



## Which brake fluid?

Whenever the topic of silicone brake fluid as a replacement for glycol is raised amongst classic car enthusiasts you soon see that some of the key issues and even some of the facts needed to make a balanced assessment are either not available or not sufficiently clear. So in the end each classic car owner has to make their own decision whether to change to silicone or stay with the original fluid, glycol. That decision is based on either their own view or, where they do not feel qualified or able to form a view, they will usually rely on the recommendation of the specialist who services their car.

The choice of fluid is a topic that does attract firm views from some quarters and in a few cases the assertions of the merits of silicone as a replacement brake fluid are made with a zeal that worries those who would prefer to see the issues more calmly presented and assessed. Well, when the topic reached this stage in a bulletin board thread on the V8 Register's website last November, it was felt an impartial article setting out information derived from original sources rather than hearsay would provide fellow members with the facts and other information as a basis upon which to make their own decision on "which brake fluid to use?" Bob Owen was approached by the chairman of the V8 Register to do the research and prepare the article as he had previously contributed a number of useful workshop notes and, whilst not a brake expert, he has a good understanding of physics from his electrical engineering training and has had a love of all things mechanical since he was a boy with a father who ran an agricultural engineering business. Equally Bob can claim to be impartial as he has some personal experience of both types of fluid having a 1974 MGBGTV8 using standard DOT4 glycol and a 1949 MG TC converted to DOT5 silicone fluid some five years ago.

Bob says "this article is an attempt to provide all the information you need to enable you to make your own choice of fluid". Nevertheless, it is important to stress that the content of this article is subject to the important caution and caveats set out in the conclusion.

## What do DOT3, DOT4 and DOT 5 mean?

DOT 3, DOT 4 and DOT 5 are standards for Hydraulic Brake Fluid performance defined by the US Department of Transportation, DOT. When it comes to Automotive Standards the US leads and the rest of the world follows; we have all heard of the SAE standard for oil, eg SAE20-50, again this is American, the (US) Society of Automotive Engineers. Broadly speaking each succeeding DOT type has a higher performance requirement than the preceding type. Although DOT 3 and DOT 4 cover glycol based formulations and DOT 5 covers silicone based formulations it is important to note that these standards primarily define performance, not composition. This means that the mixtures of chemicals used will vary from manufacturer to manufacturer depending on the market sector that they wish to address. This is particularly the case for glycol brake fluids where many manufacturers compete in a large market. Different mixes would be used depending on the aim, eg low price, good race performance, low moisture absorption for long life, etc. The DOT compliance defines a minimum performance; a particular product may far exceed the spec in its chosen area. For DOT 5 fluids the variation is much less since there are only two significant manufacturers, GE and Dow Corning (Union Carbide). This variation in exact composition can often make generalisations about the behaviour of a particular category of fluid problematical.

The criteria for the designations DOT 3, DOT 4 etc are set out in Federal Motor Vehicle Safety Standard (FMVSS) 116. (Note that DOT 1 and DOT 2 are obsolete). Caution: in the 1990s new glycol brake fluids were developed which met or exceeded the performance criteria of DOT 5. For some reason the US DOT regarded these as "non-silicone" versions of DOT 5 and gave them the designation DOT 5.1. Since glycol and silicone based brake fluids are considered non-compatible this can lead to confusion – it would have been much better designated DOT 6 or DOT 4A.

## What tests determine DOT compliance?

The current standard FMVSS116[1] defines thirteen parameters for which the fluid must meet or exceed the specified performance, those being:

**Dry boiling point**
**Wet boiling point** after exposure to a standard humidifying procedure
**Viscosity**
**pH** to ensure the fluid has no acidity
**Chemical and high temperature stability of parameters**
**Corrosion properties** tested on standardised metal test strips
**Low temperature fluidity and appearance** - no crystallisation at low temperatures
**Water tolerance** if it absorbs water there should be no sedimentation or stratification
**Low and high temperature compatibility** - no sedimentation or stratification
**Resistance to Oxidation** - longevity
**Effects on Cups** - standardised rubber cups should not be significantly affected
**Stroking properties** - operation in a standardised braking system
**Colour** for identification of the fluid

[1] *For a full examination of the spec see www.fmcsa.dot.gov/rules-regulations/administration/fmcsr/fmcsrruletext.asp?section=571.116*

Some of the tests are done on the fluid itself and others use a standardised brake test rig using drum brakes with 28mm internal diameter wheel cylinders (the rig is defined by SAE J 1703 Nov 83). Further explanations of some of the tests are given below. Some figures from the spec are shown here:

| | DOT 3 | DOT 4 | DOT 5 | DOT 5.1 |
|---|---|---|---|---|
| **Dry Boiling Point, min** | 205C | 230C | 260C | 260C |
| **Wet Boiling Point, min** | 140C | 155C | 180C | 180C |
| **Viscosity max At -40C** | 1500 $mm^2/s$ | 1800 $mm^2/s$ | 900 $mm^2/s$ | 900 $mm^2/s$ |

**High boiling point** is important in demanding braking situations where the brakes are generating great quantities of heat. If the fluid boils it turns into a gas and gases are very compressible – not a feature you want in a hydraulic braking system.

For the **wet boiling point** test the humidification process exposes the fluid being tested and a standardised SAE glycol brake fluid to the same humidification process until the SAE fluid reaches a water content of 3.7% by weight. This illustrates one of the weakest features of glycol based fluids – they are hygroscopic, ie will readily absorb water. The presence of water significantly lowers the boiling point of the fluid resulting in a reduction in braking capability. For this reason glycol fluids should only be used for 1 to 2 years before being replaced with fresh fluid. One of the major advantages of silicone fluid is that it does not absorb water and so can be left in a braking system for much longer, typically ten times as long.

A low **viscosity** is important to give responsive braking operation – quick on, quick off; you don't want your brake pedal to feel like a caulking gun. And it would not be a good idea to have brake fluid that froze! The low viscosity of silicone fluid is an advantage, especially in very cold conditions. In fact it will operate down to –50C.

The next parameter that warrants some discussion is "**Effects on Cups**". This is an area where DOT 5 fluids have been reported to give problems and indeed I have had personal experience of seal expansion with DOT 5. My MG TC was converted to silicone by the previous owner about five years ago; two years ago I had problems with brakes binding and this turned out to be due to expansion of the Master Cylinder rubber seal. The expanded rubber blocked the fluid return drilling which should be exposed when the pedal is at rest, consequently the fluid pressure was not released and the brakes stayed partly on. The cure was to turn 0.7mm off the master cylinder piston. Yet silicone fluid is widely used in TCs and other classics with only a small proportion having any problem. As pointed out by Robin Gell in one of his emails, the chief unknown here is the composition of the rubber in the seals as DOT 5 fluid composition is closely defined and most available in the UK comes from a single supplier – Automec[2]). The rubber defined by the standard is Styrene-butadiene Rubber (SBR) according to the following formulation:

| Ingredient | Parts by weight |
|---|---|
| SBR type 1503 (or Philprene 1503) | 100 |
| Oil furnace black (NBS 378) | 40 |
| Zinc oxide (NBS 370) | 5 |
| Sulphur (NBS 371) | 0.25 |
| Stearic Acid (NBS 372) | 1 |
| n-tertiary butyl-2-benzothiazole sulphenamide (NBS 384) | 1 |
| Symmetrical dibetanaphythyl-p-phenylenediamine | 1.5 |
| Dicumyl peroxide (40 percent on precipitated $CaCO_3$) | 4.5 |
| Total | 153.25 |

But how do we know that our often "anonymous" rubber seals, that are available as individual replacement parts or incorporated in replacement master and slave cylinders or servos, were made to this formulation? Victor Smith contacted Brovex Nelson[3], a leading UK seal and brake hose manufacturer, and they confirmed that their seals will work well with either glycol or silicone fluids. Unfortunately Brovex Nelson do not put their name or trade mark on their seals, just the legend "Made in England". In addition there are three or four code letters or numbers on their seals which define their type numbers. We have learnt to be suspicious of aftermarket parts of unknown origin, especially those originating in India or China, so the "Made in England" legend may at least give some reassurance.

FMVSS116 uses standardised test cups of 28mm diameter with the above rubber composition and specifies the limits of physical change in terms of maximum and minimum expansion, maximum change in hardness, guminess, carbonisation and stickiness over prolonged stroking testing on the standardised test brake rig (see "Stroking properties" below).

Note that minimum expansion is specified; this is very significant. Obviously you don't want your seals to shrink and for this reason FMVSS116 defines a minimum expansion of 0.15mm (the maximum expansion is 1.4mm). The minimum expansion requirement is not a problem for glycol fluids which naturally cause the specified rubber to expand. In fact they may cause excessive expansion in some rubbers not made to the FMVSS spec. For example, there are many US bulletin board postings concerning problems with Landrovers when using DOT 3 fluids. The stated cure is either to use DOT 4 fluids or fit American seals. Yet in the UK there are no reports of problems with DOT 3 fluids, again an indication that the glycol fluids are made to different formulations and that DOT ratings are performance minima, not composition requirements. (Some trans-Atlantic fun is had by our American friends claiming that the Brits use more natural rubber in their seal formulations in an attempt to support the former empire in the form of the Malaysian rubber plantations.)

Bearing in mind the oft cited mantra that silicone fluids expand rubber seals, it is ironic to learn that basic diorgano-polysiloxane (silicone) brake fluids in fact cause the standard American seals to **shrink**, so failing the DOT tests. Silicone brake fluids were first patented in 1946 by McGregor et al[4] with advantages cited as near constant viscosity over temperature, low freezing point, high flash point, low hygroscopicity, and low corrosivity or other effects

[2] Automec Equipment and Parts Ltd, 36 Ballmoor, Buckingham, MK18 1RQ Tel: 01280 822818, www.automec.co.uk

[3] Brovex Nelson Ltd, Highfield Road, Camelford, Cornwall, PL32 9RA Tel:01840213711 pchapman.nelsons@virgin.net

[4] US patent 2398187, April 1946

on metal and rubbers. However, early formulations caused leaching of the plasticizers from the rubber seals, so shrinking them. To counteract this, **rubber swell additives**, such as di (2-thylhexyl) azelate or tributyl phosphate are added at 1% to 5% by weight to achieve the required swell[5]. This, and other improvements in lubricity and other characteristics developed over time, eventually resulted in the DOT5 standard, published by FMVSS in Oct 1974.

The somewhat dubious sounding "**Stroking Properties**" test covers practical performance in a standardised brake test rig. This uses three single leading shoe drum brakes with 28mm diameter wheel cylinder pistons and a master cylinder with 28mm diameter piston and standardised components throughout as defined in SAE J 1703. The tests consist of repeated "stroking" to a pressure of 1000psi repeated at a rate of 1000 strokes per hour with the whole assembly in a thermostatically controlled oven. Stroking is carried out at 23C and 120C over a total of 85,000 strokes. The pistons and seals are then examined for wear and physical changes and the loss of fluid is checked. If these are within the prescribed limits the DOT rating is achieved. **So a DOT 5 fluid can only be certified DOT 5 if it has no significantly deleterious effect on rubber seals complying with the DOT 5 specified formulation**.

The Colour specification is not necessarily a natural feature of the fluid formulations but is a requirement of the DOT standards to allow identification. Non-silicone fluids, ie DOT 3, DOT 4 and DOT 5.1 should be colourless to amber. DOT 5, silicone fluids, should be purple.

Note that a third category of brake fluids exists – mineral fluids. These are used in some Citroens, Rolls Royces, Audis and Jaguars. These systems use pressurised oils in systems that have no SBR compounds. These fluids are coloured green.

**A safe maxim is that different coloured brake fluids should not be mixed**.

## What does DOT compliance <u>not</u> tell us?

Because of history, the DOT tests are geared towards examining glycol fluids and so focus on the known weaknesses of glycol fluids, such as water absorption. Some important parameters that FMVSS116 does not cover are: *compressibility, air absorption, effect on braking components if left inactive for long periods, ease of bleeding, miscibility with other fluids, flammability, effect on automotive paint finishes, environmental impact, initial cost and through life cost*.

The **compressibility** of a fluid is very small but is finite. In a hydraulic brake system the fluid is ideally uncompressible so that there is minimum loss of pedal travel and maximum feel of the brakes. Silicone fluids are less dense than glycol fluids and so are inherently more compressible. At 25C a pressure of 1000psi will cause a less than 1% reduction in volume. At 260C the reduction will be less than 3%.[6] However, of more significance than basic compressibility is **air absorption**. Absorbed air increases the compressibility of the fluid. Generally less dense fluids have more air absorption and in fact silicone fluids have substantially more air absorption than glycol fluids. This is all a matter of degree and the compressibility of silicone under normal braking conditions is not significant. The elasticity of standard brake hoses will be just as important a contributor to pedal travel. **However, for racing, with extreme braking conditions and when maximum brake feel is required, the high temperature compressibility of silicone makes it compare unfavourably with DOT5.1 or other special racing glycols**.

In my own experience my TC pedal is very firm despite using silicone fluid and remains so under pretty arduous braking, as for example experienced on the Alpine passes descended during the MG Car Club Event of the Year in Switzerland in 2008. My V8 uses glycol and yet has a more spongy pedal than the TC; but this is not due to the fluid but to the different braking system and at least partly due to the remote servo set up of the V8. A remote servo is activated by the displacement under pressure of an activating piston and so must of necessity result in increased pedal travel compared to a direct system. I have not driven my TC with glycol fluid so cannot compare, but Malcolm Sayers says that the slight increase in sponginess present on his TC when he converted to silicone was more than counteracted by fitting Goodrich reinforced flexible hoses[7]. I have given these non quantified accounts to give an idea of the degree of sponginess that can be expected using DOT 5 under non-racing conditions.

Another characteristic of fluids with dissolved air is that abrupt changes of pressure can result in the release of air bubbles into the fluid, an effect similar to having a poorly bled system. These abrupt changes can occur in ABS valves and this is, I believe, why DOT 5 fluid is not recommended for use in vehicles fitted with ABS. However, this is unlikely to be relevant to classic cars.

**Effect on braking components if left inactive for long periods**. Silicone fluids are definitely an advantage in situations where a braking system may be inactive for some time, say several months or more. This is often the case with classic cars that may be taken off the road for the winter. It is also often the case with military or other service vehicles which may be "mothballed" and is no doubt one of the major factors that led to its adoption by the US Military (see later). Glycol based systems are prone to produce sticking wheel cylinders under these conditions due to moisture ingress through the boots causing the fluid to become corrosive. Although there are other conditions caused by lack of use, this one is amongst the most troublesome. To avoid it and the others (eg sticking SU fuel pump contacts), I try to use my V8 at least every three weeks throughout the year. The silicone braked TC remains unused for intervals of three months or more over the winter and I've never had any brake problems from this.

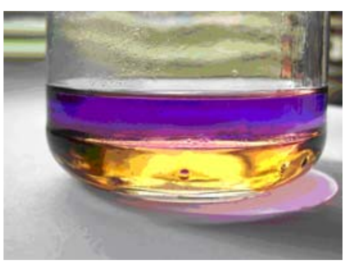
Malcolm Sayers started his classic car rebuilds fifteen years ago with a 1930s Morris Minor. He used standard glycol fluid in the braking system and every spring had to dismantle and hone the wheel cylinders to get it to work. Next he had a 1937 Morris 8 and had the same problem. He changed to silicone and the problems disappeared. Subsequently he's restored a TD and a TC and has used silicone fluid in both with no problems. Incidentally, he's never experienced any problem with swelling rubber seals. Numerous other classic car owners have had no problems with silicone amongst whom are those who contributed to the original V8 Bulletin Board thread including Robin Gell (his classic Landrover and also the MG TA belonging to his brother) and Paul Gill in his MGBGTV8 with the same fluid and seals since 1990 having covered 35,000 miles.

**Ease of bleeding** is a characteristic where glycol has the edge. The air absorption behaviour of silicone means that you can get a persistence of fine bubbles in the fluid. It is common to hear people say that they needed to bleed their silicone system twice

[5] Information from US patent 4640792, March 1987, Dow Corning.
[6] http://www.clearcoproducts.com/silicones_library.html#1
[7] http://www.goodridge.net/uk/automotive.htm

before it was right. I personally haven't had much problem bleeding my TC but I would recommend using a Gunson's Easibleed[8]. Don't be worried by spending £15 on an Easibleed or about using a bit more fluid –after all, you're saving £30 to £40 by not paying someone else to bleed it for you! Moreover, you should not have to do it every one or two years as you would with a glycol system. I wonder if some people's "sponginess" complaint with silicone is in fact down to inadequate bleeding but is put down by them to being simply that "well known characteristic" of the DOT5 fluid.

**Miscibility with other fluids**. All glycol fluids are miscible, although if you mix them you will of course compromise performance towards the lowest common denominator. Glycol and silicone fluids are immiscible in so far as they will not physically mix, silicone being lighter and so floating on top of the glycol. However, there is some disagreement about whether the presence of the two fluids together in a braking system poses a problem. Of course, to get the full advantages of a given type you must have 100% of that fluid type. Some say that there is a chemical reaction between the two fluids which causes braking problems and that, if changing from glycol to silicone, it is necessary to flush out the system with isopropyl alcohol and to change all the seals. I did a little experiment and put about 50cc of Comma DOT 4 and 50cc of Automec DOT 5 in a sealed jar and stored it for six weeks at room temperature. Initially the purple DOT 5 floated on top of the straw DOT 4, as expected. There was no apparent reaction. BUT, after the 6 weeks the DOT 5 had become colourless and the DOT 4 was dark purple[9]. Clearly, if nothing else, the dyes in the two types had reacted. But whether any other more significant reaction had taken place, and whether the observed change was deleterious to performance, I could not say.


*Silicone (top) over Glycol fluid (below) on Day 1*


*Silicone (top) and glycol (below) on Day 40*

It is clear from FMVSS116 that DOT certified fluids are compatible with rubber seals that themselves comply with the standard and so the same rubbers seals should work with either DOT 3, DOT 4 or DOT 5 fluids.

However, the standard says nothing about operation first with one type and then with another type. It is on this point that there are many warnings on various bulletin boards and auto blogs saying that you must change all seals. But there is precious little evidence about this or explanation for it. Of course, no one is going to get any blame for following what is clearly the path of least risk.

Automec's Jon Smith, in conversation with Robin Gell, said that over the last twenty years they have changed over many systems from glycol to silicone without flushing and changing seals and that they have had no problems. They are supported in this by the US Military. Spurred by the advantages of silicone fluids in terms of lower maintenance and the ability to operate after long periods of storage, the US Military produced MIL-B-46176[10], a spec based on DOT 5 but requiring –50C operation and tighter rubber swelling, flashpoint and other limits. The DOT 5 manufacturers met this tighter spec and the US Army introduced a changeover programme that started in July 1981 and was completed by June 1982. They refer to the silicone fluid as BFS (Brake Fluid, silicone) and issued the following changeover instructions[11]:

*New non-tactical (commercial) vehicles/equipment received with polyglycol brake fluid will be replenished with BFS whenever brake fluid additions are required. These vehicles/equipment are to be retrofitted with BFS at the time of major brake system maintenance. Vehicles/equipment in depots will be converted to BFS prior to shipment.*

So clearly the US Army had no qualms about even topping up glycol based systems with silicone! I've found no subsequent document that countermands this one so can only assume all went well. Of course, people may have differing opinions on the competence of the US Army . . . . If you do decide to change from glycol to silicone and to follow the more cautious approach of flushing the system then use isopropanol (iso propyl alcohol or IPA) as the flushing agent as this is a volatile solvent that dissolves both glycol and silicone based fluids and ideally follow up with a blow through with compressed air.

**Flammability**. Glycol fluids will burn more readily than silicone fluids. A typical DOT3 fluid will have a flash point of around 80C and a typical DOT 4 fluid around 90C (fluid must be at a temperature above its flash point to be ignited by a naked flame or spark. For comparison the flash point of petrol is about minus 40C and for diesel is around 55C. There is some variability dependent on the fuel formulation and the test method). Glycol auto-ignition occurs at around 300C (petrol is about 210C and diesel about 260C). This behaviour results in the US safety body OSHA (Occupational safety and Health Administration) rating glycol brake fluids as "non –flammable" and a NFPA (National Fire Prevention Agency) fire hazard rating of 1 (0 is no possible hazard, 1 is moderate hazard if exposed to hot surfaces). Silicone fluid flash point is above 200C and consequently it is rated non –flammable and non-combustible and has a NFPA rating of 0. This means that glycol fluid could be a fire hazard if it was in contact with, say, a hot exhaust manifold whereas silicone fluid would not, but that neither type warrants any particular fire precautions in normal usage. Note: A working exhaust manifold would commonly have a temperature above 300C. An engine working hard over a prolonged period could have an exhaust manifold approaching dull red heat, equivalent to 600C. The reduced fire risk with silicone fluids leads to its adoption by many in the light aircraft world. There's little thermal mass on aircraft brakes; numerous incidents have been reported where very hot brakes have led to melting of the brake hose and consequent spraying of brake fluid onto the hot brakes and a fire[12].

---

[8] Gunson, Kineton Road, Southam, Warks CV47 0DR Tel 01926 815000 www.gunson.co.uk or many car tool shops

[9] This reminds me of a classic Tommy Cooper trick where he put a black handkerchief and a white handkerchief into a tube, intoned the magic words, then pulled out the white one that had turned black and the black one that had turned white…….

[10] Current version is MIL-PRF-46176B, the major change being metrication of the units. Automec DOT 5 is compliant.

[11] Department Of The Army Technical Bulletin TB 43-0002-87, April 1981

[12] eg see www.tc.gc.ca/CivilAviation/SystemSafety/Newsletters/tp185/1-05/brakes.htm

**Effect on automotive paint finishes**. There is no doubt about the winner on this count. Glycol fluids attack paint and are pretty effective paint strippers. They also attack plastics like ABS and cause embrittlement which can lead to subsequent weakening and cracking. Silicone fluids do not attack car paint or plastics and in fact provide a water repellent protective film, more akin to a (silicone) car polish. For the classic car owner (or any other for that matter) care is needed to avoid paint damage from glycol fluids. As well as spills while filling, less obvious spillages can occur, eg thermal expansion of the fluid and consequent overflowing of a too zealously filled reservoir (leave a quarter inch gap at the top when "filling") or replacing brake shoes without first removing some fluid from a full reservoir (the displaced fluid resulting from the reduced wheel cylinder piston extension causes the reservoir to overflow).

**Environmental impact**. Information is readily obtained from MSDAs (Material Safety Data Sheets), or their EU equivalents, which must be published by law. Neither glycol nor silicone fluids are highly toxic but the OSHA classification for glycol is "Hazardous substance" due to its acute and chronic toxicity. Typically the LD50[13] for rats is 10g/kg; in humans the same susceptibility would mean a typical man ingesting a litre of glycol brake fluid would have around a 50% chance of survival. Glycol fluids are water soluble and the most sensitive fish species have an LC50[14] of around 100mg/litre; this is rated as low toxicity. Glycols are stable compounds but do eventually biodegrade; however, the preferred method of disposal is incineration. There are 30million cars on UK roads so if it is reckoned that each requires disposal of 1/2 a litre every 18 months (old fluid plus new fluid passed during bleeding, rounded to figures of the right order that give simple calculation) that equates to 10 million litres or more than 10000 tonnes of glycol a year (relative density is ~1.08). This is a significant ecological problem.

The main components of silicone fluids are non toxic. However, silicone fluids may contain up to 3% tributylphosphate additive which has a rat LD50 of 3g/kg, ie a silicone fluid containing 3% tributylphosphate would have an LD50 of about 100g/kg, or around one tenth the toxicity of glycol fluid. Swallowing large amounts could cause gastro-intestinal effects such as nausea, vomiting and diarrhoea. If silicone brake fluids were in general use then the disposal problem would be for one tenth the volume of material (assuming a 10 to 20 year change interval) with that material itself having one tenth the toxicity.

**Initial Cost**. The initial cost of silicone fluid is around six times the initial cost of glycol fluids. Current UK prices (Jan 2009) are around £30/litre for DOT 5 and £5/litre for DOT 4. Note: Here we are talking about "basic" DOT 4 from any car accessory shop. More exotic glycol brake fluids used for racing (but still designated DOT 4) can cost up to £50/litre. With allowance for bleeding, each fill would use about 1/2 litre of glycol and say 2/3 litre of silicone giving an initial cost of £2.50 for glycol and £20 for silicone.

**Through life cost**. Assumptions for the calculation are:

i) each fluid change uses 0.5 litre of glycol fluid (capacity plus bleeding loss)

ii) each fluid change uses 0.67 litre of silicone fluid (capacity plus bleeding loss)

iii) the life of glycol fluid is 1.5 years

iv) the life of silicone fluid is 15 years

then the material cost is approximately £1.67 pa for glycol and £1.34 pa for silicone fluid. If labour is included at say £40/hr (I live in the provinces!) and the change and bleed time is taken as 40mins for glycol and 1hour for silicone, the labour cost for glycol is approx £17.80 pa and for silicone about £2.70 pa. The total through life cost: glycol is approximately £19.50 pa and silicone approximately £4.03 pa

## If silicone is so good, how come no one uses it?

Well it is not quite true that no one uses it. As stated above, the US Military standardised on silicone brake fluid in 1981. After 1981 silicone fluid became a NATO standard - NATO H-547 - and is also used by numerous other armies that use US vehicles - even South Korea! And whilst it is true that no car manufacturer uses silicone fluid, a number of motor cycle manufacturers do, including Harley Davidson. It is also used by a significant number of devotees in the motorcycle and aviation worlds as well as by classic car owners. Of course, our V8s could not have used it or had it as a recommended fluid, as the DOT5 classification did not exist until 1974 when the V8 was only a year away from the end of production. But it remains true that no car manufacturer subsequently used it as standard. This is unlikely to happen now because of problems using silicone fluid with ABS brakes, which are universal, and with DOT 5 capability existing in glycol based fluids to the DOT 5.1 spec.

But why didn't it happen in the interim? I spoke to a friend, Rolf Schmidt, about this. Rolf is an automotive development engineer working for Daimler Benz in Stuttgart who owns a TC running silicone brake fluid. Rolf's personal opinion (in no way acting as an official representative of Daimler Benz) is as follows:

i)..silicone fluid is very expensive in an industry where cents count (even for Daimler Benz!)

ii)..the higher cost is compounded by greater time required for bleeding

iii).the higher thru life cost of glycol is a cost to the customer not a cost to the manufacturer

iv).glycol is known and well proven in a safety critical area of the car and is cheaper, so where is the incentive to change?

Add to this the vested interest of glycol fluid manufacturers, whose sales of glycol are around 10,000 tonnes a year in the UK alone, and who are often also involved in brake manufacture, and it can be seen that the driver for a change to silicone is small.

## Further points on water and air absorption

For water to get into the brake fluid moist air must be able to get to the fluid. This happens to a small but finite extent at the piston seals at each wheel cylinder or the caliper and master cylinder. It also happens at the master cylinder reservoir. In the reservoir the volume of fluid must be able to change, both dynamically due to fluid displacement when braking, and over time due to fluid displacement to take up lining and pad wear. This means that air must be able to enter and leave the reservoir. Traditionally this air change capability has been achieved by small air holes often having a labyrinthine path so that quiescent air change is normally very small. This minimises the amount of moisture absorbed by the fluid since the air above the fluid will be nominally unchanging and so the water removed from the air by absorption into the fluid will not be constantly replenished. Note that in a glycol system, water will be attracted to the fluid and will

[13] Lethal Dose for 50% of a population, weight of substance with respect to body weight

[14] Lethal Concentration for 50% of the population

be absorbed by it because of its hydrophilic nature. By contrast, a silicone system is hydrophobic and repels water. This is a big advantage at the pistons. However, should water enter the reservoir, for instance by condensation, it will not mix with the fluid but will find its way to the lowest point since silicone fluid is less dense than water. At this lowest point it could cause corrosion or – worse – could freeze, with possible serious consequences. **So on this argument some say that the hygroscopic nature of glycol fluids is a positive advantage**.

The same restricted air access to the reservoir fluid that was useful to inhibit water absorption in glycol fluids is also relevant to the minimisation of risk of condensation and water ingress for silicone fluids. It is clear that frequent removal of the reservoir cap to check fluid levels is in itself a generator of problems. Transparent nylon reservoirs started to appear in the 1980s with the big advantage of enabling fluid level to be checked at a glance saving time and air access. In recent years a simple method for further reducing reservoir air access to a minute level has been introduced – a flexible rubber diaphragm between the filler cap and the fluid. This displaces in sympathy with fluid movement but prevents the outside air from coming in contact with the fluid except when actually filling. An AP version is shown here[15].

*AP Nylon Master Cylinder reservoir with diaphragm*

Note that restricting air access to a silicone system reduces the risk of water ingress from condensation but does not affect air absorption over the long term. The silicone fluid will absorb air to the mean equilibrium level that the temperature and air pressure dictates. There has been some discussion of the disadvantage of using directly pressurised bleeding aids such as the Gunson Easibleed because of increased air and moisture absorption. It is true that the increased air pressure of say 10psi above atmospheric will result in a temporary increase in dissolved air, especially for silicone, and consequent possible increase in bleeding problems, but in my experience the extra convenience, not to mention one man operation, of using the Easibleed more than outweighs this. With respect to increased water absorption when used with glycol fluid I think that the half hour or so that the surface of the fluid experiences the increased air exposure is not significant.

When using glycol fluids the recommended change interval, typically 1 to 2 years, is a very “finger in the air” criterion. The major reason for the change is the increased water content of the fluid due to moisture absorption and the consequent lowering of the boiling point. Different systems and different operating and checking regimes will result in widely differing amounts of moisture absorption. The manufacturer’s recommended change interval will obviously err on the side of caution. Some indication is given by colour change, the fluid becoming darker as more water is absorbed. But this is not easy to quantify. So can we not measure the actual water content and so make a quantified assessment of when to change? The answer is “Yes”. Low cost brake fluid testers are available to the domestic market. They work by measuring the electrical conductivity of the fluid which increases as the water content increases. Often the testers are “calibrated” by first setting them to a reference level using new freshly opened fluid.


The Draper BFT1 illustrated here (stock number 59078) is available from motor accessory shops or the internet at around £40.

Gunson also do a lower priced pocket size tester (Part No 77002) for around £21. So, unless you have another reason for working on your glycol equipped braking system, one of these testers could well save you the time and money of an unnecessary fluid change, as well as being a useful safety checking aid.

## Conclusion

This article has attempted to present the facts about brake fluids and point out the pros and cons. Your decision depends on the weighting you put on these pros and cons when applied to your particular situation. What do I think? My opinion is that silicone is the best choice for the typical classic car owner who does not wish to race. However, changing fluids is undoubtedly a hassle. In my own case I will probably change my V8 to silicone the next time I have to do some major brake work, for example changing fluid or replacing a wheel cylinder. And though the precautionary principle would suggest changing all the seals, I think I will take a flier and just see how it pans out. But I would not do this just before one of our annual trips in the V8 to Italy! So keep watching the V8 bulletin board as you may yet see a picture of Bob Owen - with egg on his face!

### Caution

In researching this article I have made use of that miracle of information available to us all, the internet, and where useful I have given links to sites that provide more background or depth. However, for completeness, I have also included some anecdotal information from people who have had direct experience. Given these sources, you will understand that neither I nor the V8 Register nor the MG Car Club can accept any responsibility for the accuracy of the information provided, and any changes you make to your car are entirely at your own risk. The views expressed in this article are mine and mine alone. The V8 Register and MG Car Club take no position in recommending or not any particular type of brake fluid.

As with any other change from manufacturer's specification, you should inform your insurance company if you change brake fluid from that originally specified.

[15] AP Hydraulics Ltd, PO Box 1683, Tachbrook Road, Leamington Spa, CV31 3ZU www.aphydraulics.com