



WHITEPAPER • DIRECT LIQUID COOLING

GIGABYTE and Castrol Co-Validate Coolant Mixing for DLC Liquid Cooling Servers

EXECUTIVE BRIEFING

Jointly validated by GIGABYTE and Castrol, ON DLC PG25 coolant achieves 100% miscibility, robust material compatibility, and zero fluid degradation across GIGABYTE's liquid-cooled portfolio (G4L3/G4L4, NVIDIA GB300 NVL72, DLC GIGAPOD), ensuring seamless, zero-downtime maintenance for high-density AI infrastructure.

1 Executive Summary & AI Thermal Crisis

The expansion of Generative AI, Large Language Models (LLMs), and High-Performance Computing (HPC) has driven data center power demands into an unprecedented realm. Modern AI accelerators, including NVIDIA Blackwell, Blackwell Ultra, and the upcoming Rubin architecture, now exceed 1,000 W of single-chip TDP, while rack power densities have climbed from the traditional 8 - 20 kW to 100 - 240 kW or more.

At these densities, air-cooling infrastructure hits a rigid physical wall. Air's low thermal conductivity (~ 0.026 W/m·K) and modest convective heat transfer coefficient (30 - 60 W/m²·K) force server fans to run at high RPMs, wasting parasitic power and risking thermal throttling. As a result, single-phase water-glycol Direct Liquid Cooling (DLC) has become the most engineering-feasible thermal dissipation path available for next-generation AI infrastructure.

Table 1. Air Cooling vs. Direct Liquid Cooling: Key Thermal Parameters

	Traditional Air Cooling	Direct Liquid Cooling
Cooling Medium	Air	Castrol ON DLC PG25 (Water-Glycol)
Heat Transfer Coefficient (W/m ² ·K)	30 - 60	1,000 - 10,000
Rack Power Density (kW / Rack)	8 - 20	100 - 240+
Thermal Throttling	High thermal throttling risk at full load	Minimal thermal throttling
Data Center PUE	1.35 - 1.60	1.05 - 1.20

2 Coolant Miscibility & Physical-Chemical Integrity Analysis

In data centers, coolant mixing is an inevitable reality during fluid top-ups, system maintenance, and coolant vendor switching, or from residual factory-test fluid. To ensure absolute operational safety, GIGABYTE partnered with Castrol to evaluate Castrol ON DLC PG25 mixed with major commercial propylene glycol coolants across realistic changeover (10:90) and equal-ratio (50:50) scenarios.

Table 2. Coolant Mixing Groups and Simulated Scenarios

In-Service Liquid	Castrol ON DLC PG25	Simulated Operational Scenario
Group A PG 10 C (50%)	Castrol PG25 (50%)	Commercial crossover sensitivity test
Group A PG 10 C (10%)	Castrol PG25 (90%)	Realistic fluid changeover (10% residual)
Group B LC 25 (50%)	Castrol PG25 (50%)	Commercial crossover sensitivity test
Group C PG 25 (50%)	Castrol PG25 (50%)	Commercial crossover sensitivity test

All mixed coolant samples underwent physical-chemical testing in accordance with international ASTM standards. Across all evaluated ratios, the fluid mixtures maintained absolute physical stability with zero phase separation, precipitation, or haze formation.

Table 3. Physical and Chemical Properties of Mixed Coolants

	Method	Group A (50:50)	Group A (10:90)	Group B (50:50)	Group C (50:50)
Appearance	Visual	Clear & Bright	Clear & Bright	Clear & Bright	Clear & Bright
Density @ 20°C (g/cm ³)	ASTM D1122	1.027	1.028	1.029	1.024
pH Value	ASTM D1287	8.61	8.62	8.87	8.62
Conductivity (μS/cm)	ASTM D1125	4420	4310	4800	3380
Freezing Point (°C)	ASTM D1177	-11.6	-11.9	-12.1	-11.8
Boiling Point (°C)	ASTM D1120	106.9	105.8	111.1	104.7
Reserve Alkalinity (mL)	ASTM D1121	2.8	2.8	5.1	4.2
Bacterial Count (CFU/ mL)	Easicult	< 100	< 100	< 100	< 100

3 Metallic & Non-Metallic Material Compatibility

Corrosion prevention in micro-channel copper cold plates and stainless-steel manifolds is paramount. Particle accumulation from metallic corrosion product deposition can drastically increase loop flow resistance and lead to localized thermal hotspots.

Table 4. Metal Corrosion Results: Glassware Test

Test	Industry Acceptance	Weight Change (mg)			
		Group A (50:50)	Group A (10:90)	Group B (50:50)	Group C (50:50)
Copper (ASTM D1384)	±10	0	0	0	1
Brass (ASTM D1384)	±10	1	1	0	1
Solder (ASTM D1384)	±10	1	1	0	5
Steel (ASTM D1384)	±10	0	0	-1	0
Cast Iron (ASTM D1384)	±10	2	3	-2	-1
Aluminum (ASTM D1384)	±10	0	0	-2	-2

Table 5. Metal Corrosion Results: Simulated Service Test

Test	Industry Acceptance	Weight Change (mg)			
		Group A (50:50)	Group A (10:90)	Group B (50:50)	Group C (50:50)
Copper (ASTM D2570)	±20	3	1	4	3
Brass (ASTM D2570)	±20	6	2	0	5
Solder (ASTM D2570)	±60	0	17	1	9
Steel (ASTM D2570)	±20	0	4	0	0
Cast Iron (ASTM D2570)	±20	2	2	3	2
Aluminum (ASTM D2570)	±60	3	34	1	84 ^[Note]
pH change (ASTM D1287)	-	-0.5	-0.2	-0.3	-0.1

[Note] In Group C (50:50), aluminum weight loss reached 84 mg, exceeding the 60 mg limit. GIGABYTE's standardized liquid cooling wetted surface guidelines strictly mandate copper, stainless steel, and nickel-plated brass, completely avoiding wetted aluminum in high-density DLC loops to eliminate galvanic and pitting risks.

Non-metallic material compatibility was evaluated under ASTM D471, ISO 1817, and ISO 527 accelerated thermal aging conditions (88°C for 336 hours). Maintaining seal elasticity prevents fluid micro-leakage at quick-disconnect couplings (QDC) and manifold joints.

Table 6. Elastomer Compatibility Results: Group A 10:90 (ASTM D471)

Elastomer Material	Volume Change (%)	Hardness Change (Scale)	Tensile Change (%)
EPDM (Ethylene Propylene Diene Monomer)	-1.0	0	-6
VMQ (Silicone Rubber)	-0.3	2	-2
NBR (Nitrile Rubber)	3.0	-1	-7
FKM (Fluoroelastomer)	1.4	1	-24

Table 7. Plastic Compatibility Results: Group A 10:90 (ISO 1817 & ISO 527)

Plastic Material	Mass Change (%)	Hardness Change (Scale)	Tensile Change (%)
Polypropylene (PP)	0.1	-1	5.5
Fluorinated Ethylene Propylene (FEP)	0.1	1	-12.6
Polytetrafluoroethylene (PTFE)	0	0	-13.6
Polyamide 12 (PA12)	8.1	-14	-23.8

4 Closed Cooling Loop 3-Month Field Trial

To bridge laboratory testing with actual data center operations, mixed coolant (Group A 10:90 mixture) was loaded into a loop simulating NVIDIA GB300 Grace Blackwell Ultra with six Thermal Test Vehicles (TTV) as stable heat sources. The system operated for 12 weeks at a coolant inlet temperature of around 45°C and an outlet temperature of around 55°C, with a 2.5-3 L/min circulation rate.

Table 8. Coolant Condition During 3-Month Cooling Loop Test

	Week 2	Week 4	Week 8	Final (Week 12)
Appearance	Clear & Bright	Clear & Bright	Clear & Bright	Clear & Bright
pH Value	8.70	8.69	8.58	8.58
Iron (ppm)	< 1	< 1	< 1	< 1
Copper (ppm)	< 1	< 1	< 1	< 1
Chloride (ppm)	< 5	< 5	< 5	< 5
Sulfate (ppm)	< 5	< 5	< 5	< 5
Bacterial Count (CFU/mL)	< 100	< 100	< 100	< 100

5 Universal Adoption Across GIGABYTE Liquid Cooling Portfolio

GIGABYTE does not treat coolant validation as an isolated experiment. Instead, GIGABYTE applies this fluid miscibility, corrosion protection, and material compatibility validation standard across its entire liquid cooling product portfolio. Minor residual Castrol ON DLC PG25 may remain in a given loop; customers who subsequently introduce coolant from another supplier do so at their own discretion, and GIGABYTE does not extend this validation or any related coolant warranty to that substituted fluid. Whether deploying individual DLC servers or massive GIGAPOD AI factories, enterprise clients gain guaranteed fluid-level reliability.

Table 9. PG25 Adoption Across GIGABYTE Liquid Cooling Portfolio

Category	Representative Products	DLC Adoption	Target AI Workloads
Direct Liquid Cooling Servers	GIGABYTE G4L3/G4L4 Series	Server level: PG25-validated cold plates and manifolds	High-density 8-GPU nodes
Rack-Scale AI Solutions	NVIDIA GB300/GB200 NVL72	Rack level: closed-loop integration with CDU	Exascale LLM training & inference
Scale-Out AI Infrastructure	GIGABYTE Accelerated Deployment Unit (GADU)	Cluster level: integrated facility-to-rack coolant distribution	Hyperscale AI cloud data centers

Core Benefits of GIGABYTE DLC Solution

01

Painless Maintenance (Zero Downtime)

100% miscibility with commercial PG loops enables top-ups and vendor transitions, ensuring continuous AI compute uptime.

02

Universal Material Compatibility

Validated under ASTM D1384/D2570 to prevent metal corrosion and minimize corrosion by-products. Compatible with copper cold plates, stainless steel manifolds, CDUs, and QDCs, preserving peak thermal performance.

03

Uncompromising Thermal Stability

An extended 3-month field trial in a 9 kW loop confirms minimal fluid degradation, supporting 1,000 W+ GPUs under 100% workload without thermal throttling.

04

Leak Prevention & Asset Protection

ASTM D471 and ISO 1817 testing with key seals (EPDM, VMQ, FKM) and plastics (PP, FEP, PTFE) shows minimal swelling and hardness change, ensuring zero-leakage operation.

6 Conclusion

As AI compute scales past kilowatt-per-chip thresholds, GIGABYTE and Castrol's joint validation proves that ON DLC PG25 delivers superior miscibility, corrosion protection, seal longevity, and thermal stability in mixed-fluid environments. Embedded across GIGABYTE's liquid-cooled portfolio, including DLC servers and NVIDIA GB300 NVL72, these standards empower enterprises to deploy high-density AI infrastructure with maximum performance, zero maintenance friction, and optimized long-term TCO.

7 Warranty & Coolant Substitution Disclaimer

The miscibility, material-compatibility, and reliability validation presented in this whitepaper applies to Castrol ON DLC PG25 as supplied and maintained under GIGABYTE's and Castrol's joint specifications. A minor residual volume of Castrol ON DLC PG25 may remain in a GIGABYTE liquid-cooled loop following deployment. Where a customer subsequently introduces or substitutes coolant obtained through its own vendor, that substitution is made at the customer's own discretion: GIGABYTE does not extend this validation, or any related coolant warranty, to the substituted fluid. In that scenario, responsibility for coolant-related maintenance and issue resolution rests with the customer's own vendor, not GIGABYTE.