

# 9

# Eure!Tech FLASH

THE UP-TO-DATE TECHNICAL INSIGHT IN AUTOMOTIVE TECHNOLOGY & INNOVATIONS

EDITION 9

## LUBRICANTS & FLUIDS

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# MOTOROIL

Internal combustion engines make it possible to transform the energy generated by combustion into mechanical work. To produce movement, they have a large number of moving parts subjected to high loads and temperatures.

During operation, the moving parts rub against each other. This friction generates heat and causes wear in the components, leading to excessive play, breakages or even seizures between them.

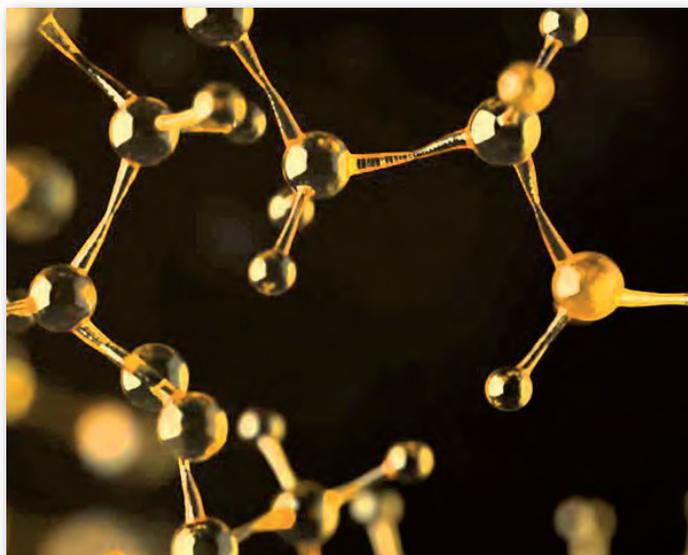
To prevent this, lubrication systems are used in the engine, creating a film between the moving components that reduces the friction and the problems it can generate. The fluid used for lubrication is engine oil.

These systems must perform a variety of functions:

- Reduce friction between components.
- Dissipate heat.
- Prevent oxidation of the system.
- Transport metal particles.



## Features



The engine oil must meet the needs of the system mentioned above. To do this, all the oils have several characteristics or properties:

- Lubricant.
- Antioxidant.
- Anti-rust.
- Anti-foam.
- Detergent.
- Dispersant.
- Thickener.
- Thinner.

For the oil to have all these properties, it is often necessary to use additives during its manufacture which will provide the required characteristics. Depending on the oil type, these additives are needed to a greater or lesser degree.

## Types of oil

In the automotive industry, there are three different types of oil used for engine lubricant depending on their origin, which may be mineral, semi-synthetic or synthetic:

### Mineral oils

Formed mainly from petroleum-based hydrocarbons, they have good characteristics as lubricants. Pure mineral oils have disadvantages such as their susceptibility to changes of their properties under high tempera-

tures, pressures and agitation. Additives are used to improve their properties and reduce their disadvantages. They are no longer in use in the automotive industry and are not used in modern vehicles.

## Hydro-cracked Oils (HC)

These are basic mineral oils which are subjected to complex processing techniques at the refinery. During the hydro-cracking process, hydrogen is added to the base oil and its impurities removed. The most reactive

components are stabilized in the latter process, improving their colour and increasing their life cycle. This type of oil provides extreme performance and contains synthetic components.

## Semi-synthetic oils

Semi-synthetic oils are produced in laboratories and use mineral and synthetic bases to improve the performance offered by the mineral oils. The processes to which they are subjected during their manufacture enable their characteristics to be improved, therefore the need for additives is re-

duced. These oils can be found on the market due to the large number of vehicles that still use them, although they are not used in newly-manufactured vehicles.

## Synthetic Oils

Produced with synthetic bases, these are formulated by modifying their molecules so that they have the required qualities by removing any molecules which do not have them. This results in oils with excellent lubrication properties, thermal stability and resistance to rust/oxidation. These are the best performing oils in the automotive industry.

In order to classify the different oils used, regardless of their origins, SAE (Society of Automotive Engineers) standards are used. This classification determines an SAE grade based on viscosity and operating temperature. The higher the assigned number, the greater the oil's capacity to maintain its viscosity at high temperature.

*Viscosity is defined as a physical quantity which measures the flow resistance of a fluid. Viscosity is measured in centipoise (cP) and relative viscosity, the ratio between viscosity and density of the fluid, is measured in centistokes (cSt). The inverse magnitude to the viscosity is the fluidity.*

In this way, it is possible to distinguish two types of oil:

### Monograde oils

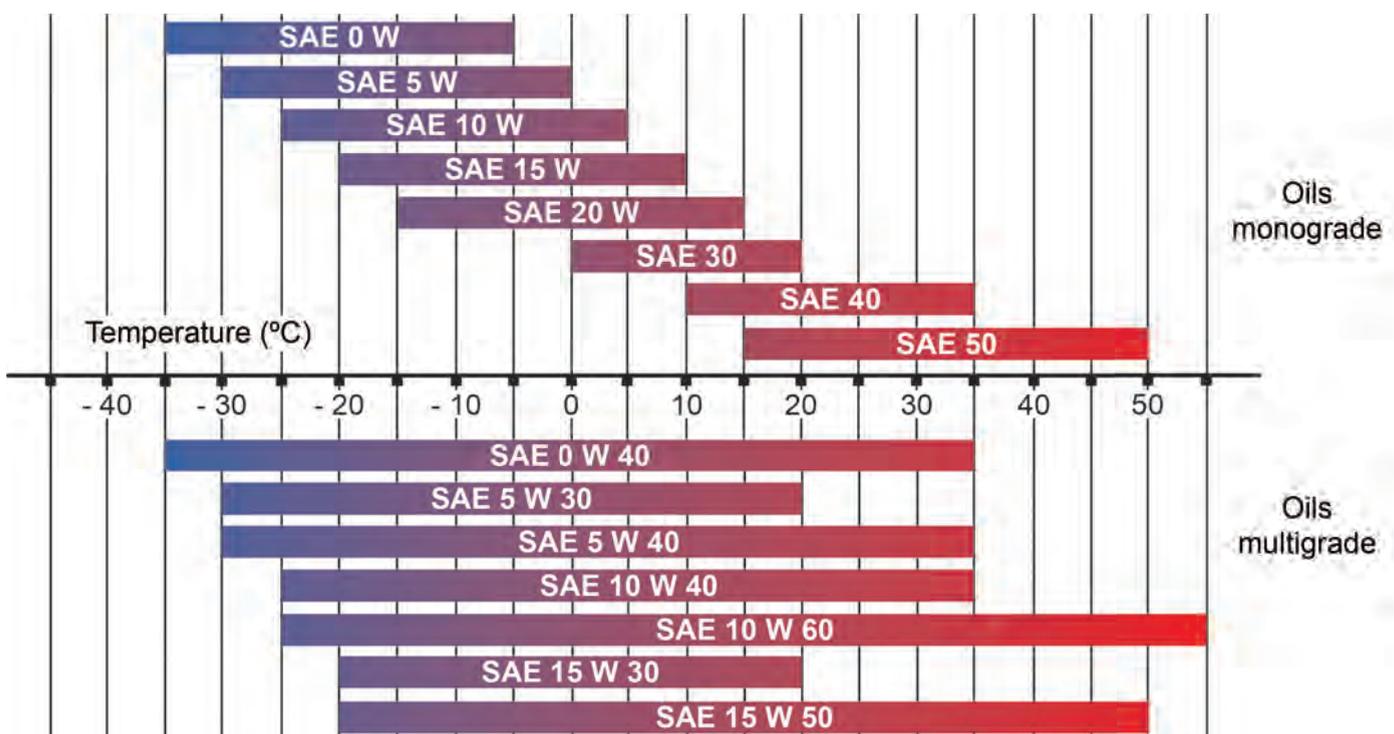
A monograde oil maintains its viscosity under very limited temperature conditions, therefore the SAE standard, as well as the viscosity grades, use the letter W (Winter) to identify those grades which perform well at low temperatures.

SAE grades from 0 W to 25 W are known as "winter oils", with SAE grades 20 to 60 used as "summer" oils due to their performance at very high temperatures. This type of oil is rarely used, as it has been replaced by multigrade oils.

### Multigrade oils

Multigrade oils are SAE W grade oils to which viscosity improvers have subsequently been added. This ensures that, at low temperatures, they have adequate viscosity for cold starting and that their viscosity is maintained at high temperatures to prevent them from diluting excessively. Furthermore, multigrade oils have an advantage in that they are more stable in temperature changes that occur in the lubrication circuit when driving.

The following graph compares the SAE grades of several monograde oils against the SAE grades of multigrade oils



## Anti-pollution and influence of the oil on fuel consumption

The current strict anti-pollution laws have required car manufacturers to develop new systems to ensure their products are ever more respectful to the environment, while retaining their performance and consumption levels.

A decrease in the levels of pollution emitted by cars is a consequence of the implementation of important modifications to the structures of engines and their auxiliary systems such as the injection, to which we have to add devices for treating exhaust gases such as catalytic converters and particulate filters.

In general, thermal engines tend to:

- Have increased power in lower volume engines (downsizing concept)
- Reach higher working temperatures
- Have more tuned engines
- Use materials with lower expansion coefficient
- Have lower fuel consumption
- Have longer interval maintenance periods

- Have lower lubricant consumption
- Have more hydraulically controlled components in the engine (variable valve timing, tensioners, pump injector, etc.)
- Emit less particles to the environment

In the use of exhaust gas treatments, such as particulate filters (DPF), three-way catalytic converters (TWC), gas recirculation (EGR), selective catalytic reduction (SCR), requires new lubricant formulations. These formulations have reduced phosphorus, sulphur and sulphated ash content.

The demands of the oil, in order to comply with the new motoring trends, allow greater durability of the oil and reduce its viscosity, volatility and contamination.

Accordingly, thanks to these new oil formulations, engines can work in a more relaxed way, managing to reduce fuel consumption and pollution.

## Type approvals

There are several organisations which implement different standards and specifications to indicate the quality of the oils, the most important being the API (American Petroleum Institute) and the ACEA (European Automobile Manufacturers' Association).

### API- American Petroleum Institute

Associated to the SAE and ASTM (American Society for Testing of Materials), they represent manufacturers and technicians for the development of tests that analyse the use of engines. For this reason, the oils are classified according to their capacity to operate under certain conditions in the engines.

This classification is designated through the use of two letters. The first letter is used to identify the type of engine in which the oil is recommended. The letters used are "S" (Spark Combustion) for petrol engines and "C" (Combustion by Compression) for diesel engines. A second letter is then used which indicates the demand for the service fulfilled by this oil, with "A" for the least demanding oil and continuing in alphabetical order as the demand increases.

Each level complies with the lower levels of demand to their own therefore, as new levels of demand appear, the previous ones are considered obsolete.

### ACEA - European Automobile Manufacturers' Association

Due to the dissolution of the CCMC (Common Market Automobile Manufacturers' Association), the ACEA emerged. Comprised of European vehicle manufacturers, they develop a system to ensure the quality of the lubricants in conjunction with other institutions. The ACEA levels are based on laboratory tests which demonstrate protection against wear, engine cleanliness, resistance to rust and viscosities at various temperatures, etc.

The ACEA classification designates, by letters, the type of engine targeted by the lubricant. The letters "A/B" are designed for diesel and petrol engines in light vehicles. The letter "C" is for oils compatible with the catalytic converter in light petrol and diesel engines. Finally, the letter "E" is for diesel engines in heavy vehicles. In addition to the letter, each level is defined with numbering.

As opposed to the API classification, the different levels do not necessarily distinguish between a higher or lower quality of oil, but different specifications of each lubricant, therefore a higher level does not necessarily mean higher quality.

The series of ACEA oils is based on continual development. On 14 December 2012 the standards for these oils were updated. The following table shows in detail the percentages of elements that go into these types of oil, the HTHS (viscosity at high temperature and high shear) and the TBN (Total Base Number) which represents the alkaline reserve of Potassium Hydroxide contained in a gram of oil (mgKOH/g) in milligrams.

Type	HTHS	Sulphated ash (%)	Phosphorus (%)	Sulphur (%)	Iron (%)	TBN (mg KOH/g)	Evaporation loss (%)
A1/B1	≥2.9 - ≤3.5	≤1.3	-	-	≥2.5	≥8	≤13
A3/B3	≥3.5	≥0.9 - ≤1.5	-	-	-	≥8	≤13
A3/B4	≥3.5	≥1.0 - ≤1.6	-	-	-	≥10	≤13
A5/B5	≥2.9 - ≤3.5	≤1.6	-	-	≥2.5	≥8	≤13
C1	≥2.9	≤0.5 %	≤0.05 %	≤0.2 %	≥3 %	-	≤13 %
C2	≥2.9	≤0.8 %	≤0.09 %	≤0.3 %	≥2.5 %	-	≤13 %
C3	≥3.5	≤0.8 %	≥0.07 - ≤0.09 %	≤0.3 %	≥1.0 %	≥6	≤13 %
C4	≥3.5	≤0.5 %	≤0.09 %	≤0.2 %	≥1.0 %	≥6	≤11 %
E4	≥3.5	≤2.0	-	-	≥12	-	≤13
E6	≥3.5	≤1.0	≤0.08	≤0.3	≥7	-	≤13
E7	≥3.5	≤2.0	-	-	≥9	-	≤13
E9	≥3.5	≤1.0	≤0.12	≤0.4	≥7	-	≤13

### “Specific” approvals of the manufacturers

There are also the manufacturers' own approvals which are exclusive to each make. Lubricants to be used in engines from these manufacturers must comply with these standards. They are based on ACEA generic standards but require laboratory and engine testing under more stringent conditions with very severe limits than those established by the ACEA. These specific standards indicate the type of

service, viscosity, maximum percentage of volatility, extended periods of use between oil changes and the use of synthetic bases in the formulation of the lubricants.

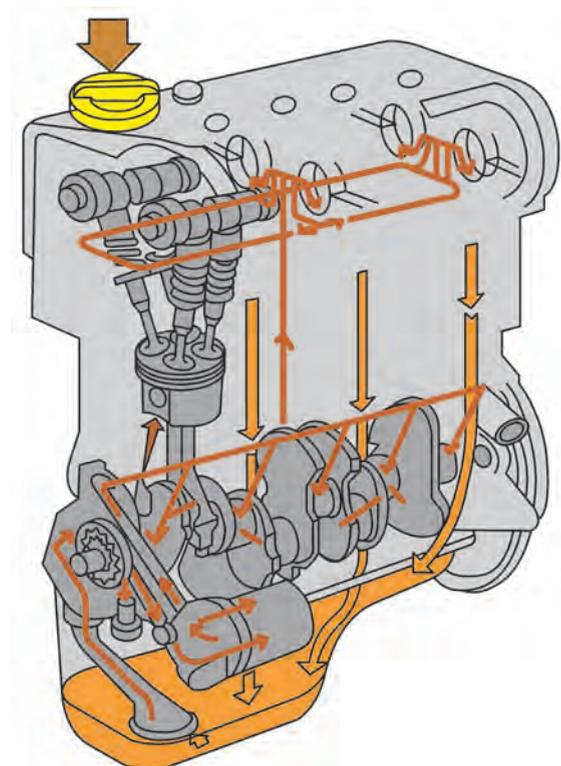
By way of example, in the following table we can see the equivalent of the oil type used by some brands.

C1	C2	C3	C4	C5
Ford Jaguar	PSA	VW	Renault	Hybrids
Mazda		Mercedes BMW		

## Lubrication system

The lubrication circuit distributes the pressurised oil through the engine. This allows the correct lubrication in the areas which require it, and also assists in the cooling of important components which the coolant liquid cannot access or cannot cool sufficiently.

The properties of the oil and the need for lubrication, due to engine performance, make the lubrication circuit crucial for engine operation. Incorrect lubrication can cause engine degradation and breakage in a short space of time.



## Operation

Lubrication of the components through the circuit is carried out in two different ways. Firstly with pressure lubrication, and secondly, with impregnation.

**Pressure lubrication:** In order to lubricate some of the engine components properly, it is necessary for the oil to be under pressure, otherwise correct lubrication and cooling will not be possible. Furthermore, there are components which do not form part of the lubrication circuit but which need oil pressure to function, such as the timing chain tensioners, variable valve timing variators, etc.

**Lubrication by impregnation:** Lubrication by impregnation takes advantage of several factors for lubricating different components without oil pressure. Firstly, it takes advantage of the oil that flows through the return ducts to impregnate components such as the timing chain, while the oil goes down to the sump. Secondly, the splash oil generated by components such as rod bearings or the crankshaft itself, creates a mist which impregnates all the components inside the engine block, such as the cylinders, connecting rod end, etc.

## Components

A lubrication circuit consists of a number of components depending on the design of the engine and its requirements. The most common components that make up the system:

**Oil pump:** Is the component for driving the oil through the whole lubrication circuit. It sucks oil from the sump through a small strainer which cleans the oil of the larger particles and sends it to the filter for filtration before reaching the main engine components. The oil pump can be of several types depending on its internal composition. The most common types are: the gear pump, the lobe pump and the internal gear or crescent gear pump.



**Heat exchanger:** This component consists of a small radiator which is used to cool the oil due to the temperatures that can be reached. It is usually located before the filter and can be of two different types: water/oil heat exchanger or air/oil heat exchanger.



**Oil filter:** This component is for filtering all the impurities and particles transported by the oil to prevent them reaching the engine components. It may be of two types: monobloc or interchangeable cartridge. The oil filter may be located inside the lubrication circuit in two different ways, either in series or in a branch. Its replacement is linked to the oil change, when it is changed in accordance with the manufacturer.



**Oil pressure sender:** Its purpose is to detect if oil pressure is present or absent in the circuit. This is a pressure switch connected to an indicator on the instrument panel. In more modern vehicles, the pressure sender does not act directly on the panel indicator, but reports to the engine unit which turns the indicator light on or off.



**Oil quality, temperature and level sensor:** This is immersed in the sump and reports the oil level, temperature and quality to the engine control unit. These values are sent to the instrument panel to inform the driver. Some vehicles also indicate when the next oil change is due.

**The oil:** Is the liquid substance which flows through the inside of the engine, lubricating and cooling its internal components. The oil replacement period is usually every 15,000 km or every year, depending on the oil quality used and the manufacturer's recommendations.



## ENGINE COOLANT LIQUID

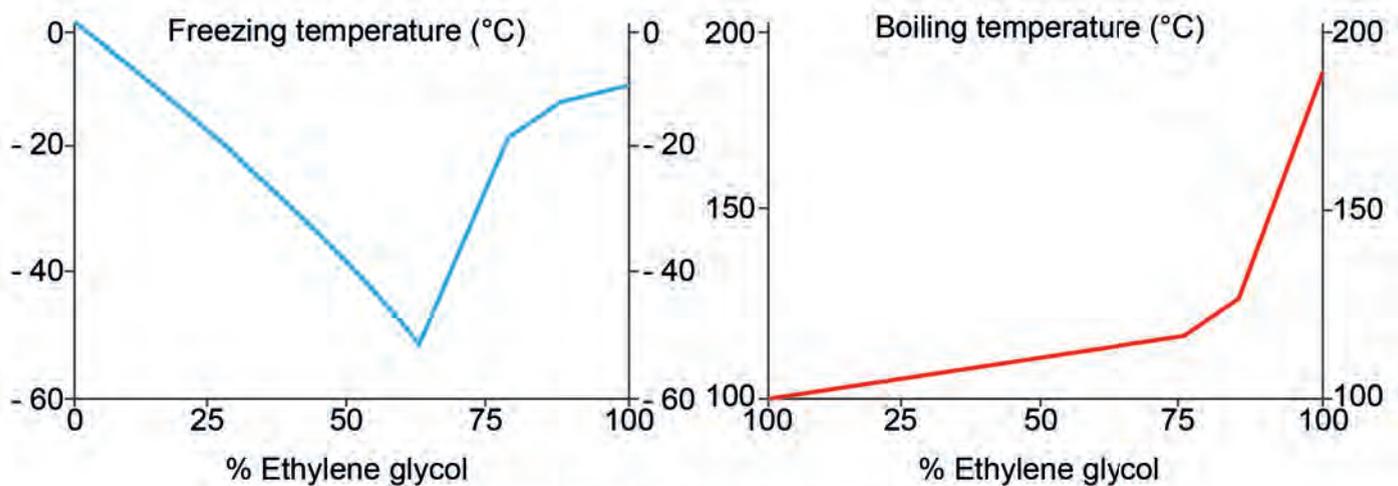
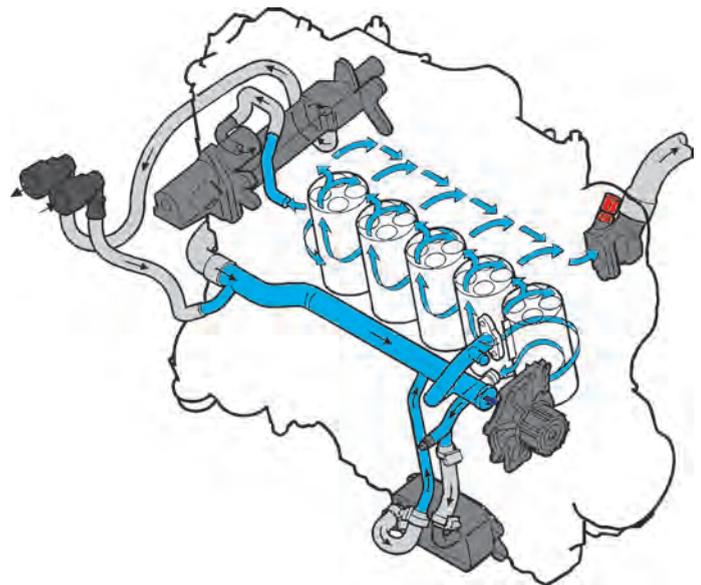
Current engines require a coolant liquid which maintains its properties for all working conditions during the time specified by the manufacturer.

### Features

The coolant liquid, also known as anti-freeze, should have the following properties:

- Low freezing temperature.
- High boiling temperature.
- Anticorrosion properties.
- Anti-foam properties.
- Compatibility with elastomers due to use in hoses and seals.
- Low viscosity.
- Minimum toxicity.

To achieve all the properties, water is used with various additives added to it, with ethylene glycol as the main one. This additive may change the boiling and freezing points therefore other additives are also introduced to prevent the formation of foam, corrosion, etc.



Graphs showing temperature against the percentage of ethylene glycol

Depending on the chemical nature of the corrosion inhibitor additive, the coolants can be classified into inorganic, organic and organic with silicates.

- The inorganics have reduced performance and are less respectful of the environment. They contain a mixture of anti-corrosive mineral additives, for example phosphates, borates, nitrates, silicates and amines.
- The organics are based on OAT (Organic Acid Technology), which is a fully organic anti-freeze with high inhibiting power preventing corrosion and cavitation in aluminium cylinder heads, pumps, etc. They are more environmentally friendly and comply with the manufacturer's requirements (dissipate heat better, longer duration and efficiency, more protection, etc.).

- The organics with silicates are based on Si-OAT (Silicate Organic Acids Technology) which combines the salts of organic acids and silicates with high inhibiting power that prevents corrosion and cavitation in aluminium cylinder heads, pumps, etc. They are normally free, for example, of nitrates, phosphates, borates and amines.

## Type approvals

The increasing use of light alloys in engine manufacturing has meant that, with the passing of time, the requirements of the coolant liquid in terms of corrosion and electrolysis behaviour have changed. The large number of metal alloys and polymers used in modern engines demands a broad range of different coolant liquids with properties suitable to each case. As

a rule, the various coolant liquids cannot be mixed with each other. In other words, it is essential to ensure that an authorised coolant liquid is used for each specific model. For this purpose the current specifications of the respective manufacturer are binding.

Anti-freeze specifications of the Volkswagen group		
G11	VW TL-774C	Silicates (high) + OAT
G12/G12+	VW TL-774D/F	OAT
G12++	VW TL-774G	OAT + Silicates (low)
G13	VW TL-774J	OAT + Silicates (low) + Glycerine

Anti-freeze specifications of Mercedes	
MB 325.0	Silicates (high) + OAT
MB 325.3	OAT
MB 325.5	OAT + Silicates (low)

Anti-freeze specifications of MAN	
324 NF	Silicates (high) + OAT
324 SNF	OAT
324 Si-OAT	OAT + Silicates (low)

## Cooling system

The purpose of the coolant system is to ensure that the correct temperature is reached and maintained in the different parts of the engine, preventing excessive heating or insufficient temperature.

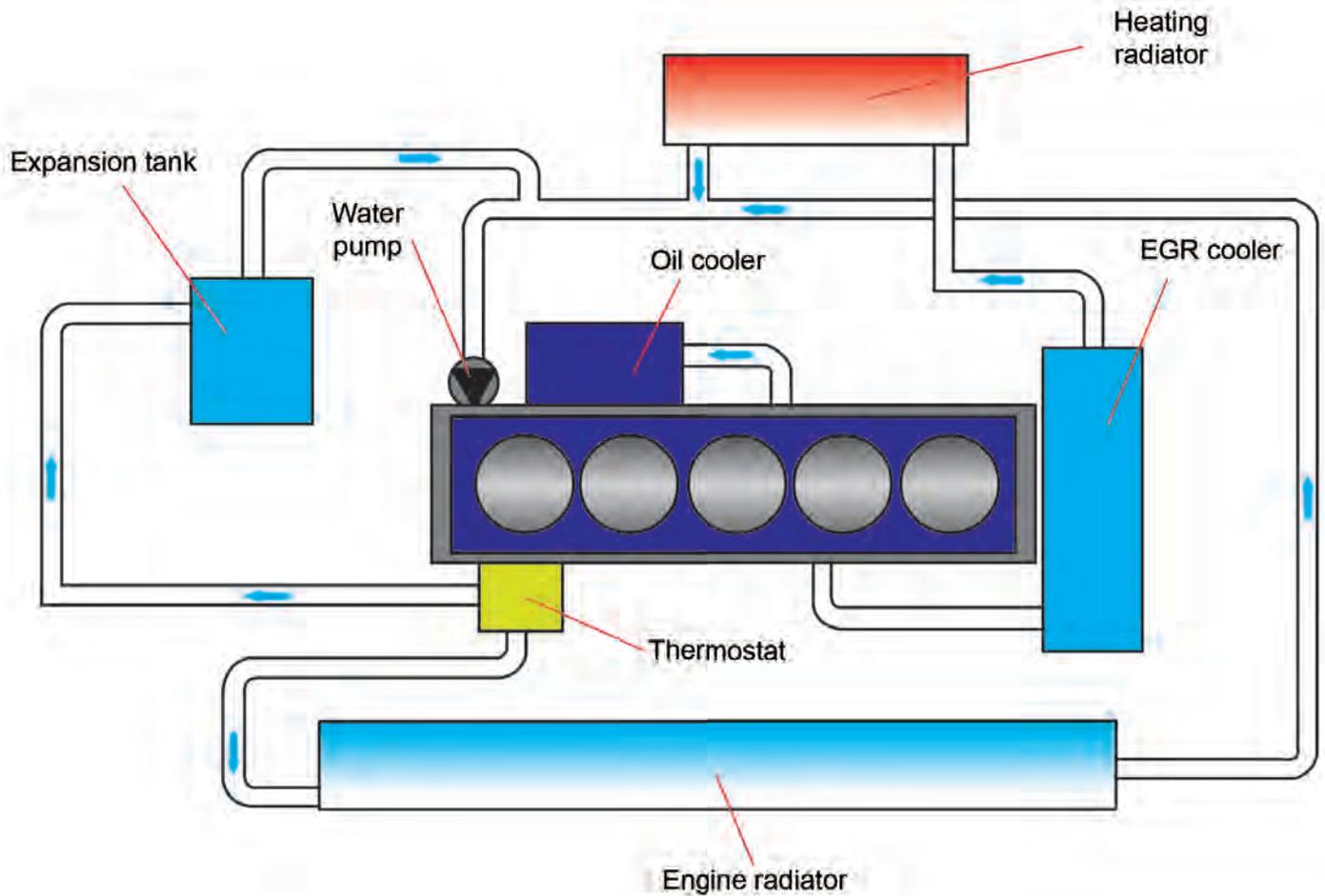
### Operation

Each manufacturer designs the coolant circuit with respect to the requirements of each engine, although the basic operation of the circuit is always the same.

With the engine cold, the coolant pump forces the liquid through the inside of the block and cylinder head so that the coolant liquid absorbs the heat from the engine. Then it comes from the engine and is directed towards several points. Firstly, coolant is sent to the heat exchangers

for the engine oil, if fitted. Then coolant is sent to the heating radiator. At the outputs of the heating radiator and from the possible heat exchangers, a thermostat prevents the coolant liquid from circulating towards the engine radiator, causing coolant liquid to return again to the pump.

As the temperature of the engine increases, the thermostat begins to open up. This means that any coolant liquid that was stagnant will begin to circulate around the engine cooling radiator to be directed to the engine block, completing the cooling cycle.



## Components

### Water pump

This component is for pumping the cooling liquid around the whole circuit. These are usually centrifugal pumps for pumping a substantial flow of water but at low pressure.



### Engine radiator

This is for transferring the heat from the coolant to the air. It is located on the front of the vehicle to increase the flow of air it receives. The liquid output and input is carried out through flexible hoses to absorb the engine movements. The engine radiators can be divided into two types: vertical-flow or horizontal-flow.

The temperature transfer is made across the contact surface between the liquid and the air. This surface can have two shapes: tubular or honeycomb.



### Thermostat

This component regulates the temperature of the coolant circuit. It functions as a valve that controls the flow of coolant liquid to the engine radiator depending on the coolant temperature. This prevents the coolant from circulating through the radiator while the engine is cold, so that the operating temperature is reached as quickly as possible.

There are more complex systems which have two thermostats to attain a different regulation between the temperature of the cylinder head and that of the engine block. Other systems use a conventional thermostat which includes a heatable resistance. Using this resistance, the engine unit is capable of opening the thermostat, maintaining a slightly lower engine temperature depending on the engine requirements.



### Expansion tank

Varies the volume of coolant liquid while the engine is running. Furthermore, a double overpressure and under pressure valve is used so that

the leak-tightness of the system does not cause serious damage to the engine. This valve can be placed in the expansion tank cap or, if fitted, in the radiator cap.

### Control units

To control the operation of the coolant system, the vehicle may have any of the following components:

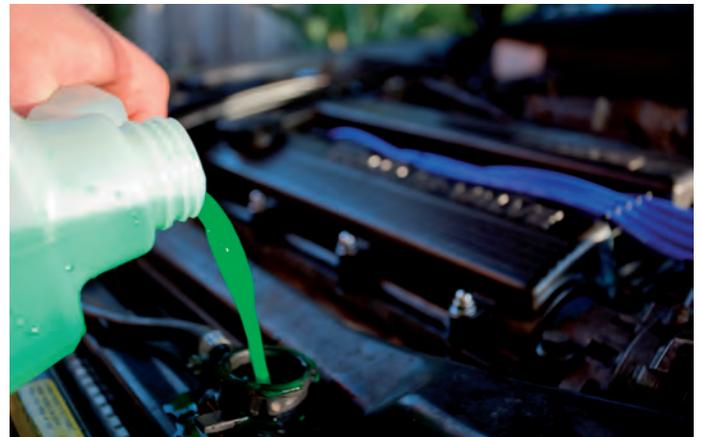
- Temperature thermoswitch: this is a temperature thermoswitch with a higher setting than the engine operating temperature. It is connected to an indicator light on the instrument panel which warns the driver if the engine overheats.
- Coolant level gauge: some vehicles have a light on the instrument panel warning of a deficient coolant level. The level sensor operates by means of a float which closes the switch when the coolant level goes down. It is usually located in the expansion tank.
- Temperature sensor: in most vehicles for correct engine management, it has one or several temperature sensors. These sensors use NTC type resistors which report to the unit. They are usually located at the coolant outlets on the cylinder head and radiator.



### Precautions

A poor quality anti-freeze can allow salts to emerge in the circuit, which can clog up the inner ducts of the engine, preventing the cooling at certain points and damaging the engine.

Fill with anti-freeze and never with water, as it will dilute the product. As a general rule, organic anti-freeze should never be mixed with inorganic anti-freeze (with silicates). If they are, the properties will never be adequate and it could cause corrosion in the cooling system. In order to change the anti-freeze to one of better quality, the circuit should be completely drained and properly cleaned. It is recommended to change the coolant liquid every 2 years or every 40,000 km. This should be done in accordance with the manufacturer's specifications.



## GEARBOX OIL

The gearboxes are subjected to constant friction of the gearing, discs, bearings and other materials used to make the gear changes smoother. To do this, a specific lubricant is required which is different from the others.

Additives are added to gearbox lubricants to prevent wear of the film layer, protect the components when the oil viscosity is insufficient to provide an adequate thickness of film, reduce friction of pressure parts, by adding specific sliding properties to the lubricant.

There are many types of gearbox, but in terms of their lubrication, they can be divided into two groups: manual driving and automatic driving. The latter can be divided into 4 types: conventional automatic gearbox with torque converter, continuously variable transmission (CVT), robotised gearbox and dual-clutch or direct shift gearbox (DSG).

## Oil for manual gearbox

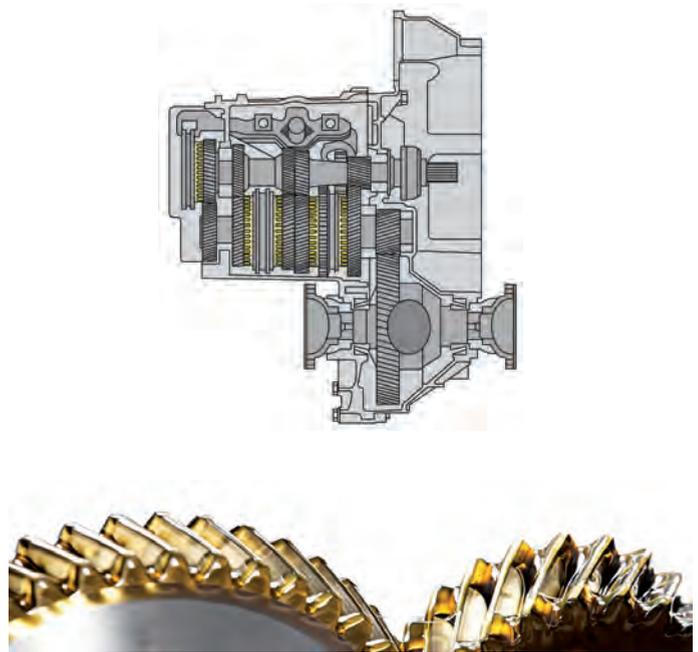
The manual gearbox oil lubricates the gears and bearings of the gearbox, as well as the differential gears depending on the vehicle.

Regarding viscosity, the oil must allow...:

- Movement between the synchronisers and smooth gear changes.
- The turning of the gears without transmitting force or causing resistance.
- Circulation between the parts thereby cooling them.
- Its passing between the bushings and bearings.
- Resistance for it to remain on the gear teeth and lubricate them hydrodynamically.

And with regard to additives to maximise pressure, these must be...:

- Quite resistant for marginal lubrication and for resisting the forces, loads and impacts.
- Of a level and quality that will not damage the bronze.
- Of a level and quality that will allow working with the synchronizers.
- Compatible with the materials used in the synchronizers.



## Oil for automatic transmissions

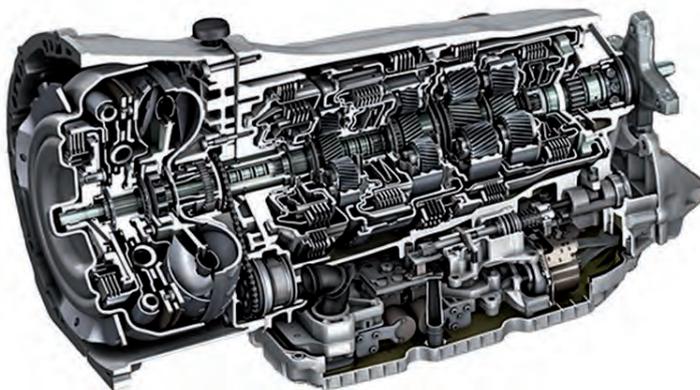
The oil usually used in these automatic gearboxes is known as ATF "Automatic Transmission Fluid". It is a special type of oil with a set of properties, which should be very resistant to rust/oxidation, changes in viscosity due to temperatures and use, and must possess the correct frictional characteristics for each type of box. Moreover, it must keep all surfaces, contacts and valves clean.

ATF oil has additives which are capable of improving its stability with respect to oxidation, inhibiting corrosion and reducing the formation of foam. With the passing of time, the additives can be degraded up to the point where even the fluid's characteristics are damaged, thereby impairing the oil's lubricating ability and viscos-

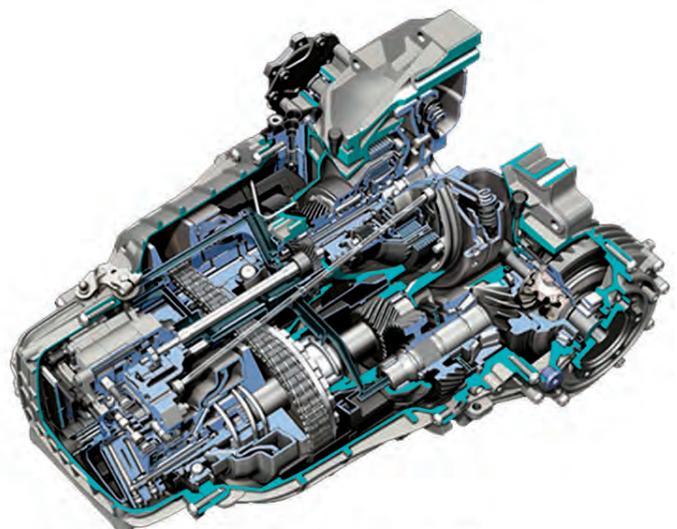
ity. That is why the ATF oil is the main cause of the problems in an automatic gearbox.

Most automatic gearboxes have an internal filter so that the oil is kept clean. Its replacement should always be in conjunction with the oil change.

There is a wide variety of automatic gearboxes on the market and each of them requires different maintenance. Always consult the manufacturer's specifications and recommendations.



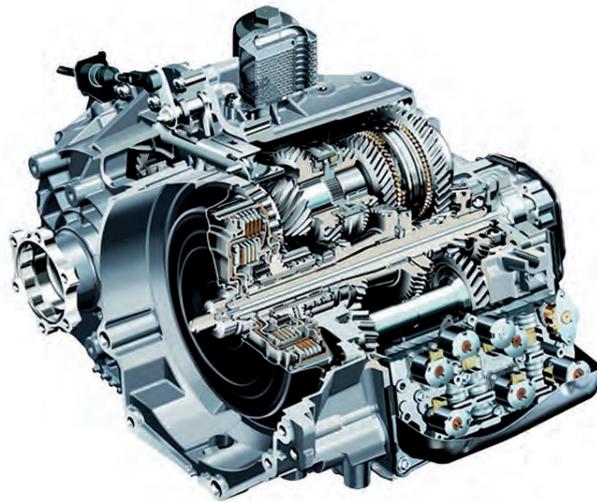
**Automatic gearbox  
with torque converter**



**Continuously Variable Transmission (CVT)**



**Robotised gearbox**



**Dual clutch gearbox (DSG)**

### Automatic gearbox with torque converter

Consists of a planetary gearbox and torque converter. The gear switching is performed using oil pressure to some brakes and clutches installed inside this box.

Oil and oil filter replacement is recommended every 60,000 km. This will prevent a large number of future breakdowns.

### Continuously Variable Transmission (CVT)

Consists of two conical plates which vary in diameter and a metal chain. There is no actual gear, rather an infinite range of ratios between the highest and lowest ratio.

These transmissions require special high friction and cooling oils which differ from the ATF oils.

It is recommended to check the oil every 15,000 km. When pulling trailers or driving in special conditions, the oil is changed every 90,000 km. Regarding the filter, it is replaced when the oil is degraded in some way. Even so, it is recommended to change it every 90,000 km.

### Robotised gearbox

Is based on a manual gearbox but without the need to be controlled by the driver of the vehicle. When driving the vehicle, the driver does not have to change the speeds or press down the clutch pedal for it to operate correctly.

It operates very similarly to automatic gears, as the gear lever can be

manually operated by the driver or the change can function entirely automatically.

It is recommended to change the oil and filter every 60,000 km, especially when pulling trailers or driving in special conditions.

### Dual clutch gearbox (DSG)

The DSG change is understood as the joining in parallel of two manual gearboxes in one single housing. It uses a mechatronic unit and an oil pump to select the gears using a double clutch. One clutch is for the odd gears (1st, 3rd, 5th, 7th) and reverse, while the other is for even gears (2nd, 4th, 6th).

as it uses different types of lubricants, one for the gearing and another for the hydraulic circuit.

The replacement of the oil and filter for these gearboxes is recommended every 60,000 km or 8 years, as mentioned, always taking into account the manufacturer's recommendations.

Inside this type of gearbox there are two types: the 6 speed and the 7 speed. The latter is different to the first, apart from having an extra gear,

# BRAKE FLUID

Brake fluid is the active element of the braking system. This is a synthetic fluid for conveying the force exerted on the pedal so the braking system components move against the friction material, thereby activating the vehicle's braking process. This same liquid is also used in vehicles fitted with hydraulic-operated clutches. The clutch pedal has a

much smoother stroke than a mechanically operated one. Each manufacturer indicates the type and specifications of the brake fluid used in their vehicles.

## Features

Regardless of their classification, all liquids must have the following properties:

- **Dry boiling point:** Defines the maximum temperature of the liquid before changing to a gas. If this temperature is exceeded, bubbles may form with a loss of efficiency. This is why a high boiling point is required capable of maintaining its state during hard braking.
- **Wet boiling point:** Defines the maximum boiling point with a percentage of water of 3.5%. Brake fluid is hygroscopic, that is, it absorbs moisture; over time it loses its properties and its boiling point reduces considerably.

- **Viscosity:** the influence of the temperature on viscosity must be as low as possible to ensure the efficiency of the liquid at high working temperatures.
- **Anticorrosion properties:** it must be anticorrosive to prevent rusting of the ferrous elements of the circuit. By using additives added to it, this property is ensured.
- **Compatibility with elastomers:** it must be compatible with plastic and rubber used in the pumps and other components of the circuit as, otherwise, these elements will break down and damage the circuit.

Boiling temperature	Liquid state
Higher than 175 °C	In good condition
Between 165 and 175 °C	Acceptable but change advisable
Below 165 °C	In poor condition, change imperative

Nowadays three types of brake fluid are used: glycol ethers, mineral and silicone oils.

**Glycol ether fluid:** is most used in vehicles. It does not come from mineral oils and its designations are DOT 3, 4 4.6 and 5.1 (not to be confused with DOT 5).

They can be mixed together, although they are of a different classification, (always adding one of the highest quality and not the other way around), but it is not compatible with mineral or silicone-based fluids. If it is hygroscopic, it should be changed every two or three years. This fluid attacks paint and varnish.

The composition of synthetic fluid DOT 4.6 is produced from polyglycol, glycol ether and glycol ether borate. It contains corrosion inhibitors and antioxidants. Its low viscosity makes it especially recommended for braking systems which combine ABS, ASC and ESP/DSC.

**Mineral oil fluid:** comes from petroleum products. Is not hygroscopic and its boiling point does not vary. LHM type mineral oil fluids are not compatible with glycol-ether or silicone fluids, therefore they should not be mixed.

**Silicone fluid:** is a high quality silicone-based fluid and its designation is DOT 5. It has a longer lifetime given that it is not hygroscopic, does not attack painted surfaces and is compatible with all forms of rubber. It is not compatible with glycol-ether or mineral based fluids.

## Type approvals

The brake fluid has to comply with certain requirements so that it can perform its function safely and efficiently. There are different rules for classifying brake fluids, although the most used is the one regulated

by the US Department of Transportation (DOT). This classification is conducted based on the dry boiling temperature (new fluid) and wet boiling temperature (used fluid).

Requirements/level	DOT 3	DOT 4	DOT 5.1	DOT 5
Dry boiling point, in °C (min)	205	230	285	260
Wet boiling point, in °C (min)	140	155	160	180
Viscosity when cold at -40° C, in mm <sup>2</sup> /s	1,500	1800	900	900

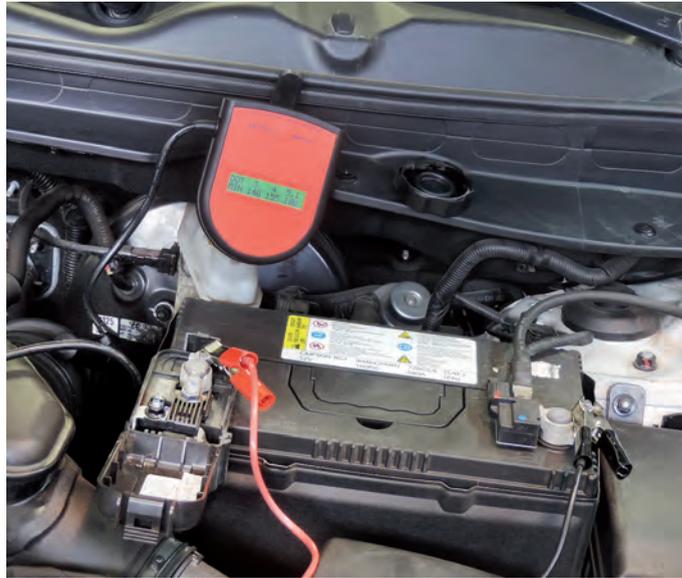
## Brake fluid status monitor

The correct state of the brake fluid plays an important role in the braking system and in the safety of the vehicle. The brake fluid should be replaced every two years, always in accordance with the manufacturer's recommendations.

It is possible to check the brake fluid using boiling point testers. The minimum permissible point for a DOT 4 fluid is 155 °C if it is extracted

from the brake callipers, but 165 °C can be tolerated if the extraction is made from the tank, given that the fluid suffers less in this area. A second test is always recommended, and this will be the final one for knowing the status of the fluid.

The types of brake fluid status checks may be the following:



- **Boiling point test using hydrometer:** Consists of inserting electronic equipment into the brake fluid reservoir. This apparatus, supplied with 12 V from the battery and built-in resistance, enables the brake fluid to be heated until it boils in order to measure its boiling point. Then, the value given is compared to the minimum boiling point shown on the hydrometer display screen.
- **Chemical testing strip:** A paper chemical strip is inserted into the brake fluid reservoir. As the liquid ages, its corrosion inhibitors break down. The test strips check for the presence of copper in the fluid to determine the status.
- **Refractometer:** this is an optical testing system which measures the moisture content using light refraction.

## POWER STEERING FLUID

The power steering systems require special hydraulic fluid. It is placed into a reservoir which is part of the vehicle's power steering circuit and carries out several critical functions required to ensure the correct system operation.



## Features

The power steering fluid transmits the force needed to operate the system components, and is capable of operating under a range of conditions, including extreme temperatures.

The vehicle manual specifies the type of power steering fluid to be used,

but there are instructions which, due to their technical characteristics, demand special products regulated by the manufacturer's themselves.

# WINDSCREEN/HEADLAMP WASHER FLUID

This fluid has a system for its storage and transmission to the outside surface of the windscreen or headlamp, maintaining good visibility and increasing safety.



## Features

This is a fluid based on special detergent and solvent raw materials, which enables all the dirt accumulated on the windscreen or in the vehicle's headlamps to be removed.

Its properties should include:

- Removal of dirt present on the windscreen or headlamps.
- Does not damage paint or plastic.
- Maintains controlled foaming without leaving a soapy film.
- Does not cause light refraction.

There are two types of product to be found on the market, some are concentrates which need to be dissolved and others already mixed and ready for use.



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