# STAYCOOL

## Summer is almost here so engine cooling systems and coolants need to be up to par

**WORDS & IMAGES** Paul Tuzson

ALL vehicle and engine systems have been up for critical evaluation and redesign for years in the pursuit of ever-greater efficiency and lower emissions. Engine cooling systems have a great deal to contribute to this effort. Consequently, some cooling system components that were once simple have been re-engineered into more complex forms to facilitate increased functionality.

In times past, most cooling system components were of cast iron or aluminium only and connected by rubber. As component forms have become more complex, things like thermostat housings are increasingly moulded from a range of plastics and similar materials suited to the harsh environment of the cooling system.

Manufacturers of the materials used for such parts strive to formulate their products for compatibility with current-generation coolants. Similarly, coolant manufacturers constantly work to create products suited to the increased range of materials appearing in engine cooling systems.

A hunt around the internet looking for information about how coolant works turns up very little about the specific chemical details. It's a bit like brake friction material: no one wants to talk about it. However, there's a great deal of material available about whether ethylene glycol (EG) or propylene glycol (PG) is the better coolant base fluid. Local coolant manufacturer PrixMax was good enough to explain to us the role of glycol, along with other, deeper details of coolants generally.

Ethylene glycol is cited as the better freeze point depressant and it has a higher boiling point. Its higher heat exchange capability and lower viscosity (better fluidity) makes EG a better medium for heat transfer than propylene glycol. The fluidity of a coolant is extremely important and modern engines are designed for variable flow rates around the overall cooling system. For instance, the flow path past a hot area like an exhaust valve seat may be designed with narrower passages to speed coolant flow and remove more heat. As with all things in automotive engineering, coolant flow is a balancing act.

Ethylene glycol and propylene glycol have different viscosities and these become more apparent under conditions where the engine is operating near its thermal capacity. This is because EG and PG thin considerably differently at high temperatures, like those present in underground mining or pit mining. PG may struggle under those conditions.

EG and PG interact with plastics and elastomers fairly similarly and although the chemistry of coolants and seals is complex, it's also well understood. Even so, physical testing is still necessary to establish the exact effect a coolant will have on a seal. For instance, some coolants are harmful to Viton seals while others aren't.

Most of us can probably remember problems in locally produced cars from coolant/seal mismatches years ago. Physical testing is the best confirmation that this won't happen again. Some of the mechanical tests employed are for tensile strength, hardness, swelling, contraction and cracking.

Ethylene glycol has a higher surface tension resulting in less leakage. Propylene glycol has demonstrated greater resistance to cavitation in some laboratory studies, probably because of its higher viscosity. However, that's for pure glycols. Adding inhibitors can change things considerably and inhibited EG performs better than inhibited PG. In the end, though, the differences between EG and PG are pretty minor. It seems that each performs about as well as the other in engine testing. In the field it's a matter of application and specific formulation.

Propylene glycol is much less of a health hazard, although fish don't like it because it absorbs oxygen from water. So spills can kill marine life. On the other hand, in some applications it's actually a food additive in its pure form. It's also used in cosmetics.

Ethylene glycol on the other hand is very poisonous. Yet it's the more common type because it's cheaper, and glycol can be one of the most expensive components in a coolant.

The important point about all of this as far as Australia is concerned is that both ethylene and propylene glycols are anti-freeze agents and therefore, not very relevant in this country because our cars virtually never freeze. Now, while temperatures do get down to zero and below in various places around Australia, they don't stay there long enough for the coolant in an engine to freeze solid.

About the only time a car will experience sub-zero temperatures for long enough to turn its coolant into a block of ice is if it's parked at the snow for a week in a decent season. So, under these, or similar conditions, a glycol-based coolant is necessary but in general, in Australia, coolant can function perfectly well without any glycol in it.

It's also widely understood that coolant raises the boiling temperature in an engine, which is very relevant in this country. Glycol-based coolants can raise the boiling point by up to nearly ten degrees in a 50/50 glycol/water mix. This is the most common mixing ratio recommended by car manufacturers: 66 per cent glycol is generally the maximum car manufacturers recommend before it becomes too viscous.

Raising the boiling point through coolant formulation seems important when considered in isolation, but things aren't as simple as that. Most of the increase in boiling temperature is due to the fact that cooling systems are closed and pressurised. While a glycol-based coolant does contribute something to an elevated boiling temperature, proportionally speaking it isn't much; the main increase comes from higher pressure. But it's not as simple as that either.

The thing about either ethylene or propylene glycol is that its thermal capacity is vastly inferior to that of ordinary water. In fact, glycol can only absorb about half as much heat as water in a given time period. This gives drivetrain engineers a choice: they can

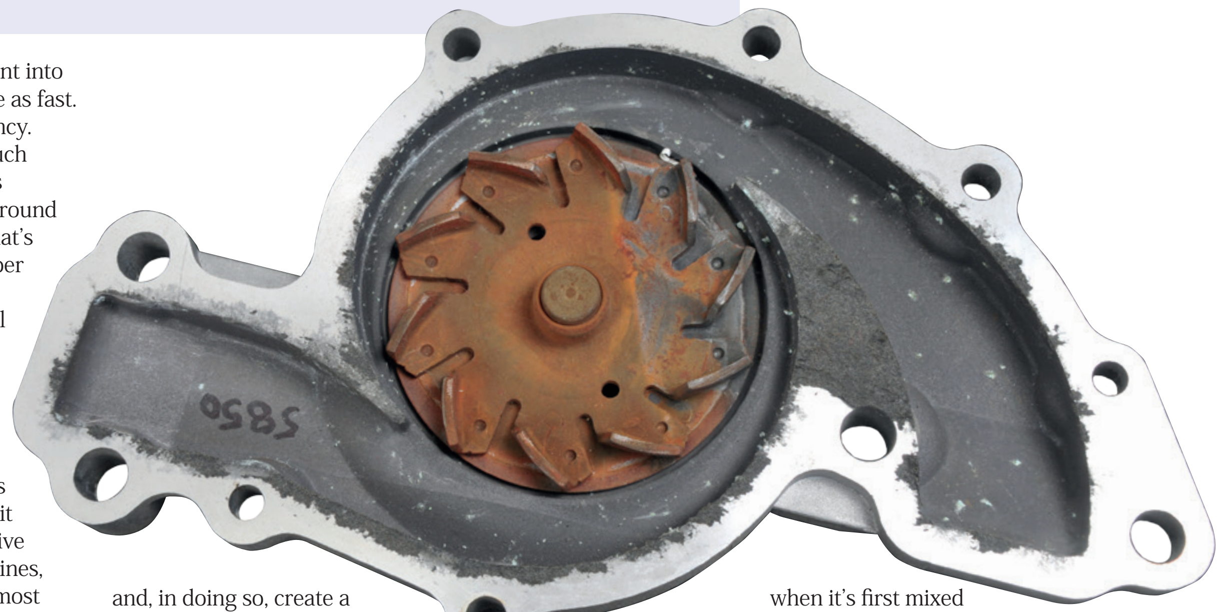

TOP TO BOTTOM: AN ATOMIC ABSORPTION SPECTROPHOTOMETER VAPORISES AND BURNS CHEMICAL SAMPLES

THE RESULT IS EXAMINED UNDER LIGHT AND THE SPECTRAL SIGNATURES OF SAMPLES ARE ESTABLISHED. SIX LIGHT GLOBES ARE AVAILABLE FOR DETECTING DIFFERENT MATERIALS

HPLC: HIGH PRESSURE LIQUID CHROMATOGRAPHY: LIQUID SAMPLES ARE EXAMINED AND ALL IS REVEALED. THERE ARE NO SECRETS LEFT ONCE SAMPLES HAVE BEEN THROUGH THE MACHINES

SOME COOLANTS COME FROM ENVIRONMENTS SO HARSH THAT PROBLEMS ARE VISIBLE TO THE EYE. THIS IS FROM A MINE IN ASIA AND SOLIDS ARE READILY DISCERNIBLE

LEFT: THERMOSTAT HOUSING – NEWER MATERIALS USED IN COOLANT CIRCUIT COMPONENTS MUST BE COMPATIBLE WITH ORGANIC COOLANTS



BELOW: THERE ARE GOOD AND BAD PUMPS. UNLESS AN IMPELLER IS PROPERLY FORMED AND HAS THE CORRECT RELATIONSHIP WITH THE HOUSING IT WILL CREATE CAVITATION. THIS IS SIMPLE RUST RATHER THAN CAVITATION

either put twice as much coolant into the system, or circulate it twice as fast. Each approach reduces efficiency.

Also, both EG and PG are much more viscous than water so it's harder to pump glycol mixes around a system in the first place. If that's not enough it's also about 10 per cent heavier than water. That raises the question: does glycol have anything going for it? Well, yes, it's a very effective anti-freeze. But again, we're talking about Australia.

The critical function of coolant additives in Australia is to prevent corrosion, not inhibit freezing. So some sort of additive package is essential for all engines, even iron blocks. It's just that most Australian coolants don't really need to contain glycol. Fortunately it doesn't hurt engines and the industry isn't going to change so glycol will continue to be used.

None of this is to say that coolant additives in general are less important than factory specifications suggest. The additives that are necessary are absolutely vital. Leaving them out or using the wrong ones will destroy an engine surprisingly quickly.

There are two basic classes of coolant, older inorganic types and modern organic formulations. There are also hybrids of the two. Conventional, inorganic inhibitors work by chemically interacting with corrosion in the same way phosphoric acid interacts with rust to turn it into a layer of iron phosphate and halt the corrosion. It's a process of conversion. However the resultant protective layer can break away over time and expose more structural material to further corrosion. The active components will again react and protect the surface, but the additives can become depleted fairly rapidly.

Modern organic type corrosion inhibitors work differently to this. Initially, they are adsorbed onto the surface they're designed to protect and, in doing so, create a molecular layer that prevents further corrosion. In technical terms an organic coolant coats the anodic site. The layer doesn't get thicker with time because the chemical action ceases when the appropriate areas of the metal are coated.

Each additive package for either inorganic or organic coolant has a range of chemicals designed to deal with specific materials. The trick is to get all the chemicals working together without interfering with each other. While an individual manufacturer with the right laboratory facilities can do it, it's most unlikely that mixing coolants from different manufacturers will result in a package of compatible chemicals, which is why different brands of coolant should, in general, never be used with each other.

So what does this mean for operators and service personnel?

Well, in most applications there's no need for glycol in coolant, even in an engine for which it's factory specified. Only the corrosion inhibitors are needed. Pre-mixed or concentrated glycol-free (water-based) coolants can be appropriate replacements for glycol-based coolant. And they're not only appropriate – they're considerably cheaper.

Topping up a system with plain water will dilute coolant. Doing so will weaken the protection provided by the additives. Coolant should always be topped up with a mix of the same coolant already in the engine. If this means making up extra coolant when it's first mixed then that's what should be done.

Distilled, de-ionised water is the only type that should be mixed with coolant concentrates. Although almost everyone would know this, tap water is still used. Some parts of the country have pretty good tap water, but others certainly don't.

Some tap waters are high in sulphates, chlorides or both. These are the corrosive ions in any mix.

ASTM International is a global standards organisation and it sets limits for chlorides and sulphates

BELOW LEFT: COPPER, SOLDER, BRASS, ALUMINIUM; RADIATORS HAVE IT ALL, PARTICULARLY OLDER ONES. CIRCULATING SOLIDS CLOG THEM BADLY

BOTTOM RIGHT: AN IRON LINER IN AN ALUMINIUM CASTING IS A CHALLENGE IF THE RIGHT COOLANT ISN'T USED



ABOVE LEFT: CAVITATION HOLES OFTEN LOOK LIKE THEY WERE MADE WITH A TINY DRILL.
ABOVE RIGHT: IT CAN BE WIDE RANGING AND THIN A WHOLE AREA BEFORE FINAL FAILURE

in water, on the general hardness of water, on the total dissolved solids and of course, on the pH. The more remote a location, the more likely it is that bore water will be used.

The calcium and magnesium ions in these hard waters can form a scale over the cooling system elements reducing heat transfer. The problem is worse at elevated temperatures. These films can also break off and become circulating solids that degrade seals and generally clog up a system. Where conditions like those outlined are prevalent, the best solution is to use a premixed coolant and top up systems when necessary using more of the same.

Maintaining coolant strength and consistency is another good reason for using a premixed coolant. Any engine in which coolant strength has been reduced from topping up is susceptible to corrosion. In iron, the result is rust and particles. In aluminium, it's aluminium oxides. It's worth remembering that abrasives are made from aluminium oxides and having these circulate through a cooling system is obviously bad and causes coolant pump seal abrasion, soft metal corrosion and cast iron liner pitting.

If a system has had the above-mentioned problems it should be flushed out, de-scaled and then filled with the appropriate coolant. When a vehicle or other engine-driven equipment is under warranty factory-blessed coolant will likely be the type used. That's all well and good but operators running different types and brands of equipment may have the annoying problem of purchasing, organising, storing and using different types of coolant to match a range of manufacturer specifications.

Filling an engine with the wrong coolant by mistake can lead to expensive damage. Under these circumstances, utilising the same coolant across a range of engines could simplify things considerably. PrixMax says that this is a typical need in many mining operations. The company also says that there have been no deleterious effects from using a single coolant in compatible engines provided that the equipment in question has been properly maintained at sites with good work practices. It's worth noting that many of PrixMax's mining customers are in the hottest regions of Asia and Australia.

Newer organic coolants are made of carboxylates, which are salts of carboxylic acids. These inhibitors remain effective over a wide pH range from slightly acidic to alkaline. Conventional or hybrid coolants have quite a high pH reading which must be maintained or they become acidic and the additives either won't work or may even work in the opposite way. So, maintaining the correct acid/base balance is one of the most important functions in formulating an effective coolant for a particular application.

The pH reading of a coolant can be reduced in a number of ways. For instance, PrixMax explained that corrosion processes lower the pH making coolant more acidic. Then, further corrosion will occur resulting in a rapidly spiraling degradation of the cooling system.

The correct pH reading in an organic coolant is maintained by a chemical arrangement known as buffering, which provides an alkaline reserve. It's a complex but neat trick. Basically, a weak acid and a related base are added to the coolant and react to form alkaline metal borates and phosphates. These maintain the coolant in an alkaline condition by neutralizing acid products formed by deterioration of coolant or by the entry of combustion products past a leaking cylinder head gasket, for example.

The current standard for coolants in Australia is AS 2108-2004. This defines Type A and Type B coolants. Type A is what's generally known as anti-freeze and under the standard it must have a freezing point of less than -12°C. That temperature corresponds with 25 per cent EG. So, coolant containing 25 per cent or more EG is a Type A coolant, or anti-freeze. Type B coolant containing between 0 per cent and 25 per cent EG will have a freezing point between -12°C (or possibly less) and 0°C.

The Australian Standard only relates to passenger cars and light commercial vehicles. There are no Australian Standards for trucks and heavy equipment. For those, European and other world standards are reference points. These generally specify glycol because of freezing northern climates.

However, there is often provision in OEM specifications from these regions covering glycol-free formulations for use in temperate climates. In summary, make sure any coolant you use for passenger cars and light commercial vehicles is compatible with Australian Standard AS 2108-2004. OEM specifications will be your guide for heavy vehicles.

Anyone who might consider glycol-free coolant a risky proposition should understand that PrixMax has world standard knowledge and experience in the field. Manufacturing coolant for the majors is a complex and technically detailed business and PrixMax in Melbourne is part of the ASTM D-15 Engine Coolants International Inter-laboratory Proficiency Testing Program. To translate, the PrixMax lab is evaluated, along with around 20 associated international labs, a couple of times a year for compliance with ASTM International Standards. PrixMax knows how to formulate quality coolants.

The laboratory and manufacturing operations are accredited against ISO 9001:2008 Quality Management Systems and ISO 14001:2004 Environmental Management Systems. Supplying to major car manufacturers calls for such compliance.

PrixMax is also producing the world's first carbon neutral certified coolants. This program is certified and audited by the Carbon Reduction Institute in Sydney. So, that's pretty cool. ■

BELOW LEFT: THIS IS A TITRATOR. IT ADDS A KNOWN VOLUME OF A SUBSTANCE TO DETERMINE ANOTHER SUBSTANCE'S CONCENTRATION. IT WAS A MANUAL TEST BUT MODERN EQUIPMENT IS MORE PRECISE

FAKE COOLANT

**Go to prixmax.com**
1800 458 459 – Technical Help
1800 458 000 – Coolcheck Analysis Program (laboratory)