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Information for the Independent Mercedes-Benz Service Professional

December 2004 U.S. $6.00 € 12.50

Anti-Freeze

Cooling System Service

Volume 4 Number 4

Mercedes-Benz

To Our Readers:

Welcome to *StarTuned*, the magazine for independent service technicians working on Mercedes-Benz vehicles. Mercedes-Benz sponsors *StarTuned* and provides the information coming your way in each issue.

The worldwide carmaker wants to present what you need to know to diagnose and repair Mercedes-Benz cars accurately, quickly and the first time. Text, graphic, on-line and other technical sources combine to make this possible.

Feature articles, derived from approved company sources, focus on being useful and interesting. Our digest of technical information can help you solve unanticipated problems quickly and expertly. Our list of Mercedes-Benz dealers can help you find original, Genuine Mercedes-Benz Parts.

We want *StarTuned* to be both helpful and informative, so please let us know just what kinds of features and other diagnostic services you'd like to see in it. We'll continue to bring you selected service bulletins from Mercedes-Benz and articles covering the different systems on these vehicles.

Send your suggestions, questions or comments to us at:

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Mercedes-Benz

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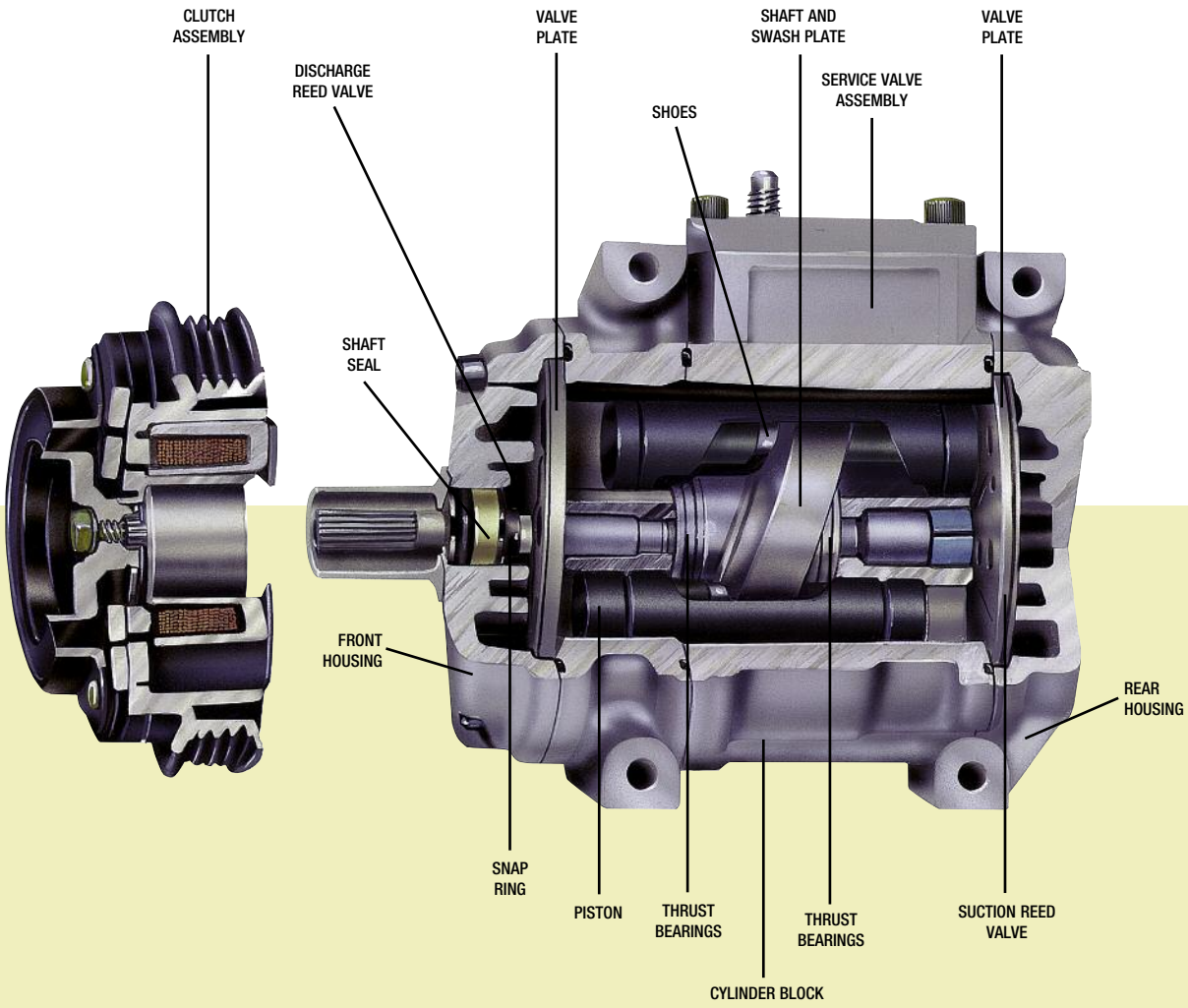

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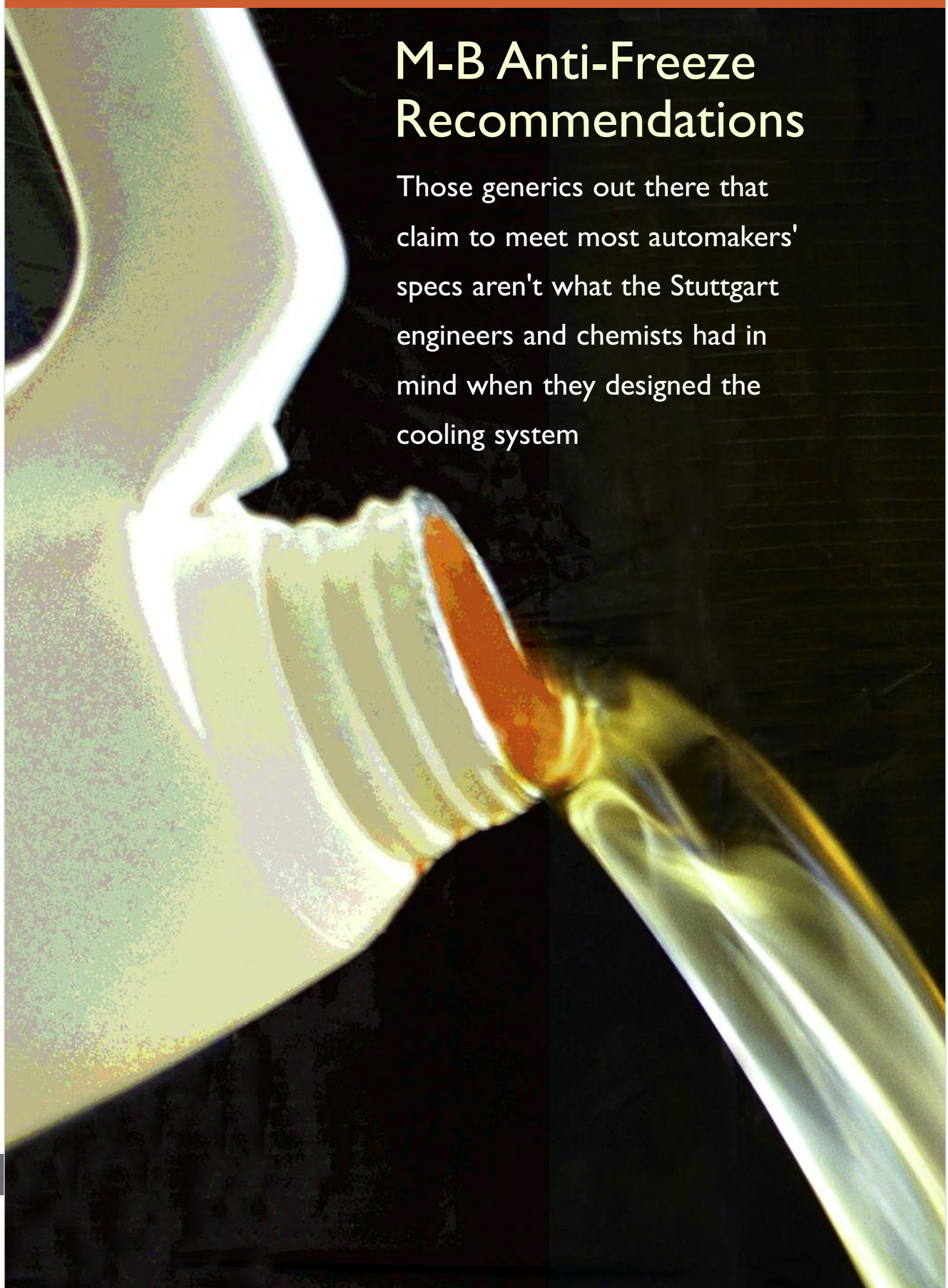
Do the Right Thing:

M-B Anti-Freeze Recommendations

Those generics out there that claim to meet most automakers' specs aren't what the Stuttgart engineers and chemists had in mind when they designed the cooling system

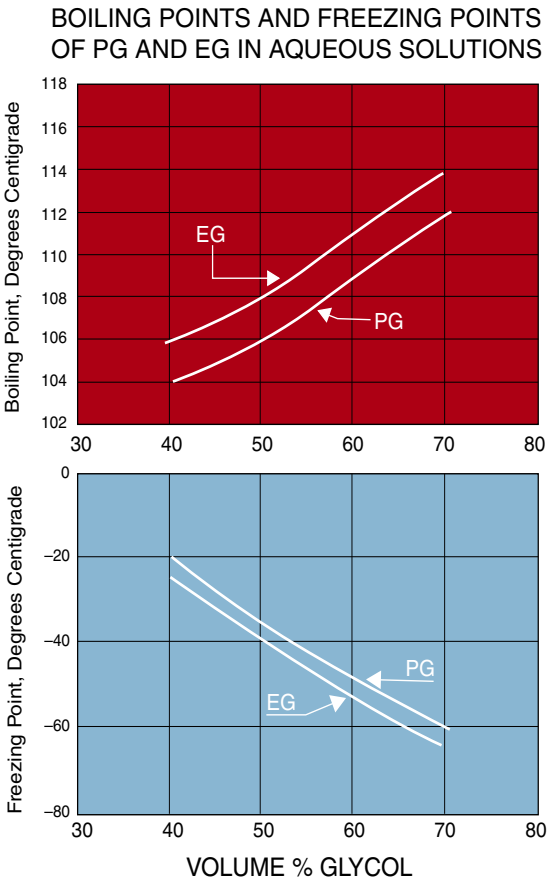


"Perfect together": Mercedes-Benz anti-freeze coolant and distilled water in a 50-50 mixture in the cooling system. An aftermarket brand that meets the Mercedes-Benz specification and/or deionized water will give the same good protection.

Changing the anti-freeze/coolant in a Mercedes-Benz vehicle, or even topping up the reservoir, is a straightforward procedure. But picking the right anti-freeze to use is not so straightforward. There are many anti-freezes on the market, and most are advertised as compatible with all others in all cars. StarTuned would like to tell you why not to use just any anti-freeze in a Mercedes-Benz, even if it's a reputable brand.

You may be thinking, "Mercedes-Benz is just trying to sell its own approved anti-freeze. It's just another one of those not-invented-here things." Sorry, but that isn't true, and we think we can explain – and hopefully convince you – to use either Mercedes-Benz's own anti-freeze, or only an aftermarket equivalent that meets the current Mercedes-Benz specification. This is particularly true today, when most of the anti-freeze aftermarket brands you'll find are very different in important respects.

First, let's explain that because Mercedes-Benz vehicles are marketed worldwide, the manufacturer must make allowance for great differences in water quality. The coolant in an engine normally is a 50-50 mixture of water and anti-freeze, and the water both improves heat transfer at high temperature, and lowers the temperature at which the coolant will freeze.



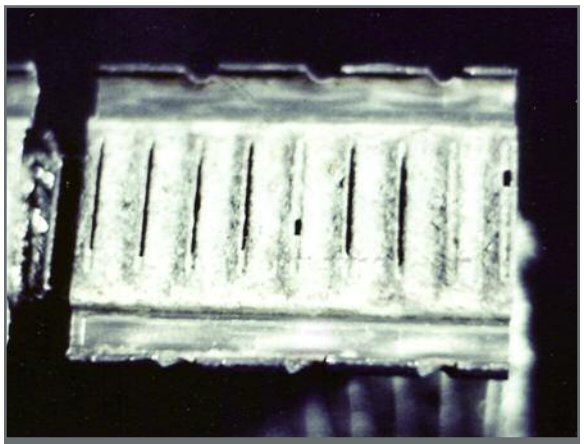
Charts show boiling and freeze points of anti-freezes in a 50-50 mixture with water. Note that EG (ethylene glycol, the glycol used in most anti-freeze) has a slightly higher boiling point and a slightly lower freeze point than PG (propylene glycol). At concentrations above 70% anti-freeze, the freeze point of the coolant actually starts to rise, so more anti-freeze is not better. The 50-50 mixture provides the best combination of freeze and boilover protection, and good heater transfer from the engine.

Water quality not only affects the rust/corrosion inhibitors in some anti-freezes, but it may contribute to electrolytic corrosion in the cooling system, which can produce deposits that affect coolant flow and heat transfer. And if the water is very hard, certain anti-freeze inhibitors – particularly phosphates – may react with the calcium and magnesium (and even iron) in hard water to produce deposits that add to the coolant flow and heat transfer problem. See accompanying report: "When to Use Tap Water in a Cooling System, and When Not To".

A refractometer provides the most consistently accurate indicator of freeze protection of a coolant mixture, and should be used by a professional technician, instead of a hydrometer or test strip.

Mercedes-Benz anti-freeze is formulated without phosphate inhibitors that produce these particular concerns about deposits. Does that mean you can use any anti-freeze without phosphates? You shouldn't, even in areas without a hard water problem, because the factory fill already has established a specific type of rust/corrosion protection mechanism. A different type of rust/corrosion inhibitor package will not continue with that form of protection and might even cancel out protection.

Consider a situation in which the amount of each different inhibitor package is split, from



Excessive electrical activity in the coolant produces electrolysis damage – corrosion that restricts coolant flow through the radiator and heater core.

use of two anti-freezes with different rust/corrosion protection mechanisms, so that each is under 40% of the coolant (as low as 25% even with a 50-50 concentration). Neither inhibitor package may be strong enough to provide its normal type of protection.

Further, Mercedes-Benz is the only passenger car/SUV manufacturer to build into the cooling system a slow-release protection device, that on some late-models permits a 15-year, 143,000 or 150,000 mile coolant replacement interval. The protection device – a packet of silica gel in the coolant reservoir – is designed to work with a Mercedes-Benz specification coolant, and not others. And that's not just a claim. We'll be very specific. (Note: That new service interval has not been extended to all models yet, and it should not be applied retroactively to older models).

Fifteen years/143,000 or150,000 miles? That must be one of those new anti-freezes you've heard about, that are used in other manufacturers' vehicles. No it isn't. And despite anything you read about "compatibility," these new anti-freezes are not approved for use in Mercedes-Benz vehicles, for specific technical reasons. So you understand the technical basis for these different anti-freezes, a brief technical summary of what they are follows.

But first, a couple of preliminary points:

All original equipment anti-freezes and most aftermarket brands are about 93-95% ethylene glycol, about 3-5% rust/corrosion inhibitors, plus about 2-3% water and/or solvent (required to keep the rust/corrosion inhibitors in solution in the container and as the anti-freeze is poured into the system)—and a leak-trace dye.

A few aftermarket anti-freezes are made with propylene glycol, which often is promoted as a less-toxic chemical, but which is not quite as effective at freeze protection. So when an anti-freeze producer says his product is "compatible" with all original equipment anti-freezes and other aftermarket brands, he's basing this on his own laboratory tests, which simply identify a possible "battleground" issue. That is, when chemicals are "incompatible," there is quick metal damage that shows up.

WARNING: Contains ethylene glycol (107-21-1), diethylene glycol (111-46-6), sodium 2-ethyl hexanoate (19766-89-3), and sodium neodecanoate (31548-27-3).

PRECAUTIONARY MEASURES: Do not drink anti-freeze or solution. Do not beathe mist or vapors. Avoid prolinged exposure. Avoid skin and eye contact.

FIRST AID TREATMENT: If **swallowed**, do NOT induce vomiting. **IMMEDIATELY** call a Poison Control Cnter or hospital emergency department. If **breathing** is affected, move into fresh air. If in **eyes,** rinse thoroughly with water for 15 minutes. If on **skin,** remove contaminated clothing and wash skin well with soap and water. If **irritation** develops and persists, call a doctor.

Ethylene glycol causes birth defects in laboratory amimals. Solution is poisonous to animals.

KEEP OUT OF REACH OF CHILDREN

WARNING!

HARMFUL OR FATAL IF SWALLOWED OR INHALED.

DO NOT drink antifreeze or solution. **DO NOT** store in opened or unlabeled containers. Avoid inhaling mist or hot vapors. Poisonous to animals. Ethylene Glycol has caused birth defects in certain laboratory animals when given orally.

KEEP OUT OF THE REACH OF CHILDREN AND ANIMALS.

CONTAINS: Ethylene Glycol (107-21-1), Diethylene Glycol (111-46-6), Sodium Tetraborate (1303-96-4), Sodium Benzoate (532-32-1), Corrosion Inhibitors, Defoamers, Silicates and Dyes.

FIRST AID:

EYES: Flush with large amounts of water. Get medical attention if irritation persists.

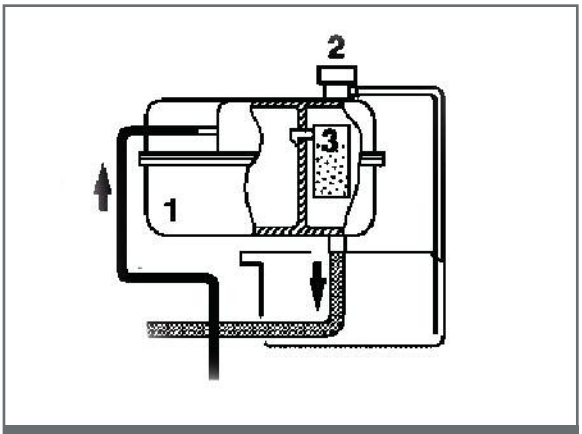
SKIN: Wash exposed areas with soap and water.

INHALATION: If affected, remove to fresh air.

IF SWALLOWED: Give 1-2 glasses of water. Call a physician or Poison Control Center immediately. Ethylene Glycol based. N.Y.F.D. C. of A. No. 4880

24-HOUR EMERGENCY NUMBER 1-800-832-6825

Read the backs of these two containers of coolant. Note the Mercedes-Benz coolant contains forms of borate (sodium tetraborate) and benzoate (sodium benzoate) as well as silicates. The other anti-freeze contains only organic acids (2-EHA and neo-decanoate).



Section of a Mercedes-Benz maintenance chart. Note that the "replace coolant" interval is 15 years or approximately 143,000 miles. The mileage interval is as high as 150,000 miles on some vehicles with the long-life recommendation, based on the scheduled maintenance interval.

However, "compatibility" doesn't mean equal protection. Even if an anti-freeze works well in one make of vehicles, it doesn't mean it will work well in all others, as we'll explain when we talk about the different types of rust/corrosion inhibitor packages.

You also should understand that the leak-trace dye simply identifies a leak. It does not tell you the type of anti-freeze. The most popular anti-freeze colors are green (various shades), yellow/gold, orange, blue, red and amber. In some cases, the colors were chosen by the anti-freeze producer to differentiate a change to a different formula, but not necessarily a specific one. In others, the color was picked because it was considered unlikely to be confused with fluid leakage from another component (washer fluid reservoir, transmission, power steering, etc.). Mercedes-Benz anti-freeze presently is dyed yellow/gold, but so are anti-freezes with totally different formulas and rust/corrosion protection mechanisms. The bottom line: ignore dye color.

Anti-freeze inhibitor packages are classified as "conventional," and "extended life." The service interval for "conventional" typically is 2-3 years and/or about 24-40,000 miles. To date, extended life may be "moderately extended" (3-4 years) or five years or more, and up to 150,000 miles. Mercedes-Benz, as noted with its 15-year/150,000-mile interval, has broken new ground.

Rust/Corrosion Inhibitor Packages

You don't have to be a chemist to understand the rust/corrosion inhibitor packages. All you should do is note the ingredients, see that they differ and realize why Mercedes-Benz anti-freeze protection mechanism truly is different, and the reasons why.

"Conventional green": The inhibitors are sodium silicate and phosphate, both proven protectors for aluminum, plus benzoate and borate (broad-range metal protection) and a "triazole," one of a group of inhibitors that protect copper-brass, plus an inhibitor that protects cast-iron.

"Japanese" green or red "conventional": It typically contains phosphates and benzoate, a triazole; plus molybdate (cast-iron protection) and nitrate (a specific type of aluminum protection). It contains no silicate.

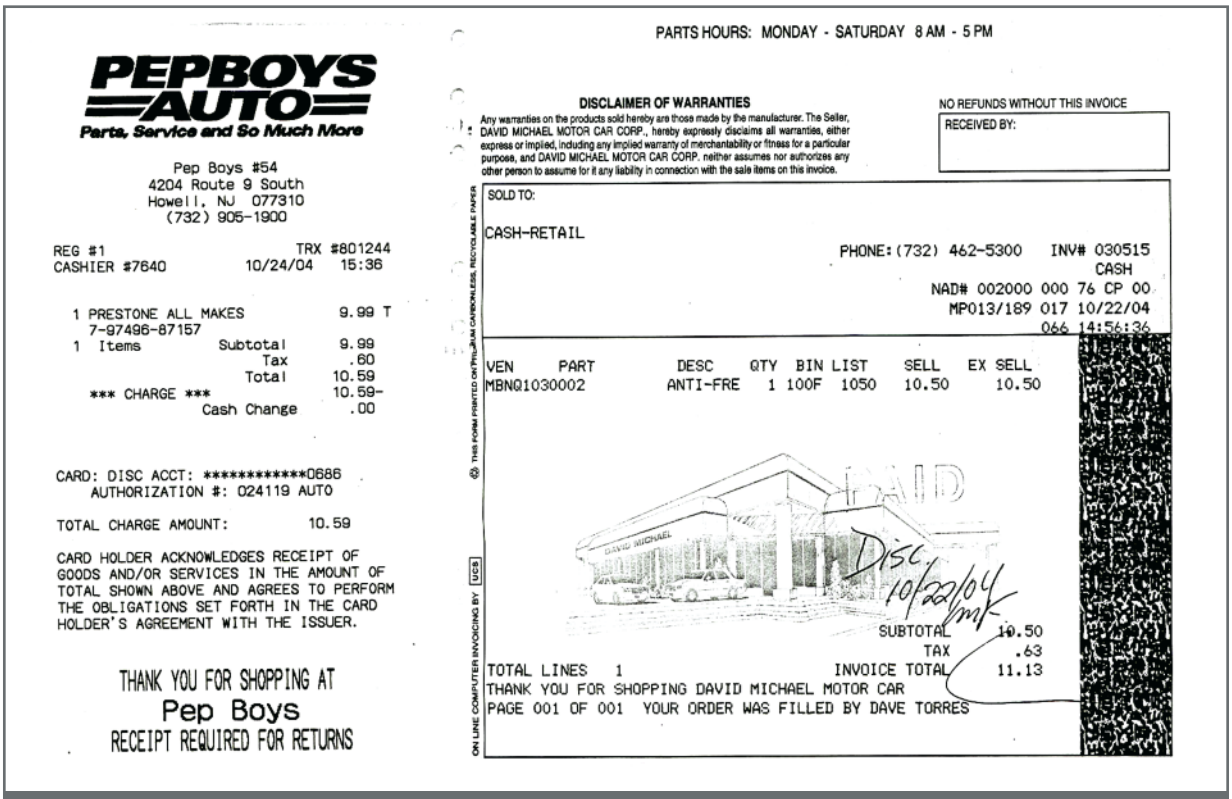
Organic acid technology/extended life coolants (called "OATs"): Although benzoate is an organic acid, it is not used in an exclusive package with other organic acids in an OAT. The organic acids used in American anti-freezes include one 2-EHA, among others (such as sebacate and neo-decanoate). They contain no silicates and no phosphates. Japanese OAT anti-freezes do not use 2-EHA but they do contain phosphate. Note: 2-EHA (2-ethylhexanoic acid) is a "plasticizer," which means it softens plastics. Gaskets are made with plastic and there have been laboratory tests reported by other manufacturers, that raise concerns about coolant-sealing gasket leakage with 2-EHA.

Mercedes-Benz type hybrid: Originally developed to work well with both diesels and gasoline engines, this anti-freeze uses a low-silicate formula. It also contains benzoate and borate, plus benzo-triazole for copper-brass protection, nitrate and nitrite (protects cast-iron liners in diesels). It was demonstrated to be a robust formula that would work for extended intervals, and with Mercedes slow-release "refreshment" of the coolant, capable of long life in a well-maintained system.

It's the Mercedes-Benz cooling system itself -- the metallurgy, the gasket materials, the flow pattern of the coolant plus the use of the silica gel packet – that combine with the field experience to assure that a particular anti-freeze is the right choice.

The long-term validation of the Mercedes coolant in a Mercedes cooling system avoids the need to deal with the concerns about OAT coolants. Why would you want to take a chance with anything other than the Mercedes-Benz recommended hybrid type? If you buy your anti-freeze from an aftermarket source, use a reputable brand that meets current Mercedes-Benz formulation, typically labeled a G-05 coolant. We bought Mercedes-Benz authorized anti-freeze from a Mercedes-Benz dealer, and the list price was only a dollar and change more than the price of national brand anti-freezes in an auto parts store.

Note: some anti-freeze suppliers claim their products meet specifications of all manufacturers, and provide a long list of manufacturers' specifications their products meet. However, over the years all vehicle makers have used a number of different specifications, not all of



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MERCEDES-BENZ MODELS WITH COOLANT REPLACEMENT INTERVAL OF 15 YEARS / 143,000 OR 150,000 MILES

2003-2005

E-Class including CDI (diesel).

S-Class (including V-12 bi-turbo) *

M-Class

SLK Class (including new model with four-valve V-6)

2004-2005

C-Class

CLK Class

SL Class

2005

CL Class (including V-12 bi-turbo)*

* Three-year coolant replacement interval for the intercooler circuit of the bi-turbo

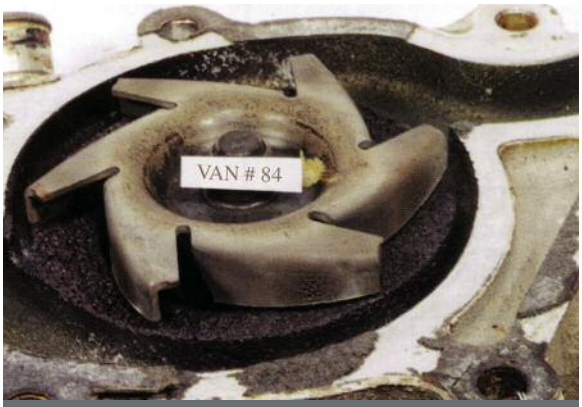
them current. The list may not apply to the models you're working on, so be cautious.

Anti-freeze producers also may claim that if you drain the cooling system, you avoid any performance issues when you switch coolants. However, this is not necessarily true in a Mercedes, where specific protection has been established with silicate inhibitor and the system is designed for continued "refreshment" from the silica gel. Further, it is very difficult to completely drain the modern cooling system in all cars, although use of good coolant changing equipment should remove about 90%. So long as the new coolant is the same type as the old, there's no question about its performance.

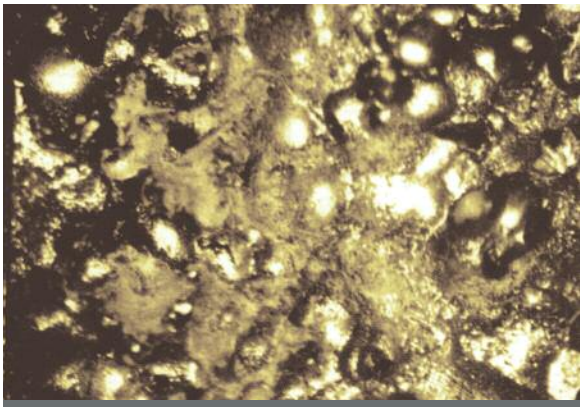
Why some ingredients and not others?

Both silicates and phosphates work very quickly, and are very effective in protecting aluminum, "painting" the cooling system surfaces with an anti-corrosion coating. Silicates also are regarded as a harder coating, and not a problem in hard water, so they are the Mercedes-Benz choice for primary protection.

The speed of protection is important. Not only do silicates work quickly in new engines, but also to protect new parts that are installed, and in a situation called "water pump cavitation erosion-corrosion." Under some operating conditions (particularly high temperature, high-load), the coolant may form low-pressure bubbles as it's drawn into the water pump, and these bubbles collapse as they flow through the pump chamber. The collapse occurs with explosive force, chiseling and pockmarking the pump surfaces protected by the anti-freeze inhibitors. This eroding of the surfaces of the pump chamber exposes unprotected "bare metal," which corrodes. The long-term effect: deterioration of water pump performance, leading to overheating and in winter, to poor heating performance from low coolant flow. That's why Mercedes and many other vehicle manufacturers rely on silicates.



This coolant pump chamber was pockmarked by cavitation erosion-corrosion, which would eventually reduce performance of the pump.



Seven times multiplication of the coolant pump surface clearly shows the pockmarking that leaves metal unprotected, and subject to corrosion.

By contrast, OAT coolants may take 5,000 miles to protect a metal surface. Although OAT coolant inhibitors are very long-lasting (hence their use in extended-life anti-freezes), their slowness to protect is a problem when there is cavitation erosion in the water pump.

However, silicates are "used up" in providing protection throughout the cooling system. This is not in itself a problem, so long as the "painted" silicate protection is maintained. However, as noted, some silicates continue to be needed for extended service, to perform such functions as water pump internal "repair" protection.

Although most manufacturers have recognized silicates' advantages, others were apprehensive about using a high-silicate formula to get long-term protection from it. Mercedes-Benz has been using the silica gel in a meshed-plastic container inside the coolant surge reservoir for many years to gradually "refresh" the silicate content over a period of years.

You may be wondering about the use of silica gel, which is well-known as a desiccant (to

absorb moisture) in many packaged goods exposed to ambient humidity, and even in some older automotive air conditioning systems.

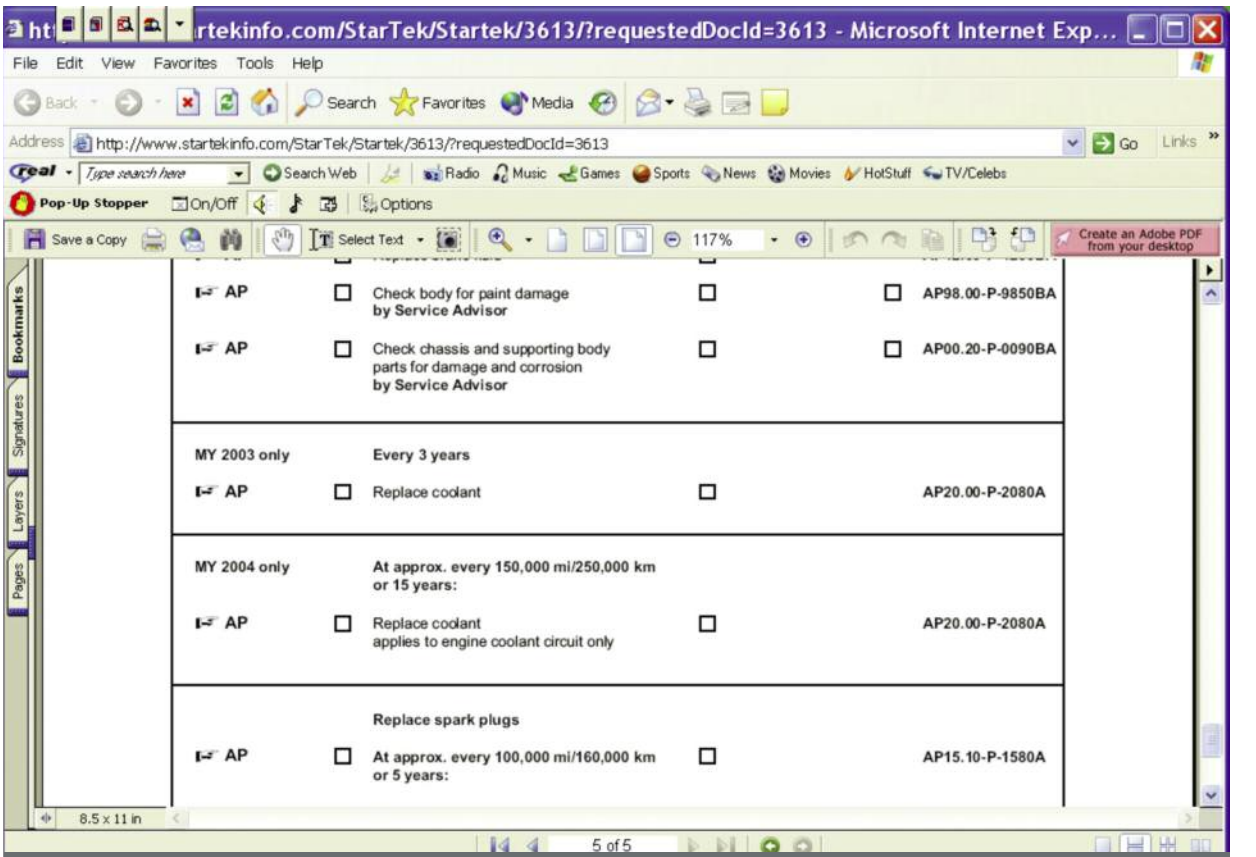
However, in a coolant reservoir, it works differently, by absorbing enough coolant to establish a "balance" and dissolve very slowly to replace silicates used up to protect metal surfaces in the cooling system. The silica gel packet gradually adds a very tiny amount of silicate inhibitor to the coolant over the years, reaching a "plateau" in the coolant.

You don't have to replace the silica gel. In fact, laboratory tests show that even after many years, most of the inhibitor remains in the gel, still available to add protection. An anti-freeze chemist described it as a "silicate trust fund." Actually, the concept is somewhat similar to the use of time-release additives in the coolant filters of some "big rig" (Class 8) diesel engines.

Anti-freeze inhibitors have different metals to protect, so the Mercedes-Benz formula is totally-balanced to protect them all. To be able to extend the service interval from three years (still the service interval on some new models and all older ones), Mercedes has re-engineered components as required. That's why the service interval was increased so dramatically only after both re-engineering of cooling system components and the long period of field and laboratory experience with the silica gel "refreshment."

Mercedes-Benz coolant service intervals

Mercedes-Benz with its hybrid coolant has long been able to recommended a moderately-extended service intervals of three years, 50% longer than with conventional coolants. After cooling system re-engineering and testing, plus the rust/corrosion inhibitor refreshment by the silica gel packet, the interval has been extended to 15 years (143,000 or150,000 miles, the variation based on the regular maintenance schedule).



Section of a Mercedes-Benz maintenance chart for the SL. Notice that this one lists a three-year coolant replacement interval for 2003. The 15 year/150,000 mile interval only applies since 2004 model year, as explained in the listing that follows.

However, the new interval applies only to certain late-models and should not be applied retroactively to older ones.

Further, Mercedes-Benz continues to recommend that the coolant level be checked, and adjusted if necessary,: (using authorized coolant/water mixtures only) at each scheduled maintenance service, which ranges from 10,000 to 13,000 miles or once a year.

There's also are special situations. One is the 6.0-liter V-12 "bi-turbo" engine, which has a second cooling system circuit (with an electric coolant circulation pump) for the turbocharger intercooler. That circuit still carries a three-year coolant replacement, which should be performed as part of scheduled maintenance. Another is the 2005 SLR McLaren, which carries a four-year coolant replacement interval.

Although the following list of models sold in the United States was drawn from the Mercedes-Benz scheduled maintenance forms, you also can refer to the owner's manual if you have any doubt about the correct interval. And if you use the Mercedes-Benz technical information website (www.startekinfo.com), you'll be able to check service literature for any changes.

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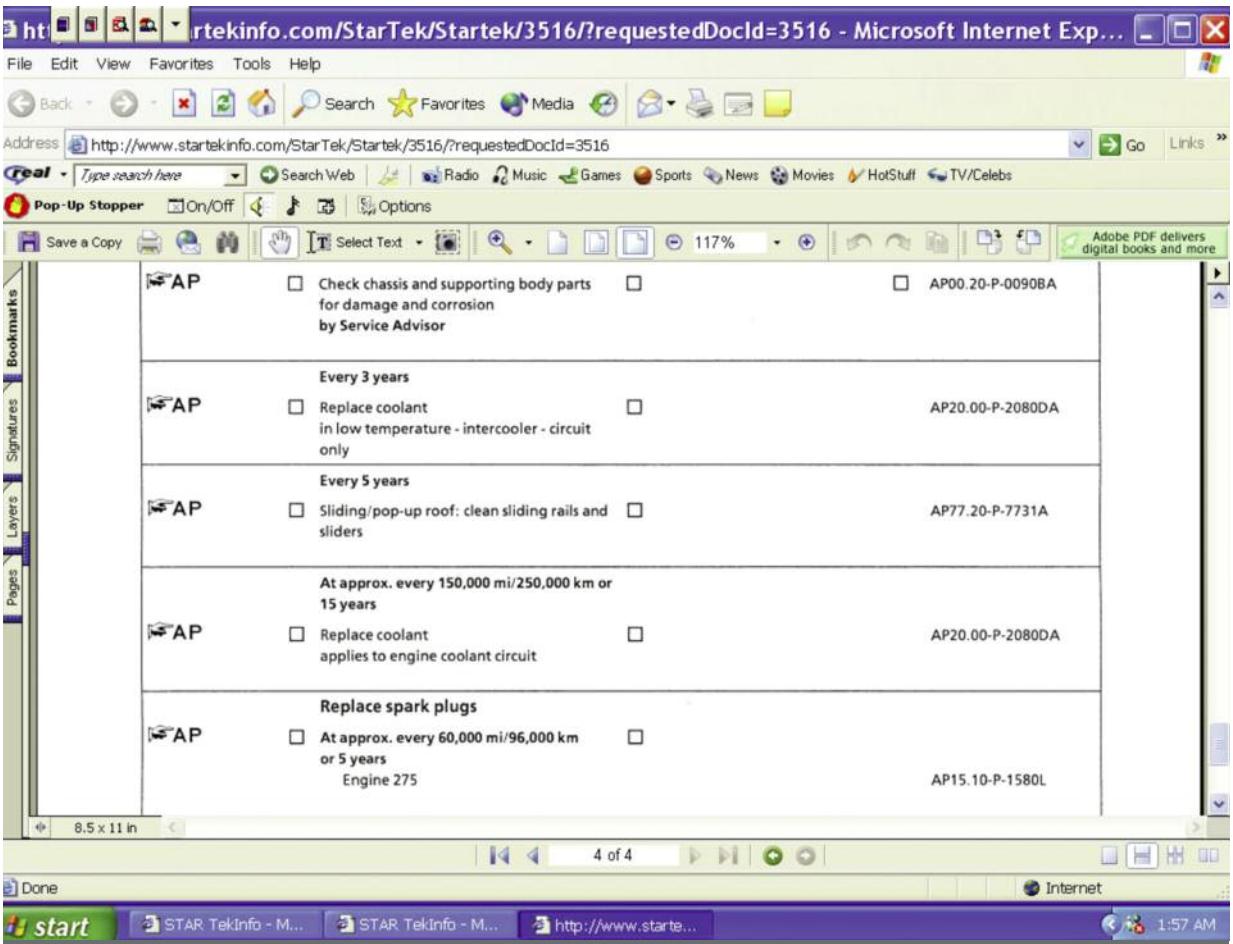
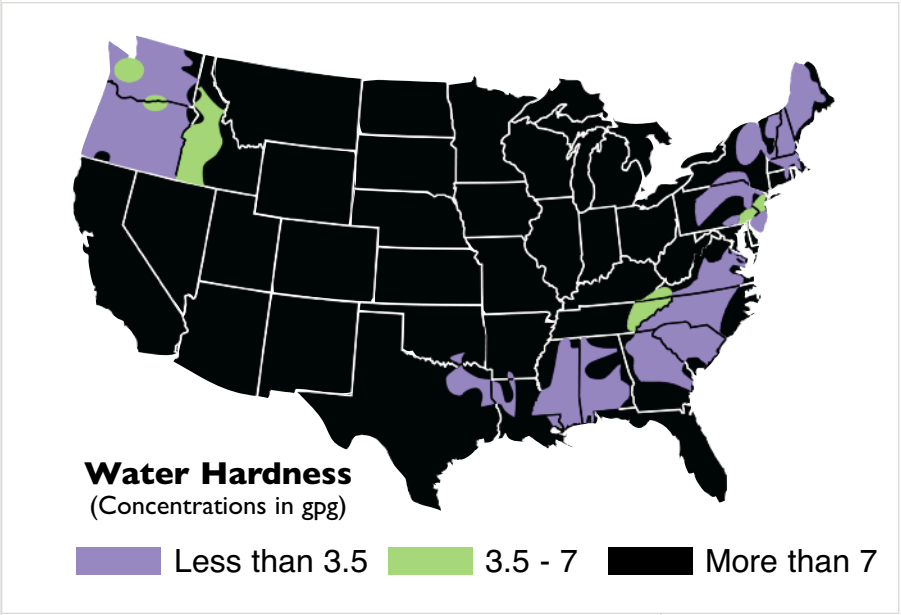


Section of the Mercedes maintenance chart for the S-Class shows a three-year coolant replacement interval for the "low-temperature circuit," which is the turbocharger intercooler. The interval for S-Class engines is 15/150.

When to Use Tap Water in a Cooling System, and When Not To



Tap water, even if it's good enough to drink, is not necessarily good enough for a car's cooling system. Hard water is the primary issue, and water in the U.S. is generally hard. But what does hard really mean and how hard is too hard?

Tap water that comes from underground wells and aquifers may pick up mineral and metallic particles, primarily calcium and magnesium, which are the key ingredients in "hardness." Approximately 17 parts per million of these particles are the starting point, and any number over 120 ppm is considered somewhat hard. Most household "hard water" measurements are in grains – 17.1 ppm equals one grain, and 7 grains is equal to 120 ppm.

In some areas the water hardness is as high as 850 ppm – 50 grains. For automotive use, you wouldn't want to use anything close to that. In fact, the best policy is to use only water 7 grains (120 ppm) or lower, and the lower the better.

Elsewhere in this report, StarTuned notes that Mercedes anti-freeze avoids the use of inhibitors that may cause special problems in hard water. However, don't take that to mean that using Mercedes anti-freeze prevents any issue with hard water. It doesn't. Hard water still is not good for any cooling systems, because the minerals and metals may result in deposits that could restrict heat exchangers. In addition, if the water is very hard, metallic particles may contribute to electrolysis failure of automotive heat exchangers. Virtually all coolant is at least slightly conductive. And if you ground a voltmeter and insert the positive probe into the coolant, you'll find a small voltage–often under 0.1 V. Metallic particles in coolant add to the current-carrying ability of the coolant (equals higher voltage that forces current through the heater and/or radiator to electrical ground to complete the circuit). This electrical activity causes corrosion to form and the corrosive deposits may restrict either or both heat exchangers

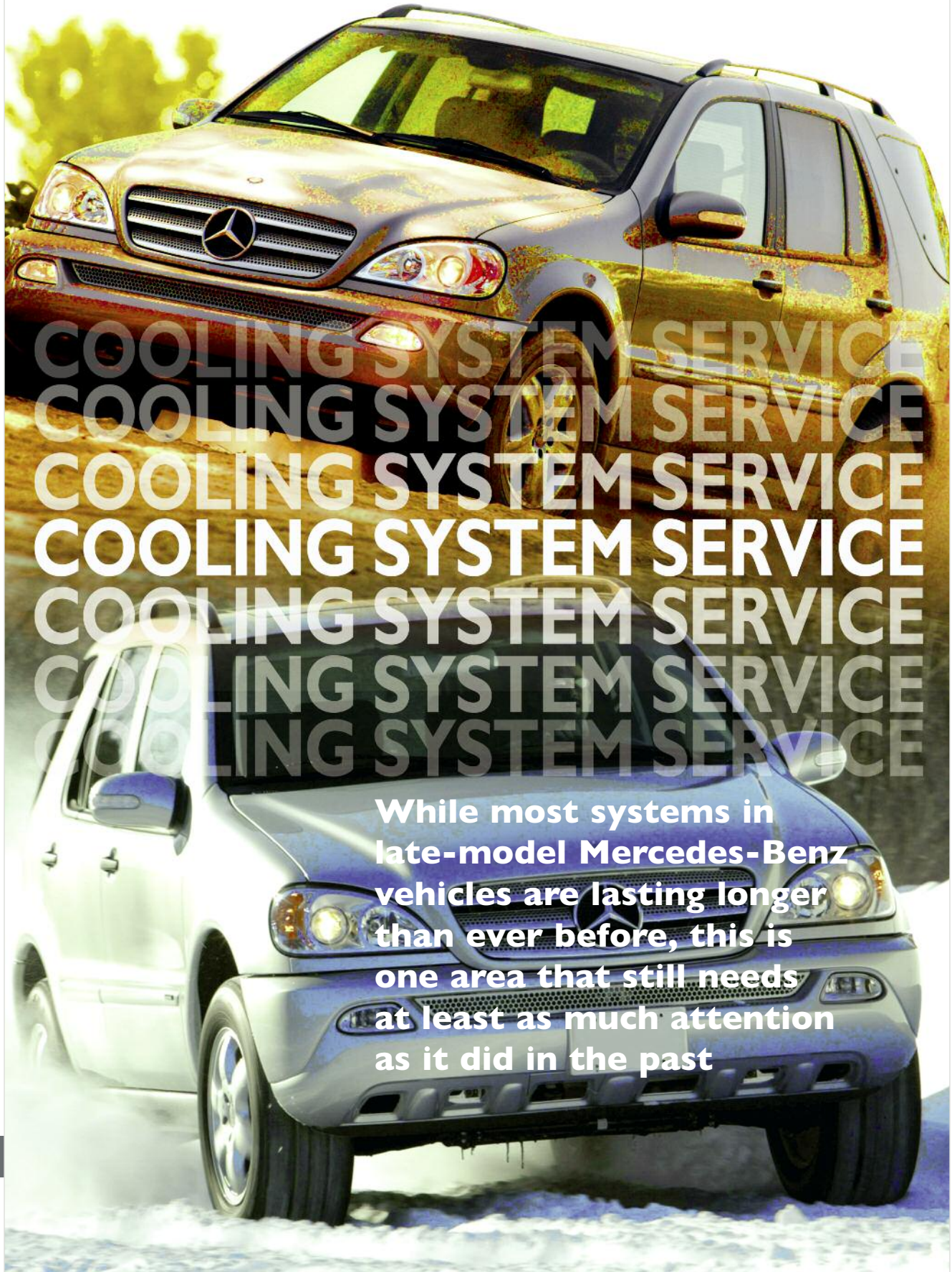
How can you tell if the water is "soft" enough for use? A simple way is to look at household use of water in your area. The water is hard if laundry requires more than the minimum amount of detergent to clean clothes, if deposits build up in sinks, tubs and washing machines, and if household spray irons and coffee makers plug up and require frequent cleaning. Water test kits are available, or ask a local distributor of water softening equipment to test for you.

Or you can pick up containers of distilled or deionized water, sold in supermarkets. For well under $1 gallon, it's an inexpensive item for which a customer should be willing to pay when you explain the advantage.

Distilled water has been boiled to a vapor, which then is condensed, so virtually all of the hardness grains are left in the boiler.

Deionized water (also called "demineralized water") is softened water. The water is passed through a resin bed, in which the calcium and magnesium ions are "exchanged" for sodium. Yes, the salt content of the water goes up a bit, but the water is even lower in content of the hardness grains than distilled water. So it's suitable for automotive use, too.

Growth Area:



While most systems in late-model Mercedes-Benz vehicles are lasting longer than ever before, this is one area that still needs at least as much attention as it did in the past

Winter is probably not the time when you're thinking about overheated engines, but this condition is more common than you might think in any season of the year. Summertime is when you might get more customers reporting that their cars are running hot – hardly surprising, since it's hotter outside and you have the added load of the A/C condenser. But you need to think about the cooling system in the winter as well – they don't call it anti-freeze for nothing.

To the layman, the engine cooling system is a simple undertaking: Just pump water through the engine to extract excess heat. But good technicians know better. There's nothing simple about it, especially when there's a problem to be located. The layman isn't far off, however. It really is just a liquid used to move heat around. But, as we all know, the devil's in the details.

Although modern engines are much more efficient at converting the heat released in the combustion chamber into useful work than their predecessors were, there would still be plenty of waste heat left to destroy the inner workings if it were not carried away by the cooling system.

Waste heat

Even modern, fuel-efficient engines generate large amounts of waste heat – better than half the energy put into the internal combustion engine comes out as heat, not work. Left to itself, the metal of the engine would eventually melt if all that heat wasn't managed. Air cooling just isn't enough for a large engine, so, like the iron horizontal single in the very first automobile (the Benz Patent Motorwagen of 1886), we use water, or at least a mixture of water and some helpful chemicals. Bertha Benz, on that famous first car trip, used more than ten times as much water in keeping the engine cool as she did gasoline to make it run.

The engine of the 1886 Benz Patent Motorwagen was water cooled, and that copper jug on top served as the heat exchanger. It wasn't pressurized, however – the water just boiled off.

Engineers carefully create passages within the engine to allow liquid coolant to flow, extracting the excess heat both quickly and evenly. Heat always flows from hotter areas to cooler areas, which is actually the second law of thermodynamics, so the exact rate of heat transfer depends on the temperature difference. A greater difference means faster heat flow. If you don't like your coffee too hot, delay adding the milk, which would cool it down, since the hotter black coffee loses its heat to the environment faster than the cooler milk-laden brew would. Engine designers know this, too, so the coolest water is introduced into the engine where the greatest amount of heat needs to be extracted.

(Continued on page 20)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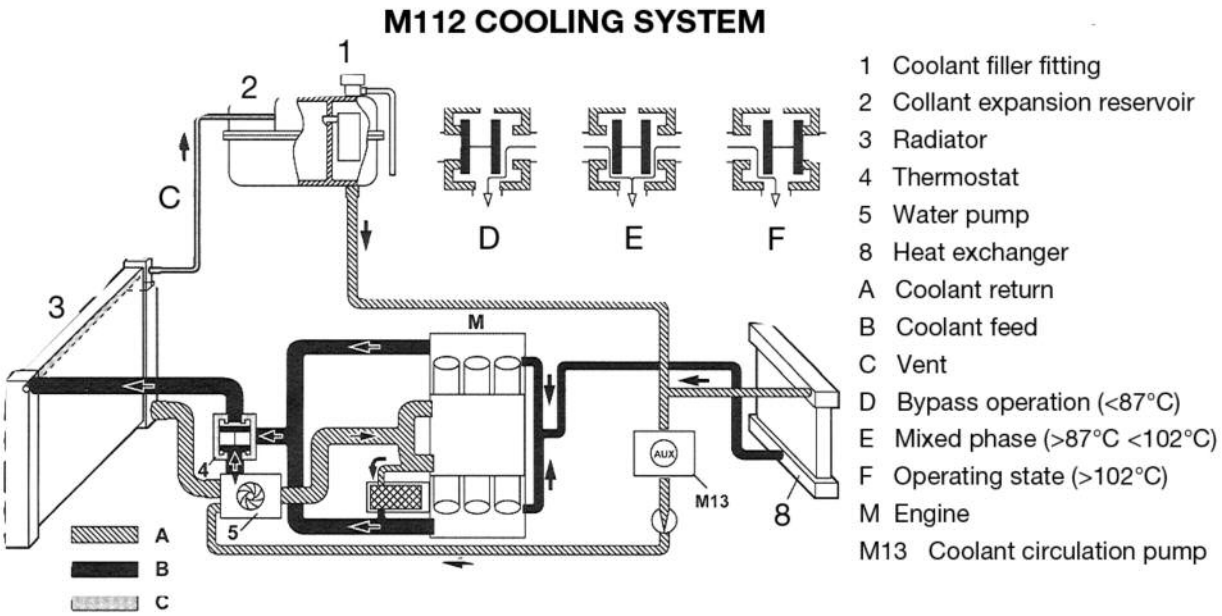
(Continued from page 17)



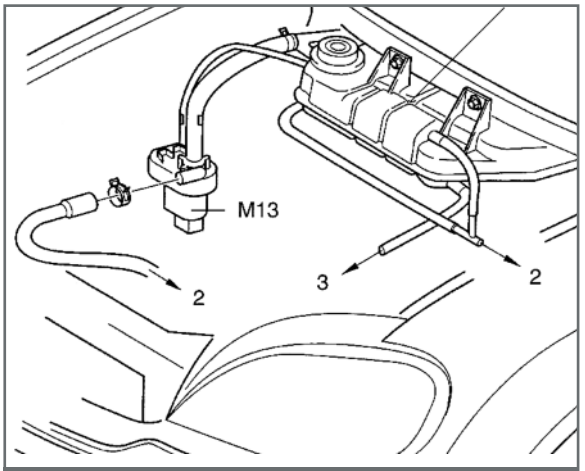
This diagram of an M-Class V6 cooling system shows that the coolest water is introduced into the engine where the greatest amount of heat needs to be extracted. Also, note the auxiliary coolant pump (M13).

Even the flow rate is calculated for greatest effect. Mercedes engineers validate their designs every August in Death Valley, CA by driving in some of the hottest weather imaginable, with the A/C on, of course, to see if their calculations of thermal capacity pass the real-world test. Disturb any part of that carefully-designed system, and on a cool day you might not notice. But let it get a bit warm out, or start towing a load and you'll see the needle pegging in no time, which can lead to catastrophic (and expensive!) damage.

Exchange and efficiency

Once you pick up all the heat, you have to dump it somewhere. While a little bit is useful in heating the passenger cabin, the bulk of the heat is transferred to the local environment by air flowing (forced by the fan and the forward movement of the car, and aided by convection) over the radiator. Again, heat transfer is proportional to temperature difference (called the "delta"), so the idea is to get the coolest air to flow over the hottest possible coolant. You see, the actual temperature of the system doesn't matter much (as long as it's within the limits of the materials involved), just the absolute amount of heat transferred in a certain time.

In other words, there's a good reason why modern engines run hotter than those of just a generation ago: Efficiency. Hotter engines burn fuel better, and hotter coolant moves heat more efficiently. Everyone wins.



Some Mercedes models use an electrically-powered auxiliary coolant pump. Controlled by the All Activity Module, or AC push button unit, it maintains a consistent flow at low speeds, helps get heat to the cabin, and runs after the engine is shut off to prevent hot spots and heat soak problems.

Water vs. glycol

The ability of a material to absorb and release heat is known as its specific heat. Water has a very high specific heat, which means that it would be an ideal fluid for the movement of heat. The only problem is that it doesn't have a great temperature range for that task – it boils and freezes under fairly ordinary conditions. Nonetheless, a cooling system running pure water would run the coolest. We had a neighbor who insisted on running 100% anti-freeze in his pickup truck. Despite our scientific explanations of specific heat and viscosity, he stated, "It runs hot already – if I added water, it'd really be boiling over, so I'm sticking with the pure stuff." He never did understand why it ran hot in the first place.

Unfortunately, water also causes corrosion and deposit formation, which is a big problem in a cooling system since it clogs up the small passages in the radiator and engine and also interferes with heat transfer. While distilled water won't cause mineral deposits and contains no harmful chemicals such as chlorine, it's actually the worst for corrosion since it has a strong affinity for just about everything, which grows even stronger when it gets hot. To prevent this, we add at least a small amount of impurity, designed to satisfy the water's thirst for metal.

Freezing

If the water temperature falls below the freezing point, it freezes. Seems obvious, but that's the most important reason to add even more impurities to the cooling water, to prevent it from freezing. Frozen water does not circulate, and it cannot carry the excess heat away. Although the heat of the engine will quickly melt what's in the block, that heat will never reach the radiator. If that weren't bad enough, water has a very nasty surprise for us when it freezes.

Most materials shrink when they get cold, and expand when they get hot. A mercury thermometer is proof of this, and the effect is very linear across a wide temperature range. Water, though, is different: Cool it down and it contracts, all right, until about 38 deg. F. Then, it starts to expand again. By the time the water freezes, it has expanded a few percent and, since it's now a solid in a confined space, it has the power to crack open the strongest engine block. Freeze plugs are installed in the block to help relieve the pressure, but they are not always effective.

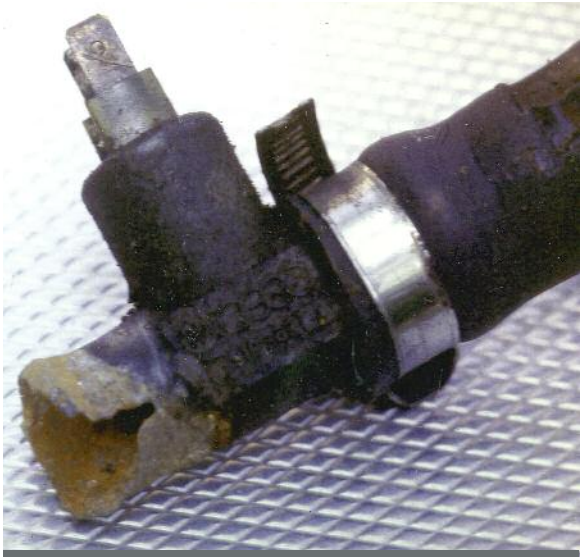
Modern anti-freeze uses ethylene glycol and other chemicals to lower the freezing point of the coolant to some range that's determined by the percentage of water in the mix. A 50/50 mixture freezes around -34 deg. F., plenty of protection for most places. If you live where it gets colder than that, move.

Boiling hot

Similarly, the anti-freeze also raises the boiling point of the water slightly, but that effect is hardly worth mentioning. Not that it's too small to be of notice, but it's really not necessary – we can also raise the boiling point of water by increasing the pressure contained in the cooling system. At one atmosphere, pure water boils at 212 deg. F. Add 50% anti-freeze, and that goes up to 225 deg. F. Raise the pressure to 2.4 atmospheres (about 20 psi) and it now boils at 275 deg. F. Although the anti-freeze helps with boiling point, it's the pressure cap that allows modern engines to run at 120 deg. C without overheating.

Corrosion and goop

Even though adding anti-freeze to the cooling system actually reduces its efficiency (as we said, by reducing the specific heat of the fluid) and it's not really necessary for boiling protection (that's what the pressure cap is for), there's still a good reason to use it: corrosion protection. Metal corrodes, rust for iron and steel, and white oxide for aluminum, and when that happens inside an engine, it can't be good. Increase the temperature, and the chemical reaction speeds up. While most anti-freeze solutions provide reasonable protection against rust, not all work as well on aluminum. Mercedes-Benz has used aluminum blocks for a long time, and their anti-freeze solution is carefully formulated to prevent aluminum oxide.



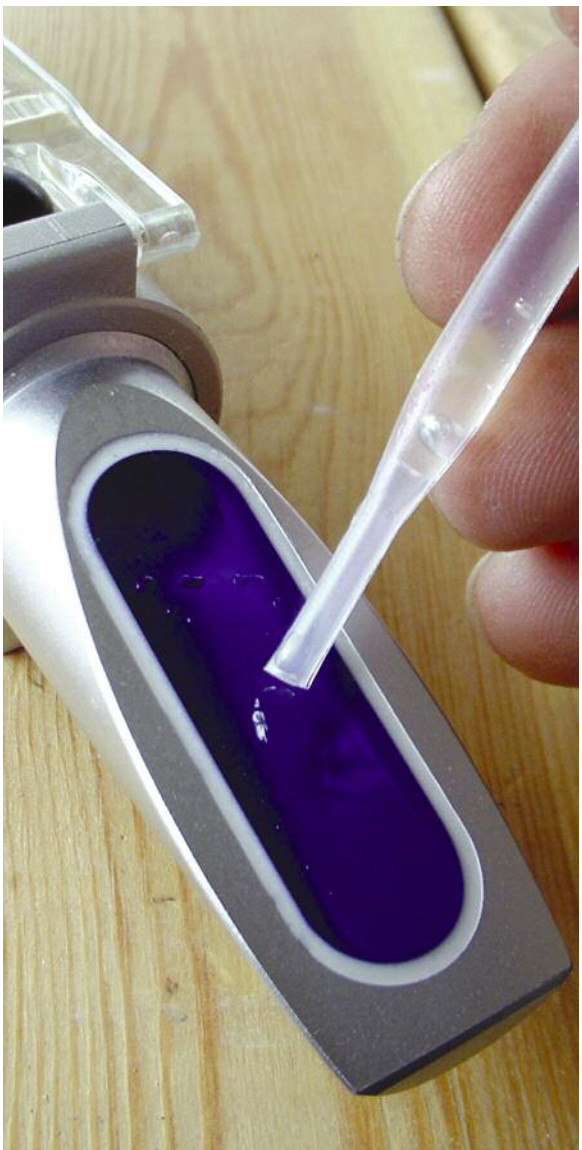
Neglected coolant maintenance, or the use of the wrong anti-freeze, will not only lead to clogging and inefficient heat transfer, but also to component erosion/corrosion and leaks at connections and joints.

In the shop, it's always obvious which cars used the real stuff, and which the heavily advertised generic. Aside from color, the goop that forms with the generics is simply absent from the cars using the M-B anti-freeze. That goop, made of chemicals in the anti-freeze that react with the metal of the cooling system, turns into sludge and eventually gums up the whole works. Generic might be a little cheaper, and it'll do in a pinch, but we always use the real stuff in our own cars.

Reality check

With that review of essential cooling system theory out of the way, we can move on to applying the science for practical purposes. How many times have you had a customer come in and say, "It's running a little hot. Can you have a look at it?" Hopefully, the driver actually understands the normal temperature for his car, and now sees the gauge registering higher than usual. In case you didn't know, a Mercedes engine isn't overheating until the gauge hits the red, usually around 120 deg. C. The point is, an engine that ran at 95 deg. C when it was new might regularly hit 105 deg. C after some miles, and that's not a cause for major alarm.

The first step is to have a look at the coolant - with the engine cold, of course. Imagine the danger of suddenly releasing the pressure on a cooling system that's above the boiling point. Because the pressure is released, everything in the entire system boils all at once, causing the scalding hot coolant to spew wildly about. Anyway, the coolant should be clean, clear and bright, not murky and clumpy. Using a hydrometer or refractometer (the better choice), check the percentage of anti-freeze. As we said, too much will cause an engine to run hotter.



The hydrometer has been the standard tool for gauging the percentage of anti-freeze in the coolant blend for decades, but a refractometer is far more accurate and dependable.

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If you can peer inside the radiator (maybe by removing a cap or hose, or perhaps by pressing a boroscope into service), that can give you some big clues on the system's condition. Heavy whitish corrosion and/or colored jelly are signs of a system in trouble.

Flushing

If the overheating is mild, and has built up gradually over time, then cleaning out the cooling system will probably do the trick. Mercedes sells powdered citric acid for this purpose, which you mix with water and run through the system (after draining it, of course) for a few minutes, and then flushing out the system again. Draining a Mercedes engine properly takes more than just opening the radiator petcock. Don't forget the drain plugs in the block as well. In every case, there is a published procedure, and it's always best to look it up or ask your local dealer about it.

If a leak isn't obvious, a pressure tester is still the first thing to use to locate it. Pump up the system, then look around under the hood with a good light and listen carefully for hissing.

A basic flush without the acid cleaning is also an item on the regular maintenance sheets, and should be done as a matter of course every few years, depending on the model. After a few years, the additives in the anti-freeze can turn acidic and slowly but surely cause permanent damage. A simple drain and refill, as with brake fluid, can prevent a lot of problems for little cost. We've never been fond of extended-life claims for coolants because this maintenance is relatively cheap compared to the repairs it might prevent.

Sometimes a flush helps, sometimes not. If there is a faulty component in the system, it needs to be replaced. While we most frequently find components whose only fault is a leak, these are rarely the cause of overheating. Coolant loss can be from a simple hose, connection or heat-exchange component leak, or from a more serious problem such as a blown head gasket. Pressurizing the system with a hand pump is still the primary method of locating leaks. Combine that with your boroscope inserted into the spark plug or glow plug holes to search for head gasket leaks. Of course, you know to look for telltale whitish residue.

In hard cases, nothing will work better than adding fluorescent dye, running the engine, then looking around with a UV light.

Note that a small drip from the weep hole at the bottom of the water pump housing is completely normal. The coolant helps lubricate the pump shaft seal, and a few drops will always get past.

Clogs

If the overheating started suddenly and ferociously, then there's probably something impeding the flow of coolant. A common suspect is the thermostat, but don't just drop in a new one and call it a day. Personally, we've found chunks of rubber hose, cigarette butts, and a handful of leak-stop particles clogging up the works, sometimes in unexpected locations.

When you get a complaint of no heat, you need to check the heater core circuit for clogs. If a flush makes no difference, check water flow using a garden hose. Be sure to open the monovalve by removing power from it, or opening the heat valve in older cars, or nothing will flow.

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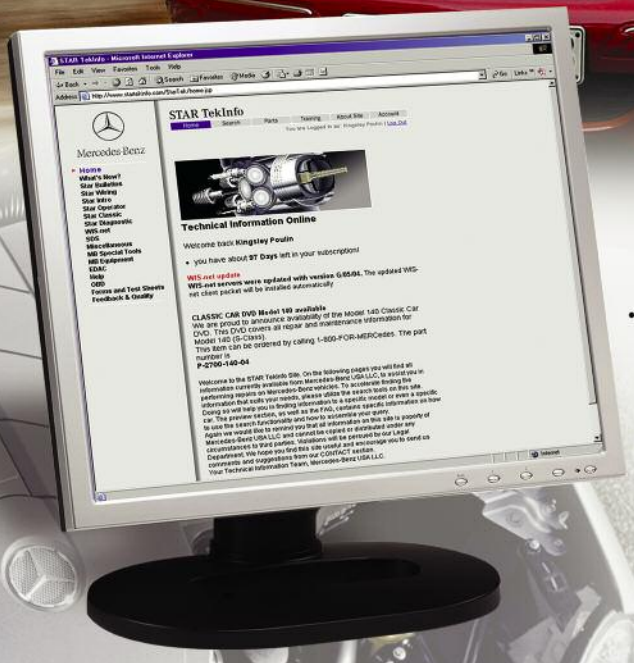

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After you get a basic understanding of heat flow from using a non-contact infrared pyrometer on normal systems, it can help you locate clogs and hot spots.

Components

In difficult cases, you may have to remove components from the system and check them individually. Thermostats are checked in a pot of hot water with a thermometer. The radiator is checked for flow with a garden hose (with the engine cool as you don't want to cause thermal shock). Try running the water through backwards, and any crud will get washed away. Anything less than full flow needs to be corrected. Hoses are inspected on the inside carefully by eye, finger and flashlight. If you find any deterioration or sponginess, replace it, even if chunks aren't falling off it. They're cheap parts compared to a ruined engine.

Check the water pump as well. Some aftermarket pumps have been known to have large clearances between the impeller and body, hurting pumping efficiency, and there have also been cases of loose impellers. Mercedes-Benz pumps are quite reasonable, and warranted, of course. And don't forget to check the pressure cap because if it blows off at too few psi, there will be coolant loss, and if at too many psi it may cause some other component to start leaking.

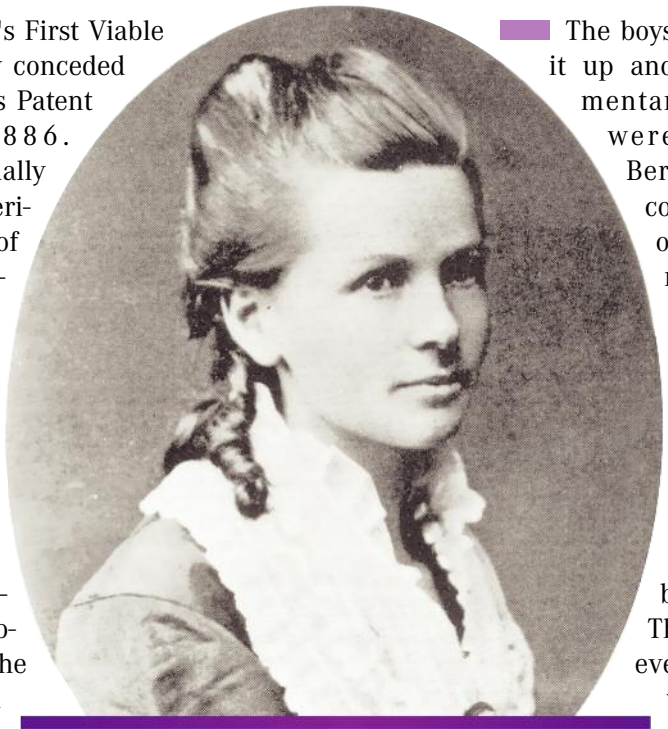
One frequently underestimated component is the fan shroud. If missing or damaged, average operating temperature will increase by perhaps 10 deg. C. While you're there, make sure the engine fan is working properly by seeing that it's spinning well with the engine running, and reacts when you rev it up. Also, run the engine long enough to ensure the electric auxiliary fans kick in – run the A/C to speed up that process. Blown fuses and worn motors are not unheard of.

If the overheating complaint is not due to one of the removable components (thankfully, it usually is), then you have your work cut out for you. Most customers wouldn't pay for an engine teardown for a mild overheat complaint, so you're limited to inspecting what you can, making sure the system is clean, having the right anti-freeze mix in there, and being reasonable about what constitutes overheating. Having the gauge edging near the red when idling in beach traffic in July with the air conditioning on is not necessarily an indication of system trouble. Educate your customers on how to help the system cope with severe conditions – shifting to neutral to remove load, holding the throttle open a little when the car's not moving to increase pumping speed and get that fan spinning, even shutting off the A/C, if necessary.

By the way, the possibility of overheating incidents is one reason for the trend at M-B toward synthetic motor oil. Sure, it costs more, but it can avoid incredibly expensive internal engine damage because its film strength holds up at far higher temperatures than does that of ordinary oil.

Although pure water carries the most heat, we need to treat it with anti-freeze to keep it from damaging the engine and cooling system components. A regular maintenance program of coolant replacement, along with inspections of hoses and other components, helps prevent catastrophes. When problems do occur, they need to be diagnosed just as carefully as those in any other system, and addressed. While the cooling system may seem simple, it is one of the more complex and critical mechanical systems in the vehicle.

Bertha Benz's Famous Ride



The title of the World's First Viable Automobile is generally conceded to belong to Karl Benz's Patent Motorwagen of 1886. StarTuned's editor actually had the chance to experience driving a replica of this engineering landmark built from the original prints, thanks to Mercedes-Benz and Hemmings Motor News. Sitting way up high on a not-so-stable three-wheeled chassis gave us a true appreciation of the courage exhibited by Bertha Benz, the inventor's wife and mother of their two sons, when she took her famous ride.

It seems that Herr Benz didn't have iron-bound faith in his own creation, so had never driven it farther than about 20 km. There were other impediments such as frightened horses and outraged citizens. Frau Benz, however, whom her husband later described as "fearless and courageous," was unfazed by such concerns, and had great confidence in Karl's achievement. Since her husband didn't seem about to prove that it could withstand a long trip, and, by extension, that travel by automobile was a practical proposition, she was determined to prove it herself.

So, one morning in August, 1888 she roused their two sons, 15 year-old Eugen and 14 year-old Richard, out of bed while Karl was still asleep, and together they pushed the Model 3 out of the shop and far enough down the street so her husband wouldn't hear it start. As you might expect, the boys were deeply into the details of their dad's contraption, so were pretty good mechanics. Bertha left a note for Karl saying that they'd gone to visit her mother, who lived in Pforzheim, but not mentioning that they intended to do so in the Motorwagen.

The boys had no trouble firing it up and mastering the rudimentary controls, so they were off. Apparently, Bertha's notion of the country roads that led out of Mannheim wasn't very precise, so their route was circuitous at best. This added distance meant that the five-liter fuel tank was woefully inadequate, and Frau Benz had to stop at several pharmacies to buy benzine.

The cooling system was even more demanding than the carburetor. Since it wasn't pressurized, water simply boiled off to the tune of well over a liter per kilometer.which necessitated numerous refillings at farms, wells and ponds along the way.

By evening, they hadn't quite made it to Bertha's mother's house, so they stayed at a hotel. Meanwhile, Bertha was thoughtful enough to send Karl two telegrams during the day to let him know that they were the ones who'd taken the car, and that they were safe.

The somewhat mischievous trio returned to Mannheim within a few days, and the round trip added up to an astonishing 180 km. One can only wonder what Herr Benz's reaction might have been when his wife burst in bearing newspaper accounts of the excursion. Talk about mixed emotions! She'd stolen his car, but she'd done it out of her faith in his work, and garnered publicity to boot. The boys were one thing – teenagers are usually up for anything, the riskier the better, and better yet if it involves mobile machinery – but what spurred a demure German housewife to motor around the countryside on marginal roads at up to 12 mph? Every man should have a wife who believes so strongly in him.

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FACTORY SERVICE BULLETINS

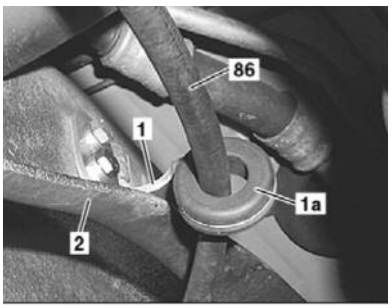
These suggestions and solutions for technical problems come from service bulletins and other technical information published by Mercedes-Benz, selected and rewritten for independent repair shops.

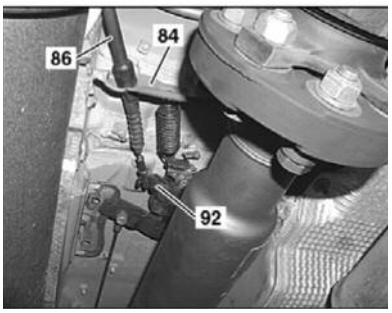
Noises from Parking Brake Cable

CL and S-Class, '00 through '04

A complaint of a noise coming from the rear of the vehicle may be due to a broken parking brake cable bracket. The original brackets are welded to the rear axle carrier and may fail from normal vibration, allowing the cable to rattle against the carrier or the sub frame.

Replacement brackets bolt on. Use the following procedure:





1. Pretension the parking brake's automatic cable slack adjuster (92 in the illustration). Refer to WIS document AR42.20-P-0520-01A.

2. Unhook the left and right parking brake cables (86) from the automatic cable slack adjusters and unclip them from the retaining plates (84) mounted on the undercarriage (Unclipping Tool W129 589 11 63 00 is available).

3. Bolt on the new brackets (1), then install their rubber grommets (1a). You can make grommet installation easier by coating them with liquid lubricant (Naphtolen H, BR00.45-Z-1003-06A).

Note: *Always replace both brackets even if only one is broken. Break off an unbroken bracket by bending it back and forth until the metal fatigues to failure, then file or grind down any sharp edges on the carrier.*

4. Clip the left and right parking brake cables into the retaining plates and hook them back into the automatic cable slack adjuster.

5. Slacken the automatic cable slack adjuster. Refer to WIS document AR42.20-P-0520-02A.

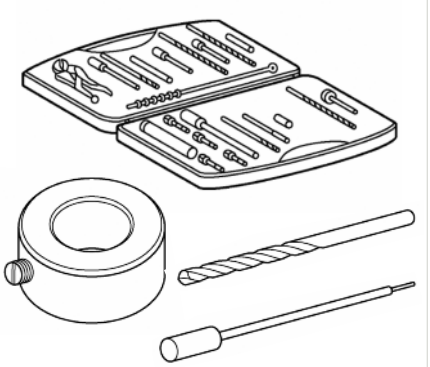
Note: *On vehicles that do not have pre-drilled holes in the rear axle carrier (2) for the brackets, you'll have to drill your own. Refer to WIS document AR42.20-P-2001-01I.*

6. Check the version of the pedal assembly. Refer to WIS document BT42.20-P-0510-01A.

7. Operate parking brake several times and check the pedal travel.

8. If the pedal travel is not within specs, adjust the parking brake according to WIS document AR42.20-P-0540I.

Repair Kit for Glow Plug Threads in Cylinder Head



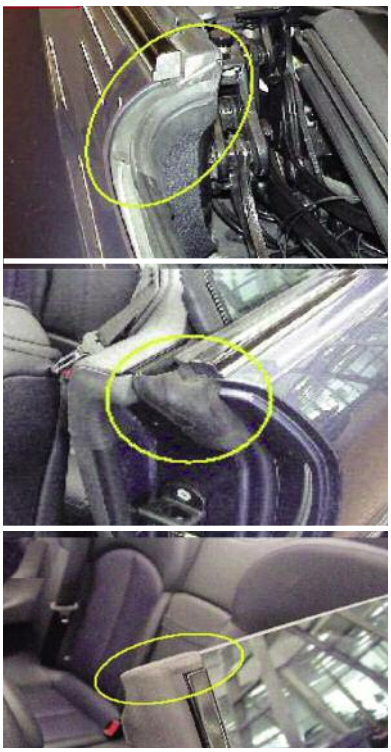
Save that expensive cylinder head! A repair kit is now available for damaged glow plug threads and/or broken off glow plugs. It makes it possible to accurately drill out the glow plug bore and install a threaded insert.

The repair kit can be ordered as a Special Tool (611 589 00 99 00), and costs $650. Also, the wear and tear components of the kit can be individually ordered as needed, along with additional replacement threaded inserts.

Cracking Noises from the Soft Top Seals with Roof Closed

CLK

This noise is probably caused by the sliding coating on the seals wearing at differing rates. If the coating is worn away, the seals can make cracking sound at the contact points while the vehicle is being driven.



It is not necessary to replace the seals to quiet things down. Instead, treat the areas shown in the illustrations with special sliding compound (A001 989 50 51) as follows:

1. Clean the contact points on the seal on both sides.

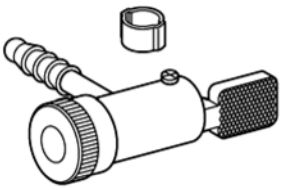
2. After cleaning, apply the special lubricant to the dry seal and allow it to soak in for approximately 20 minutes.

3. Open and close roof several times.

4. Remove any of the excess lubricant.

Sensotronic Brake Control (SBC) Bleeding Procedure

SL and E-Class, all years



The SBC brake hydraulic system must be bled with the menu-assisted STAR Diagnostics "Bleed Brake System" and "Inspect Brake System For Air" functions, or aftermarket equivalent, after the replacement or removal/installation of the following components: SBC hydraulic unit (A7/3), brake operating unit, suction line, pressure reservoir, brake lines or hoses, brake fluid reservoir, or brake calipers. Reference WIS documents AH42.10-P-0002-01T and AR42.10-P-0012R.

Further, when performing repair work on an SBC system, it is imperative that the brake system only be bled with Mercedes-Benz-approved bleeding equipment. The procedure requires that the unit must maintain a constant pressure of at least 2 bar, but not to exceed 3.5 bar. In conjunction with the approved brake bleeder, the electrohydraulic brake adapter (EHB) tool must also be utilized in order to ensure that the brake fluid receptacle bleeding hose is securely affixed to the brake caliper's bleeder screw (reference WIS document AR42.10-P-0010-02R)

Approved Mercedes-Benz brake bleeders are available through the MBUSA Standard Service Equipment Program (SSEP): 1-888-458-4040.

Tire Pressure Monitoring System Implausible Fault Messages

SL500

Implausible fault messages in the instrument cluster and/or implausible body electrical system function in Model 230.475 vehicles may be the result of a hardware fault in the tire pressure monitoring system control unit, which may impair CAN-B operation. This can cause malfunctions in the

instrument cluster and display instruments (jumps in fuel level or temperature indicator, for example). Various warning and fault lamps may go on and off in cycles, or exterior lights switch on and off without obvious cause. Depending on the duration of the malfunction, fault codes (CAN communication disturbance) may be stored in various control modules linked to CAN-B, such as tire pressure monitoring, SAM, EIS, lower control panel, vehicle power supply control module, automatic air conditioning, instrument cluster, etc.

The solution is to replace the tire pressure monitoring control module (N88), Part Number 001 820 95 26.

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