



# Castrol ON Direct Liquid Cooling PG 25: Operating guide



## Fluid properties, characteristics, compatibility, and safety processes

This guide is intended to provide an introduction to Castrol ON Direct Liquid Cooling PG 25, including its use cases and benefits, properties, typical characteristics, materials compatibility, safety guidance, handling and storage conditions, and system design considerations.

## 1. Introduction

Castrol ON Direct Liquid Cooling PG 25 heat transfer fluid has been introduced to address the challenges presented by the higher TDP (Thermal Design Power) of current and emerging CPUs and GPUs. Air cooling has been the traditional method for dissipating heat in IT applications, but with the advent of AI we are now at an inflection point where rack power densities and silicon designs require liquid cooling.

Direct liquid cooling, sometimes called direct-to-chip cooling, utilises Castrol ON PG 25 heat transfer fluid to manage the CPU and GPU temperatures. Cold plates sit on top of the heat-generating components and capture the heat through the fluid, with this heat subsequently being removed from the fluid by a heat exchanger placed in a Coolant Distribution Unit (CDU) positioned within the rack, the row or at the periphery of the room. The proprietary formulation provides for extended life performance with the inhibitor package depleting very little over time when maintained in accordance with the recommended guidelines.

Castrol ON Direct Liquid Cooling PG 25 is a propylene glycol-based heat transfer fluid that supports the deployment of direct-to-chip cooling in data centre and edge environments. It's specifically formulated to provide durability and longevity, whilst at the same time delivering excellent heat transfer and outstanding corrosion protection. The product is supplied in a diluted state and requires no further preparation prior to installation and system start-up, saving time and cost when attending site.

## 2. Properties of Castrol ON Direct Liquid Cooling PG 25

Castrol On Direct Liquid Cooling PG 25 is dyed fluorescent green to provide quick and easy identification of any leak within the Technology Cooling System (TCS). A visual inspection of the fluid should provide a particulate-free result, with any deviation indicating the necessity for further chemical analysis to determine the root cause of the issue.

Castrol ON Direct Liquid Cooling PG 25 is formulated with high-quality propylene glycol diluted at 25% weight in purified water and with the latest generation additive package consisting of corrosion inhibitors, stabilisers, pH buffering agents and antifoam.

### 3. Typical Characteristics

**Table 1** reports the typical properties for Castrol On Direct Liquid Cooling PG 25. Key physical characteristics at different temperatures are reported in **Table 2**.

<b>Table 1: Typical properties</b>	
<b>Properties</b>	<b>Typical value</b>
Propylene Glycol, % Weight	25%
Corrosion Inhibitors and Water, % Weight	75%
Appearance	Clear liquid, free from suspended matter
pH	8.5
Boiling Point (°F / °C)	214 / 101
Freezing Point (°F / °C)	15 / -9°C
Sulphates, ppM	5
Chlorides, ppM	5
Iron, ppM	1
Copper, ppM	1
Electrical Conductivity @ 20°C (μ S/cm)	> 2000

<b>Table 2: Physical characteristics from -10 to 100°C</b>				
<b>Temperature, °C</b>	<b>Density, g/cm<sup>3</sup></b>	<b>Specific heat, kJ/kg K</b>	<b>Thermal conductivity, W/m K</b>	<b>Dynamic Viscosity, cP</b>
-10	1.032	3.93	0.466	10.22
0	1.03	3.95	0.47	6.18
20	1.024	3.98	0.478	2.86
40	1.016	4	0.491	1.42
60	1.003	4.03	0.505	0.903
80	986	4.05	0.519	0.671
100	979	4.08	0.533	0.509

## 4. Wetted Material Compatibility

Wetted materials are those coming into contact with the heat transfer fluid such as, but not limited to, pump seals, heat exchangers and quick-connect seals. The heat transfer fluid specification is tied closely to the wetted material list and compatibility should be evaluated against the complete range of temperatures the materials will be subjected to. Any additions to the wetted material list will require (re)evaluation of the heat transfer fluid.

It should also be noted that operation of the system above the recommended maximum fluid temperature can cause a breakdown in fluid performance and reduce the expected lifetime of the product.

### 4.1. Metals and Metal Alloys

Experimental data on corrosion protection is available for a certain range of metals and metal alloys, as per **table 3**. Most of the alloys used in liquid-cooled computer racks are also used in industries with highly demanding conditions already so that the properties allow estimates as to their compatibility with MPG / water-based coolants when experimental data is not available. Expected compatibility between Castrol On Direct Liquid Cooling PG 25 with a range of metals and metal alloys commonly used in liquid-cooled computer racks is reported in **table 4**. This doesn't waiver the user's responsibility to run their own application-related tests. In general, highly oxidising, reducing conditions, extreme pH drops and increases as well as corrosion-promoting impurities have to be avoided.

**Table 3:** Corrosion Protection Performance

Test Metal	ASTM D8040 limits (mg/g)	OCP Guidelines limits (mg/g)	Results (mg/g)
Copper	10	5	< 5
Solder	30	10	< 5
Brass	10	-	< 5
Steel	10	-	< 5
Cast Iron	10	-	< 5
Aluminium	30	-	< 5

**Table 4:** Compatibility with metal and metal alloys

Material	Material details as per OCP Guidelines	Compatibility*
Copper	CDA110, CDA1020, CDA1220, CDA1100	Compatible with PG / water-based fluids from ASTM D8039 corrosion test results, see table 3
Brass, <15% Zinc		Compatibility with PG / water-based fluids can be predicted since with less than 15% Zinc, dezincification is not expected
Stainless Steel	304L, 316L or higher grades	Compatible with PG / water-based fluids from ASTM D8039 corrosion test results, see table 3
Chrome	Plated corrosion-resistant materials	Quick connects made of stainless steel should be used. It is recommended to avoid nickel-plated and chromium-plated quick connects until these are proven satisfactory. This is because after many uses, the plating can be worn away and the underlying metal exposed to the heat transfer fluid.
Nickel	Excluding Hastelloy B and other alloys designed to reduce environments	Although corrosion inhibitors may protect underlying metal, the galvanic couple created by the exposed metal with the plating material may increase the corrosion tendency. Plated quick connects should be inspected regularly.
Titanium	Grade 2 (UNS R50400)	Compatibility with PG / water-based fluids expected
B-Ni-6	88.9% Ni + 11% P	
BCuP-2	93% Cu + 7% P	
BCuP-3	Cu 89%, Ag 5%, P 6%, others 0.15%	Compatibility with PG / water-based fluids can be predicted
BCuP-4	Cu 87%, Ag 6%, P 7%	
BCuP-5	Cu 80%, Ag 15%, P 5%	
TF-H600F	Cu 74.9%, Sn 15.6%, P 5.3%, Ni 4.2%	

\*At normal fluid operating temperatures, that should not exceed 65°C. Should temperature exceed this value, wetted material compatibility at the targeted temperature should be reassessed.

## 4.2. Elastomers, plastics and sealants

Expected compatibility between Propylene Glycol / Water mixtures with a range of elastomers, plastics and other materials used in liquid-cooled computer racks is reported in **table 5**. However, the compatibility of Castrol On Direct Liquid Cooling PG 25 with specific elastomers, plastics, sealants and other materials used in the cooling circuit components such as tanks, piping, pumps, gaskets and seals must be verified by the component material supplier before use.

**Table 5:** Rubber, plastics and sealants compatibility

Material	Compatibility*
EPDM	Compatible
Viton	Compatible
PTFE	Compatible
FEP	Compatible
HDPE	Compatible
PP	Compatible
PEEK	Compatible
Loctite 567 thread sealant	Compatible

## 5. Safety

Castrol recommends the user always consult the latest Safety Data Sheets prior to implementing the fluids in your facility. Please also consider any local laws and regulations prior to use, noting that these may change at periodic intervals. It is the responsibility of the user to ensure suitability of the fluid for the individual application and compliance with the relevant jurisdiction.

It is important that the user is prepared to handle system leaks at a small and large scale, ensuring absorbent materials and fluid containers are on hand for any incidents. Water may be used to clean up any residual fluid outside of the TCS.

\*At normal fluid operating temperatures, that should not exceed 65°C. Should temperature exceed this value, wetted material compatibility at the targeted temperature should be reassessed.

## 6. Handling and storage conditions

<b>Handling</b>	Refer to Section 4 – First aid measures and Section 8 – Personal protection of MSDS (Material Safety Data Sheet).
<b>Storage</b>	<ul style="list-style-type: none"><li>✓ Always keep the container/drum tightly sealed.</li><li>✓ Store the product in a cool, dry place away from direct sunlight.</li><li>✗ Avoid water ingress.</li><li>✓ For long-term storage it is preferable to keep the product indoors at temperatures below 45 °C /113°F.</li></ul>

## 7. System Design Considerations and Preparations

It is recommended that system filling and drainage points are allowed that also accommodate the addition of any boosters on an ad-hoc basis without interrupting the operation of the TCS. These points should meet the specifications outlined in the wetted materials list and ensure there are no sections of pipework where fluid can stagnate leading to bacterial growth and system inefficiencies.

It is important that dynamic flushing of the pipework system is carried out to remove any debris, dirt or particles from inside the system. This should be done in accordance with the cooling system provider's recommendations and warranty requirements. If a chemical clean is conducted prior to system fill, it is important that all chemical cleaning fluid should be drained, and the pipework flushed with water until all residue is removed.

During system start-up and operation, filtration is likely to be in place to prevent particles being trapped in different parts of the system. It is recommended the user consult the cooling system vendor guidelines on filter sizes and the reduction in filter micron size during system filling.

Mechanical engineers should be consulted to ensure the system is viewed at a holistic level that prevents excessive pressure drop or flow velocity due to incorrect pipe sizing. The TCS approach temperature will influence the viscosity of Castrol ON Direct Liquid Cooling PG 25, which will in turn impact the system pressure drop. Air bleed points should be designed at the high points of the system to allow venting during the system fill and prevent potential problems leading to adverse thermal performance, potential system downtime, possible pump cavitation, and/or pipework corrosion.

## 8. Fluid maintenance and inspection

Upon completion of system flushing and filling with “fresh” Castrol ON Direct Liquid Cooling PG 25, it is recommended that the system is run for a period of 15 minutes and a fluid sample taken and stored in order that a baseline of the system is recorded.

In the absence of a dynamic monitoring system, in mission-critical applications it's recommended that the user adopts the guidance provided by the Open Compute Project (OCP) in their paper “Guidelines for Using Propylene Glycol-Based Heat Transfer Fluids in Single Phase Cold Plate-Based Liquid Cooled Rack”. On a quarterly basis, the fluid pH levels should be checked to prevent acid build-up resulting in ferrous metals being attacked or increasing alkalinity where the fluid can target aluminium or copper. Glycol concentration must be monitored since levels are susceptible to degradation over time, resulting in a loss in system effectiveness and potential damage to components. Turbidity of the fluid should also be checked as a further indicator of the fluid health.

On a bi-annual basis, it is suggested that a sample of fluid is sent for a full lab analysis in order that the amount of metal in the fluid can be accurately identified, to ensure the corrosion protection chemicals are in the right range, to verify the level of buffering agents and organics present and to obtain a more granular reading on acidity in the system.



**For any additional information or concerns, please contact your Castrol representative or reach out via email at [liquidcooling@bp.com](mailto:liquidcooling@bp.com).**

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