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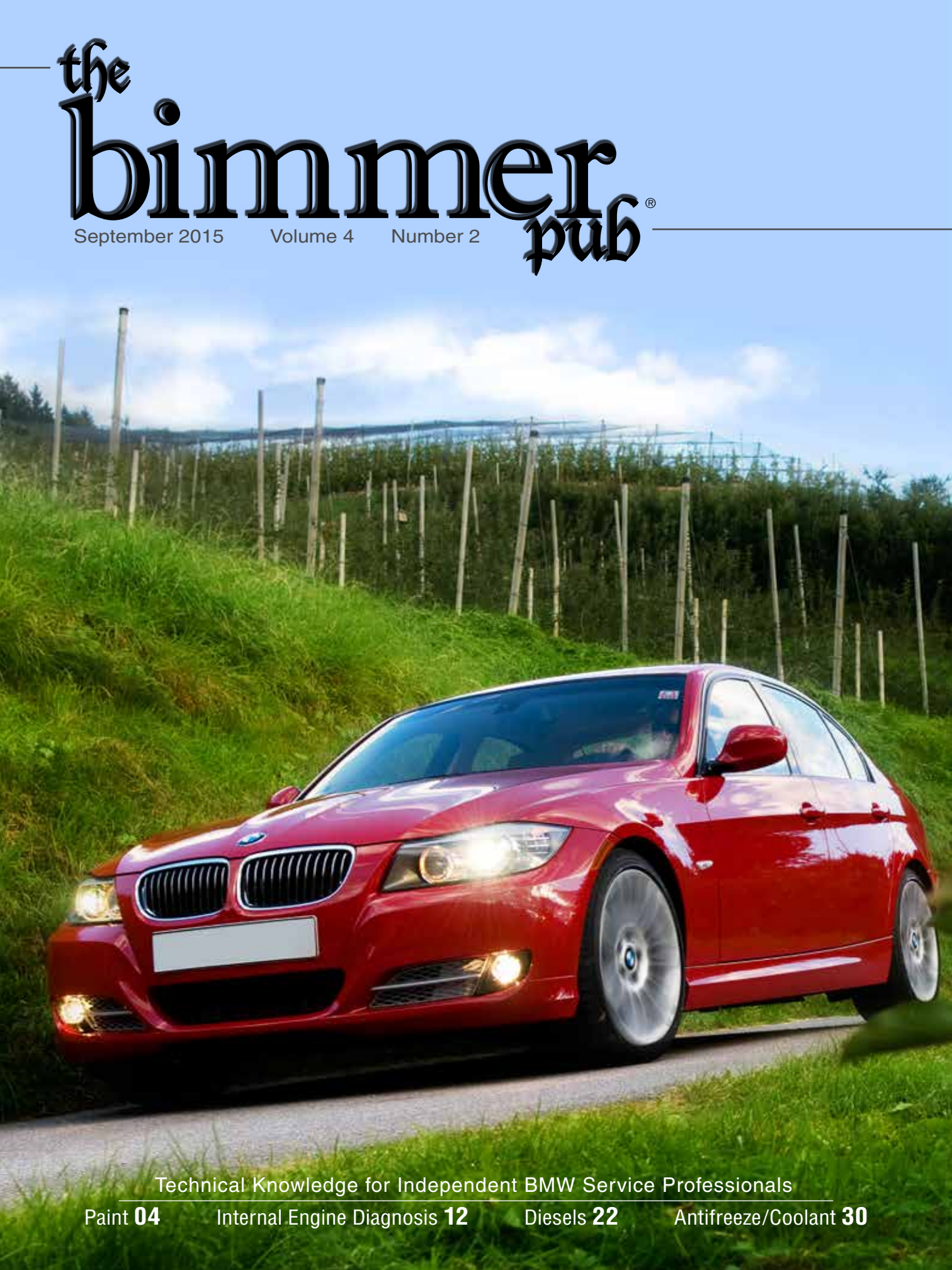

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September 2015 Volume 4 Number 2
Technical Knowledge for BMW Service Professionals

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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.

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

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Thanks for your continued interest.

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Contents

Waterborne Paint:

Green Is the Color of Savings

Lead image courtesy of BMWNA.
Supporting photography courtesy of Asbury Automotive Group, Duluth, Georgia.

The cost-effectiveness of using BMW-approved waterborne paint has been improving at a rapid pace over the last decade. The primary reason to use the technology is no longer just environmental protection, but is now the significant savings it offers to collision repair facility operators. Waterborne paint saves labor time, energy cost, materials expense, and reduces color match or panel blending problems.

European automakers began eliminating volatile organic compounds (VOCs), which are ozone pre-cursors, from automotive coatings in the 1990s. The U.S. EPA jumped on the bandwagon in 1999 with strict limits on VOC content in all automotive coatings.

The limits are, of course, a good thing. VOCs contribute significantly to formation of ground-level ozone, which is a major component of the smog we see in high car-count cities. Breathing ozone can damage lungs, inflame asthma, and cause other respiratory problems.

Waterborne paints meet all current limits for automotive coatings VOC content. We have come down from approximately 75% solvent in conventional basecoats to only 10% solvent in waterborne basecoats, and have reduced solvent by up to 60% in clearcoats.

Out of the Solvent Fog

BMW became the first OEM to use waterborne paints in the U.S when in 2010 it began using the technology in its factory in Spartanburg, South Carolina. In addition to the environmental benefits of cutting VOC emissions, the BMW switch from solvent to waterborne basecoat allowed a new way of applying primer that significantly reduced equipment, paint application and heat curing costs.

BMW factories have sophisticated control of temperature, humidity, and other paint environment conditions, plus robotic technologies that work

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.

Because waterborne is a thinner paint film than solvent, 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.

with the precision of the best human painter, but faster. Could waterborne cost reduction benefits also apply to the aftermarket, where collision shops have to be more adaptable to variations in local weather impact on their painting environment, don't have robot technology, because they typically paint only a part of the vehicle body, and have color match objectives that the factory doesn't have to address?

With BMW ColorSystem, the answer is emphatically yes. ColorSystem is a water-based line that provides a factory-like finish, with shorter drying times than conventional solvent, excellent color match, high gloss, plus high solids and UV protection for durability.

Better Coverage

As solvent content of basecoats came down, solids increased. Waterborne basecoats contain 20% pigment in their metallic or pearlescent formulations, one-third more than the 15% pigment content in solvent-borne basecoats. Waterborne allows painters to get the same coverage and hiding ability while spraying less paint. Using the BMW ColorSystem saves material cost and application 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.

Such a Flake

The flakes of pigment that give a paint its color drift down from the surface to the bottom of the paint film as it dries. Think of the flake as a very small piece of metal that is in the paint as it is sprayed. Instead of drifting horizontally like a feather in a gentle breeze, gravity makes paint flakes tend to turn sideways so they can sink faster. Once the flake reaches the bottom, it flattens, or "flops" into a more horizontal position.

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.

Mirror, Mirror, In the Paint

Metallic flakes function somewhat like a mirror, except their surface is covered with whatever color the paint is supposed to represent. As light reflects out of that mirror and through the paint, it lightens the appearance of the color.

If the flake isn't at an angle where it can reflect the light as the factory intended, the color will not match the rest of the vehicle. For example, if the flake is still vertical when the paint dries, an observer will see very little light reflected out, and the finish will appear darker than areas in which the flakes are in a flat or more horizontal position.

Time Travel

Paint that dries before the flakes have reached the intended depth in the film will lock the flakes in at the wrong angle. It won't matter that you picked the color that is recommended to match the factory finish, or that you followed the paint mixing instructions correctly. Flakes that dry while more vertical than intended cause a color match failure.

Getting the correct drying time is also critical to the proper appearance of pearl finishes, even though the pigment particles are spherical instead of flat. There is no angle of reflection to a sphere. The pearl reflects the same amount of light from any part of its round surface. The depth the pearl has reached in the film by the time the paint has dried however, affects how much of that light reaches the eye of the viewer. Pearlized pigment particles that dry in the middle of the film will reflect more light, and appear brighter to the viewer than pearls that reach and settle at the bottom.

Controlling the Flop

You cannot control how quickly a metallic flake or pearlized particle sinks in the paint film. You can, however, manipulate the speed at which the paint dries, and thereby lock the flake or pearl in place at the desired level within the film.

With solvent, you controlled the drying process primarily by putting in the right reducer and keeping the booth in the paint manufacturer's recommended temperature range. Yes, there were different hardeners for different coatings, but in general, there were not many other factors to manipulate in order to control the time it took to dry the finish enough to remove the vehicle from the booth.

With waterborne materials, a variety of factors affect the length of time it takes for the paint to dry. How "wet" you spray, the rate of airflow in your booth, the humidity level, and booth temperature are all factors that are at least equal to reducer in their importance for controlling drying time for waterborne paints.

You have to spray wet enough to allow the metallic flakes time to settle down to the desired level in the paint film before it dries. One exception is colors for which the factory wants the flakes to tilt a little in the film rather than lie flat. The tilt makes the flake reflect light to the side, rather than perpendicular to the flat surface. For this sideways tilt, you add a flop adjuster, sometimes called a "kickstand." Like the device that keeps a bike from falling, flop adjusters lock the flake in a pre-set angle before the paint dries. They make the color appear lighter when looked at from the side, but darker when seen straight on.

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

The biggest factor determining how wet you spray is the paint itself. The BMW ColorSystems software that identifies the correct paint mix ratio for a given color will give you several choices of paint color formulas. Each different formula works best for a given ambient temperature and humidity to give the desired color. Choosing which formula to mix and spray is similar to making the decision for solvent, whether to use a slow, medium, or fast reducer.

With solvent, you chose the reducer and your decision-making was basically done. With waterborne, you have more decisions to make. You have to consider ambient temperature and humidity at the time you will begin spraying, select the paint formula from among the choices provided by the ColorSystems software, and adjust a variety of additional factors to get the proper paint viscosity. See "Waterborne Spray Adjustments" sidebar for just a few examples of factors and spraying outcomes.

Use separate guns for waterborne basecoat versus clearcoat. Each has a different nozzle size to accommodate the differing viscosities of clear versus basecoat.

The ColorSystem 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. The recommendations will differ for high temperature/high humidity conditions, which tend to result in drying too slowly, versus high temp/low humidity, which leads to drying too quickly. Study the ColorSystems guidelines, pick the recommendations that best match ambient temperature and humidity conditions in your booth, and follow them closely.

On a summer day with 95 deg. F. temperature and 90% humidity, the high humidity is slowing evaporation of the water from your paint. You can bump the booth temperature up to 100 deg. F. The 5 deg. F. increase will decrease the humidity by as much as one-third, down to 60%. The paint will apply better because it is not too wet, and will also dry faster. And you may be surprised to find that you can personally tolerate the 100 deg. F. temperature because the new lower humidity allows more evaporation of sweat from your body, just as it helps waterborne paint flash-off.

If it is a 30 deg. F. winter day, your compressed air likely started at no more than 10% humidity, and after being heated up to 70 deg. F., may be no more than 5% humidity when you begin spraying. If you cool the air down just 5 deg. F. to 65 deg. F., you will gain enough humidity to make paint application smoother. Then once paint application is complete and you are ready to dry it, a little bump up in temperature can pull the humidity out and speed flash-off.

Note that you'll also need a good water filter and de-humidifier for

your compressed air supply. If you don't, you could have so much moisture being added directly to your paint that you actually alter its viscosity. In addition to causing application problems, excess moisture in your paint will slow drying.

Got Air Flow?

BMW engineers design vehicle bodies with smooth surfaces and strategically placed, gentle curves that minimize air turbulence, reduce aerodynamic drag, and enhance driving dynamics and fuel economy. To maximize paint drying efficiency, you have to counter that aerodynamic slipperiness with air turbulence.

You'll continue the laminar (downdraft) air flow at 120-400 fpm as occurred during spraying, and add horizontal air flow at 200-600 fpm. Check your ColorSystem 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. Once they master the air flow turbulence setup, painters routinely experience a 20-30% faster drying time.

Make sure that if you use blowers to push air horizontally during drying, your booth is ultra-clean. Increased air turbulence can lift dust and particulates off of the floor and other horizontal surfaces and add them to the air flowing over your wet paint film.

Learning Curve

A funny thing happened on the way to removing solvent from automotive refinish paint booths. After initial doubts about paint coverage, fears about materials cost, and worrying about the learning curve to achieve reduced drying times, aftermarket painters got used to waterborne paints and quickly fell in love with them. The most often heard reaction once the painter has a little experience with waterborne is, "I'll never go back to solvent." If you're not already there, talk to your ColorSystem supplier. ●

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.

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Photo by Michael Furman

BMW Internal Engine Diagnosis
Right About What's Wrong

We've seen engines torn down when the real problem was in the ignition system, rod bearings replaced when a wrist pin was knocking, valve jobs done when a timing chain was actually at fault, oil pans removed because of a bad oil pressure sending unit, etc. So, you'd better be very sure you're right about what's wrong. Here, we cover the traditional basics, with a note on VANOS.

More and more, we're seeing BMWs with hundreds of thousands of miles on their odometers that have "never had a head off." Chalk that formerly-impossible longevity up to several factors: ever-improving designs and materials, better oils and filters, and a precisely-metered fuel mist that doesn't wash the lubricant off the cylinder walls.

Still, human nature being what it is, and given the incredible number of miles people drive their beloved BMWs, you're going to be faced with internal engine problems from time to time. If it's premature, chances are it's due to neglected maintenance (who, me?), and sometimes a repair isn't the right fix; replacement is. Regardless, whenever you want to find out what's going on inside that BMW engine, your diagnostic skills are going to be tested. We hope the following will help you pass.

Comm, eyes, and ears

As with all repairs, careful communication with the customer at the outset is of primary importance, and that's especially so given the high costs involved in this kind of work. What, specifically, is the complaint? Rough idling, high oil consumption, noises, poor performance, and puddles of oil on the driveway are probably the most common symptoms of something amiss in the engine assembly. Taking a test drive with the car's owner aboard will help prevent misunderstandings.

Nikolaus Otto, 1832-1891

An overall visual and auditory examination should come next. You might see or hear something obvious, such as a crushed exhaust pipe, or a sludge-packed oil filler cap. This is related to stepping back and taking a comprehensive, holistic view of the vehicle's condition and "lifestyle" before you jump to any unfortunate conclusions. For example, we remember having an OHC V8 in our shop with a low-power, rough-running complaint. The car was in pristine condition otherwise, so we immediately engaged our standard diagnostic mode, neglecting to note the odometer reading. After wasting quite a bit of time, we finally noticed the mileage – 243,000! No mystery then that the nylon timing chain tensioning components should have disintegrated, putting valve/crank synchronization out of whack. Lesson: Look at the big picture. Besides mileage, how was it maintained? Has anybody else ever been inside that engine? What kind of driving has it been subjected to? Highway cruising takes a lower mechanical toll than commuting in stop-and-go traffic, or short hops.

A bulletin search is another crucial preliminary. It would be embarrassing to miss a pattern failure.

The top diagnosticians we know have commented that getting as much information as possible from the full assembly prior to teardown gave them the best chance at locating and repairing the problem once they were down to the dirty parts. In other words, collect all the clues and evidence you can before rendering the engine inoperable.

Of course, you'll want to see what your scan tool, either hand-held or PC-based, tells you early on since it's so easy. But something like an OBD II P0300 code (random misfire) doesn't really point you in any specific direction. So, here we're going to talk about more direct and time-honored troubleshooting.

Squashed air

Compression is one leg of the tripod that supports internal combustion, just as important as fuel and ignition. Regardless of all the technology in modern engines, that basic physical fact is exactly the same now as it was in 1876 when German engineer Nikolaus Otto patented the four-stroke cycle. So, underneath that high-tech exterior there's still just a piston pump.

First, listen carefully, both to what your brain is trying to tell you about the symptoms and to the engine itself. Asking a few question in your head will help: Is the idle uneven? Are power and fuel mileage declining? Does it smoke and use a lot of oil? How about backfiring, hard starting, or high emissions that resulted in failure of a pollution test? Start it and note if it cranks unevenly or takes a long time to fire up, both of which suggest poor compression.

Today's cars typically go a long, long way before they develop conditions that reduce compression. There will always be exceptions, however. Then there are vehicles that have exceeded that long, long way, but are still worth fixing. BMWs are a prime example of that. People love them, so will commonly want to get them back into good shape at almost any price.

As far as probabilities are concerned, the most likely culprits are burned or sticking valves, valve train or cam drive or lift troubles, failed rings, and damaged pistons. A violated head/block seal, which was once a common breakdown, is seen much less frequently since BMW adopted MLS (Multi-Layer Steel) head gaskets, although it still happens due to faulty installation during service or severe overheating that warps castings.

Use your scope to find out if the ignition system is in good shape -- we've seen heads pulled when the real culprit was a bad plug, wire, or cap. Then, do electronic or relative compression and cylinder balance tests.

Of course, many old-fashioned technicians like to get an initial idea of the situation with a manual cylinder balance check. Pulling one plug wire at a time to find out if a particular hole has little or no effect on idle quality and speed when disabled is about the most useful troubleshooting trick known to man for older cars, especially where there's a definite miss. That is, if you remember to disable whatever computerized idle stabilization device is present. And use well-insulated boot pliers or that hot-stuff electronic ignition might blow your pacemaker. With coil-over direct ignition, of course, this isn't a manual operation anymore, requiring electronic equipment. You can, of course, kill injection instead of spark.

Vac knack

A vacuum gauge can be helpful at this point, although its readings may be inconclusive or ambiguous. You'll get the most useful results at curb idle speed with the engine fully warmed up. A typical healthy powerplant will produce 15-20 in. Hg.

A steady low reading may be caused by a vacuum leak or late valve timing due to a worn or jumped camshaft drive mechanism. If the needle drops at regular intervals, suspect a leaking valve, whereas if such drops occur irregularly, a sticking valve is indicated. Floating over a wide range suggests a bad head gasket seal. Rapid needle vibration is evidence of loose valve guides.

Since backpressure can interfere with cylinder filling, check for a clogged catalytic converter or crimped pipe by holding 2,500 rpm. The reading will drop when you first open the throttle, then stabilize. If it starts to fall afterwards, there's probably an exhaust restriction.

PSI

Whether or not you've isolated a cylinder or two as the source of the problem, it's time to unscrew the spark plugs and do a traditional dry/wet compression test. Old hat? Maybe, but you'll know if there's a problem even if nothing else says so.

Although the results will usually be inconclusive, the use of an old-fashioned vacuum gauge can at least give you an idea of an engine's pumping ability. Compare the readings to those in the data stream.

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You already know how to do a compression test, of course, but here are a few subtleties that'll help you avoid a costly mistake:

- Blow out the plug wells or debris could temporarily hold a good valve off its seat.
- Since you're dealing with aluminum threads, better loosen those plugs with the engine cold, then just snug them back down enough to fire it up.
- Readings will only be accurate at normal operating temperature.
- Pull all the plugs to make cranking easier.
- Make sure the battery and starter are up to the task of achieving normal cranking rpm.
- Block open the throttle plate.
- Disable the ignition. Not only will open secondaries zap the electronics with more voltage than they might be able to take, it's also asking for an explosion.
- Even though the clear-flood mode is supposed to halt injection during WOT (Wide Open Throttle) crank, you can be doubly certain to eliminate gasoline spray by shutting down the fuel pump and blowing the residual pressure through the rail's test Schrader into a rag, or by unhooking injector connectors.
- You need at least four pulses per cylinder.

Record the first and fourth pushes of the needle. Why? Let's assume a normal reading of 185 psi. A constant (unwanted) hole in the cylinder will allow pressure to built uniformly with each push. For example, you may see 30-60-90-120. This tells you that the leak is there all the time and is uniform in size -- a burnt valve, perhaps, or a badly blown gasket. On the other hand, 90-100-110-120 tells you that the cylinder is sealed up to a point, after which something breaks down or leaks. This is typically how rings fail, but a leaky head gasket will also behave this way. As a rule, the first push should be half or more of the fourth push. For our 185 psi cylinder, we'd expect to see 120-145-165-185, or thereabouts.

Test dry, then wet -- add a tablespoon of oil to each cylinder. Wet testing isn't always effective, however, because the oil may not get evenly distributed around the top ring. If a low reading jumps substantially after the addition of a few squirts of oil, you've got a ring/bore problem. On the other hand, if wet readings are only slightly higher, and this rise is roughly the same for all cylinders, valves are implicated.

The difficult part is judging how much variation among cylinders, or between dry and wet readings, represents a serious problem. Say you've got 100 psi in one, but about 140 in the others, and adding oil brings them up only five psi or so. Is a valve job necessary?

That depends. Obviously, the low one is leaking somewhere, possibly through an exhaust valve, and erosion is going to make it get worse pretty rapidly, so the proper thing to do is get in there and attend to the seats and faces. On the other hand, if it's not bad enough to cause a miss yet, and the customer has been frittering away his or her money on luxuries

There's still nothing that can give you a better inside picture of the pressure tightness of that cylinder than the traditional dry/wet compression test. But don't just look at the max reading. Instead, observe how the needle jumps with each of four impulses.

like food and shelter so can't afford major work this month, maybe he or she can simply live with it. Just make sure the customer understands that no amount of tuning or other external attention will make that engine run any better or go any farther before that cylinder loses it altogether. At least there's some good news -- the rings are okay.

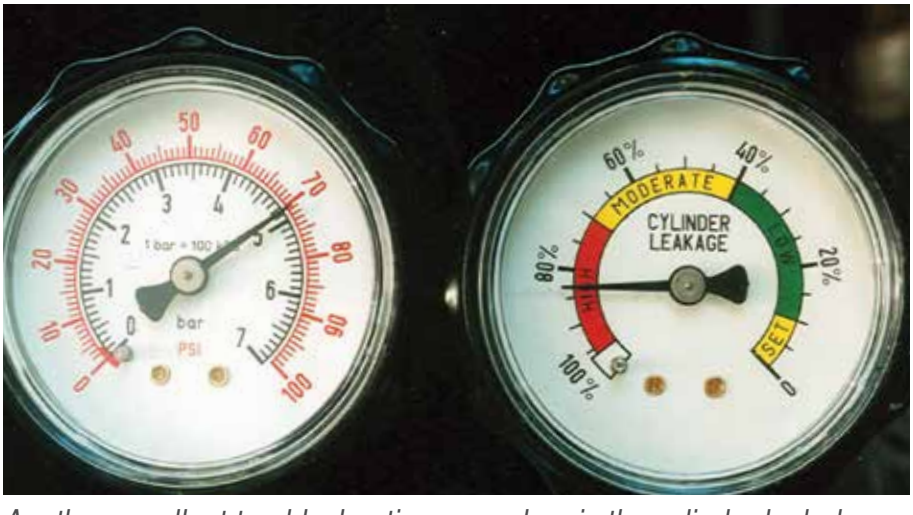
Poor pressure in two adjacent cylinders should make you think about a blown head gasket. Confirm this by looking for coolant in the oil or on the spark plug, and by checking for evidence of compression in the cooling system. Hold the probe of an exhaust analyzer over the radiator filler neck to see if you get an HC reading, or remove the thermostat housing and water pump belt, then watch for bubbles. Another possibility is one of those water-filled testers you stick in the radiator neck -- again, bubbles are the tip off.

Escape volume

Gauging compression isn't the only time-honored procedure that's still useful for assessing an engine's ability to squeeze air. There's also the cylinder leakage test, which is done by pumping maybe 90 psi into the spark plug hole with the valves closed, and listening to where it escapes. Hissing at the intake points to the inlet valve, and the same sound at the tailpipe indicates the exhaust.

There'll always be some noise at the oil filler hole because even the best rings can't seal completely (gaps, you know). The trick is to tell when it's excessive, which you can probably do by comparing cylinders. And this test is great for fingering a leaky head gasket -- remove the radiator cap, look for bubbles, and listen.

An improvement on this theme is the use of a gauge that lets you know what percentage of the available pressure is escaping, which is called a cylinder leak-down test. With the plugs out, bump the engine over until the cylinder in question is at TDC of its compression stroke. Use a regulated air supply of 70 to 100 psi, which you compare to the pressure the cylinder is capable of holding. Older engines tend run some pretty high leakage numbers, so look for consistency and don't worry too much about those big numbers if the engine is running smoothly at idle. We've seen engines with uniform leakage numbers of 50% perform just fine. We've also tried to fix those numbers, and found out that going from 50% to 20-25% made no appreciable difference in the way the engine ran. Newer engines typically produce low numbers -- under 10%. If you get a high reading on a cylinder with no recorded misfires, check for carbon. Crank the engine over a few times to dislodge particles and repeat the test. If the numbers come down, you may be fighting carbon.



Another excellent troubleshooting procedure is the cylinder leak-down test. The gauge set lets you know what percentage of the pressure being pumped into the cylinder is escaping.

There's more to throw into your mental threshing machine before you make your grand diagnostic pronouncement. Anything that holds a valve open, such as a broken spring or a sticking guide, will certainly cause a low compression reading. While these can usually be fixed without removing the head, chances are the valve is burned to a crisp (it can only cool when closed, after all) and/or bent. You can try making the repair and see what happens, but there's no guarantee of success.

Low cylinders that don't produce more pressure after oil has been introduced into them may not have valve sealing trouble. A wiped cam lobe or other valve train failure can result in a miss because the cylinder isn't being properly packed. Check lift before you start unscrewing head bolts.

Absolutely no compression in a cylinder does not necessarily mean a valve is stuck open or burned away, either. There could be a hole in the piston, and we remember an engine that was still running, albeit roughly, even though the piston was entirely gone along with the whole rod so that when we yanked the head we were looking down on what was left of the crank pin.

In cases where that BMW suddenly refused to start and you got weird compression readings, a jumped timing chain is a more likely possibility than bad valves, which deteriorate gradually. If the powerplant isn't freewheeling (that is, the valves hit the pistons if they're out of synch), however, you might to have to remove the head anyway for the replacement of some bent stems.

Who's knocking?

You know it when you hear it: a deep, hollow sound, not at all like valve train click-clacking. The universal term for this disturbing noise is knocking, and it's perfectly appropriate because it makes you think of knuckles on a wooden door. And it's a pretty sure indication of a problem in the engine's foundation, the precursor of certain catastrophe.

But conclusion jumping is a dangerous sport. Your plans for a simple rod bearing job will have to be greatly modified if the crank turns out to be bad, the rod big ends are stretched so there's no crush factor to keep the bearings from spinning, or the knock is really emanating from a loose piston pin fit.

Identifying the source of that nerve-jarring knock can be tricky, and the biggest challenge is distinguishing between a loose rod bearing and a worn-out wrist pin. It's indeed unfortunate that one sounds pretty much like the other.

With a little patience, however, you should be able to determine what's at fault. Use a stethoscope to listen to the engine while it's idling hot. A rod bearing makes more noise at the oil pan than elsewhere, and a wrist pin more racket up on the water jacket. Hold rpm at 2,500, jerk the throttle open and let it snap closed. This will accentuate rod knock, whereas pin noise won't change very much.

Pumping liquid lube

Next, check oil pressure by screwing in a mechanical gauge. Specifications are usually given hot, at idle and between 2,000 and 2,500 rpm. Why low and high speed? Pump speed naturally affects the volume pumped, and, of course, an oil pump generates volume only. Pressure is built by trying to push that volume through small spaces, such as the bearing clearances. Because the pump is of the positive-displacement variety, it'll move anything you put into it, pressure will rise as the discharge is restricted up to the set point of the pressure relief valve. The old standard of 10 psi per thousand rpm still works fairly well, but in an effort to reduce horsepower losses, late models often have reduced maximum pressures. Always refer to specs.

Oil pressure sending units aren't always 100% dependable, so we like to back up our diagnoses of bottom-end problems with readings from a mechanical gauge. Make sure the engine's fully warmed up.

Make sure you've let it run for plenty of time before you render a verdict -- 50 psi cold can turn into 5 psi hot. Also, don't rule out a pump or bypass relief valve problem, or the presence of low viscosity oil (we once knew a guy who liked to fill his crankcase with ATF). The relationship of flow to bearing clearance is important. Assuming that normal clearance is .001 in., flow will increase by a factor of five if you just double the clearance to .002. If you go to .004, oil flow increases by a factor of 25. Interesting, particularly in light of the fact that most engines won't knock at .004 in. on the rods. Sooner or later, the pump's volume is exhausted, pressure drops and the light comes on.

If the pressure fluctuates, think low level, entrained air, or suction leaks. Maybe the pan is running dry due to the installation of a high-volume pump. Or, perhaps a massive internal leak is draining the pan. A high-volume pump needs more pan capacity because at high rpm the oil is pulled out of the pan and held in windage. The oiling system is just that: a system. More is not always better unless all the components are matched. Any suction leak between the oil pickup and the pump will create fluctuations, as will air pulled in due to excess flow through worn-out bearings that sucks the pan dry.

If oil pressure is low all the time, suspect an internal leak such as bad bearings, or a leaky oil gallery plug. A worn-out oil pump can cause low psi, but as it's the best-oiled piece in the machine it's not a good sign for the rest of the internals.

If pressure's low at idle, but okay at high rpm, the pressure relief valve is probably stuck open. In cases where the psi is fine at idle, but low at high rpm, think restricted pickup screen, although a suction leak could be the culprit. Pressure high all the time? The relief valve is probably stuck shut, which can blow the filter.

Carbon, maybe

Killing cylinders, either with a scan tool or manually, is often mandatory for nailing down the offender. A rod knock tends to quiet down with the cylinder killed, but a pin tends to get louder. Still sounds the same? You may be dealing with a carbon knock. If a heavy carbon ridge has formed above the top of piston travel, it can eventually force a violent rock-over, producing a harsh, loud piston-slap type of noise. Also, carbon can build up in the quench areas to the extent that the piston actually contacts it at TDC, which causes a mechanical knock or even a slap knock. In the early stages, a carbon knock will mimic a slap in that it will go away as the temperature comes up.

Whether the mechanical diaphragm type, or one of the new electronic amplified versions, a mechanic's stethoscope is about as indispensable as it gets where nailing down noises is concerned.

We've seen enough of this lately to recommend de-carbonizing as a first step. You may have to treat the engine two or three times. Today, we have such good chemical intake tract and combustion chamber cleaning systems that everybody's abandoned grandpa's manual de-carbonizing.

One of the techniques used to find out if that noise is carbon-related is the floating throttle rev test. Take the engine up to about 2,000 rpm, snap the throttle open to increase cylinder pressure, then rapidly close it to pull high intake vacuum. Watch that rpm -- it's easy to over-speed the engine. What you're trying to accomplish is loading and unloading the pistons, pins and rod bearings. You have to do this rapidly from snap open to closed in order to achieve maximum load. Picture the internals of the engine, and you'll see what you're trying to do. You need to punch the piston down, then suck it up. If there's mechanical looseness in the rod/piston/pin, the rap will get a lot louder as you do this. If the noise remains constant (other than going away some as it heats up), it's probably carbon.

Petroblaze

As we all know, excessive oil consumption is usually due to bad valve stem seals or guides, although since the adoption of Viton seals that's not nearly as common as it used to be. But rings still fail. Unfortunately, you can't check an oil control ring because it's the third one down. The compression rings may be fine, but the oil ring may be varnished, jammed, or "unitized." Valve guides or seals also cannot be effectively tested. As a rule, if it smokes on start-up or after a long, hard decel, it's probably guides or seals. If it smokes on acceleration, it's probably rings.

Variable Nockenwellensteuerung

VANOS, the system whose name is derived from the German words in the above subhead, has been around a lot longer than you may think. BMW first introduced it 23 years ago, and double VANOS appeared in 1996. It's always provided a perfomance edge to the engines so equipped, and has proved to be pretty dependable. That is, except in cases where regular oil maintenance has been neglected. Plenty of oil pressure is needed for proper system operation, so anything that interferes with that will cause troubles that may be hard to pin down.

We covered VANOS diagnosis in-depth in the March, 2013 issue of ***the bimmer pub*** (visit www.thebimmerpub.com and click "Archives"), so we'll just say this here: The presence of this system gives you even more justification for stressing the need for proper maintenance to your customers than you ever had before. ●

While this double VANOS unit exhibits great engineering, it's still vulnerable to poor maintenance.

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TLC Keeps Bimmer Diesels on Top

Since they were introduced in 1983, BMW diesels have shown themselves to be very durable and dependable. That is, if they receive proper maintenance. No? Then you'll need to do some diagnosis before you fix anything.

Tens of thousands of loyal, enthusiastic BMW diesel owners and drivers enjoy tens of thousands of miles of spirited, trouble-free economical driving year after year. Now and again, however, driving is not so trouble-free and problems intrude on the pleasures of driving a BMW. Here are a few issues – some major, some not -- that bear reporting, basically falling into three broad areas:

- loss of power
- fuel delivery
- engine damage

Turbochargers are a probable cause of power loss

Diminished power is perhaps the most common diesel ailment, and – almost universally -- falls on turbocharger-related issues. BMW diesels rely on turbochargers to give them the punch needed for superior performance, but can fail to operate normally causing significant power drop, or fail and require significant repair. Things that can have a dramatic effect on a turbo's life include:

- Loose or split vacuum hose
- Insufficient or incorrect oil
- Ignoring normal service intervals
- Clogged crankcase breather
- Oil feed line blockage

If turbo failure is suspected, but no definitive symptoms are apparent, a quick check of vacuum pipe connections and the condition of the vacuum reservoir is in order -- the problem could be simply a disconnected or cracked vacuum hose. If these are okay, a diagnostic scan can show DTCs (Diagnostic Trouble Codes) specific to turbo operation. Some diesel turbo-related codes, symptoms, and causes include:

- 3F01 Boost Pressure sensor inactive. There is one pressure sensor located above the turbo and another one under the inlet manifold that control the EGR valve. Removal and cleaning of this valve may clear it, but replacement may be required.

- 4521 Boost pressure control pressure may be too high.
- 4530 Boost pressure control pressure may be too low. This can indicate clogged variable vanes in the turbo, and it may be necessary to check vane operation manually.
- Turbo Whistle. Wear and tear over thousands of miles of spirited driving may cause some turbos to whistle more than others, but if the whistle is more of a scream that sounds like a police siren and the engine has no power over 1,000-2,000 rpm, check the play on the turbo's shaft ASAP.

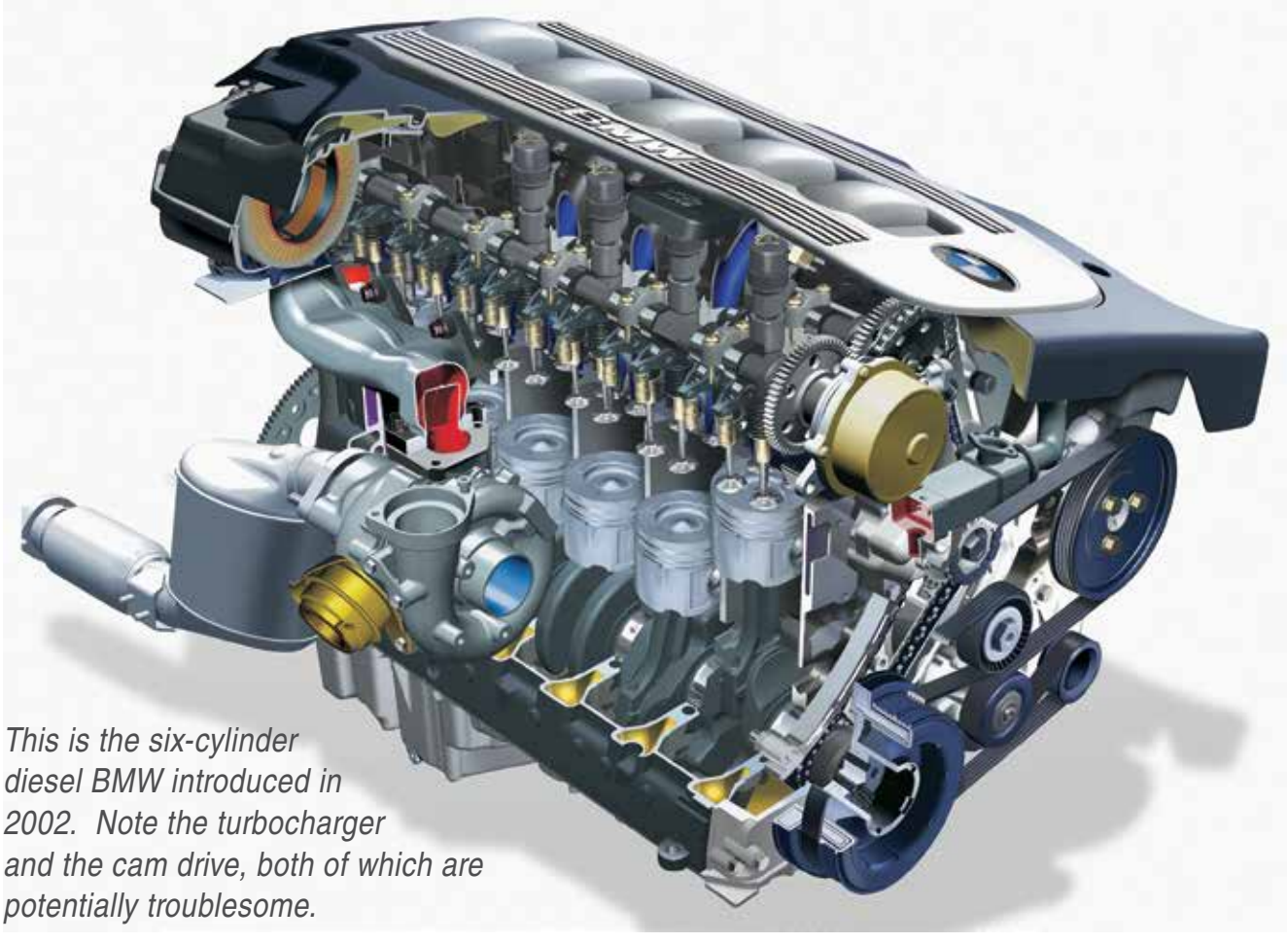
Remove the air pipe to the turbo's inlet after the engine is cool and grip the turbo's shaft between thumb and forefinger to check side to side (radial play) and end to end 'float' (axial play) on the bearings. Axial float should be 0.025mm to 0.1mm which can hardly be felt, while radial float is normally 0.3mm to 0.6mm, felt as a definite rocking. A dial gauge is required to accurately measure float, but if either axial or radial float feels excessive the unit may need immediate attention.

Unusually high oil consumption with blue exhaust smoke can indicate worn turbo seals, and in very rare instances the engine can begin to run on its own crankcase oil, causing plumes of smoke from the rear of the vehicle. In this case, turning the ignition off will not stop the engine running, and engine seizure could happen – the engine must be stalled, possibly by covering the intake with a suitable piece of heavy plywood. With a manual transmission, popping the clutch in a high gear with the brake pedal engaged might do it.

Primary turbo problems

BMW turbos, vital to the power of the engine, can cease to do their job for several reasons, including:

- Boost pressure leaks, where the turbo is functioning correctly, but the boost pressure is being lost



This is the six-cylinder diesel BMW introduced in 2002. Note the turbocharger and the cam drive, both of which are potentially troublesome.

before it can enter the engine due to cracks, splits or poorly fitted hoses on the induction side. This can cause noticeable power loss, with the engine sending out excess black smoke.

- Turbo not creating boost, due to the fact that the exhaust system feeding the turbo has leaks, causing loss of exhaust volume delivery and power loss.
- Blocked or gummed-up air filters, starving the turbo.
- Variable vanes seized on the turbo from soot and carbon buildup, causing the pitch angle of the vanes to stick. This can cause either poor power pick-up or dropping power in higher rev ranges.
- Faulty info from sensors on the engine can also create power problems, where the turbo is being instructed incorrectly by the ECU -- diagnostic software will help identify suspected sensors or problems.

And remember, the VTG variable vane system is the key to sound turbo – and engine -- performance.

Turbocharger failure or seal replacement

Turbo failures on BMW diesels appear most commonly with the M47TDU20 series of engines, particularly the 2002-2003 model years. These engines saw the first installation of common-rail technology for BMW diesels, with displacement increased and balance shafts incorporated to subdue larger-displacement four-cylinder engines' vibrations.

"Swirl flaps," butterfly valves much like a throttle body plate located in the individual intake runners, could wreck the turbo if they fail. Over time, retaining screws that hold the flaps to the actuating rods could work loose and drop into the combustion chamber, causing obvious foreign object damage. The screws could go into the exhaust manifold and then into the turbo, damaging turbine blades and housing. This problem was subsequently mitigated by changing to one-piece engineered plastic flaps.

Another possible turbo problem is a clogged crankcase breather filter. If the breather filter clogs, crankcase pressure rises, blowing motor oil past the turbocharger shaft seal. This could be diagnosed as turbine failure rather than blown seals. Turbochargers usually act up when seals, bearings, or bushings fail due to insufficient lubrication or oil contaminants that cause abrasion to the seals, bearings, or bushings in turbines spinning at speeds up to 100,000 rpm.

Changing oil and air filters at regular intervals is the best protection against premature turbine failure.

This 2008 turbocharger has electrical adjustment of the geometry of its blades, and works with an 1,800 Bar Piezo injection system.

Wait, CBU shows similar symptoms

But wait, another power loss situation is not from the turbo at all, it's CBU – carbon buildup, primarily in the intake manifold, and usually brought on by either low-cetane and high-sulfur diesel fuel, faulty EGR valves, or what is a common problem, "soft" driving techniques that baby the engine with no hard charging so that soot from the EGR system build up as carbon deposits in the intake

manifold. Carbon build-up appears to be a problem with some 3 Series and other vehicles with significant mileage, driven gently for short, stop-and-go trips. CBU often brings:

- Weak power – sometimes very weak power
- Reduced-Power light comes on
- SES (service engine soon) light comes on

BMW issued a recall to correct EGR valve weakness on specific vehicles, which appears to have taken care of the CBU on these vehicles. But CBU is a possible problem on any diesel from whatever carmaker, and curing it can involve thoroughly cleaning the intake manifold to remove the gook built up in it, which can be done by soaking the manifold in solvent, or with ultrasonic cleaning.

Reduced power and SES lamps on could trigger trouble codes:

- 3FF1, Air Mass Sensor
- 4583 and 4585, NO_x sensors
- 4AFS, zero quantity adaptation injector #3
- 4C04, check EGR
- 4595, smooth running controller

Beware of loose fuel cap!

Any of these codes could lead to replacement of multiple components and physically checking and cleaning or replacing the intake manifold, which may or may not correct carbon buildup or keep the SES light off. BMW believes diesel fuel in the U.S. typically of a lower cetane rating than that used

The 2008 six has an aluminum crankcase and coated piston skirts.

in Europe, and is hampered by EPA regulations for sulfur content, contributing to soot creation and carbon buildup.

The lack of spirited driving could almost guarantee carbon buildup, and occasionally running the vehicle hard could well prevent this problem. And, if the SES lamp keeps appearing no matter what, before going into correction mode consider that the SES warning could be from nothing more than a loose fuel cap!

Make sure the cap clicks when tightened. If not, this will almost certainly cause an SES light. So, first check the fuel cap, tighten it until it clicks if it wasn't tight before, and the SES may well go out after a calibrated number of driving cycles.

Common Rail injector failure, other problems

BMW began installing (very) high-pressure common rail fuel injection systems in its diesels years ago. Basically, the Robert Bosch common rail system, operating at extreme pressures of up to 30,000 psi (2,000 Bar), controls the injection of diesel fuel at the right moment, in the right quantities, and with the correct pressure. This ensures that the diesel engine not only runs smoothly, but also economically. A common rail accumulator system on a four-cylinder BMW diesel engine includes:

- Air-mass meter
- ECU
- High-pressure pump
- High-pressure accumulator (the rail)
- Injectors
- Crankshaft-speed sensor
- Coolant-temperature sensor
- Fuel filter
- Accelerator pedal angle sensor

Even this older six has four valves per cylinder.

Symptoms of a failing injector include:

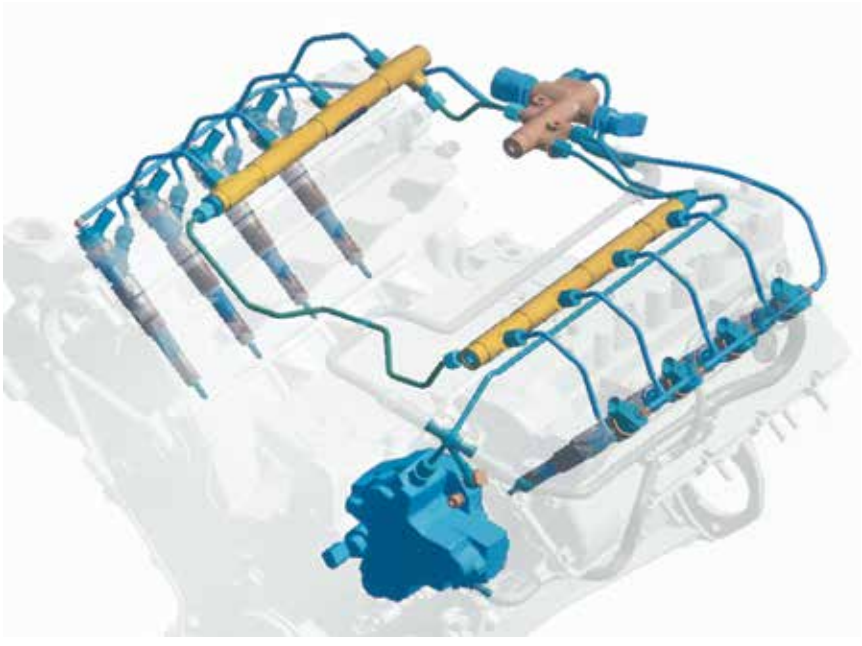
- A loud knock audible with windows down when the vehicle is cold or when the sound bounces from a wall or other solid object
- Poor fuel economy
- Rough idle
- Reduced fuel mileage
- Engine misfire
- Hard or difficult starting
- Hesitation on acceleration

Dirty or worn-out injectors can also cause pre-ignition

or detonation, death for a diesel. Detonation is a fairly common problem in which fuel remaining at the end of the normal air/fuel burning cycle spontaneously combusts. Detonation has the potential to break engine components and cause pitting and scuffing of the pistons. Common rail injection operates with vastly more pressure than previous systems, and this has a definite impact on injector longevity. The injectors fire four to five times per combustion stroke, instead of just once, and have a much smaller operational tolerance than previous injectors.

Injectors can be replaced individually, but diagnosis on the vehicle is the absolute key to validating a failed injector. The ECU must be coded when replacing injectors to recognize that the injector has been changed. Common rail is a complete system, comprising injectors, pump, ECU, rail, and sensors. Common rail pressures have hovered around 20,000 psi (1,333 Bar) for several years, and have climbed to over 23,000 psi (1,533 Bar) in some engines. Higher pressures increase the speed at which fuel is injected into the cylinders, improve atomization and vaporization, and shorten the fuel delivery time, which provides greater flexibility with engine timing, improves engine performance, reduces emissions, and improves fuel economy.

Fast-acting piezo injection technology, utilized in the latest common rail systems, has the potential of reducing fuel consumption by about three percent, reducing emissions by as much as 20%, increasing engine



The Robert Bosch common-rail system makes a huge difference in how smoothly, efficiently, and quietly a modern BMW diesel runs. Precisely-timed multiple injection events avoid having one "big bang," and 20,000 to 30,000 psi really atomizes the fuel.

This old pop tester we used for traditional diesel injectors is useless with common-rail. It only goes up to 5,000 psi, which we once thought was a lot.

power by as much as five percent, and reducing overall engine noise.

CAUTION: Common rail works by pumping pressurized fuel into the "rail" for delivery through injectors at more than 20,000 psi. Before any service is performed on injectors or any other element of the system, it is imperative to relieve the pressure in the rail. Exposure to diesel fuel at 20,000 psi or higher could cause serious bodily harm.

BMW Common Rail systems are actuated by DDE (Digital Diesel Electronics) ECU controllers, depending on the years and engines. The first series of diesel engines used the DDE1 control unit, found in the M21-powered E30 324d and td, and the E28 524d and 524td. DDE 2 and DDE 2.1 were used on M41 and M51 engines. DDE 2.1 used an updated air mass meter with an internal air temperature sensor, while DDE2 has a separate sensor in the manifold. DDE 2.2 is an updated version of the previous DDE 2.1, and was introduced in 1995. This system was used on the M51TU engines.

DDE 3 is the BMW name for ECUs found in the M47 range of four-cylinder diesels, used in the E46 320d. DDE 4 is in the M57 range of 2.5L to 3.0lL six-cylinder engines, and the DDE4.1 was used in a twin master/slave arrangement in the M67 V8 diesels, with each ECU controlling one bank of engine cylinders.

DDE5 is another update to the M57 and M67 diesel engine controllers. It is a second-generation common rail system with rail pressures increasing to 23,000 psi (1,533 Bar) and complies with the European EU3 emissions standard. DDE 6 is used on M57 and M67 engines from 2005 on, using the same 23,000 psi common rail system.

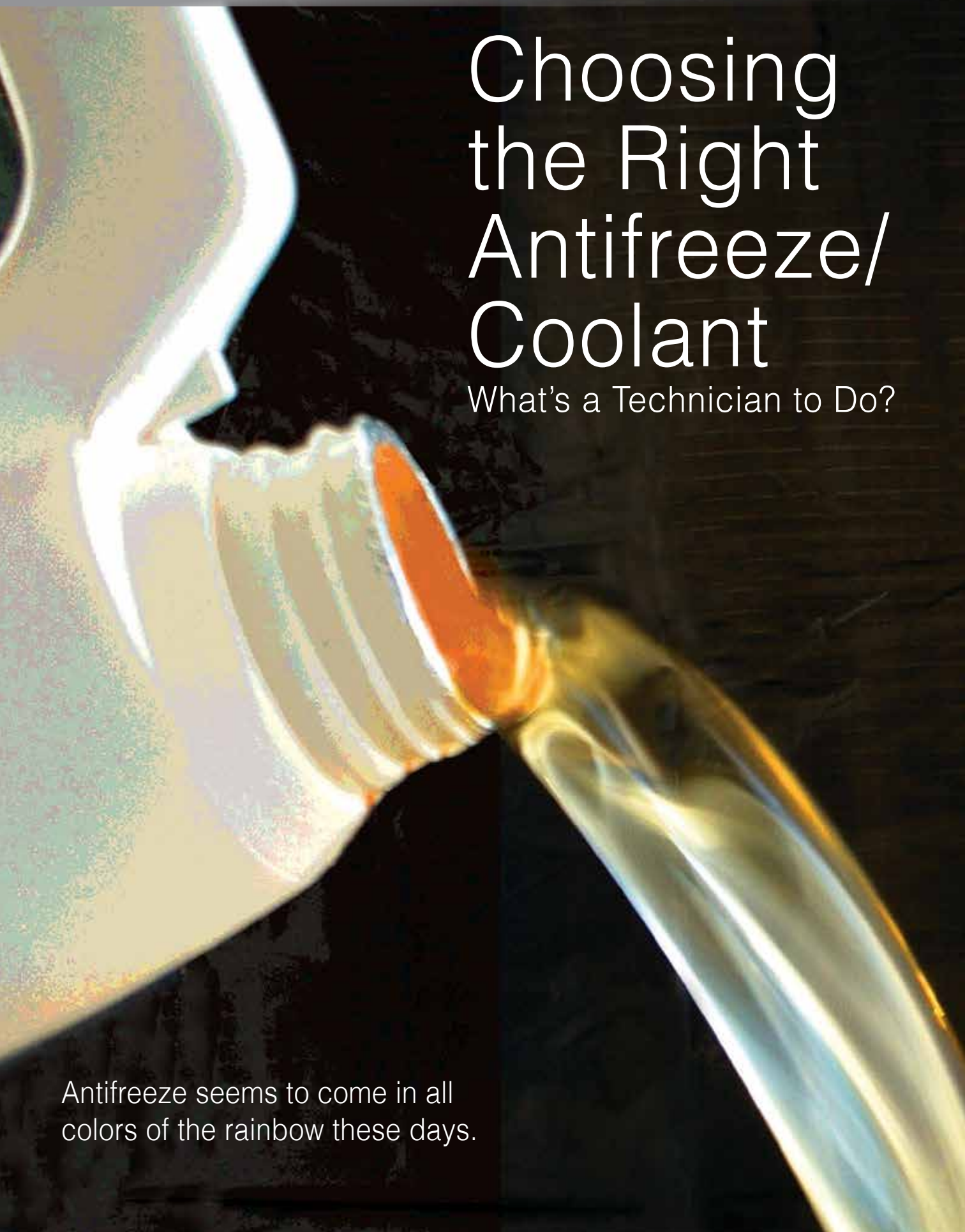
Fault codes vary and are specific for each DDE series.

Follow ***the bimmer pub*** for future installments of our on-going diesel diagnosis coverage. ●

A balance-shaft system was added to the 2007 four-cylinder diesel to make it as smooth as a six.

Choosing the Right Antifreeze/ Coolant

What's a Technician to Do?



Antifreeze seems to come in all colors of the rainbow these days.

Which one is right for BMWs?

To be precise, the liquid you pour into a radiator should be referred to as "antifreeze/summer coolant" because it not only keeps the icebergs away in winter, but also helps prevent boilover in summer. In addition, antifreeze contains an additive package that protects against corrosion and degradation of aluminum, steel, and iron components that are wetted by the coolant. Most brands and types of antifreeze on the market today are based on ethylene glycol (more on this later...).

It is interesting to note that these various ethylene glycol solutions continue to lower the freezing point down to about -60 deg. F., with a concentration of 70% antifreeze, 30% water. Beyond a concentration of 70%, the freezing point of the coolant actually rises, with pure ethylene glycol antifreeze freezing at about 10 deg. F.

On the other hand, the boiling point of a solution of ethylene glycol antifreeze continues to rise with the concentration of the antifreeze, with pure ethylene glycol boiling at about 387 deg. F.

And consider this: each pound of pressurization in a cooling system raises the boiling point by about three deg. F. So a ten-pound pressure cap will raise the boiling point of pure water to about 242 deg. F. And that same pressure cap used with a 50/50 mixture of antifreeze and water will yield a boiling point of about 255 deg. F., which can spell the difference between comfortable motoring on a hot summer day, or a boilover by the side of the road.

It All Started With Alcohol

As recently as the 1950s, automotive antifreeze was alcohol-based. Formulations of the day prevented freeze-ups, but presented several shortcomings. They lacked the additives that have become so important in more modern cooling systems, and the alcohol tended to boil off and vaporize, resulting in less protection against freezing, and bringing the need for frequent replenishment in order to restore freeze-up protection.

So, in that long-ago era chemists came up with blends based on ethylene glycol, which has become the basis of nearly all antifreezes since. These products, in a typical 50/50 mixture with water, provide freeze-up protection to about -34 deg. F. The 50/50 mixture is a convenient number to remember, and ethylene glycol is not subject to the evaporation that degraded the freeze protection of alcohol antifreeze.

In its natural state, ethylene glycol is clear, syrupy, and odorless, although it does have a bit of a sweet taste. And therein lies a concern. Ethylene glycol

Ethylene glycol freezing point vs. concentration in water

Weight Percent EG (%)	Freezing Point (deg F)	Freezing Point (deg C)
0	32	0
10	25	-4
20	20	-7
30	5	-15
40	-10	-23
50	-30	-34
60	-55	-48
70	-60	-51
80	-50	-45
90	-20	-29
100	10	-12

Ethylene glycol boiling point vs. concentration in water

Weight Percent EG (%)	Freezing Point (deg F)	Freezing Point (deg C)
0	212	100
10	215	102
20	215	102
30	220	104
40	220	104
50	225	107
60	230	110
70	240	116
80	255	124
90	285	140
100	387	197

is toxic, and can be fatal if ingested by humans or animals. A bittering agent is typically added to ethylene glycol-based coolants, but its basic sweetness, and usual bright coloring, make it appear to be an attractive beverage, especially for children and animals. So care must be taken when handling and disposing of these products.

Now for the Rest of the Story

In the typical 50/50 antifreeze mix, the water and ethylene glycol account for about 97% of the volume; the remainder consists of a variety of additives that fight corrosion, resist foaming, dye for identification purposes, and probably bittering agents to help avoid poisoning.

The anti-corrosive additives often include silicates and phosphates. Silicates work well in preventing corrosion of aluminum cooling system components. Phosphates work equally well in preventing corrosion of steel components, like water pump impellers, but lose their effectiveness over time.

Today's antifreeze additive packages tend to fall into one of three categories:

Inorganic Acid Technology (IAT)

These additives include both silicates and phosphates which, combined, help ward off corrosion of aluminum and steel components. But because they tend to precipitate out and break down, they should normally be replaced and replenished every two years. This worked reasonably well for decades. Its biggest shortcoming is the need to replace it fairly often or risk corrosion of vital cooling system components.

Organic Acid Technology (OAT)

With this type of additive package, chemists have replaced the silicates and phosphates with other materials, like carboxylate, sebacate, and 2-ethylhexanoic acid (2-EHA). These blends offer freeze protection comparable to IAT, but provide a much longer service life, although at a price premium.

Of particular concern in newer BMWs and other cars, however, is the presence of substantial quantities of 2-EHA, which is a "plasticizer." That means it tends to soften plastic cooling system components, which presents problems with vehicles that have PTRs (Plastic Tank Radiators), plastic expansion/overflow tanks, thermostat housings, water pump impellers, spacers in various gaskets, etc. Some manufacturers substitute sodium benzoate in place of the 2-EHA, but that too functions as a plasticizer and is to be avoided in systems with plastic components.

One other concern with OATs arises if the coolant level in the system is allowed to fall. While these additive packages prevent corrosion in aluminum and steel, they are only effective as long as the metal parts are constantly immersed in coolant. If the coolant level drops, metal surfaces do not retain the anti-corrosion properties of the formula. As a result, oxidation develops rapidly, forming deposits that can grow, break off, and obstruct vital coolant passages in the engine and elsewhere.

Just looking at the coolant in the overflow reservoir won't tell you much. You'll get a better idea of the level and corrosion situation by removing the radiator cap (engine cold, of course). The floating stick is a nice touch.

Hybrid Organic Acid Technology (HOAT)
As the name suggests, HOAT blends include some proportion of various different technologies. HOATs are similar in chemical composition to OATs, but typically with silicates and/or phosphates added. The concentration of these materials is large enough to provide corrosion protection for metals in even if the cooling system is not kept full, while being small enough to avoid most plasticizing action.

HOATs have an even longer service life than OATs, but with a corresponding price penalty. On the more positive side, HOATs are more likely to perform well in hard water solutions, where IATs and OATs are more effective when used with distilled water. Testing has shown that phosphates can react with certain elements found in hard water, such as calcium, iron, and magnesium, forming deposits that can seriously compromise the effectiveness of the cooling system. So, sophisticated coolants like genuine BMW antifreeze/coolant are phosphate-free.

But What About Waterless Coolants?

There are some antifreeze products on the market that are offered as waterless, and are intended to be used full strength straight from the jug. Often, these are propylene glycol-based as opposed to

We beg to differ. Depending on the design, construction and materials found in the cooling systems of today's cars, no single antifreeze blend can properly protect and preserve sophisticated cooling systems.

more conventional ethylene glycol-based antifreezes. Propylene glycol does have some advantages over ethylene glycol. Remembering that these products are intended to be used in 100% concentrations, they have a very high boiling point so they can be used with minimal system pressurization, and they never freeze at any temperature. Also, they are non-toxic.

As with most things in life, however, there are trade-offs. These products are far more expensive than conventional antifreeze, which can prove doubly costly if a burst hose or cooling system leak should cause a total loss. Further, they are not compatible with ethylene glycol-based antifreeze, so topping off of the coolant must be done with the same type of product, which is not commonly available at retailers, parts stores, or service facilities. So, while such products may be suitable for certain heavy-duty, commercial, racing, and industrial applications, they are not well-suited to passenger car use.

"Suitable for all Vehicles"

Don't believe everything you read. Well, you can believe everything you read here in ***the bimmer pub***, but don't believe everything you read on the Internet and in product advertising. Some retail brands of antifreeze are promoted as being suitable for any make or model of car, and compatible with any other type of antifreeze. But don't fall for it. For all the reasons outlined above, there are certain advantages and disadvantages to the various additive packages used in antifreeze blends. And no one formula can meet the needs of a wide variety of makes and models built with various plastics, aluminum, steel, and other materials. Nor can compatibility with all of the various OE blends be assured, since the chemistry can vary widely based on engineering needs.

As a result, a "fitsall" antifreeze may not offer adequate corrosion protection for your customer's BMW and, in fact, may contain additives that can actually degrade the materials in a BMW's cooling system. Furthermore, chemical incompatibility may result in the formation of deposits or globules that can restrict radiator tubes, heater core tubes, and other small orifices, compromising the effectiveness of the cooling system and risking substantial customer expense and dissatisfaction.

So What Should I Use?

The answer is as close as the parts department of your local BMW dealer. That's the only place where you can buy the bluish-tinted antifreeze compound that's exactly right for the needs of your customer's prized and precious BMW.

And there are many reasons -- specific reasons -- why you should use only this product in BMW cars. Genuine BMW coolant is engineered to meet the exacting needs of BMW vehicles. It is a hybrid coolant that contains no phosphates, no 2-EHA, low levels of silicates and, unlike some hybrid coolants, contains no nitrites, which can combine with other chemicals to form nitrosamines, which are carcinogenic.

Rather, genuine BMW coolant contains an exclusive blend of corrosion inhibitors, defoamers, dyes, and bittering agents that provide optimal cooling, corrosion protection, compatibility with all cooling system components, and provide a long service life. ●

Only genuine BMW antifreeze is compounded to contain the precise blend of the proper chemicals to afford reliable freeze-up and boilover protection while being fully compatible with the various materials wetted by the coolant.

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