Revised Summary of Citroën Hydraulic Fluids

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Editors Note:
Tony Jackson first began supplying the Citroën virtual community with this summary several years ago.

Up to this time, however, it has only been available in text form. I have chosen HTML as the ideal universal format for widespread assimilation and easy modification of this information. With the Internet as a conduit, it has become easier to track the many experiences of owners of these unusual and fascinating cars. Citroën lovers are a resourceful lot, given the complexity of their cars and the diversity of their geographic locations. Unlike many popular collectable cars, older hydropneumatic Citroëns were scattered thinly into the remotest corners of every continent. Even in places where they were once frequently sighted, they now are getting more and more difficult to find.

Keeping old cars in running condition is challenge enough, but these Citroëns offer the extra complication of hydropneumatic systems. This radical approach to vehicle design is just one of the innovations that make these cars endearing and a fascination to those who prize them.

Given the increasing difficulty in finding the original specification hydraulic fluids, owners have often relied on ingenuity to devise alternate sources. The Fluid Summary is an attempt to provide an easy to modify source of information on these ongoing trials.

It must be stressed that the authors do not in any way wish to take responsibility for consequences arising from the use of any of this information. Readers are hereby informed that all of this work is fully experimental in nature, and any actions taken by the readers will be construed as being taken on their own volition. In other words **USE THIS INFORMATION AT YOUR OWN RISK.**

We also wish to invite the Citroën community to feel free to offer us information on your efforts. This document is by no means complete or final. As you can see by the following chapters, charts and articles, there are many gaps in our knowledge. Please send your contributions to the authors.

Original Fluids For LHS Cars Top

Early production cars used red colored LHS fluid. Their main hydraulic components were painted black. This fluid proved to be problematic because it was hygroscopic and anything less than frequent fluid changes resulted in corrosion and damage to the system, particularly in humid climates. LHS was apparently manufactured only by Eugene Kuhlmann in France and Deutsche Pentosin Werke in Germany. All other suppliers bought from one or other of these and then packaged it under their own labels: Castrol, Lockheed, Total, BP, Shell, Esso and Bendix. LHS originally was castor-based. In 1963, synthetic-based LHS2 supplanted the old formula. Some problems subsided, but hygroscopy was still an issue.

Everywhere except in the US production changed in 1966 to use a green-dyed mineral fluid, LHM, which did not take up water, and which has proven highly successful ever since. LHM was not compatible with the seals used in cars built previously, so the hydraulic component color was changed to green as a warning. Cars sold in the US changed to LHM during 1968 due to delays in governmental certification.

LHM was introduced at the following serial numbers for all except US export models:

DS19A-H	4 316 000
DS19A-M	4 442 000

DS21-H	4 376 200
DS21-M	4 473 100
Cabriolet DS21-H	4 376 050
Cabriolet DS21-M	4 473 020
Cabriolet Chapron DS21-H	4 376 000
Cabriolet Chapron DS21-M	4 473 000
ID19B	3 710 001
Familiale ID19FA	3 535 000
Break, Ambulance, etc ID19FA	3 536 000
Familiale ID21F	3 554 000
Break, Ambulance, etc 21F	3 554 500

LHM for US export models was introduced at the following serial numbers:

DS19A-H	4 330 000
DS20-H	4 332 001
DS20-M	4 451 001
DS21-H (including cabriolet)	4 621 000

DS21-M (including. cabriolet)	4 490 001
ID19B	3 794 600
ID20	3 820 001
Break ID19FA-M	3 546 800
Break ID19FHA	3 980 380
Break ID20F	3 980 501
Break ID20FH	3 985 001
Break ID21F	3 561 600
Break ID21FH	3 575 350

Alternate Fluids For LHS Cars **Top**

Lockheed 70R1 grade fluid was initially specified by the factory for cars sold in the US. By 1966 the factory approved any fluid to SAE 70R3, including Mobil Super HD, Delco Super 11, Lockheed Wagner 21B, Mopar Hi Temp. Specification SAE 70R3 was later replaced with DOT 3.

Standard glycol-based DOT 3, DOT 4 or DOT 5.1 brake fluid works but allegedly causes problems. It is very much less viscous, especially at high temperatures, and has much poorer lubricant properties than LHS. Rolls Royce used DOT 3 in bottles labeled RR 363 for their application of Citroën patents, but theirs was a much more restricted use of hydraulics.

The main difference between DOT 3 and DOT 4 ratings has to with the dry and wet boiling temperatures of the fluids. The designation "heavy duty" that one sees attached to these ratings means that the fluid in question has a higher rating for the wet/dry boiling point that the specification for that category but not high enough to elevate it to the next category.

Some believe that silicone-based DOT 5 fluid would be an improvement as it does not take up water, but I think it would be prudent to replace all seals before doing so. In the light of experience in cars with non-powered hydraulic brakes and clutches, where seals have already deteriorated (probably due to moisture in the glycol fluid), they quickly fail when the change is made to silicone. DOT 5 Silicone fluid has a tendency to foaming. Dale Ice recommends the use of an anti-foaming

agent made by Dow Chemical Co. (phone 1-800-FOAMFREE).

It should be further noted that DOT 5 does not absorb moisture, it displaces it. So water entering the system will settle in low places or accumulate in points of low flow. And because of a problem with trapped air bubbles, bleeding the system is more difficult. The air bubbles will cause altered braking action because a tendency toward spongy feel. Further, DOT 5 does not attack paint as glycol based fluid can, but it leaves a residual behind that can cause problems with subsequent paint application.

Several owners have run cars satisfactorily on silicone for years. Some use a filter between the pump and tank to collect sloughed off material before it blocks anything. They report problems caused by its very highly insulating nature. Weeping around the brake mushroom can cause trouble with the brake switch. Steps must be taken to isolate this part. Also, trouble with contamination of ignition points has been reported. Many owners convert their systems to electronic, thereby eliminating the points.

DOT 5.1 is a new category for glycol/glycol ester based fluids that essentially match the Silicon fluids for dry boiling point. They should not be confused or mixed as they are incompatible.

Other owners have suggested that the addition of castor oil to the glycol-based fluids improves lubrication and ride without causing harm. This theory is supported by the discovery that the original specification LHS was castor oil based. At one time, Citroën was recommending the use of castor oil as an additive, but troubles cropped up in very cold climates as the castor oil thickened. Castrol R racing oil (used by some racing motorcycles) is one source. Model aircraft suppliers are another. In addition to its effect on lubricity the castor oil raises the viscosity to around 35 mPa.sec at 75 deg. Fahrenheit, the same as LHS (plain Glycol brake fluid of DOT 3 or 4 has a viscosity at this temperature of 23.1 mPa.sec). This mixture has been used for some time without problems, except in cold climates. If the car is to be used while ambient temperatures are below the freezing point, the castor oil fluid should be drained and replaced with DOT 4 brake fluid. For more information of this experiment, please go to Mark Bardenwerper's web site .

LHS cars can be converted to LHM if all the seals are replaced with LHM-type seals. This sounds like a better use of the labour of changing all the seals than going for DOT 5. The metal components were not changed when Citroën changed to LHM, save the color change from black to green. This step should not be omitted for reasons obvious!

Texaco Biostar is an interesting alternative which has the advantage of being safe to handle and is biodegradable. It is also apparently compatible with both types of seals, being based on rapeseed. But I worry about Biostar in low temperatures. A pour point of -20C could pose problems in some parts of the world in winter - Texaco say it is for use between -15 and +80 degrees C. Presumably farmers must face this problem - I wonder whether there is an agricultural solution to this? Also, I would imagine there is a risk that some parts of the system might exceed 80 degrees C. From the figures it is clear that Biostar is a good bit more viscous than LHS or LHM at the temperatures for which I have information. I guess this would have the effect of stiffening the damping, which some might like, and of increasing the work required of the system in various ways. The main worry may be increased loads on the pump, which might reduce its life expectancy a little.

Those of us with older ID/DS cars using brake fluid need to be more diligent regarding fluid

changes. When the car raises, fluid moves out of the reservoir, drawing in air from which water is absorbed. This problem is aggravated in moist climates and lessened in dry. High moisture content can greatly increase corrosion problems in the system - especially on parts in areas where the fluid is static, i.e. the brake cylinders. And just like LHM, the viscosity modifiers and lubrication additives all degrade over time. In our cars it will happen faster than non Citroën systems because of the much higher working pressures and the constant circulation.

Specifications For Fluids Used In LHS Cars; LHM included for comparison. Do not use! Top

Characteristics	Units	LHM+ **For Comparison Only Do Not Use!**	LHS 2	DOT 3	Texaco Biostar 32	Mark's Mix (18.5% Castor Oil/DOT 4)
Colour	-	Green	Red	Amber	Clear	Yellow
Density at 15C	Kg/l	0.830	1.007	?	.92	~1
Viscosity at -40 C	cSt	<1200	?	1182	?	?
Viscosity at 21 C	cSt	?	32.4	?	?	34.7
Viscosity at 40 C	cSt	18	14.5-16.5	8.59	32.6	?
Viscosity at 100 C	cSt	6.3	4.5-5	2.1	7.53	?
Viscosity index	-	355	256	30	210	?
Pour point	Deg C	-62	?	?	?	?
Boiling point	Deg C	255	?	?	?	?
Flash point	Deg C	135	99	149	210	?

Notes
The figures for DOT 3 come from two sources. In places they differ, but I think the effect is marginal (RR 363 has viscosity of 2.38 at 100 C, whereas Texaco DOT 3 has 2.1. I've taken the Texaco figures where I have a choice) The density figures seem quite variable. I have figures for the similar DOT 4 of

1.055. Castor oil has a similar density to DOT 4, so Mark's mix would be around 1, i.e. not a problem.

Biostar comes in two grades, 32 and 46, both rather more viscous than the LHM or LHS, and both with an importantly lower viscosity index than LHM. I have chosen Biostar 32, which is the version nearest to the Citroën specs. Biostar is the only oil I have checked for which Texaco make particular claims about wear resistance. It sounds as though this might be worth trying in a system which has suffered wear - e.g. from the use of brake fluid. However, its rather high pour point and low viscosity index might give one pause before using it in very cold conditions, and it would be a comfort to know its specified upper temperature for use (80 C) is safe.

Original Fluids For LHM Cars Top

Best is LHM. No other freely available fluid has the same viscosity, and any replacement runs the risk of giving rise to behaviour other than that which was originally intended, most particularly in conditions of extreme temperature.

Properties of LHM+ (the latest version, fully compatible with original LHM, recommended by Citroën):

- Exceptionally high viscosity index
- Very low pour point
- High stability
- Excellent lubricating properties
- High boiling point
- Non hygroscopic
- Very good protection against corrosion

Alternate Fluids For LHM Cars Top

Next best is what is known in the aviation community as "red oil" (MIL-H-5606). It is cheap to buy and is near LHM in viscosity (it's slightly lower). Having existed before LHM, it's reasonable to believe that Citroën would have allowed it if they thought it delivered what they required. But the demands of the Citroën system are unique and very specific. It is also conceivable that they were concerned with the color similarity of LHS, a potential disaster for older car owners, should incompatible fluids be accidentally intermixed.

The actual specifications for LHM differed from the earlier version of "red oil" in one important aspect, VI (viscosity index). The VI represents how much a fluid's viscosity changes with temperature. The higher the number, the more constant the viscosity will remain across a given temperature range. As of 2/97, MilSpec 5606(F) was supplanted by 5606(G). The major improvement was in the area of low temperature viscosity. The VI for LHM is over 350, while the older 5606(F) red oil was around 300. The VI of the new MIL-H-5606(G) is now above 350, matching LHM. For comparison, the VI for Dexron (regardless of type) is only about 200. One should still be aware that the viscosity of red oil is still lower than LHM at all temperatures.

A comparison of MilSpec 5606(G) and LHM+:

- Seal compatibility - fine
- Non-foaming under high pressures - fine
- Viscosity/temperature stability - fine

- Lubrication qualities - fine
- Corrosion resistance- fine
- Volatility - passable
- Resistance to thermal breakdown - fine

Third best is Dexron automatic transmission fluid, commonly used in automobiles. More than twice as viscous as LHM at low temperatures, Dexron may be problematic in cold conditions. Dexron is an acceptable "emergency" fluid that can be used until either LHM or 'red oil' (MIL-H-5606) fluid can be put back into the car. The basic problem with Dexron is that it has very poor lubrication qualities. Keep in mind that a number of critical hydraulic components in your car rely on very close tolerances. The long term use of Dexron in a car will lead to excessive wear in these areas. As internal leakage increases, system cycling increases, which in turn puts more stress on the source/supply for the system. By long term we are not talking about weeks or a few months, but wear can start in as little as a year in a heavily used car.

Automatic transmission fluids are highly specialized due to their dual purpose. They are specially engineered to provide proper lubrication to the transmission's bearings while providing enough friction so that the transmission's clutches work as designed. Therefore their requirements conflict with the specifications of LHM in two critical areas, viscosity and wear resistance.

Owners are warned not to use type F or Mercon. These fluids diverge excessively from requirements. They use a lot more friction enhancers and cause much more wear than Dexron. Ford type F or Mercon compatible transmissions will not shift properly unless the specific fluid is used because of clutch design.

Dexron has evolved into newer versions, types II and III. In each, the thermal properties have been improved and the amount of friction enhancers reduced.

A car with a Dexron transfusion that has lasted for a number of years and has high mileage may not take kindly to a charge of standard LHM or LHM 2. The only cure for these cars is to use a slightly thicker fluid such as AirCraft #15. Just because a fluid does not destroy the seals does not mean that it is not causing other problems that may take years to surface.

A comparison of Dexron and LHM+:

- Seal compatibility - fine
- Non foaming under high pressures - passable
- Viscosity/temperature considerations - thick at low temperatures
- Lubrication qualities - slightly inadequate
- Corrosion resistance - passable
- Volatility - passable
- Resistance to thermal breakdown - passable

Late Breaking Information Top

At least one owner is using a hydraulic fluid made by Kendall called Hyken Glacial Blue. As of this time, we have no further information. Some Mercedes and BMW cars use a fluid called Pentosin CHF. We've found two versions of this, and both look to be suitable for use in later D series suspensions (they are even green) according to the information we have. They are usually expensive! Mercedes uses a fluid called ZH-M in some of their cars for power steering and self-leveling rear suspensions. This fluid, while almost certainly harmless to seals in Citroën cars, has a lower viscosity index and its viscosity is generally lower than that of LHM. This would demand more work of the high pressure pump and would have a small effect on suspension behaviour. It might also be a bit marginal in high ambient temperatures, or when the brakes were really punished, as when descending a long mountain pass. It is, however, probably a better option that ATF (see below). It is cheaper than the Pentosin CHF fluids but costlier than ATF. We have added that data to the chart below, though so far there are no confirmations of owners' experiences and the viscosity index seems low. The only conclusion I have right now is that it is likely that there may be several hydraulic oils that could work in LHM cars. The most logical reason would be that mineral based fluids have become the norm while glycol based fluids are nearly extinct.

Specifications For Fluids Used In LHM Cars Top

Characteristics	Units	LHM+	Pentosin CHF 7.1	Pentosin CHF 11S	ATF+3	Texaco MIL-H-5606(G)	ARAL Vitamol ZH-M
Colour	-	Green	Green	Green	Red	Red	Green
Density at 15C	Kg/l	0.830	0.857	0.825	0.825	0.86	.861
Viscosity at -40C	cSt	<1200	1050	<1100	1500	?	6000 (?)
Viscosity at -20C	cSt	?	?	230	?	?	?
Viscosity at 0C	cSt	?	75	?	?	?	?
Viscosity at 20C	cSt	?	32	?	?	?	~32
Viscosity at 40C	cSt	18	18	18.6	36.8	13.5	16
Viscosity at 50C	cSt	?	14.3	?	?	?	?
Viscosity at 100C	cSt	6.3	6.0	>6	7.65	5.0	~4.2
Viscosity index	-	355	326	320	185	372	181
Pour point	Deg C	-62	-62	<-62	-45	-80	-40

Boiling point	Deg C	255	?	?	?	?	?
Flash point	Deg C	135	?	?	?	?	140

Seal Compatibility Top

A seal's compatibility is determined by its durability in the fluid that it must operate in. The systems that we are concerned with use glycols (normal brake fluid) or petroleum (paraffin /mineral oil/others) or synthetics fundamentally designed to supplant them.

Seals come in many shapes. Automatic transmissions have "o" and square rings, flanged, or lip seals and gaskets. Primarily, the hydraulic systems in our cars use o-rings and protective covers such as those found on the ends of the height correctors and in the suspension ram boots. But seals can also be made of other elastomers, metal, paper or other fiber products, or specialized plastics such as teflon.

For glycol based fluids the material of choice is ethylene propylene (epm, pdm). Introduced in 1961, it still has the best resistance to brake fluid. A new compound that has been recently introduced and shows promise as being suitable for both glycol and petroleum based fluid is Aflas (TFE Propylene/trademarked 3M).

For Petroleum based fluids (LHM, Dexron, 5606 Spec) the following materials are the most widely used: Fluorocarbon based, (Vinylidene fluoride - hexafluoropropylene) also know under the trade name Viton (and others) and Nitrile (NBR or Buna N, Acrylonitrile-Butadiene Copolymers). Of the two Viton has the best mechanical strength/temperature resistance and is much more expensive compared to Buna N. While there are others, the above two are the most common.

The seals in our cars are of two types - static and dynamic. Static seals are those where the sealing faces do not move. Dynamic seals are those where one or more of the sealing faces moves relative to the other. To list a few, the power steering rack, suspension cylinders, brake pistons, clutch engagement control/steering speed control (in SM's), height control valves, rear brake articulating joints on ID/DS series are all examples of dynamic sealing points. The high pressure pump has one dynamic seal, though it is a metal to metal seal at its driveshaft. The suspension sphere diaphragm is a special kind of seal and presents real problems from a design standpoint. Not only must it be resistant to the fluid in use, it also has to have extremely low gas permeability, excellent flexibility and tear resistance over a wide range of temperatures and pressures.

When Citroën introduced LHM in 1966, they ran into serious high temperature problems with the diaphragm material during the first couple of years, primarily with gas permeation. This problem has been almost completely eliminated in the latest cars, such as the C5. The diaphragms are now 2 ply.

More complete information on seal compatibility can be found at Engineering Fundamentals and Marco Rubber .

Before I close I'd like to address the issue of fluid changes and why they remain important even when using LHM or Milspec 5606(G) fluid. Owners of LHS cars already acknowledge the fact that they must make frequent changes because of hygroscopy. The lubricating qualities of the fluids used in later cars also degrades with use. The long chain polymers that are used to improve viscosity and provide improved lubrication under extreme pressure begin to break down. This is caused by the physical shearing of these chains as the fluid is pumped under high pressure throughout the system. Keep in mind that just because the fluid looks "clean" does not mean that it is providing optimum protection. The factory recommendation of a yearly change is not overly restrictive. On this same note I noticed in Total's web site a reference to a special cleaning fluid for LHM systems called Hydaurincage. Owners of LHS cars have been known to use a mix of alcohol and castor oil.

Furthermore, corrosion can occur in later cars, too. Corrosion comes from two main sources, galvanic and oxidative. The anti-oxidants that are used have a finite life (as any anti-oxidant has). Just because the fluid is non hygroscopic does not mean that oxygen gas is not being absorbed by the fluid, another reason to change fluid on a regular basis.

Credits Top

Image courtesy Pomini Paolo

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