VEHICLE ENGINE COOLANTS

Technical guidelines and a practical guide to antifreeze selection, compatibility and maintenance for the coming season.



1. Introduction and the primary purpose of antifreeze

Engine coolant (antifreeze) is essential for maintaining the optimum operating temperature and protecting the engine throughout the year. In addition to freeze protection, it provides efficient heat transfer and protects the cooling system against corrosion, cavitation, scale and damage to sealing components.

Main functions of engine coolant:

• Temperature control: removes heat from the engine, preventing overheating in summer and freezing of the system in winter.
• Protection against corrosion and cavitation: corrosion inhibitors protect aluminium, copper, brass, steel and cast iron.
• Prevention of deposits: the correct mixture of antifreeze and distilled water reduces scale and deposit formation.
• Protection of seals and hoses: additives reduce drying, cracking and chemical degradation of elastomeric components.

Coolants are also used in industrial systems, generator sets, heat pumps and HVAC systems.








2. Chemical composition and base fluids

Coolant consists of a glycol base, water and a package of additives and corrosion inhibitors.

Main base fluids:

• Ethylene glycol (EG): the most widely used base in the automotive industry owing to its efficient heat transfer and good low-temperature properties. It is toxic and requires careful handling.

• Propylene glycol (PG): a less toxic, biodegradable alternative intended for applications with more demanding environmental and safety requirements.

• Glycerol: used in certain modern formulations, such as G13, to reduce the environmental impact of production.

The role of distilled water:

Antifreeze concentrate is diluted with distilled or demineralised water. Tap water can cause scale and deposits. The usual 50:50 ratio provides good thermal performance and freeze protection, typically down to approximately -37 °C.

3. Antifreeze types by additive technology

While the glycol base lowers the freezing point of the fluid, the additive technology determines its corrosion protection, service life and compatibility with engine construction materials. Four main categories are distinguished according to the chemical composition of the additives.

1. IAT (Inorganic Acid Technology)

Traditional technology based on inorganic acids and salts (silicates, phosphates and borates). Commonly used in vehicles manufactured up to 2000.

• Characteristics: provides rapid, immediate protection by forming a thicker protective layer on metal surfaces. The replacement interval is short: 2 to 3 years or approximately 50,000 km.

• Applications: older engines with copper, brass and cast-metal components. Over time, silicates may precipitate out of solution and form sediment if the coolant is not replaced regularly.

2. OAT (Organic Acid Technology)

Advanced technology based on organic acids (carboxylates), free of silicates and phosphates.

• Characteristics: provides long-term protection for 5 years or up to 150,000 km. It acts selectively, passivating microscopic corrosion sites as soon as they form, without creating thick deposits across the entire internal surface of the system.

• Applications: modern aluminium engines and high-performance cooling systems. It has a more favourable environmental profile and high stability at elevated operating temperatures.

3. HOAT (Hybrid Organic Acid Technology)

Hybrid technology combining the immediate corrosion protection of inorganic additives (silicates) with the long service life of organic acids.

• Characteristics: provides balanced protection for aluminium, steel and copper components. Average service life is 4 to 5 years (100,000-150,000 km).

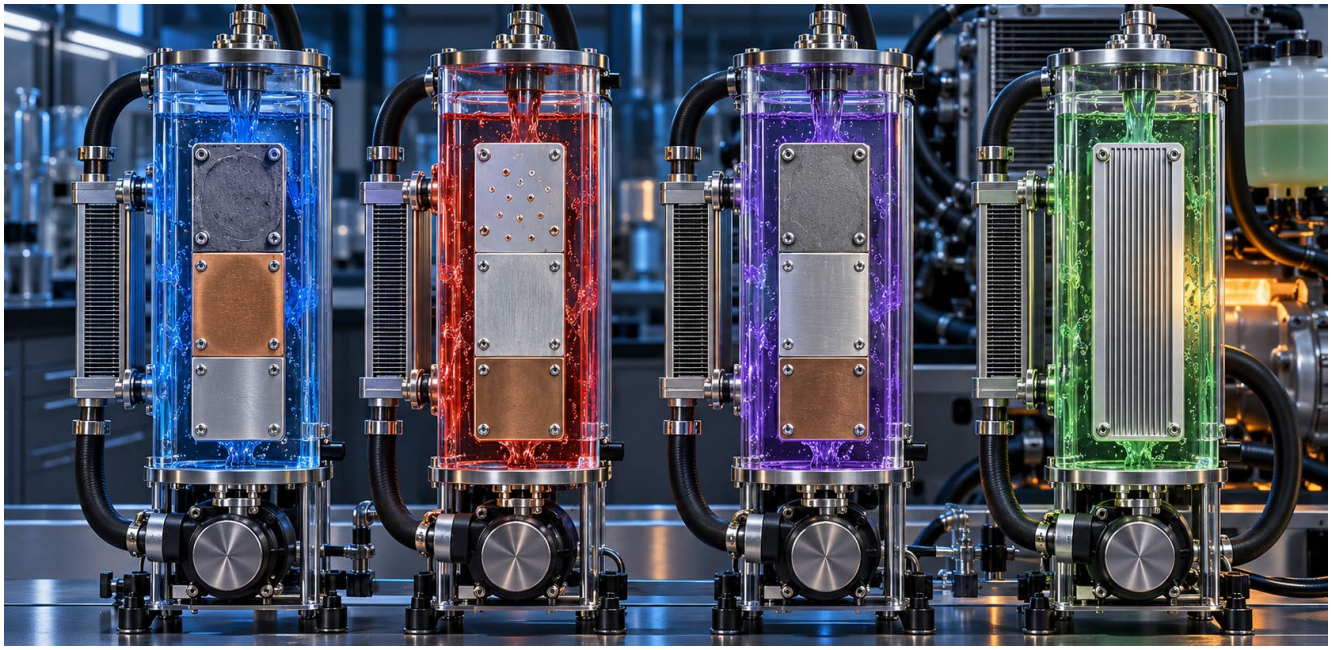
• Applications: European and American vehicles of recent and intermediate generations, e.g. VAG Group, BMW, Mercedes-Benz and Ford.

4. P-HOAT (Phosphate-Hybrid Organic Acid Technology)

A phosphate-hybrid variant combining phosphates and carboxylates, developed to meet the specific requirements of Asian vehicle manufacturers.

• Characteristics: excellent protection of aluminium surfaces under high thermal loads. Silicate-free. Replacement intervals exceed 5 years (up to 250,000 km).

• Applications: vehicles from Asian manufacturers (Toyota, Honda, Nissan, Hyundai and Kia). Formulations intended for Asian vehicles more frequently use phosphates instead of silicates to meet specific requirements for coolant pump cavitation protection.



4. Compatibility table and mixing antifreeze

Mixing incompatible coolant formulations is a common cause of cooling-system failure. Chemical reactions between different additive types, e.g. inorganic silicates and organic carboxylates, cause precipitation, formation of a gelatinous mass (gel), neutralisation of corrosion inhibitors and complete blockage of the radiator and coolant passages in the engine block.

Important: identifying antifreeze by colour is unreliable. Colour is merely an added pigment and is not standardised internationally. Selection must be based on the technical specification (IAT, OAT, HOAT, P-HOAT) or the vehicle manufacturer's specifications, e.g. VW TL 774-D/G12, G13, MAN 324 or MB 325.0.

Overview of coolant formulation compatibility

Type 1	Type 2	Compatibility rating	Consequences of mixing
IAT (inorganic)	OAT (organic)	**INCOMPATIBLE**	Formation of sediment and gel, neutralisation of additives, blockage of coolant flow through the radiator.
IAT (inorganic)	P-HOAT (phosphate)	**INCOMPATIBLE**	Chemical reaction between silicates and phosphates; precipitation of solid deposits in the system.
OAT (organic)	HOAT (hybrid)	**CONDITIONAL**	Depends on the formulation. The expected service life of the OAT formulation is reduced.
OAT (organic)	P-HOAT (phosphate)	**INCOMPATIBLE**	Phosphates impair carboxylate performance; risk of accelerated aluminium corrosion.
HOAT (hybrid)	P-HOAT (phosphate)	**CONDITIONAL**	Risk of precipitation if the phosphate-silicate balance is disrupted.

5. Diagnostics, fault symptoms and recommendations

To ensure reliable vehicle operation and avoid costly repairs, regular technical inspections of the cooling system are recommended every 10,000 km or during the annual service in the 2026 season.



Service and maintenance instructions

1. Freezing-point measurement: use an optical refractometer to check the freezing point; avoid unreliable hydrometers. The recommended freezing point is between -35 °C and -40 °C.
2. Flushing when changing coolant: when changing the coolant type or if cloudiness is observed, thoroughly flush the system with distilled water and a dedicated cooling-system cleaner.
3. Use of distilled water: always dilute antifreeze concentrate exclusively with distilled or demineralised water at a 1:1 ratio.
4. Compliance with manufacturer specifications: use only coolants that meet the specific standard stated in the vehicle's technical documentation.

Diagnostic overview of cooling-system fault symptoms

Fault symptom	Possible technical causes	Recommended service procedure
Engine overheating	• Low coolant level / system leakage • Internal radiator blockage due to sediment or scale • Faulty thermostat or temperature sensor • Coolant pump failure or loose drive belt	Stop the vehicle and switch off the engine; check the coolant level. If sediment or corrosion is present, flush the entire system.
Slow warm-up to operating temperature	• Thermostat stuck open • Faulty radiator fan control switch	Replace the thermostat to prevent increased engine wear and unusually high fuel consumption.
External coolant leakage	• Damage to hoses, connections or radiator walls • Loss of sealing at the coolant pump seal	Pressure-test the cooling system for leaks; replace damaged lines and seals.
Internal coolant loss	• Damaged cylinder-head gasket • Cracked engine block or cylinder head	Urgent mechanical diagnosis: test for combustion gases in the expansion tank.

5. Pantherol antifreeze: classification by additive technology and OEM specifications



The Pantherol coolant range provides comprehensive coverage for passenger cars, commercial vehicles, agricultural and construction machinery, and stationary industrial systems. All products are formulated with high-purity monoethylene glycol (MEG), without glycerol (except G13, where it is used as an environmentally oriented stabiliser), and offer high resistance to foaming and cavitation.

1. Conventional IAT technology (first generation - up to the late 1990s)

Exclusively inorganic additives (salts, silicates, borates and nitrates), with no organic acids, for use in older engines containing copper, brass and cast-iron components. The disadvantages are rapid silicate depletion (replacement after 2-3 years or 50,000 km) and a greater tendency to form deposits.

Pantherol's modern range does not include conventional IAT antifreeze, as this technology has largely been phased out in contemporary specifications.

2. Hybrid technology (HOAT / G11)

Products in this group are based on a hybrid combination of inorganic inhibitors (silicates) and organic components. They provide rapid passivation of metal surfaces and effective protection for traditional and more modern cooling systems containing brass, copper, cast iron and aluminium.

• Pantherol Antifreeze Blue G11 / Green G11 / Green G11 Ready Mix: concentrate (blue or green fluid) or ready-mixed coolant (green, ready to use, -36 °C). Glycerol-free formulation with high reserve alkalinity. Suitable for passenger cars, commercial vehicles (MAN PriTarder), stationary generator sets and motorcycles.

• Pantherol Antifreeze G48 (on request): blue ethylene-glycol-based concentrate intended for a wide range of European vehicles and industrial applications.

Key OEM specifications and industry standards:

• **Volkswagen Group:** VW Group TL 774-C (G11), Audi / Seat / Škoda TL 774-C.

• **BMW Group:** BMW GS 94000, BMW N 600 69.0, BMW LC-87, MINI BMW LC-87, BMW Motorrad LC-87.

• **Mercedes-Benz** / **Daimler:** MB 325.0, DTFR 29C100, MB 325.2 (ready mix), MB 326.0, DTFR 29D100, MB 326.2 (ready mix), Smart MB 325.0.

• **MAN** / **DAF** / **Volvo** / **commercial vehicles:** MAN 324 Type NF, MAN 324 NF PRITARDER, DAF 74001, Iveco 18-1830, Volvo Trucks TR 1286083, Volvo Construction.

• **Industrial and stationary generator sets:** Deutz DQC CA-14, Cummins 85T8-2, Caterpillar, Perkins, Liebherr LH-00-COL3A, Jenbacher TA 1000-0200, 2G Energietechnik.

• **General international standards:** ASTM D 3306, ASTM D 4985, ASTM D 4656, BS 6580:2010, AFNOR NF R 15-601, SAE J814 / J1034.

3. Advanced organic acid technology (OAT / G12+)

Pantherol Antifreeze G12+ is a glycerol-free, long-life concentrate based on monoethylene glycol (MEG content 96-98%). It combines the long-lasting properties of organic acids with rapid inhibitor action at oxidation sites (selective passivation). It effectively prevents cavitation and localised overheating, while protecting seals and elastomeric hose components for up to 5 years or 250,000 km.

Key OEM specifications and industry standards:

• **Volkswagen Group:** VW / Audi / Seat / Škoda TL 774 D/F (G12, G12+).

• **Commercial vehicles and passenger cars:** MAN 324 SNF, MB 325.3, DTFR 29C110, MB 326.3, DTFR 29D110, DAF 74002, Renault 41-01-001 / S-Type D, Volvo Coolant VCS / VCS 2.

• **Heavy equipment and machinery:** Ford WSS-M97-844 D, Caterpillar MAK A4.05.09.01, Cummins CES 14439 / CES 14603, Deutz DQC CB-14, John Deere JDM H5, Komatsu AF-NAC.

• **General international standards:** AFNOR NFR 15-601, ASTM D 3306 / D 4656 / D 4985 / D 6210 / D 5931, BS 6580:2010, SAE J1034.

4. Silicate organic acid technology (Si-OAT / G12++ & G12 EVO)

This category combines organic carboxylates with precisely dosed, stable silicates. It immediately forms a micron-scale protective film on metals and provides exceptional resistance of aluminium alloys to pitting corrosion and cavitation under high thermal stress. The formulation contains no borates, amines, phosphates, nitrites or 2-ethylhexanoic acid.

• Pantherol Antifreeze G12++: premium pink concentrate with a service life of up to 6 years / 250,000 km for passenger cars or 500,000 km for commercial vehicles.

• Pantherol Antifreeze G12 EVO: innovative, advanced pink concentrate optimised for newer-generation petrol, diesel, hybrid, plug-in and LPG powertrains.

Key OEM specifications and industry standards:

• **Volkswagen Group:** VW Group TL-774 G (G12++), TL-774 L (G12evo), TL-774 J (G13 coverage), VW TL 774-C/D/F/G/J.

• **BMW, Mercedes-Benz, MAN, Volvo, Scania:** BMW / MINI / Rolls Royce LC18, MB 325.5, DTFR 29C120, MB 326.5, DTFR 29D120, MAN 324 Si-OAT / MAN 324 Si-OAT evo, Scania TB 1451, Volvo Trucks TR1286083 / TR-31854114-002, Volvo Automobile TR-31854114-002.

• **Industry and machinery:** Deutz DQC CC-14, Cummins CES 14603 / CES 14439, Liebherr LH-01-COL3A, MTU MTL 5048, John Deere (>2011).

• **International standards:** ASTM D 3306 / D 4985 / D 6210, BS 6580:2010, AFNOR NF 15-601 (11/2020), JIS K 2234:2006, China GB 29743-2013, ÖNORM V 5123, CUNA NC 956-16, SANS 1251:2005.

5. Glycerol-containing lobrid technology (Si-OAT / G13)

Pantherol Antifreeze G13 is a premium purple concentrate formulated with monoethylene glycol (MEG) and environmentally friendly glycerol. The synergy of organic additives and silicates (lobrid technology) creates a stable protective film that prevents cavitation on coolant pump impeller blades and cylinder walls. High reserve alkalinity (8.5 ml) neutralises acidic products. Free of nitrites, amines and phosphates.

Key OEM specifications and industry standards:

- **VAG Group:** VW Group TL 774 J (G13) - Volkswagen, Audi, Seat, Škoda, Cupra, Bentley, Bugatti, Lamborghini.
- **International standards:** ASTM D 3306, ASTM D 5931-13, ASTM D 1287-11, BS 6580:2010.

Pantherol product range summary

Product name	Colour*	Additive technology	Main OEM specifications & standards	Recommended replacement interval
Pantherol G11 / G48 (concentrate & ready mix)	Blue / green	Hybrid (HOAT / G11 / silicates)	VW TL 774-C (G11), BMW GS 94000 / LC-87, MB 325.0 / 325.2, MB 326.0 / 326.2, MAN 324 NF, DAF 74001, ASTM D3306	2-3 years / 50,000 km
Pantherol G12+	Pink	Advanced OAT (carboxylates / glycerol-free)	VW TL 774 D/F (G12/ G12+), MAN 324 SNF, MB 325.3, MB 326.3, Ford WSS-M97-844 D, Cummins CES 14439, Volvo VCS	5 years / 250,000 km
Pantherol G12++	Pink	Si-OAT (organic + silicates, free of borates/nitrites)	VW TL 774-G (G12++), MB 325.5/326.5, MAN 324 Si-OAT, Scania TB 1451, Cummins CES 14603	6 years: 250,000 km (passenger cars); 500,000 km (commercial vehicles)
Pantherol G12 EVO (coming soon)	Pink	Si-OAT EVO (advanced Si-OAT without 2-EHA)	VW TL 774-L (G12evo) / G13, BMW LC18, MAN 324 Si-OAT evo, Volvo TR-31854114, Deutz DQC CC-14	6 years: 250,000 km (passenger cars); 500,000 km (commercial vehicles)
Pantherol G13	Purple	Lobrid Si-OAT (MEG + glycerol)	VW TL 774 J (G13) (VW, Audi, Seat, Škoda, Bentley, Lamborghini), ASTM D 3306, BS 6580	5 years / 250,000 km

* Standard colours for easier identification.