The selection of motor oil for classic Minis

By Richard Widman

This is the fifth draft of this paper to help you with the determination of the right oil for your Classic Mini. I'm sure there will be additional questions that will arise or points that I have not explained to the satisfaction of some readers. Due to the number of dubious products I've seen recommended on FaceBook and in forums, I've added a table with the specs published by various companies

Please send your questions or suggestions to me at: rlwidman@hotmail.com

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The Selection of motor oil for our Minis follows closely on one of the principals of Parkinson's Law, which goes something like this: *The time spent on any subject is inversely proportionate to its cost, since very few people have expertise in things like designing a space rocket, but everyone has an opinion on motor oil.* (He actually takes the discussion from a budget for space travel development down to the level of deciding what brand of coffee to use in the break room of congress). There are at least a thousand oils to choose from, and each of us has a personal preference as to brand loyalty, color of bottle, or viscosity. Unfortunately, our Mini's can't speak for themselves in our native tongue.

To be clear, you can put just about any oil in your Mini and "*not have problems*", depending on what you consider a problem. I have people who tell me they use "*xyz oil"* and they don't have problems, that with that oil they sometimes get as many as 100,000 km between overhauls. To me, that is a problem. I expect 500,000 km as a minimum.

Another concern with the selection of oil is that people often refer to oils by a partial name, or only one of the characteristics. Two people might comment differently on any given viscosity, say, 10W-40, one saying it is too thin, while the other says no. But when you get down to the specifics of the brands used by each, once pressed into action in the bearings, or between the gears, one brand retains 15% more of its body to lubricate with once it is under pressure. Some oils shear down much more than others. In many cases a 20W-50 is thinner in the bearings than a 5W-40 or 10W-40. You get what you pay for. There are also people who swear by a specific brand, when that brand has 5 or more offerings of that viscosity, all of different quality and standards. But they only recommend the brand instead of the brand and product.

The Basics of Lubrication

There are 3 main concepts of lubrication:

- **Hydrodynamic**: This is what the viscosity does, as it creates a cushion of oil that keeps the moving parts separated.
- **Boundary**: This is where the additives act, either through polar or chemical reaction on the metal surfaces when there is no cushion of oil. This is normal lubrication in flat tappet valve trains, transmissions, and piston rings, among other places. This is also what lubricates during start-up of the engine until the oil reaches the parts.

- **Mixed**: This is the combination of these, when the cushion becomes too thin, which would be normal in many parts of the engine and transmission.

Please note that throughout this paper I use the popular term "*Thinner*" instead of lower viscosity, and "*Thicker*" instead of higher viscosity.

History

When the Mini first came out, the best oils on the market were what we call API SB today. Many brands recommended API MS or DG, which was the most advanced on the market, later to be called API SC (1964). Most people who knew anything about flat tappet valve trains began recommending the addition of ZDDP plus or similar additives, as the SB oils had very few additives, somewhere in the neighborhood of 200 ppm of phosphorous from the ZDDP. There were still problems, and in 1968 new oil formulations were launched with a category we call API SE. I have a Mini service manual that recommends SE oils, ranging from 5W-20 to 20W-50 in viscosity.

Thanks to a reader of my previous paper on flat tappet protection, I was able to analyze a can of "MS-DG" oil from the late 60's. That analysis showed 517 ppm of zinc and 482 ppm of phosphorous, slightly higher than half the level of today's SN oils, and 30% of today's diesel formula oils. It only had 807 ppm of detergent.

So, it is true that just about any oil on today's market is better than what was available when many Minis were produced. And we need to remember that oils were improved to give more protection to the parts, longer change intervals, etc. It is also true that today we expect more of the cars, and many of us drive more sportingly than when they were cheap commuting cars. **If you are not interested in the maximum performance and longevity of your Mini, or reasons for these recommendations, you can skip to the summary on page 14.**

Here we could also note that Hydrocracked oils were not yet invented, so all mineral oils were API Group I. The most saturated were the Pennsylvania base stocks with high paraffin content (although eventually it was found that all that paraffin was clogging up engines and should be removed), or very weak Texas types of base stocks, where the non-saturated molecules (high evaporation, low viscosity index, fast deteriorating) caused shorter oil change intervals and less protection.

Synthetics were in the early development, still lacking the esters that keep the additives in suspension and the seals at the right size (softening instead of hardening), so they got a bad name for leaking.

First things first

The first thing we should consider is the Owner's Manual that came with the cars when they were new. And just in case there are different recommendations in the service manual, we should check them as well. Finally, we should consider developments in oils over the last 60 years, as most of today's oils do not shear like older oils, whether mineral or synthetics.

To begin with, we should consider that the design of the engine, where its transmission, whether manual or automatic, is attached and using the same oil. This will affect the oils we choose for our Mini's. And it keeps us from using the oils we use in our Mini's in modern cars.

Design

The Mini engines, as all engines, have a bypass valve that diverts excess oil pressure and flow back to the oil pan when it reaches more than the pressure it needs, preventing rupture of filters or O-rings, and maintaining enough oil in the pan instead of having excess waiting in the valve cover to return by gravity. According to the various manuals I have, The Mini started out with this at 60 psi, later using 70 psi, then 50 psi with the Cooper, and finally, with the SPI and later, 30 psi. This bypass valve should not be confused with the one in the oil filter or it's housing, as that one is there to guarantee the flow of oil to the bearings, when the oil is too "*thick*" to push through the filter paper or the filter is clogged from soot or particles.

The most important factor in lubrication of an engine is the viscosity. It needs to be strong enough to hold its cushion in the bearings and keep the crankshaft from the rod bearings. But it also has to be "*thin*" enough that it can get there quickly. The "*thicker*" the oil, the more wear you have every time you start the engine.

There are three basic areas that we need to examine in order to judge the right viscosity, considering that we may be starting the engine at freezing temperatures and driving them at engine temperatures of 90ºC or more.

To understand the following dimensions, I will compare them to something we can relate to: *A human hair*, which has a nominal diameter of about 80 microns (µm). It is also worth noting that the human eye can only see things that are larger than 40 µm.

Looking at the following charts from the manuals, we see that our clearance in the rod bearing varies from 12 µm to 69 µm on the 85H engines, and 25 µm to 51 µm on all the rest. So, we need oil that will flow into spaces one-sixth to one-third of the width of a human hair when the engine is properly rebuilt, increasing with wear to two-thirds (or so) of that width on a worn engine.

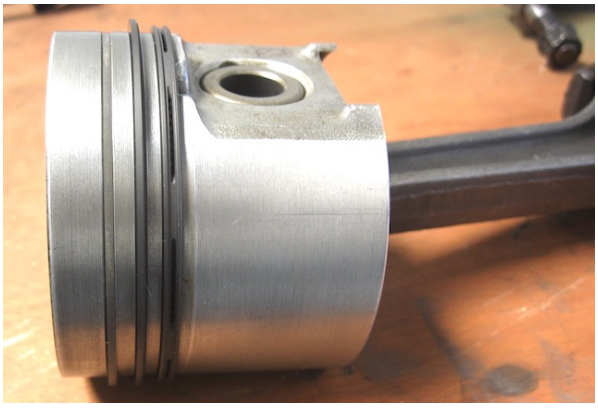
We should also note that the main bearing clearances basically fall within the same ranges, so no adjustments need to be made.

Looking at the piston skirt-to-cylinder clearance, we see that the 85H, 99H, and 10H engines have less clearance than the bearings. This means that if the oil is too "*thick*", it needs to get pushed down by the piston skirt instead of lubricating the cylinder walls and flowing out the oil control rings and cooling the piston crowns.

Bearing running clearance:	
85H:	
Front	0.012 to 0.051 mm
Centre and rear	0.031 to 0.069 mm
All other engines:	
Front, centre and rear	0.025 to 0.051 mm
Camshaft endfloat	0.076 to 0.178 mm

Piston-to-bore clearance:	
85H:	
Top of skirt	0.066 to 0.81 mm
Bottom of skirt	0.015 to 0.030 mm
99H and 10H:	
Top of skirt	0.060 to 0.085 mm
Bottom of skirt	0.010 to 0.026 mm
12H:	
Top of skirt:	
1275 GT	0.070 to 0.114 mm
Cooper S Mk III	0.063 to 0.072 mm
Bottom of skirt:	
1275 GT	0.031 to 0.056 mm
Cooper S Mk III	0.048 to 0.063 mm
12A:	
Top of skirt	0.074 to 0.114 mm
Bottom of skirt	0.023 to 0.064 mm
Main bearing running clearance:	
85H, 99H* and 10H	0.025 to 0.068 mm
12H and 12A	0.017 to 0.058 mm

We should also note that these clearance specs are very similar to the BMW Minis, where 0W-30 and 0W-40 oils are recommended. Obviously, those do not have to concern themselves with the transmission parts and forces.



Note that the control rings have very small openings, as do the pistons. In addition to these small groves there is a 38 to 89 µm gap between them and the piston groove. Oil that is too "*thick*", and does not flow well, does not cool the pistons, and often burns in these grooves, building carbon and "*sanding*" the cylinders. Note below how the carbon has formed in this piston and locked the rings into the grooves, where they cannot seal against the cylinders.

In the following pictures we can see the way this carbon builds up, and the small passageway that it has to flow through to take the engine heat back to the sump.

Carbon filled groves in SPI piston	Actual drain holes behind oil control ring
	

Valve train

We should also consider how long it takes for the oil to get from the oil pump in the gear box to the valve train on top of the engine. The noises caused by this delay can be very noticeable for a few seconds of running dry on engine starts. Noise equals damage.

If you ever get a chance, watch how a 20W-50 comes up to the valve train and just flops over, not spraying around all the parts like it should. Then put a 10W-40 in and watch how it sprays everywhere.

Manual Transmission

We also need to consider that this oil must lubricate and protect the transmission. In the case of the manual transmission, the Mini uses needle bearings and roller bearings. The best lubricant for needle bearings is relatively thin, so that it can flow into those small areas between the needles. The best for roller bearings is often "*thicker*", depending on the size and type. The design and size of the synchronizer cones is also important, as "*thick"* oil is much harder to displace than thin oil. Smaller synchronizer design and needle bearings are why most cars since about 2005 have recommended 75W-80 and 75W-85 oils, or ATF in their manual transmissions, while most cars produced from the mid 60's until then recommended 75W-90 oils. We will use 75W-90 oils for our viscosity comparisons in the graphs below.

Automatic Transmission

The AP automatic transmission used in the Mini is very sensitive to viscosity since the grooves on the discs are very shallow. The oil must displace quickly. And It should have additives to make the discs grab each other instead of slipping or chattering.

If today's gasoline oils, meeting API SN or the latest ACEA specs are used in this transmission, the discs will slip and wear out rapidly, just like slipping the clutch of a manual transmission car. While diesel formulations do not have those slippery friction modifiers, and are therefore better, the Motorcycle MA2 oils have a special friction modifier that make them grab between 35% and 100% better than diesel formulations (depending on the brands). MA2 oils will give noticeably better shifting and less particles in the oil and filter when you change it.

Here is a chart with the coefficient of friction of the different motorcycle categories. The MB category is for Scooters and many other dry-clutch motorcycles, so the coefficient of friction is similar to car engine oils. You will note that a MA2 oil has up to 5 times more grab on the discs as a car or dry-clutch motor oil. This results it up to 5 times better clutch wear and performance.

3. Clutch Test Results of Friction properties (JASO T 903:2011(ANNEX A))

Test Method	Evaluation Item	Test Results	Standard Index			
			MA	MA2	MA1	MB
JASO T 903:2011	* DFI (Dynamic Friction Characteristic Index-DFI)		≥1.30 and <2.50	≥1.85 and <2.50	≥1.30 and <1.85	≥0.50 and <1.30
	* SFI (Static Friction Characteristic Index-SFI)		≥1.25 and <2.50	≥1.70 and <2.50	≥1.25 and <1.70	≥0.50 and <1.25
	* STI (Stop Time Index-STI)		≥1.45 and <2.50	≥1.85 and <2.50	≥1.45 and <1.85	≥0.50 and <1.45

There are some diesel formulations on the market that claim to meet MA2 performance. Most will meet the MA1 specification. Those that claim MA2 have probably tweaked them to meet the low end of the MA2 friction scale and be able to say that. I don't know of any brand that publishes their actual friction coefficient.

Additives and formulations

The oil we put in the engines of our Minis must fight off byproducts of combustion, protect sliding "flat tappet" valve trains, protect needle and roller bearings in the transmissions, and provide a certain level of EP protection for the gears, while allowing synchronization in the transmission.

Obviously, we will never consider putting a standard transmission oil or gear oil in our Minis, since their formulation with sulfur/phosphorous EP additives would cause serious damage to the engine parts and form acids instead of neutralizing them.

But should we put current friction modified API SN gasoline engine oils in there? ***The answer is no,*** for two basic reasons. **First,** just like any flat tappet engine, with the sliding action of our valve trains, we are better protected by ZDDP than the modern friction modifiers designed for roller bearing rockers and various other things. With valve spring pressure originally 70 lbs. and then 94 lbs. (not as high as some engines, but higher than many of that time.), we need that ZDDP. And **second**, because they are too slippery for the synchronizers. The manual transmission Minis are best served by diesel formulation oils since they have higher levels of ZDDP. The ZDDP does a better job of protecting the valve train, and most of them will provide between 45 and 50 lbs. of protection in the Timken tests, covering the GL-4 manual transmission requirements. We can also use some special classic car oil formulations, although they are not necessary. For those that are concerned with this recommendation for diesel formulations, I recommend you check out this paper on the subject where the testing is explained, rather than repeat most of those 30 pages here.

Note that ZDDP is a great anti-wear additive, composed of zinc and phosphorous. The ZDDP sticks to the metal parts of the engine by magnetic attraction. (They are polar in nature). But too much will cause galling to the cam and other steel parts under pressure. SAE (*Society of Automotive Engineers*) studies show that 1800 parts per million (ppm) is the maximum limit most steel will withstand without damage. 2000 ppm has been shown to cause serious damage to camshafts and gears. This means that it is very dangerous to put additional additives in any oil, as you would need to know the formulation of that specific oil and the additive we are considering, then calculate the amount to use. Diesel formulations generally contain between 1000 to 1400 ppm of zinc and phosphorous from ZDDP (CI-4 was the highest), quite sufficient for the protection we need. They have more detergent than we require, but that does not hurt anything. I have seen classic oils offered that range in phosphorous from 1200 to 2000. The latter of those would cause damage to the cam and possibly gear teeth.

Don't be fooled by the mention of ZDDP in the oil. One "Classic Car Oil" says "It is formulated with ZDDP (zinc/phosphorus) on their web site and spec sheet. **All motor oils** (except SA) are formulated with some amount of ZDDP.

Here is a table with the specs of various CK-4 diesel oil formulations (latest spec at this time), as tested by the Petroleum Quality Institute of America (PQIA).

PHYSICAL TESTS		Rotella T4	Valvoline HD	Valvoline Premium Blue	Warren Lubrigua	Delvac 1300 Super	CAT	Kendall Super-D	Delo 400 SDE	Duron HP	Duragard	CarQuest	STP PRO	O'Reilly	Ryal Purple Durale	NAPA
TBN, mg KOH/g (ASTM D2896)		10.04	9.68	10.05	9.43	10.1	9.87	9.92	10.34	9.79	9.92	9.67	10.08	9.53	8.99	9.52
Viscosity @ 100ºC, cSt (ASTM D445)	12.5 to <16.3	15	14.8	14.89	15.1	14.1	13.7	15.33	14.5	14.9	15.92	15.6	15.2	15.7	14.3	14.8
Viscosity @40ºC, cSt (ASTM D445)		112	111	113.59	111	106	102	114.2	110	113	113	119	114	117	100	109
Viscosity Index (ASTM D2270)		139	138	136	142	135	134	141	135	136	151	138	139	142	147	140
Viscosity @-20ºC mPa s (cP) (ASTM D5	7,000 Max	6,160	5,846	6,338	5,177	6,373	6,290	5,704	5,563	5,333	4,289	5,786	6,484	5,722	4,253	5,866
Volatility NOAK				12				10.2			9.4					
ELEMENTAL ANALYSIS																
Additives																
Calcium, ppm		2,045	1,801	1,453	1,044	1,772	1,890	1,840	1,532	1,093	1,079	1,056	1,047	1,008	2,420	1,738
Magnesium, ppm		18	420	620	937	548	528	400	706	1,030	1,016	1,024	965	983	9	419
Phosphorus, ppm	1,200 Max	969	1,099	1,020	976	789	1,000	1,090	715	1,041	1,074	1,038	1,031	994	963	1,031
Zinc, ppm		1,070	1,233	1,141	1,077	879	1,118	1,245	786	1,221	1,187	1,164	1,134	1,127	1,057	1,127
Molybdenum, ppm		3	61	50	57	42	43	<1	119	63	66	63	59	60	<1	59
Barium, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boron, ppm		179	126	66	2	71	72	147	346	<1	3	<1	2	<1	<1	119
Silicon, ppm		4	6	7	4	9	7	9	8	5	4	4	4	4	6	6
Potassium, ppm		8	1	<5	<1	1	1	<5	2	3	<5	<1	2	<1	<1	<1
Manganese, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium, ppm		<1	<1	<1	<1	<1	<1	98	<1	<1	<1	<1	<1	<1	<1	<1
Copper, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sodium, ppm		1	1	<5	<1	2	2	5	1	<1	<5	<1	<1	<1	3	<1
Vanadium, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Contaminants																
Silver, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Aluminum, ppm		<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Iron, ppm		<1	<1	2	<1	1	1	2	1	<1	<1	<1	<1	<1	1	<1
Nickel, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Lead, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Antimony, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Viscosity

Viscosity is the resistance of a fluid to flow. The higher the resistance, the higher the viscosity number. The higher the viscosity, the more heat is generated by its movement and the less it circulates (flows).

Viscosity is a term that is not well understood. Oil is a Newtonian fluid. That means its thickening or thinning rate is not directly related to the temperature. Many people feel the viscosity of the oil in their fingers and assume it is like that in the engine. It "*thins*" down severely at engine operating temperatures, and "*thickens"* at colder temperatures.

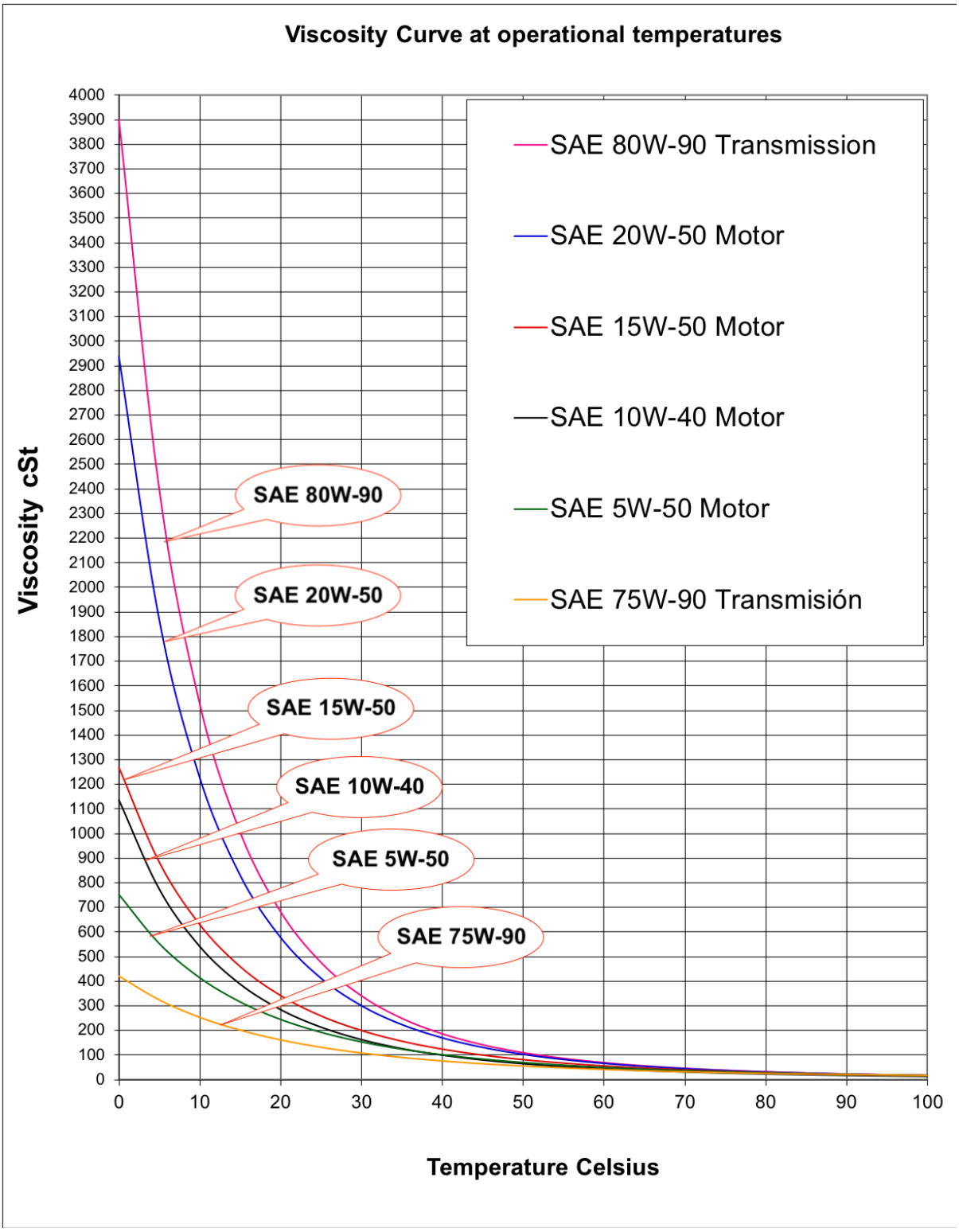
The finger test is not only erroneous for the temperature, but for the fact that it does not consider contaminates or degradation. A cheap multigrade oil will "*thin"* out temporarily under pressure, or permanently from high temperature or continuous pressure cycles, so a cheap 10W-40 may well be a 10W-30 after 2,000 miles or so, but then begins oxidizing and absorbing soot, thickening back to what you might think is good by 4,000 miles. But it is no longer protecting like it should. It is causing excessive wear in the engine. The cheaper oils will also collapse temporarily under pressure in the bearings, returning to normal as they flow through the engine, and even as analyzed, only leaving excessive wear on the bearings, and in the case of Mini's, the transmission gear faces.

The finger test, or the visual observations I often see made in shops, also does not consider the density of the oil and its resistance to shear. More about that later.

Secondly, there are **four viscosity scales** for lubricating oils. Two are automotive scales determined by the Society of Automotive Engineers (SAE). One of these is for engine oils, while the other is for gear oils. In general, we can think of a SAE 50 engine oil being the same viscosity of a SAE 90 gear oil.

In the following graph, we can see how an assortment of oils work at different temperatures. This first graph starts with 0ºC (32ºF) and shows the relationship of various transmission and engine oils as they heat up in use. Note that at 0ºC (32ºF), a 20W-50 is almost three times "*thicker"* than 10W-40, being very difficult to pump and lubricate in both the engine and the

transmission. It shows that if anyone thinks they need a SAE 50 for high temperatures, they would be much better off with a 5W-50.

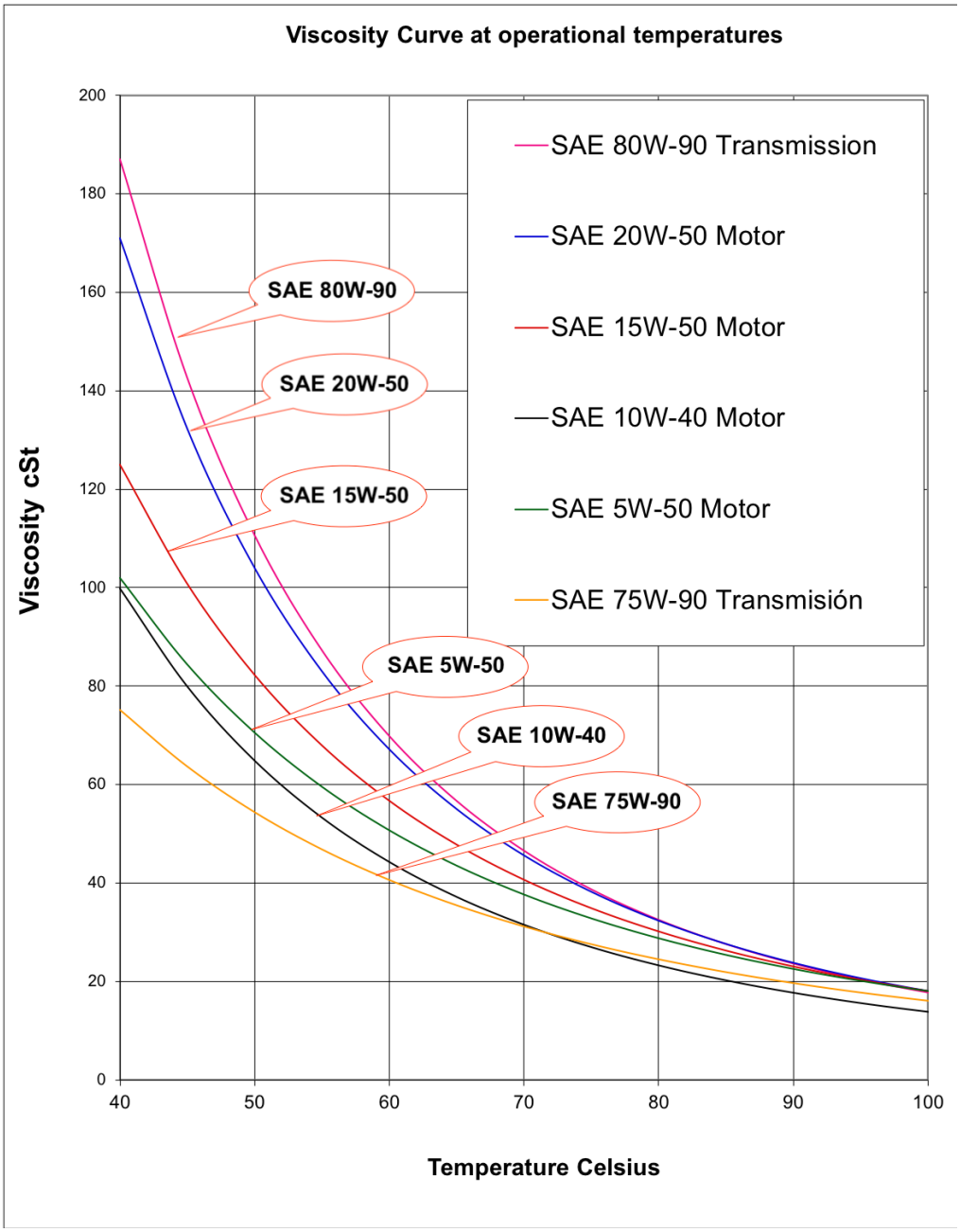


Note that we are not talking about Density. If we were to add a line for the Density, it would be a straight, sloping line, and each oil would have its own line, depending on the density of the base oil and additives.

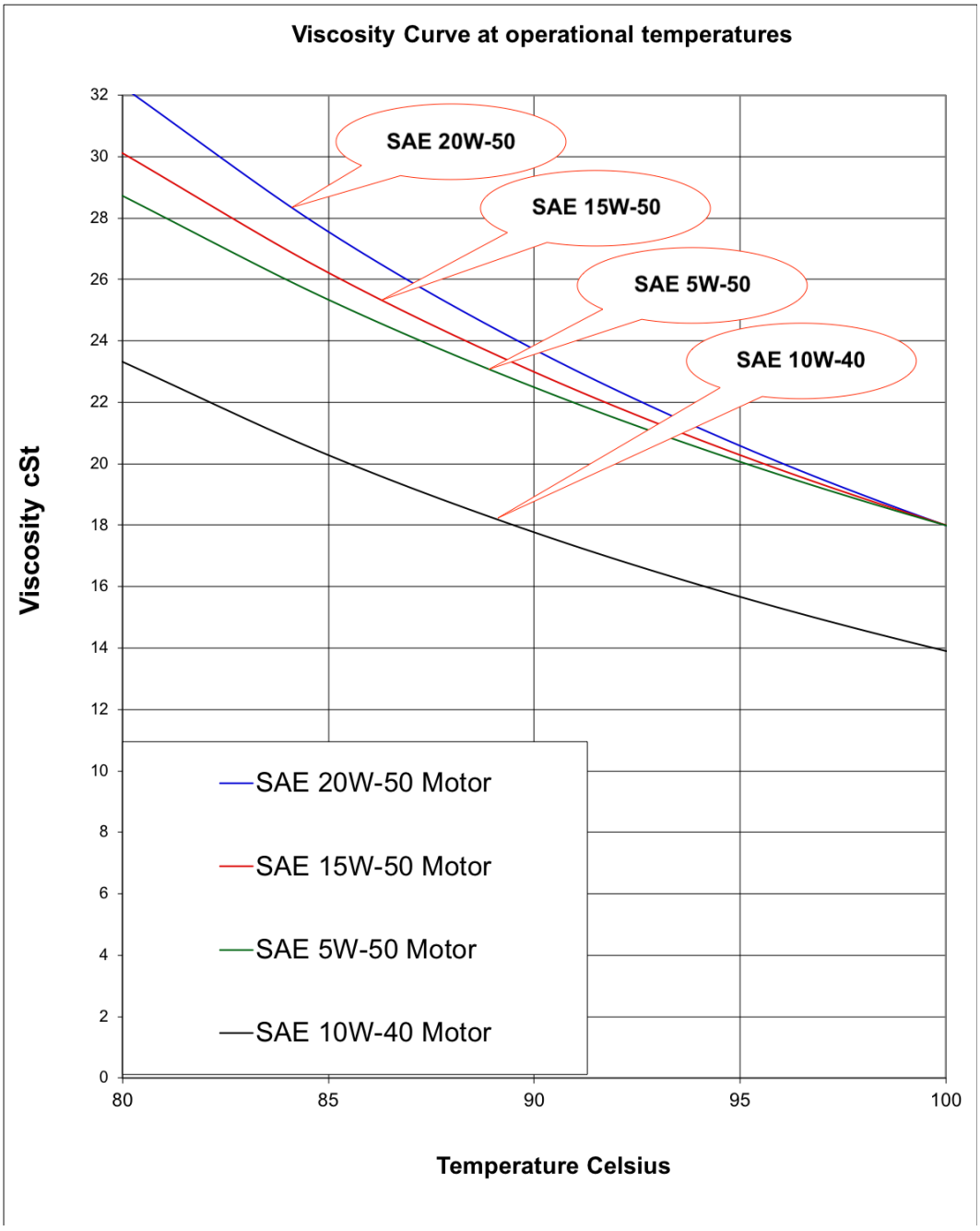
The two gear oils are only shown for relative viscosity. They should never go in a Mini.

People often tell me that 10W-40 is too "*thin*" for a transmission. You will note in the second graph that at temperatures below about 75ºC, a 10W-40 engine oil is "*thicker*" than a 75W-90 transmission oil at most temperatures.

In this second graph, we see how these same oils flow at higher temperatures, as they begin to heat up and operate in the engine and transmission.



When we look loser at the viscosity in the hotter parts of the engine, eliminating the gear oils from our graph, we can see how the three examples of xW-50 oils converge to the same viscosity, albeit much "*thicker*" than the 10W-40 in our examples.



The reason to graph these oils is to see the effect on the temperature on the oil. If we think, for example, that we should have about 18 cSt at 90ºC, why would we use oil that only "*thins"* down to 24 cSt at that temperature?

Or, if we think we should have an oil that is 24 cSt at 90ºC, why would we use a 20W-50 that is 2900 cSt (120 times "*thicker*") at freezing temperatures and 170 cSt (7 times "*thicker*") at 40ºC?

Recommendations in manuals

It is interesting to note the variations in owners and service manuals. Here is what is published by Austin/Morris/Rover.

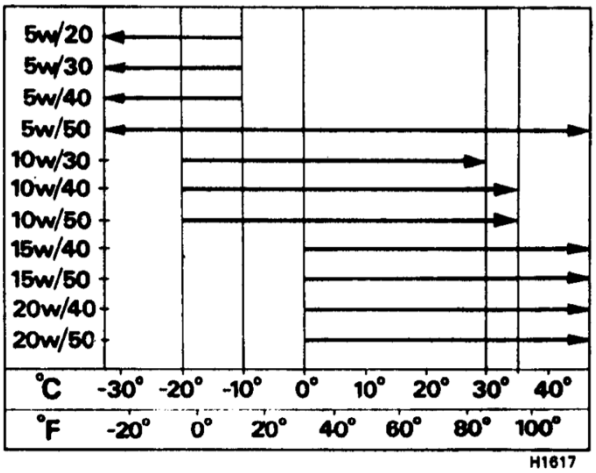
In this first table, we see recommendations (ignoring the column for really cold climates) of 10W-30, 10W-40, 10W-50, and 20W-50.

SERVICE LUBRICANTS

Component	Engine/Transmission Unit Distributor, Carburetter Dashpot, Oil Can		
Climatic conditions	**All temperatures above −10°C (15°F)**	**Temperatures 10°C to −20°C (50°F to −5°F)**	**All temperatures below −10°C (15°F)**
Minimum performance level	British Leyland Service Fill Lubricating Oil Specification for Passenger Car and Light Commercial Petrol Engines B.L.S. OL.02		
MOBIL	Mobiloil Special 20W/50 or Super 10W/50	Mobiloil Super 10W/50	Mobiloil 5W/20
SHELL	Shell Super 20W/50	Shell Super 10W/50	Shell Super 5W/30
BP	BP Super Visco-Static 20/50 or 10W/40	BP Super Visco-Static 10W/30 or 10W/40	BP Super Visco-Static 5W/20
CASTROL	Castrol GTX	Castrolite	Castrol GTZ
DUCKHAMS	Duckhams Q. 20–50	Duckhams Q. 5500	Duckhams Q. 5–30
ESSO	Esso Uniflo 10W/50	Esso Uniflo 10W/50	Esso Extra Motor Oil 5W/20
TEXACO	Havoline 20W/50 or 10W/40	Havoline 10W/40	Havoline 5W/30
PETROFINA	Fina Supergrade 20W/50 or 10W/50 or 10W/40	Fina Supergrade 10W/50 or 10W/40	Fina Supergrade 5W/20

It should be noted that oils of 50 years ago had serious problems with **viscosity shear** and high concentrations of unsaturated molecules that collapse under pressure, leading many manufacturers to recommend "*thicker*" oils, especially when they would be in contact with gears, which tend to mill, or grind, the polymers used to form multigrade oils. Today's group II base oils need less polymers to maintain their viscosity and body, and today's polymers are generally much more resistant to shear, although they vary in quality with the price paid. The better synthetic oils do not use polymers to be multigrade. Cheaper synthetics will contain polymers, although they use less, and should be the best polymers available.

In another publication Austin/Morris/Rover show the viscosities the way many brands used to do (and still do for the third world).



While there is some logic to it, we should consider what "*can*" be used, and what is "*best*" to use.

According to this chart, you could use any oil that is 10W-30 up to 10W-50 if your lowest startup temperature is -20ºC.

It also then suggests that 15W-40 up to 20W-50 are suitable for startup temperatures of 0ºC and above.

The SAE J300 standards have changed a bit over the years, but, as we see in the next chart, the oils are not tested at the same temperatures, as they are not expected to behave the same way.

SAE Viscosity Grade	Low Temp. Cranking (cP)	Low Temp. Pumping (cP)
0W	6,200 @ -35°C	60,000 @ -40°C
5W	6,600 @ -30°C	60,000 @ -35°C
10W	7,000 @ -25°C	60,000 @ -30°C
15W	7,000 @ -20°C	60,000 @ -25°C
20W	9,500 @ -15°C	60,000 @ -20°C

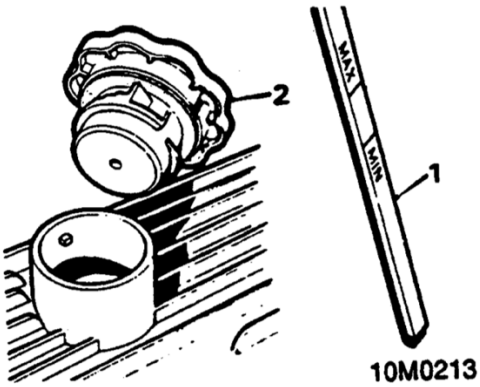
Oils that claim 15W, cannot "*thicken*" to more than 7,000 cP at -20ºC, and oils that are 20W must not "*thicken"* to more than 9,500 cP at -15ºC. So, these two oils have very different cold flow properties and should not be considered similar.

Note that we are using "centipoise" (cP) on this test instead of "centistokes" (cSt). The conversion depends on the density of the oil. Viscosity in centistokes will be 10% to 15% higher.

Centipoise is also used to measure the actual film strength in the bearings, at 150ºC, under pressure, where a xW-30 must maintain 2.9 cP or higher, an xW-40 must maintain 3.5 cP or higher, and an xW-50 must maintain at least 3.7 cP in the ASTM "High-Temp/High-Shear" (HT/HS) test. I have a 5W-40 synthetic that maintains 4.0 cP in this HTHS test (and a group II SAE 15W-40 with 4.2 cP). With the right 10W-40, you can have a physically thicker cushion in the bearings than with many 20W-50 oils made with cheaper base oils that barely pass the 3.7 cP limit.

The HTHS test is the most critical for bearings and for our transmissions, as it shows how thick the actual fluid barrier is in those places under pressure.

Here are a couple more pieces of manuals, this time from 1992. The owners' manual recommends 10W-30, although notes that this is up to 30ºC. The service manual says 10W-40.

The 1992 service manual	The 1992 Owner's manual (note that it says up to 30ºC)
ENGINE OIL AND FILTER **Oil level check** Always check oil level and drain oil with the vehicle standing on level ground and use engine oil of specification 10w/40 for topping up and refilling.  10M0213	**Oil specification:** 10W/30 engine oil, meeting RES.22.OL.G4 or ACEA A2:96. Suitable for use in temperatures between -20° C to +30° C (if climatic temperature falls outside these limits, seek advice from your dealer). Most major oil companies produce engine oils to the above specification.

Summary

The decision of the right oil takes you to a diesel formulation (API CI-4 or later) or a specialty oil if you want to take care of your valve train and gears, since that gives you the GL-4 gear protection that transmissions need. You do not want a common gasoline formula oil, such as SN. When I refer to a specialty oil, I am not talking about those that say they are for classic cars, but those that actually list, in their specifications, the levels of ZDDP and preferably the Shear Test results (HTHS). Note that these ZDDP levels should never be more than 1800, and better if they are in the 1000 to 1600 range. Amsoil, Redline, and others have listings for excellent specialty products if you want synthetic. The major brands have excellent diesel formulations of mineral and synthetic oils. A properly formulated oil such as these should not be adulterated with additives.

If you have the automatic transmission, **you need a JASO MA2** oil, and absolutely NEVER put additives in it as they will keep the discs from grabbing.

For viscosity, take a good look at the graphs and take a look at how fast those curves take you down into the viscosity range where it can circulate and protect. For most recently rebuilt engines, the manuals and graphs show that a 10W-40 would lubricate faster and better than a 20W-50, but I would look for one with a high HTHS so that you have the best of both worlds:

circulation and *shear strength*. But if you feel you need something "*thicker*", I recommend a 5W-50 instead of 20W-50, as it will flow much better on startup and have a much stronger film thickness (HTHS) in the bearings.

I have had people say as long as it has the API certification it is fine. While that is a basic truth if it is the diesel certification, in our Minis, shear strength is very important in the gears. So, where an xW-40 must not shear down below 3.5 cP, which is sufficient for the engine, why not the better ones with 4.0 or more? These are made from group II base oils or better. There are also some oils that meet the standards when new, but shear rapidly in use. I have seen several that do not last more than 2000 km. And don't forget, API certification for gasoline engines will not protect our Mini transmissions and valve trains.

After some comments, I am adding a comment on three oils that were mentioned in a Facebook post. Unfortunately, these oils are promoted on Mini sites. The first is an oil that is sold, in theory, for classic cars, but I would not let near any of my classics.

- Looking up the first, I see it is an obsolete SE/CC oil. That has about a third of the additives needed for GL-4 transmission protection, and not close to enough for a Mini Valve train.
- The second has no claim of quality on its label or web site. Just says it is basic protection for older cars. It probably is little more than cheap base oil, and will oxidize, shear down to less than needed in the bearings and gears, and form sludge in the engine.
- The third actually has a few details posted for its product, so we will look at them specifically. It says it is a 20W-50 and that it meets the obsolete API spec SF/CC that would have been the best available for gasoline engines until 1989 or diesel until 1979. It has 700 ppm of zinc in its ZDDP to protect our gears and valve train (about half of what you get in CI-4). It is a group I base oil, which means it has a low natural viscosity index (more polymers to shear), and less than 90% saturated molecules (most group I are 75-80%). Unsaturated molecules are what decompose and absorb soot, form sludge, and turn into carbon deposits. They also note that it has a low detergent/dispersant package so that the contaminates can fall out of suspension. This was the thought of engine builders back before oil filters were developed. This will cause excessive sludge in any engine. This is an oil I would never use in any engine.

Characteristics	
SAE Viscosity	20W-50
Viscosity Index (VI)	130
Performance Level	API: SF / CC MIL-L-2104B
Zinc as ZDDP (ppm)	700
Base Oil Group	Grp I
Detergent-Dispersant Package	Low
Other	-

After so many debates with people with empirical recommendations that have no real basis in maximizing engine and transmission life, I'm adding a table that actually lists brands, and their published data. This chart is for the 20W-50 viscosity of these brands, although **many Mini's should be using 10W-40**. The data is what they have published as of April 2022.

Brand	Typical CK-4 Diesel Spec oil	Valvoline VR-1	Duckhams Q	Millers Classic Pistoneeze	Millers **Classic Mini** Oil	Castrol GTX Classic	Comma Classic	Mobil 1 15W-50
API Spec	CK-4	SL	SL	SJ/CF	SF	SJ	SE/CC	SN/CF
Viscosity @ 40ºC (cSt)	160	187	156.2	N/A	147	163	145	125
Viscosity @ 100ºC (cSt)	18.0	20	18.01	N/A	16.7	18	17.2	18
Calcium (ppm)	1500	N/A	2080	“High”	“Moderate”	N/A	2200	940
Magnesium (ppm)	850	N/A	0	N/A	N/A	N/A		650
Zinc (ppm)	1100	1400	1120	1020	N/A	1300	800	1300*
Phosphorous (ppm)	1000	1300	971	Est. 900	N/A	1200	700	1200*
Moly (ppm)	50	N/A	125	N/A	N/A	N/A	N/A	75
Boron (ppm)	70	N/A	0	N/A	N/A	N/A	N/A	75
Base oil	**	Group II	N/A	Group I	N/A	N/A	N/A	Syn

- N/A: Does not specify
- Millers Classic Trans M does not list more than viscosity on their site
- Millers Motorsport CTV Mini 20w50 does not list more than viscosity on their site
- Mini Spares Classic does not list anything except the “Low” detergent and 1300 ppm of zinc
- “Rock Oil 20W50 for classic Minis” is sold on line, but I can’t find any specs
- ** Typically Group II in the US, but often still group I in Europe as Group II base oils are still mostly imported
- * Mobil lists this as SN, but it is way over the allowed phosphorous content for an SN oil, and would poison a catalytic converter of a modern car.

I will add products to this table (within reason) if you have one to suggest. **My email is at the end of this paper.**

Your key is to look for a product with somewhere between 1100 and 1600 ppm of zinc. If a brand does not tell what their content is, I doubt that it is good. From those products listed, other than a diesel truck formulation (CI-4 or CK-4), The Valvoline VR-1, Castrol GTX Classic, and Duckhams look decent.

It should be noted that since almost no car manufacturer (I know of only one, in India) recommends 20W-50, it is an oil normally sold on price, not quality. You may be getting something that will shear down to below a good 10W-40.

On viscosity, remember there are two important points:

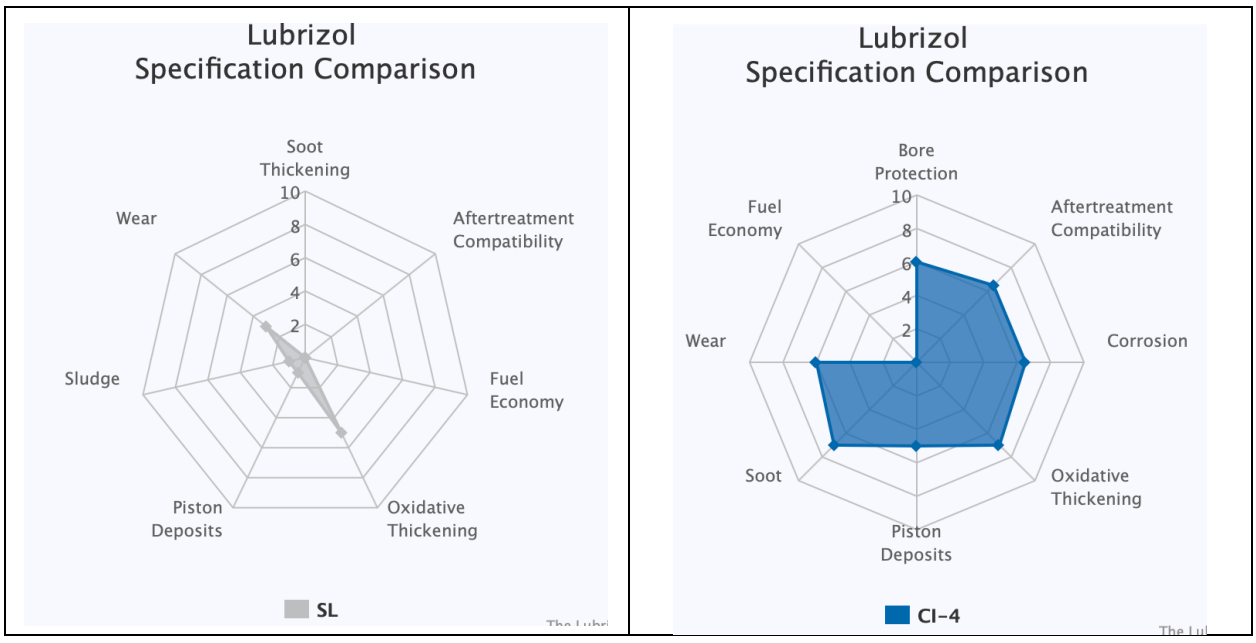
- How well the oil flows up to the valve train and into the main & rod bearings on startup and until it reaches operating temperature.
- The physical film thickness when it is hot and compressed in the bearings (HTHS value).

At one time, the API was looking to require the HTHS value on the labels. This idea was killed with the excuse of being too complicated for the consumer. For European oils, the ACEA standards do not identify anything over 3.5 cP on the HTHS, but **to have that final high shear value of 3.5 or greater you need a C3 or C4 ACEA rating.**

While I, like all car manufacturers, recommend never using an aftermarket additive in the oil, there is, in my opinion, one exception to this rule. I have "fixed" the compression and leaking of many engines by driving about 2000 km or more with an Ester based additive that dissolves carbon and sludge, while softening and swelling dried seals. While I have my own brand of this, I will not mention it by name, as this is not an advertisement. The most recognized and available product on the market is "AutoRx", sold over the internet.

This synthetic-ester based additive is especially handy for those of us with classics that get little use, since the oil is changed less often and splashes up around all the seals less, letting them dry out and shrink.

For those that still think they should use older formulation oils, such as those I mentioned above, I will add these spider graphs from Lubrizol Corp. (one of the major oil additive companies and member of API). It shows a dramatic difference between SL and CI-4 oils. They don't go back and try to put the oils older than SL on the chart, as they would be small dots. The shaded areas show the level of protection.



At this point, most Minis on the road have been repaired to some extent. ***There is no perfect oil for all Mini's in their current condition***, so here are some things to consider (covered in detail above):

- Never use an API SN rated oil in a Mini.
- If you have the AP automatic, your best performance and least wear will normally be with a 10W-40 JASO MA2 motorcycle oil.
- If you have a manual transmission, find an oil with at between 1000 and 1600 ppm of phosphorous. This will either be a diesel rated oil or a specialty oil.
- **Never put additives in the oil you buy**. Very few people can calculate and improve the formula. For those that want more detail on why, check this link on the development of the standards. This recommendation also includes Moly based additives, as they will keep the synchronizers from working as designed. The only exception being what I explained on the previous page.
- If you have low oil pressure (the gauge measures between the pump and bearings), you should use a "*thicker"* oil until you replace the bearings or correct the pump.
- If you have low compression, you may want to increase the oil viscosity slightly to compensate until you rebuild, although you should consider that this will cause higher valve train and bearing wear until that time. You might also try the cleaning product mentioned above to clean up the rings and improve compression.
- If you have worn main shafts in your transmission, you should use a "*thicker"* oil to compensate for that wear, but considering the increased wear you are causing the valve train and bearings.
- If you have poor synchronizer action, you should consider reducing the viscosity (unless you are using a SN formulation that should be changed out first).
- If you decide to stay with the faster flowing 10W-40, you can certainly use a 5W-40 synthetic. It will probably have a higher HTHS viscosity in the bearings and gears than a mineral 10W-40. It is also easier to find in a diesel formulation.
- If you decide you need an xW-50, seriously consider a synthetic, preferably 5W-50 or 10W-50. You will have much better startup flow and protection. Remember that the "50" in that spec is the flow resistance. The HTHS value is much more important.
- But whenever any engine is properly rebuilt, no matter the car, you should go back to factory spec viscosity. In the case of the Mini, not rebuilding the transmission at the same time *might* affect that procedure.

I would like to conclude this with a list of recommended oils, but that is not possible, since formulations vary from country to country, even within the same brand and name. I know of excellent, group II base stock oils produced in some countries by certain brands, while they use cheap group I base oils in another country, yet put the same product name on the oil.

What I can recommend, is that after reviewing these factors, when you look at the shelves full of oil, or the internet, look first at the all the oils of viscosity you have chosen that are CI-4 (or even CK-4), JASO MA2, Classic, or whatever you determined, and if possible check their HTHS and base oil. Then look at the price. The last thing to look at is the brand name.

I will add that, personally, I use a Semi-Synthetic JASO MA2, 10W-40 in my SPI. I rebuilt it to "standard" specs about 1000 km ago (as of the initial writing of this paper).

And one final recommendation:

When someone asks what oil to use, remember the points in this summary, and avoid the pitfalls I mentioned at the beginning.

Additional comments on Facebook posts:

- Someone recently posted a comment that you should always use mineral oil, never synthetic, as (in his opinion): "In a Mini engine, using synthetic of any kind is best way to ruin your engine in the long term. This has been far explained everywhere.". He also states "Always mineral, oil has synthetic is a bad option for iron engines and the gear of the Mini will eventually destroy them." [sic]

  That is completely false. *Within any given API category and viscosity*, all oils have to pass the same tests for iron and copper wear, corrosion, seal compatibility, evaporation, shear, etc. Some will pass marginally better than others (less wear). Comparing any particular mineral oil with any particular Synthetic oil ***of the same specification and viscosity***, the Synthetic always wins. He also does not explain where "*Everywhere*" is. If he referred to a particular scientific study, we could look at it to verify that it was run properly and under what circumstances. I once saw a presentation that claimed to prove that ZA-27 bearings (zinc/aluminum) had less wear than Bronze bearings in Komatsu track pinion bearings, showing less wear particles in oil analysis than the Bronze. But they used a sulfur/phosphorus gear oil instead of the recommended Komatsu oil. Those of us that understand tribology know how damaging sulfur/phosphorus oil is to bronze bearings and gears under pressure.

  People often compare very different products to make these statements. If you compare a Synthetic SN oil with a CI-4 of any base oil formulation, you will have more gear and valve train wear with the SN, as the SN does not have the same amount of ZDDP as the CI-4, whether it is synthetic or not. SN oils are great for modern cars, but, as noted above, do not protect sliding movements as well as higher ZDDP content oils, and will cause slippage of synchronizers and discs in the transmissions of our Minis.

  I keep seeing people say "Don't use '*brand xyz'* because it does not have enough ZDDP. This is a terrible generalization. Almost every company makes an oil with enough ZDDP. Just look for the right product in their product offerings.

- There are people who swear by single grade motor oils and claim they are solutions to everything. In actuality, they cause serious wear on every start-up of the engine, and have less additives (except specialty oils), as the industry basically considers them obsolete. They have the additives of a CF oil (similar to the SL shown above in the graph).
- I have also seen people write *"I have used the same oil for 40 years. I'm not going to change now"*. While their Mini might be 40 years old, the oil is not the same. As noted above, today's automotive oil has friction modifiers that make it much more slippery at

moderate pressures than the oils of even 20 years ago. This will make it harder for synchronizers to work. At the same time, automotive oils of today have reduced ZDDP so they reduce the protection of the flat tappet valve train and gear faces. ZDDP increased steadily from 1950 to about 2005 for both gasoline and diesel formulations and has then been reduced to protect the catalytic converters and other phosphorous sensitive parts.

It should also be noted here that sticking with one brand and type does not mean you have the same formulation. Oils are constantly improving, and while most of those improvements are great for the average car, many are detrimental to our classics.

- Another person recently posted that he was having trouble with his Mini transmission, that he had changed the oil and added a tube of Lucas ZDDP. The Lucas web page says one tube in 4.5 quarts of oil results in 5000 ppm of ZDDP in the oil (No mention of whether they start with an SN at 800 or a CI-4 at 1400 ppm). Please remember the SAE paper where more than 1800 is dangerous, and more than 2000 will definitely cause galling of cams and gears. Anywhere near 5000 ppm of phosphorous will destroy your cam and gears.
- Someone recently posted that they wanted to increase their oil pressure, so would it be all right to add SAE 90 gear oil? The sulfur/phosphorous additive in the gear oil would cause serious damage to the engine parts, and as we said at the beginning, SAE 90 gear oil is about the same viscosity as a SAE 50 motor oil.
- People often say modern oils, or a given oil, have had the ZDDP eliminated. It has been slightly reduced, but not eliminated, as you have seen in the table above for diesel formulations. Here are some high mileage gasoline formulations of today, as tested by PQIA.

Test Results for High Mileage Motor Oils  CLICK BOTTLES FOR DETAILS											
		SAE 5W-30, API SL	SAE 5W-30, API SN	SAE 5W-30, API SN	SAE 5W-30, API SN	SAE 5W-30, API SN	SAE 5W-30, API SN	SAE 5W-30, API SN	SAE 10W-30, API SN	SAE 10W-30, API SN	SAE 5W-30, API SN
PHYSICAL TESTS (click test for details)	Standards (a)										
TBN, mg KOH/g, (ASTM D2896)		8.06	6.76	8.51	9.72	6.94	8.91	7.75	7.27	7.03	6.57
Viscosity @ 100ºC, cSt, (ASTM D445)	**9.3 to 12.5**	11.12	9.79	10.06	11.49	10.14	10.83	12.01	10.75	10.69	10.25
Viscosity @ 40ºC, cSt, (ASTM D445)		66.34	57.14	58.20	69.28	58.90	61.50	73.77	71.07	70.73	60.60
Viscosity Index (ASTM D2270)		161	157	161	160	161	169	159	140	139	158
Viscosity @ -30ºC mPa s (cP) (ASTM D5293)	**6,600 Max**	5,687	5,988	5,126	5,875	6,124	5,594	6,141	n/a	n/a	5,471
Viscosity @ -25ºC mPa s (cP) (ASTM D5293)	**7,000 Max**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5,772	5,911	n/a
NOACK volatility, mass % loss, 1 hr, @ 250ºC (ASTM D5800)	**15 Max (b)**	12.6	15.6/16.5	10.9	13.6	15.2	14.1	13.3	13.4	14.6	13.9
ELEMENTAL ANALYSIS-b,c											
Additives											
Calcium, ppm		2,097	1,565	2,016	2,475	1,563	2,405	2,190	1,644	1,605	1,806
Magnesium, ppm		11	8	8	10	9	25	9	10	8	13
Phosphorus ,ppm	**600 to 800**	990	730	749	768	730	782	749	744	757	752
Zinc, ppm		1,071	784	810	882	788	866	804	805	814	806
Molybdenum, ppm		102	<1	<1	258	<1	42	<1	<1	<1	38
Barium, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Additive and/or other											
Boron, ppm		216	<1	<1	110	2	<1	76	<1	2	182
Silicon, ppm		5	2	2	5	4	3	8	4	4	7
Potassium, ppm		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Manganese, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Copper, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sodium, ppm		<5	441	441	<5	439	<5	<1	455	454	<5
Vanadium, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Contaminants											
Silver, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Aluminum, ppm		1	<1	<1	4	<1	<1	3	<1	<1	3
Chromium, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Iron, ppm		<1	<1	1	1	1	<1	<1	1	<1	<1
Nickel, ppm		<1	<1	<1	<1	<1	<1	<1	<1	1	<1
Lead, ppm		<1	<1	<1	1	1	<1	<1	<1	<1	<1
Antimony, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin, ppm		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

I hope this is helpful. If you have questions or comments, feel free to write to me at rlwidman@hotmail.com