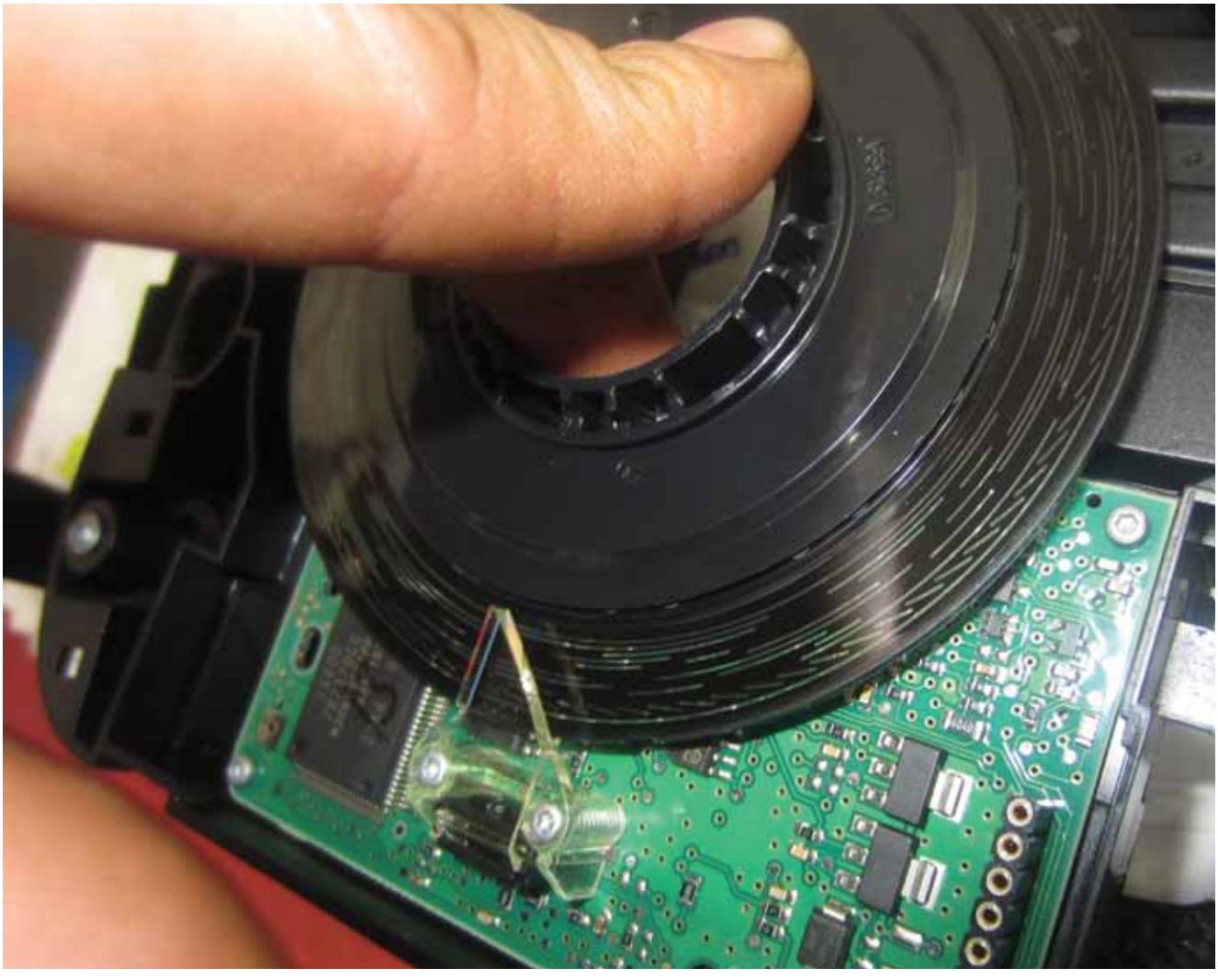
Components involved

In order to take any of these approaches, you need to understand how this system works. BMW has an interesting set-up, which has several different peculiarities depending on the specific system you're working on. So, we're going to talk about the system in general. BMWs may use a

steering angle sensor behind the steering wheel, a cumulative steering angle sensor attached to the rack and pinion, a DSC module, and an AL (Active Steering) module, all connected to each other through the F-CAN line.

The cumulative sensor attached to the rack and pinion sends a signal to the AL module that indicates the exact position of the steering rack. If an alignment was done, or for some reason the signal was lost, it would need to be recalibrated in its own right (this is in addition to the steering angle sensor recal). If you are not sure if there is a cumulative steering angle sensor present in addition to a regular steering angle sensor, just remove the car's bottom cover and inspect the rack and pinion where the steering shaft connects to it. If there are no signs of an additional sensor, then you are working on a vehicle with only a DSC and steering angle sensor. Stay focused on that, or, if you use your scan tool, try to communicate with the AL module. If there is no communication, most likely it does not have the cumulative sensor.

The E90's is a simpler system with just a steering angle sensor and a DSC module. To recap, we already tried calibrating the sensor twice and coding the module once, but with no success.



You might be surprised to find so much technology and so many functions in one component. The SZL switch cluster comprises LEDs, an encoded disc, a line camera, the clock spring assembly, and the turn signal, cruise control, and wiper switches. What we're interested in here is the condition of the encoded disc.

Rotating the encoded disc and examining it carefully revealed the surface damage that was disrupting the optical signal and confusing the system. The only remedy was replacement of the whole SZL switch cluster.

The way we diagnosed this car was through understanding how the sensor actually works.

Camera work

The steering angle sensor consists of LEDs and an optical conductor. The conductor sends the LEDs' light through an encoded disc into a line camera. When the light travels through the camera, the position of the LED light amounts to an analog signal that is stored in an electronic evaluation unit. This unit converts the analog signal into a steering angle signal the module can read. All of these different components are built into one unit called the SZL (the steering column switch cluster or center). Inside the SZL are also the clock spring assembly, turn signal switch, cruise control switch, and wiper switch. No wonder it is so much money!

Now, do you remember how all the lights came back on when the car was turned to the right? From our understanding of the system, the optical conductor on this E90 is picking up a weak amount of LED light through the encoded disc when turning to the right, confusing the electronic evaluation unit and setting all those codes. When we opened up the SZL, we found marks on the encoded disc, confirming our theory that this is where the signal was not being picked up by the line camera.

Since the rest of the encoded disc looked good, it made sense that we were able to relearn the steering angle even though the sensor was indeed bad. The system apparently forgets the correct steering angle when the proper data is not sent to the electronic evaluation unit when the wheel is in some particular position. With this little bit of knowledge and some visual inspection, we could feel better ordering a $525.00 part, and save time putting it all back together without ever whipping out a labscope.

After installing the new steering column switch cluster, we coded the DSC module again. The steering column switch center is coded automatically when you code the DSC with your scan tool. Then, you re-learn the steering angle one more time and clear the codes. When we road tested the vehicle, being careful to take several sharp right turns, the lights did not come back on and the repair was good.

Special note to the techs out there who work under the tyranny of the clock: The removal and replacement of the steering column switch cluster is not tough. Simply disconnect the negative battery cable, remove the airbag, steering wheel, connections to the SZL, and then the four screws that hold the steering column switch cluster. No special tools needed to do this job. ●

ORIGINAL BMW REMANUFAC

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

CTURED A/C COMPRESSORS

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

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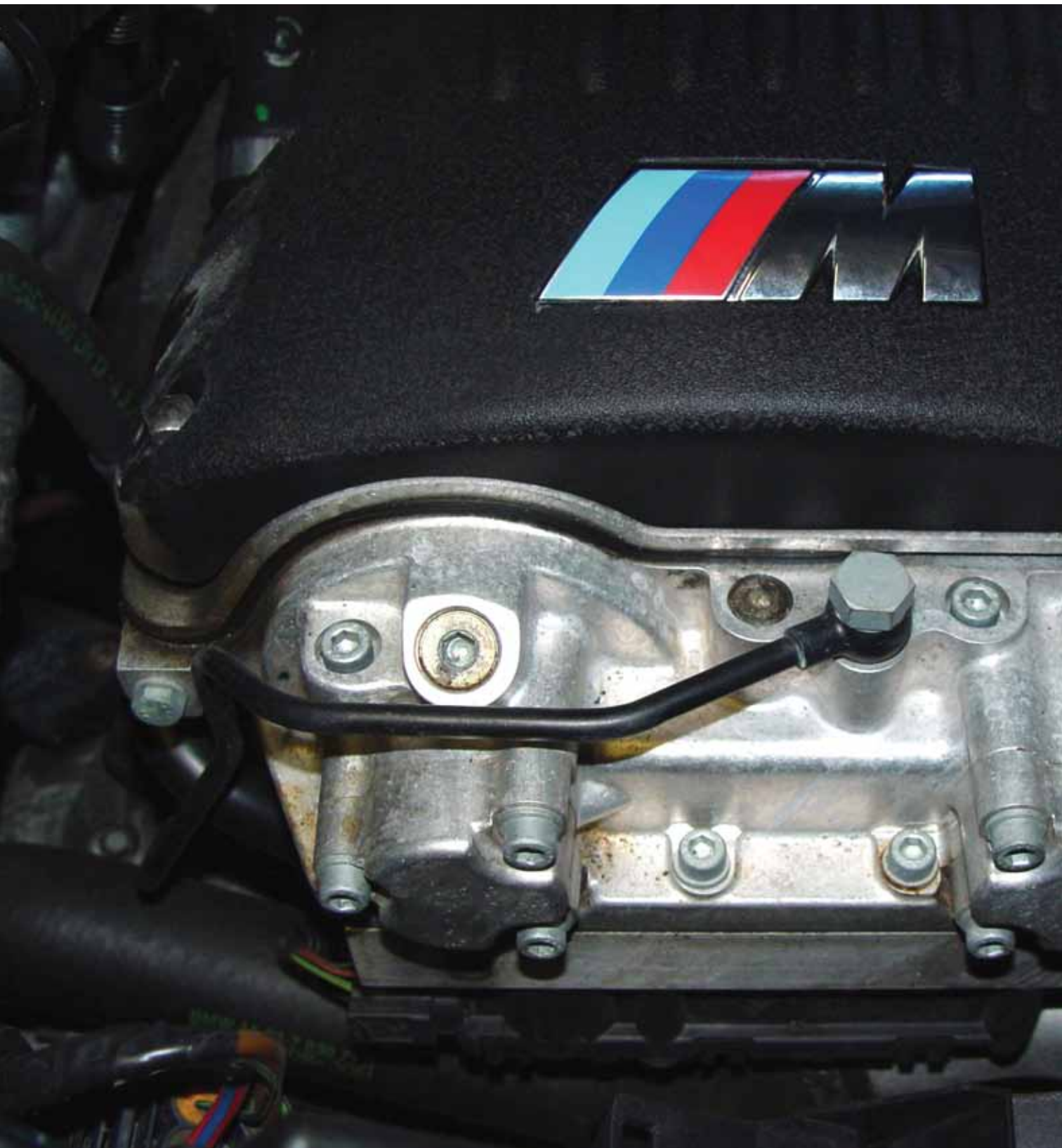


Timing

Valve diameter, lift, and overlap are all contributing factors to the volumetric efficiency of an engine. If you can vary the relationship between the intake and exhaust valves you can broaden the power band and still have a smooth, clean idle. Variable valve timing is a great advance -- as long as we can keep it working.

If you've ever built an old-fashioned pushrod V8 engine for high performance, you might be familiar with a little item called an "offset cam drive key." This is basically just a Woodruff with a step in it that indexes the sprocket to one side or the other of its slot in the nose of the camshaft, allowing you to advance or retard valve timing as you see fit to shift the power curve up or down the rpm scale. A variation on this is the offset bushing used for pin-drive-type sprockets. Having the valves open and close earlier gives better low-end and mid-range output, while the opposite contributes to increased power as you near redline. But, obviously, you have to choose one or the other, and, with single-cam designs, intakes and exhausts are equally affected, which isn't anything like optimal.

How about if you could make this dynamic with valve timing changes occurring when appropriate? Combined with separate adjustments for the intake and exhaust cams of a DOHC engine, the potential improvements in power output, efficiency, and idle smoothness become very dramatic indeed. This situation was the impetus for the introduction of VANOS (a somewhat implausible abbreviation of the German ***va***riable ***No***ckenwellen***s***teuerung), BMW's name for its highly-accurate variable valve timing system. The original version, introduced in 1992 on the M50, operated on the intake camshaft only, and had just two phase-change points. This

evolved into the much more sophisticated Double Vanos, which not only adjusts the timing of both the intake and exhaust cams, but does so in an infinitely variable manner.

NOTE: *Valvetronic is BMW's variable valve lift system. It uses a fast-acting (300 milliseconds for full range!) mechanism controlled by a dedicated module to dynamically alter valve lift profoundly enough to allow for the elimination of the traditional throttle and its attendant pumping losses. In many models beginning in 2001, it's used in conjunction with VANOS for the most efficiency and power imaginable. This is a separate system that we'll cover in a future issue of* ***the bimmer pub****.*

Spiral action

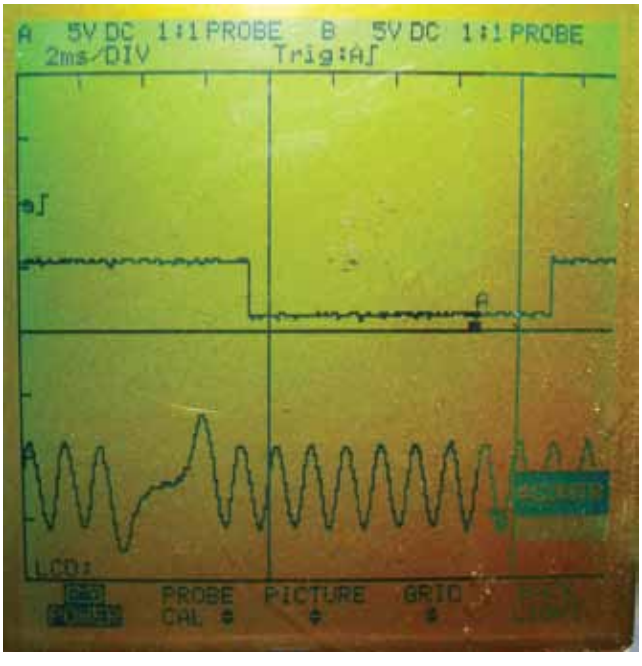
The basic mechanical principle at work here begins with a cam-drive sprocket that engages the camshaft itself through a helical or spiral gear. When engine oil pressure is applied to this mechanism (as controlled by the DME through a one-wire solenoid valve), it moves the gear axially against a spring, changing the positional relationship between the sprocket and the shaft. In other words, the cam is twisted slightly from its static position with regard to the crankshaft.

Cam timing is retarded with the engine off, at idle, and just above, which contributes to smoothness and helps get the cat hot quickly. As rpm rises, the DME applies the hydraulic pressure that pushes the gear, twisting the camshaft and providing 12.5 degrees of advance for improved response and extra efficiency. At 5,000 rpm and up, valve timing is again retarded for maximum cylinder fill. As we said, this original system is either on or off. There is no modulated control.

Double

The later-model BMWs you see in your shop are equipped with Double VANOS. Here, the timing of both the intake and exhaust camshafts is continuously variable through a range of up to 40 crankshaft degrees for the intake, and 25 degrees for the exhaust. Besides the broadening of the

The first VANOS unit, which debuted in '92, has one helical-gear mechanism for advancing the intake cam. It only featured two phase changes, but allowed for a combination of smooth idle and improved mid-range and top-end power.



Using a dual trace oscilloscope you can monitor the crankshaft (lower trace) and camshaft (upper trace) position signals relative to one another. This is the intake cam/crank relationship on a 2000 M3. After activating the solenoid, you should see their relative positions change.

BMW Group Fuel System Cleaner

power curve such control affords, it also allows for the "internal" EGR (Exhaust Gas Recirculation) effect that cuts pumping losses while fighting NOx.

With Double Vanos, the intake cam is still held in its retarded position and advanced with VANOS actuation, but the exhaust does exactly the opposite. It is held in the advanced position by its spring, and retarded by the application of oil pressure.

A later generation of Double VANOS operates in much the same way, but integrates the two oil control solenoids into one unit. Another change is that now there are two intake and two exhaust cam solenoids. One solenoid in each system closes to build the oil pressure needed to move the VANOS gear, and the other instantly vents the oil passages to allow the gear to return to its "home" position. In previous versions, the VANOS solenoids were continuously supplied with 12V, and the DME controlled the ground side. On systems with integrated solenoids, on the other hand, they are always grounded and the DME switches power to complete the circuit.

As you can easily imagine, all VANOS systems require high and steady oil pressure for adjusting the camshafts quickly and accurately (any time lag may set a code). Everything from a weak pump to loose engine bearings should be taken into consideration if psi is below specs.

When installing the single VANOS unit, you have to make sure the gear is in its retracted position. In other words, when the gear is pushed all the way in toward the VANOS unit.

Double VANOS was the next evolutionary stage of BMW variable valve timing. This system advances the intake cam and retards the exhaust cam through a range of up to 40 crankshaft degrees for the former, and 25 degrees for the latter. It adds complexity, but enhances power output and efficiency.

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Scope and scan

All generations of VANOS are big contributors to the superior performance characteristics of BMW vehicles, but, just as with everything else automotive, stuff happens over time, which brings us to the art of diagnosis. Poor performance, MIL-on, and noise are typical symptoms of something gone awry in the system, and electronic troubleshooting will probably be the first thing you think of. We'll get to pattern failings later.

To verify that the requisite cam twist has actually taken place, the DME monitors sensor inputs. BMW did not put a sensor on the cam sprocket itself and another on the camshaft. Instead, the crankshaft position sensor signal is compared to that of the camshaft position sensor. In testing VANOS, you can do much the same thing. Using a scope or graphing multi-meter, you can monitor the relative positions of these sensors. Then, you can actuate the VANOS solenoid and see if this relationship changes. As with any electrical solenoid monitoring, looking at current draw during activation is always a good idea. This can help determine if the solenoid is shorted or sticking.

You can use a scan tool to monitor VANOS activation, but it needs to have factory-specific data to give you the actual desired reading and any deviation from that to determine if the intake cam is being advanced sufficiently or not. Keep in mind that on some Siemens systems (not Bosch), a different cam sensor called a Pulse Angle Generator is used. This sensor receives a sine wave from the DME. On another wire, it receives a modified signal when the shutter wheel on the camshaft passes by the sensor. It's difficult to scope this and watch the crank sensor at the same time.

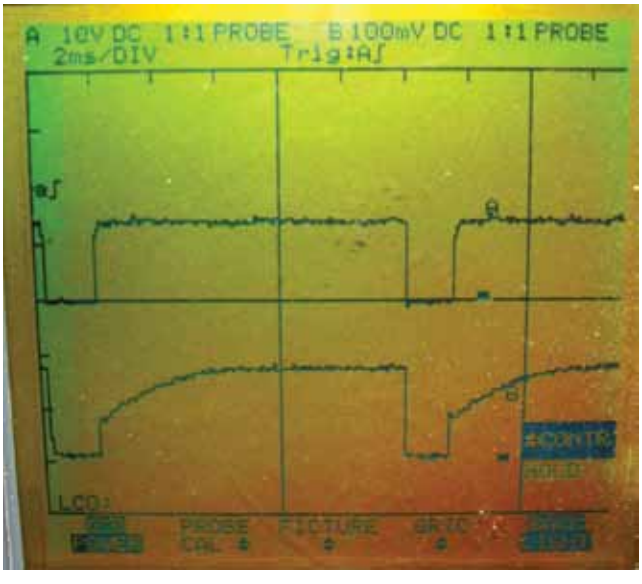
To verify that the system is operating, the DME monitors the camshaft position sensors just after a cranking event, then starts to energize the solenoids to control valve timing. You can watch

When installing the variable valve timing actuators on Double VANOS, you'll need these special tools to properly set the gear depth position. These are available through your local BMW dealer's parts department.

the cam and crank sensors on a scope, but with Double VANOS you need to include the exhaust cam position sensor signal. Regardless of whether a Bosch or Siemens control unit is present, the cam position sensors are Hall-effect. They generate a square wave while the engine is spinning. One wire is a 12V power supply, then there's the signal, and ground. The signal wire has a 5V reference, which gets toggled to ground to generate the square wave, but unplugged you should read 5V.

You can run the engine and watch the relationship change between either the intake cam sensor signal, or the exhaust cam sensor signal, relative to that of the crank sensor. In higher-rpm testing, you will have to speed up the timeframe on your scope. Once again, compare scan data. Look for the "actual" cam timing readings and compare them to the desired cam sensor positions, and you should be able to determine if the VANOS system is operating properly.

You can monitor factory-specific scan data. You should see three readings for each camshaft. One is the desired or target value, which is where the DME would like to place the intake and exhaust cam positions. The second is the actual reading -- where the DME has determined the cams are by using the crankshaft and camshaft position sensors. The last is the minimum or reference reading the VANOS unit can have. This should help you determine the camshaft positions if the engine is difficult to start.



One way to analyze VANOS solenoid operation is to monitor the current pattern of an activated solenoid. Here, the intake cam advance solenoid has been activated by accelerating the engine. Notice how the voltage trace (upper) goes up to 12V during activation.

You can monitor the crankshaft and camshaft position sensors with a dual- trace scope. It would not be a good idea, however, to activate the solenoid manually! These solenoids have two diodes in them, so there is the danger that you could damage the unit. You can run the engine and monitor the activation of the solenoids as well as the relative positions of the cam and crank sensors to determine if VANOS is operating properly.

Patterns

The following are some patterns to keep in mind during diagnosis:

- On older models, the material used for the VANOS piston seals often wasn't up to the job, and failed before 100K miles, resulting in poor performance. BMW recommends that the whole VANOS unit be replaced, but we'll bet you'll look for seal kits before you ask your customers to spend such serious money.

- You'll sometimes encounter a rattling sound coming from the front of the valve train. This may be due to sprocket mounting bolts that have come loose, or to a worn-out bearing in the VANOS actuation unit. Either way, removing the valve cover will let you see and feel the movement.

- Varnish, coke, and sludge deposits can cause the solenoids and gear piston units to plug up and start working only intermittently. There are little oil screens inside the solenoid valves that are particularly prone to clogging. Poor performance and codes from lagging actuation, which the DME can detect, will be likely.

If sludge is indeed the problem, there's a good chance that disassembly and a thorough cleaning of all the components involved with spray solvent will rectify the situation.

NOTE: *For years, we've been seeing BMW owners lulled into a false sense of security where oil change intervals are concerned because they believe the huge lube capacity of these engines is insurance against problems. Well, sure, the presence of nine qts. or so of oil does help, but it can't do miracles. Regular (and frequent) oil changes are still needed to avoid the deposits that cause problems, especially in intricate systems such as VANOS.*

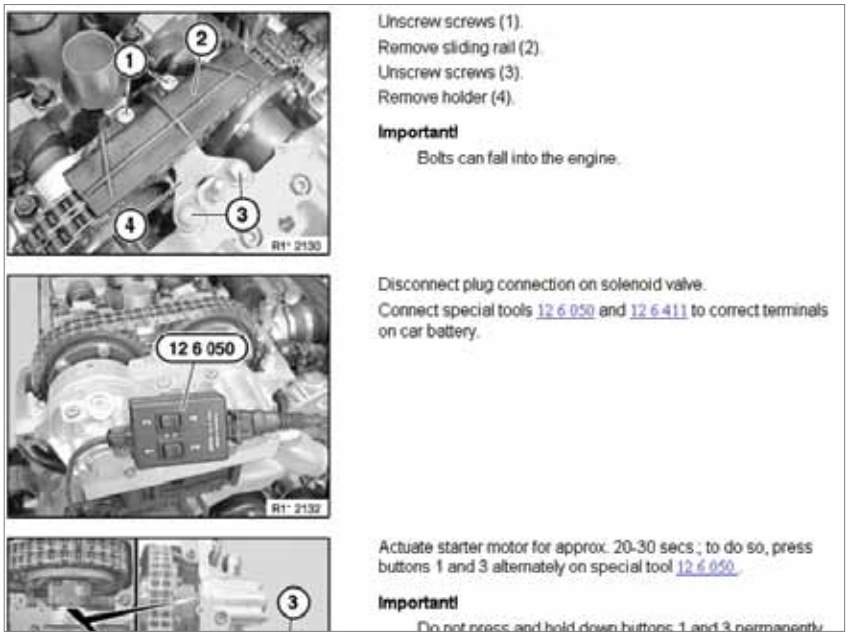
Work rules

There are some important caveats in direct VANOS service, or any other work that involves the disassembly of the system (such as cylinder head R&R) that don't seem to be widely-understood among technicians.

Whenever the VANOS unit must be removed, verify that the camshaft drive gear is in the retarded position before installing the timing chain. Just because you have the cams locked down in the rear does not mean that the intake cam gear is in the retarded position. As mentioned earlier, the gear is spring-loaded, but the mechanism can stick in the advanced position. Once the chain is on, the VANOS unit should be installed with the helical gear pushed in toward the VANOS unit, away from the cam gear. As oil pressure is applied, it pushes the piston outwards toward the intake cam gear. This action causes the cam timing to advance. Make sure the piston is pushed all the way in when installing the VANOS unit.

You should be aware that after engine shut-down, VANOS positions the camshafts for better engine starting, so the cams may not be in their service or default positions. To get the gears into their service positions you need to activate the solenoids for the intake and exhaust cams. Compressed air, along with activating the solenoids, will force the oil out of the pistons and position them where they need to be.

The exact procedure for servicing VANOS must be followed. Compressed air must be added to the VANOS unit to remove any residual oil and move the actuating pistons to their service positions. With the air line connected, rotate the engine twice. This will allow VANOS to return to its default position. Do not turn the engine backwards! The chain tensioner piston may be forced all the way in and this would allow enough slack for the chain to jump a tooth. The next step is to lock down the crank and camshafts and remove the variable valve timing unit. More detailed service procedures are available on the BMW service information website. ●



With a paid subscription to www.bmwtechinfo.com, you can access detailed service information such as R&R of the Double VANOS unit pictured here. It's only $30 for the day, $250 a month, or $2,500 for a year. Some shops add the daily charge to the customer's bill.

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BMW's Frozen Matt Paint

Cool as Ice

BMW Frozen and Individual Matt paints create a soft sheen instead of a mirror-like shine. The satin finish is elegant and stylish, and is selling out faster than the company can produce cars with this dramatic look.

Since its 2010 introduction when the full annual production – all 30 units – of the new M3 Frozen Gray Edition sold out within 12 minutes of becoming available, BMW has known it has a hit with its new frozen paint finish. The luxury carmaker has introduced more models featuring the matt (you're probably used to seeing this word spelled "matte," but all BMW literature has it without the "e") Frozen finish each year. Now called "Individual", as befits the unique aesthetics of the elegant finish, the matt paint option has been expanded to the BMW M5, 6 Series Gran Coupe, and the 7 Series.

There's obviously a trend afoot here that will logically result in your seeing this sophisticated BMW matt finish in your collision shop sometime soon. This article will familiarize you with the basics, and perhaps give you the confidence you need to tackle repainting on these striking vehicles.

As a starting point, it's important to understand that a matt finish such as used on the BMW models mentioned only reflects about 20% of the light that hits it. The rest is diffused to the point that there is no discernible reflection on the surface. You can't comb your hair or straighten your tie by looking at yourself in a matt-finished panel. While BMW's Frozen paint isn't as absorptive as that of a stealth bomber, it's in that direction. In contrast, traditional gloss paint reflects over 90% of the photons that strike it.

Satin Doll: The 650i Gran Coupe in the BMW Individual Frozen Bronze Metallic color shows off with a slightly higher gloss level than typical matt finishes.

Photos courtesy of BMW NA and DuPont.

The BMW Individual Frozen Bronze Metallic matt finish plays with light, reflecting here, absorbing there, to accentuate the 640d Gran Coupe's fluid lines and understated muscularity.

Where it happens

The above might make you think that this phenomenon occurs deep in the finish layers, but the opposite is the case. The effect is achieved in the clearcoat only, so your experience with basecoat application will still be valuable in your work.

The unique look is obtained by the use of different hardeners, reducers, application methods, and drying options. The factors are what make the clearcoat actually absorb more light than traditional paint finishes, but although the finish has a lower sheen, it still meets the same durability standards for protection against stone chipping, corrosion formation, bird droppings, tree sap, and other environmental hazards as non-matt coatings.

After applying the Frozen paint clearcoat, any final coating errors cannot be buffed out. No matter how diligently you might try, you'll never get a uniform, even level of sheen. Dirt particles, mottling or striping due to improper spray technique, variations in film thickness,

Satin Doll: The BMW Individual 7 Series by Paris-based designer Didit Hediprasetyo in Frozen Diamond Metallic finish shows off a sophisticated, slightly higher gloss level than typical matt finishes. Production was limited to only five of these ultra-luxe models when it was introduced in 2012.

and other visible defects require complete repainting of the final topcoat. For this reason, BMW strongly encourages the use of the procedures and materials recommended by matt paint system manufacturers.

Beyond formula into artistic judgment

Of course, the paint manufacturer's recommended mixing formula is important. Even minor deviations from the specified ratio of hardener and reducer to the clearcoat paint itself will lead to significant changes in the level of "matting" (gloss reduction).

Three color "Letdown Panels" receive a clearcoat application. They won't look different until the clear has fully cured. That's because the basecoat is the same for each panel. The color differences are entirely the result of different clearcoat mix ratios. Letdown Panels are absolutely critical to match both color and gloss level to a matt finish vehicle. Prepare several Letdown Panels, each featuring different mixing ratios of matting agent and clearcoat, and distinct wetter/dryer spraying methods.

But matching a matt finish is more than just formula numbers. It requires careful visual inspection. You must pay attention to both color and gloss level. Different areas of the vehicle body may require different gloss levels. Film build can cause a color shift if painting over OE clearcoat.

Additionally, the gloss level for the vehicle being painted may have changed due to its age and cleaning history. This may, for example, necessitate painting the entire side of a vehicle instead of just the damaged panel in order to produce a matched gloss appearance on that side.

Other factors affecting the degree of gloss in your finished job include whether the hardener and reducer are slow- or fast-acting, whether you use a relatively dry or wet spray method, dry film thickness, ambient temperature, flash-off time, and drying method. Different combinations of these factors can alter gloss level by up to 20%.

This variability makes color/gloss "Letdown Panels" mandatory. After looking up the color formula recommended by the matt paint system manufacturer, spray at least three test cards with different ratios of matting agent (flattener) and clearcoat.

After drying (colors will appear significantly darker when dry), compare each Letdown Panel to the vehicle, and evaluate both color and gloss level.

Check in natural daylight. Hold the card against the vehicle surface to ensure that your viewing angle and light source are the same as for the area being repaired.

Once you determine which Letdown Panel best matches the vehicle, you'll know which combination of hardener ratio, fluid tip size, and ambient temperature range yielded that match. You'll know exactly how to refinish this particular vehicle.

Letdown Panels are not new. Professional painters already use them with many tri-coats and pearl finishes. The little extra preparation allows you to paint with confidence.

Right: Evaluate Letdown Panels while they are attached to the surface to be painted. Compare the color and gloss level of the three test panels to that of the vehicle, all under the same light angle and intensity.

With Matt, How Well You Do What You Do First is Especially Critical for Achieving Perfection

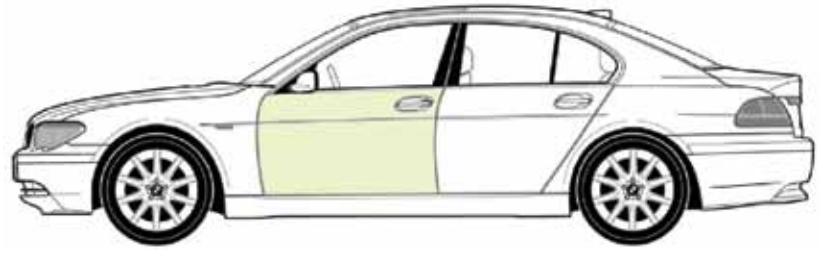
Proper preparation for a matt refinish is necessary to the success (and efficiency) of your paint job. Because you cannot sand or polish a matt finish, removal of any dirt or imperfections in the topcoat requires a complete re-do.

Even before you start sanding to level and prepping the surface for paint adhesion, you must remove any oil-based contaminants by wiping the surface with the wax and grease remover recommended by the approved matt paint system manufacturer. Do not substitute thinner or reducer in place of the wax and grease remover as this is likely to cause fisheyes when you apply the paint.

After sanding, remove any dust and residue with the cleaning agent recommended by your matt paint system manufacturer.

Obviously, paint will not stick to dirt or oil-based contaminants. Before and after sanding and between undercoats and topcoats, clean the surface with wax and grease remover.

Matt clearcoats flash off faster than those of traditional gloss paint, so you must maintain a wet edge as you spray. Experiment with the amount of overlap in each spray pass.



The BMW ColorSystem refinish manual recommends applying color and matt clearcoat edge-to-edge on a damaged panel. Differences in the age of the factory paint and any spot refinish would make the repaired area reflect light differently. Does the phrase "stick out like a sore thumb" sound like anything you want to hear from your customer?

Spray consistency is key

"Mottling" describes a finish that looks streaked, spotty, or striped. It is often the result of an unbalanced spray pattern, or not observing the proper flash time between basecoat and clearcoat. For example, if one pass is heavier than the others, that area may appear glossier after curing. Try to spray so that you maintain a wet edge, but that no single pass is heavier than the others.

Tilting the spray gun can place more paint at the top or bottom of the pattern, making film thickness uneven in that area. If you paint while too tired (don't expect sympathy from the boss), you may inadvertently allow your arm to drop while spraying. This tilts the spray fan up, resulting in more paint being deposited on the bottom portion of the pass than at the top, and, bingo, you've created a horizontal stripe in your finish.

Experiment with overlap. If a 50% overlap leaves light streaks between passes, try 75%. Be sure to maintain consistency with each pass.

To further reduce the appearance of striping, spray in two different directions in the same coat. After you've completely covered the panel with horizontal passes, cover again in that same wet coat using vertical strokes.

You can also help prevent mottling by using the correct spray gun settings (needle/nozzle/pressure), holding the gun perpendicular to the surface being sprayed, and following the matt paint system's recommended flash and dry times.

No after-painting corrections allowed

All manufacturers of matt paint systems recommend edge-to-edge application of matt clearcoat on panels being repaired. Differences in film build, original paint aging, cleaning history, and other factors make a spot repair likely to reflect light differently from the way surrounding areas do. The blended section stands out, which is by definition unsatisfactory with matt or flat finishes (or with any paint repair, for that matter).

There can be no de-nibbling or polishing of matt or flat finish topcoats. Any rubbing or polishing to eliminate imperfections will increase the gloss level in the area where mechanical pressure is applied.

Dirt can be removed at the basecoat stage, or after the first coat of clear has flashed off. If inspection reveals any dirt in the final clearcoat, the job must be re-prepared, and the full repair area clearcoated again.

Regular or extra-crispy?

Matt finishes are either baked or air dried. Oven-dried finishes may have slightly more gloss than those that are air-dried, so be sure to follow the paint manufacturer's drying recommendations. A collision repair instructor with BMW NA tells tbp, "Infrared curing is more complex than traditional spray booth drying. The most consistent, best quality results are achieved with convection drying in a spray booth."

Similarly, be careful not to spray your clearcoat too wet. A heavy spray may leave too much solvent remaining during the curing process, which prevents gloss die-back to the proper level for the desired soft matt sheen.

You won't be able to tell if you have too much gloss until curing is complete. The clearcoat goes on glossy as traditional finishes do, then dries flat. By then, if you notice too much gloss it is too late for anything but a removal and re-spray of the last clearcoat application.

Pay attention to the paint manufacturer's recommended flash-off and drying times. These companies invest a lot in research and field testing to make sure that their recommended mixing, spraying, and curing techniques produce the best finish.

Adjusting the Degree of Gloss of Matt Clearcoats (source: Spies Hecker)

Factors Affecting Degree of Gloss	
HIGHER GLOSS LEVEL	**LOWER GLOSS LEVEL**
Hardener with higher solids content	Hardener with lower solids content
Slower hardener	Faster hardener
Slower reducer	Faster reducer
Higher application viscosity	Lower application viscosity
Thicker dry film	Thinner dry film
More flash-off time	Less flash-off time
Force drying	Air drying

Final exam

The final matt finish should have a uniformly low gloss. The surface may appear on close inspection to have small patterns and a slight texture, but these are normal matt-finish characteristics.

Looking down on the hood and then across the roof from the same standing position, the gloss level of the two different surfaces will appear different even if they are not. Viewing the surface at approximately 60 degrees reveals less gloss than at a flatter angle. To judge gloss level, try to view an entire side of the vehicle at a consistent angle. Do the same for all horizontal surfaces. When you get it right, seeing that classy matt finish you just applied will make you proud. ●

Approved BMW Exterior Paint Systems Suppliers

- Approved BMW ColorSystem
- Glasurit 923-57 Clear (for Frozen refinish)
- Standox
- Spies Hecker

(Source: BMW)

The plug-in hybrid BMW Concept Active Tourer presented at the 2012 Paris Motor Show features exterior surfaces in high-gloss polish with brushed velvet matt on the undersurface. The subtle shimmering between matt and gloss emphasizes the play of light and shadow created by the new exterior finish.

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