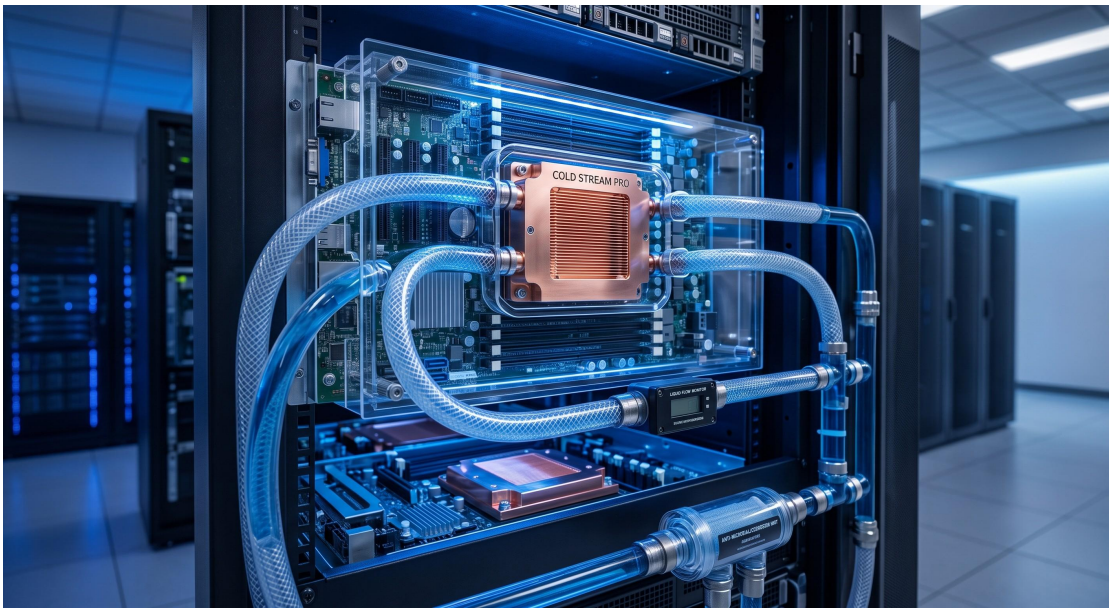
Cold Plate Liquid Cooling System Secondary Loop Anti-Corrosion Protocol - Official Technical Overview & Hardware Datasheet

EXECUTIVE SUMMARY

The Cold Plate Liquid Cooling System Secondary Loop Anti-Corrosion Protocol establishes a comprehensive engineering framework for the mitigation, monitoring, and management of corrosion within the secondary (facility water) loop of high-density telecom and datacenter cold plate liquid cooling deployments. As rack power densities escalate beyond 30 kW per cabinet, direct-to-chip liquid cooling has transitioned from a niche thermal strategy to a mainstream infrastructure requirement. However, the long-term reliability of any liquid cooling architecture is fundamentally governed by the chemical and electrochemical stability of its fluid pathways. This document defines the protocol requirements for fluid chemistry management, material compatibility, real-time corrosion monitoring, and lifecycle maintenance procedures that collectively ensure a design life exceeding ten years for wetted components. The protocol is applicable to all cold plate secondary loop deployments across edge, core, and hyperscale environments, and is engineered to interoperate with standard facility water systems, CDUs, and manifold assemblies.



ARCHITECTURE & CHASSIS DESIGN

The secondary loop anti-corrosion protocol is implemented across four functional layers: fluid specification and treatment, wetted material selection and compatibility, active monitoring and telemetry, and maintenance and remediation procedures. Each layer is designed as a modular control point that can be independently audited and validated.

The fluid specification layer mandates the use of a propylene glycol or ethylene glycol based coolant with a minimum 25% volume concentration, supplemented with a multi-component corrosion inhibitor package. The inhibitor formulation must include azole derivatives for copper and brass protection, phosphate or phosphonate compounds for steel and aluminum passivation, and a buffering agent to maintain pH within a narrow band of 7.5

to 9.0. Conductivity must be maintained below 200 µS/cm to minimize galvanic corrosion potential, and chloride content must remain below 10 ppm to prevent pitting corrosion of stainless steel and aluminum components.

The wetted material selection layer enforces a strict material compatibility matrix. Copper and copper alloys are permitted for cold plates and heat exchangers, provided they are paired with compatible inhibitors. Stainless steel 304 or 316L is the standard for fittings, pumps, and manifold bodies. Aluminum is permitted only in brazed plate heat exchangers with a protective nickel or zinc coating. Elastomeric seals must be constructed from EPDM or FKM materials with low extractables and verified compatibility with the chosen coolant chemistry. Dissimilar metal couples must be electrically isolated or sufficiently separated in the electrochemical series to prevent galvanic acceleration.

The active monitoring layer integrates inline sensors for pH, conductivity, oxidation-reduction potential (ORP), temperature, flow rate, and pressure differential. These sensors feed a telemetry pipeline that provides real-time corrosion risk scoring and alerts operators to deviations from baseline chemistry. The protocol specifies sensor accuracy tolerances, calibration intervals, and data retention policies.

The maintenance and remediation layer defines the procedures for fluid sampling, inhibitor replenishment, loop flushing, and component replacement. It establishes a quarterly sampling cadence for critical installations and an annual full-loop audit for all deployments. Remediation thresholds are defined for each parameter, with corrective action workflows that range from inhibitor top-off to full fluid replacement and passivation re-treatment.

HARDWARE FEATURES

The anti-corrosion protocol is supported by a suite of hardware components engineered for chemical compatibility and monitoring integration. The primary hardware elements include the following.

The Corrosion Monitoring Sensor Module (CMSM) provides inline measurement of pH, conductivity, ORP, and temperature with a 4-20 mA or Modbus RTU interface. The module is constructed from PEEK and 316L stainless steel and is rated for 10 bar operating pressure.

The Fluid Sampling and Injection Manifold (FSIM) enables safe extraction of fluid samples without loop shutdown and allows for inhibitor injection via a double-isolation valve arrangement. The manifold includes a 50-micron particulate filter and a visual flow indicator.

The Secondary Loop CDU (Coolant Distribution Unit) is available in 1RU and 2RU form factors with integrated chemistry monitoring ports, a variable-speed pump, a plate heat exchanger, and a control interface that supports SNMP v3 and RESTful APIs. The CDU is designed for 1+1 redundancy and supports hot-swappable pump modules.

The Chemical Compatibility Test Kit (CCTK) is a field-portable kit that enables onsite verification of inhibitor concentration, pH, and conductivity. The kit includes titration reagents, calibration standards, and a digital colorimeter.

All hardware components are constructed from materials that meet the protocol's wetted material compatibility matrix and are tested to withstand the specified coolant chemistry for a minimum of 10,000 hours of continuous operation.

COMPLIANCE & STANDARDS

The Cold Plate Liquid Cooling System Secondary Loop Anti-Corrosion Protocol is aligned with the following industry standards and regulatory frameworks.

ASHRAE TC 9.9 Liquid Cooling Guidelines define the thermal and fluid quality

requirements for datacenter liquid cooling systems. This protocol exceeds the baseline chemistry recommendations of ASHRAE by enforcing tighter conductivity and chloride limits.

OCP Cooling Environments and ACS (Advanced Cooling Solutions) specifications provide interoperability requirements for CDUs, manifolds, and cold plates. The protocol is designed to be compatible with OCP ACS-compliant hardware.

ISO 9223 and ISO 11844 provide corrosivity classification standards for atmospheric and immersion environments, respectively. The protocol references these standards for corrosion rate estimation and material selection.

ASTM D1384 and ASTM D2570 define standard test methods for corrosion inhibition in engine coolants and are adapted in this protocol for electronics cooling fluids.

IEC 62321 and RoHS Directive 2011/65/EU restrict the use of hazardous substances and are respected in all wetted materials and inhibitor formulations.

REACH Regulation (EC) No 1907/2006 governs the registration and evaluation of chemical substances and is applicable to all coolant additives specified in this

protocol.

TECHNICAL SPECIFICATIONS

The following table summarizes the key technical parameters of the anti-corrosion protocol and associated hardware.

Parameter	**Specification**
Coolant Base	Propylene Glycol or Ethylene Glycol, 25-50% volume concentration
pH Range	7.5 to 9.0, buffered with phosphate or phosphonate compounds
Conductivity	≤ 200 µS/cm at 25°C
Chloride Content	≤ 10 ppm
Corrosion Inhibitor Package	Azole derivatives, phosphate/phosphonate, buffering agent
Wetted Materials	Copper, 304/316L Stainless Steel, EPDM, FKM, PEEK
Monitoring Parameters	pH, Conductivity, ORP, Temperature, Flow Rate, Pressure Differential
Monitoring Interface	4-20 mA, Modbus RTU, SNMP v3,

	RESTful API
Operating Pressure	10 bar maximum
Design Life	10 years for wetted components, 10,000 hours continuous operation
Sampling Cadence	Quarterly for critical installations, annual full-loop audit
Compliance Standards	ASHRAE TC 9.9, OCP ACS, ISO 9223, ASTM D1384, RoHS, REACH

ORDERING OPTIONS

Ordering options for the Cold Plate Liquid Cooling System Secondary Loop Anti-Corrosion Protocol hardware and service components are structured to support both greenfield deployments and brownfield retrofits.

CDU-1RU-AC: 1RU Coolant Distribution Unit with AC input, integrated chemistry monitoring ports, and 1+1 pump redundancy.

CDU-2RU-DC: 2RU Coolant Distribution Unit with DC input, enhanced heat rejection capacity, and dual chemistry monitoring ports.

CMSM-KIT: Corrosion Monitoring Sensor Module kit including sensors, cabling, and calibration certificates.

FSIM-MANIFOLD: Fluid Sampling and Injection Manifold with isolation valves and particulate filter.

CCTK-FIELD: Chemical Compatibility Test Kit for field deployment, including reagents and digital colorimeter.

PROTOCOL-SVC-ANNUAL: Annual anti-corrosion protocol audit and remediation service, including fluid sampling, inhibitor replenishment, and system passivation verification.

PROTOCOL-TRAINING: Onsite or virtual training program for facility operations teams covering fluid chemistry management, monitoring interpretation, and remediation procedures.

All hardware components are shipped with a calibration certificate and a material compatibility declaration. Service components include a detailed scope of work and a compliance report upon completion.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