Community Specification

Key Specifications and Evolution Roadmap for Coolant Distribution Unit (CDU) (Version 1.0)

Authors:

Huang Sihao, Huang Qiang, Shenzhen Envicool Technology Co., Ltd.;

Huang Huanwen, Han Yi, Zhang Kai, Li Jian, Li Baoyu, Li Quanxu, and Liang Dongxu, Huawei Digital Power Technologies Co., Ltd.;

Tian Ting, Liu Yongbin, Beijing Douyin Information Service Co., Ltd.;

Liu Xingqiang, JD Cloud Computing Co., Ltd.;

Ren Bing, Beijing Baidu Netcom Science Technology Co., Ltd.;

Zhou Zhenxin, Cai Zhiping, Zhang Xiao, Li Pengkun, Huawei Technologies Co., Ltd.;

Cai Yuelin, Ruijie Networks Co., Ltd.;

Xu Xin, Sugon Data Infrastructure Innovation Technology (Beijing) Co., Ltd.;

Liu Ronghua, Thermal Control Technology (Shenzhen) Co., Ltd.;

Qi Yangzhou, Sun Di, Sun Yongcai, Guangdong Shenling Environmental Systems Co., Ltd.;

Yu Rongdong, Guangzhou Yeso Automatic Control Technology Co., Ltd.;

Dai Fei, Liu Chao, Guangzhou Goaland Innovation Technology Co., Ltd.

Open AI Infra Community of the Global Computing Consortium (GCC)

Open Specification License (Type A)

This license is a legal agreement between the contributors to this open specification (this Specification) and its users. By using this Specification, you agree to be bound by the terms of this license. If you do not agree to be bound by the terms of this license, you shall not use this Specification, and your use of this Specification may constitute infringement. If the documentation is distributed in a compressed package (such as a ".zip" file) that contains this license, all files in the package are subject to this license, unless otherwise explicitly excluded.

1. Definition

1.1. This License: refers to this Open Specification License (Type A). No entity other than the Global Computing Consortium has the right to modify this License.

1.2. This Specification: refers to the information such as design materials or digital code licensed under this License, regardless of the carrier or the manner in which it is expressed, including but not limited to schematic diagrams, mechanical drawings, flowcharts, explanatory text, circuit or printed circuit board wiring diagrams, integrated circuit layout designs (including topologies/mask works), component arrangement diagrams, and other explanatory materials.

1.3. Compliant Product: refers to a product that fully meets all the normative requirements specified in this Specification for the corresponding product form.

1.4. Contributor: refers to an entity that has signed the Contributor License Agreement (Type A) either expressly or impliedly and has participated in the development of this Specification.

1.5. Licensee: refers to an entity that complies with this License and performs (a) any act of using, copying, modifying, or distributing this Specification, or (b) any act of manufacturing, commissioning the manufacture of, or distributing hardware.

1.6. Distribution: refers to the act of transmitting, publishing, providing, or otherwise transferring this Specification to a third party through any medium.

1.7. Modification: refers to the adaptation, translation, combination, or other transformation of this Specification.

1.8. Essential Patent: refers to a patent that is necessarily infringed or utilized in the implementation of the technologies or methods explicitly described in this Specification.

2. Grant of Intellectual Property Rights and Non-Assertion Covenant

2.1. Grant of Copyrights: Subject to the Licensee's compliance with all terms and conditions of this License, particularly Section 2.2, each Contributor under the Contributor License Agreement (Type A) hereby grants the Licensee a perpetual, worldwide, non-exclusive, royalty-free, and free-of-charge copyright license to reproduce, create derivative works from, publicly display, publicly perform, sublicense, and distribute this Specification and its Modifications, solely for the purpose of the Open Specification Projects of the Global Computing Consortium.

2.2. Conditions for Grant of Copyrights:

The Licensee may reproduce and distribute this Specification and/or its Modifications in any medium only if the following conditions are met:

2.2.1. The Licensee shall provide a copy of this License to recipients of the Specification;

2.2.2. the Licensee shall retain all copyright, integrated circuit layout design right, patent, trademark, and attribution notices contained in this Specification, except for those that do not pertain to any part of the Specification;

2.2.3. if the Licensee modifies and distributes this Specification, the Licensee shall provide the Global Computing Consortium with a description of the modifications and the contributed modified files.

2.3. Non-Assertion of Patents: Subject to the Licensee's compliance with all terms and conditions of this License, each Contributor, in accordance with the Contributor License Agreement (Type A),commits not to initiate any patent infringement litigation or other legal proceedings against the Licensee for making, using, selling, offering for sale, or importing the Compliant Product, under any of its Essential Patents, except for those Essential Patents identified in the Exclusions Notice of this Specification.

2.4. Termination of Non-Assertion of Patents: Termination by the Licensee's Claim: If the Licensee initiates patent infringement litigation or other legal proceedings against a Contributor for the Compliant Product under Essential Patents, then all grants, licenses, and commitments made by the Contributor to the Licensee under this License shall terminate, unless such litigation is in response to a first such litigation against the Contributor.

3. Miscellaneous

3.1. Except for the license terms specified in Section 2 above, this License does not grant any other intellectual property rights.

3.2. Disclaimer: The Licensor provides this Specification on an "AS IS" basis, without warranties of any kind, express or implied, including but not limited to any warranties of title, non-infringement, quality, merchantability, fitness for a particular purpose, or suitability. The Licensee shall independently assess the appropriateness of using, reproducing, modifying, and distributing this Specification and its Modifications, or manufacturing, using, selling, offering for sale, or importing products developed based on the aforementioned documents, and shall assume all risks associated therewith, as well as all other risks associated with exercising the rights granted under this License.

3.3. Limitation of Liability: Under no circumstances, and under no legal theory, shall the Global Computing Consortium or any Contributor be liable to the Licensee for any damages arising from any use, reproduction, modification, distribution, or use of the Specification and its modifications or contributions therein, or the manufacture, use, sale, offer for sale, or development of products based on the aforementioned documents, including but not limited to loss of profits or any form of indirect, incidental, special, or consequential damages, whether based on breach of contract, tort (including negligence), or any other cause, and regardless of whether the damaged party has been advised of the possibility of such damages.

4. General Provisions

4.1. If the Licensee breaches this License, all licenses and covenants granted to the Licensee under this License shall automatically terminate, and the Licensee shall immediately delete and cease using this Specification and its Modifications. Upon termination of this License, Sections 3.2 and 3.3 shall survive. Termination of the licenses and covenants under this Section shall not affect the authorization of downstream recipients who have obtained copies or rights from the Licensee under this License.

4.2. Governing Law: This License shall be governed by and construed in accordance with the laws of the People's Republic of China.

Version Change History

Version	Description	Contributor
V0.8	Public release	As above.
V1.0	1. In Section 2, added the definitions of four core terms to improve the terminology system. 2. In Section 4, added the technical requirements such as primary side supply/return temperature, secondary side flow control, motor energy efficiency, filtration, and constant pressure coolant replenishment system. 3. Appendix A.1: Added Networking Architecture Analysis - Derivation of CDU Performance Specifications, and specified the recommended design basis for power levels. 4. Corrected repeated content and text errors in the sections and optimized the clause statements.	As above, the following contributors are added: Huang Qiang, Han Yi, Zhang Kai, Li Jian, Li Baoyu, Li Quanxu, Liang Dongxu, Liu Yongbin, Zhou Zhenxin, Zhang Xiao, Li Pengkun, Ren Bing, Sun Di, Sun Yongcai, Dai Fei, and Liu Chao.

Contents

Open Specification License (Type A) 1

Version Change History 3

Key Specifications and Evolution Roadmap of CDUs 5

1 Scope 5

2 Terms and Definitions 5

2.1 Liquid cooling 5
2.2 Cold plate 5
2.3 Cold plate liquid cooling 5
2.4 Coolant distribution unit 5
2.5 Coolant 5
2.6 Micro module 5
2.7 Cabinet power density 6
2.8 Approach temperature 6
2.9 Internal make-up pump 6
2.10 External fill pump 6
2.11 Beta ratio 6

3 Status Quo and Development Trend 6

3.1 Status Quo and Development Trend of Rack Power in Data Centers at Home and Abroad 6
3.2 Networking Mode and Architecture 7
3.3 Pain Points of CDU Product Application 7

4 Definition of Key CDU Specifications 7

4.1 General Requirements 7
4.2 Performance Requirements 8
4.2.1 Heat Exchange Performance 8
4.2.2 Hydraulic Performance 8
4.3 Design Requirements 9
4.3.1 Connections and Monitoring Devices 9
4.3.2 Dimensions and Power 10
4.3.3 Filtration Precision 10
4.3.4 Auxiliary Devices 10

Appendix A 11

A.1 Networking Architecture Analysis - CDU Performance Specification Derivation 11
A.2 Example of Key CDU Specification Parameters 13
A.3 Example of key specifications of the CDU -850 kW 15
A.4 Example of key specifications of the CDU -1300 kW 17

Key Specifications and Evolution Roadmap for CDU

1 Scope

This document specifies the key specifications and technical evolution roadmap including the general requirements, performance requirements, and design requirements for the coolant distribution unit (CDU) used in the cold plate liquid cooling system of data centers.

This document is applicable to the design, selection, and application of CDUs for liquid-cooled equipment rooms in newly built, reconstructed, and expanded data centers.

2 Terms and Definitions

2.1 Liquid cooling

Liquid cooling is a heat dissipation technology that uses liquid to carry away heat from heat-generating components.

2.2 Cold plate

A compact heat exchanger that uses a cooling medium to exchange heat with heat-generating components.

2.3 Cold plate liquid cooling

A liquid cooling technology that uses a cold plate to contact heat-generating components, uses liquid as the cooling medium, and carries away heat from the components through the flow of the cooling medium in the cold plate cavity. The cooling medium is circulated between the cold plate and the coolant distribution unit (CDU) through pipes and related devices, and the heat generated by the components is exported from the electronic information equipment.

2.4 Coolant distribution unit

A device consisting of a heat exchanger, circulating pump, pressure maintenance device, fluid make-up device, and control system. It can drive the secondary side piping system, transfer the heat of IT equipment to the cooling source system through the heat exchanger built in the CDU, and provide functions such as temperature control, pressure control, flow control, anti-condensation control, and isolation of the fluids on the primary and secondary sides.

2.5 Coolant

A fluid that exchanges heat in the fluid cooling system. The coolants involved in this document include single-phase formulated coolants such as water-ethylene glycol, water-propylene glycol, and pure water.

2.6 Micro module

A micro module refers to a standardized data function unit that integrates the rack, power supply and distribution, cooling, cabling, monitoring, and fire suppression subsystems. It is designed with factory prefabrication and modularization, and can operate independently. This enables fast deployment, elastic expansion, and efficient O&M of data centers.

2.7 Cabinet power density

The cabinet power density refers to the operating power consumption of IT equipment carried by a single rack, which is usually measured in kilowatts per rack (kW/R, where R stands for rack).

2.8 Approach temperature

The difference between the secondary side supply fluid (outlet) temperature of the CDU and the primary side inlet temperature in rated operating conditions.

2.9 Internal make-up pump

A pump that connects the CDU circulation loop and fluid make-up tank to automatically supply coolant to the system.

2.10 External fill pump

A pump used to inject coolant into the CDU fluid make-up tank. It may be built into the CDU or installed externally, and is also referred to as the coolant injection pump.

2.11 Beta ratio

The ratio of the number of particles larger than a given size upstream of the filter to the number of particles larger than the same size downstream of the filter. It is a core parameter for measuring the relative filtration precision.

3 Status Quo and Development Trend

3.1 Status Quo and Development Trend of Rack Power in Data Centers at Home and Abroad

Driven by the global demand for AI computing power, the average power density of the industry is increasing from the traditional level to 20 kW to 30 kW. Cutting-edge applications such as AI clusters have already reached 100 kW per rack, and are continuously evolving towards higher power densities of 200 kW or 300 kW. In this context, SuperPods are the direct product and core driving force for the leap in power density of data center racks.

As a high-density AI computing unit that supports foundation model training, a SuperPod aggregates dozens to hundreds of AI accelerator cards into a logically unified computing power pool using high-speed interconnection technologies within a rack, thereby achieving computing power pooling at the scale of tens of thousands of cards.

SuperPods have the following different characteristics in development at home and abroad:

Domestic development: Multiple vendors have launched mature products, resulting in a landscape characterized by "participation of multiple competitors, with system-level solutions prevailing." System-level engineering innovations, such as higher rack density and efficient power supply and heat dissipation, are employed to bridge the gap in single-chip manufacturing processes. Representative products include the Huawei CloudMatrix384 SuperPod and the Alibaba Cloud Pangu 128 SuperPod.

International development: The NVIDIA NVL72 rack serves as a benchmark, while technological diversification is also evident. For instance, AMD and Meta have jointly launched the ultra-wide Helios rack, and Google has introduced solutions based on its self-developed TPU.

In terms of heat dissipation technology, technologies such as cold plate liquid cooling have become an inevitable choice for addressing the high heat density that exceeds the limits of air cooling.

3.2 Networking Mode and Architecture

Currently, to meet the design requirements of high power density, data centers (especially those with SuperPod architectures) generally adopt a deployment scheme based on micro modules. In a typical domestic design, a micro module is usually configured with a 2500 kVA transformer, which can support an IT load of approximately 2.3 MW (considering the derating of the transformer load rate in the Internet industry and the load power of the UPS configuration). Correspondingly, to handle the heat generated by high-density computing power, the maximum liquid cooling capacity of a single micro module is generally planned and designed at 2.5 MW (considering a 10% redundancy in CDU capacity).

The redundancy configuration scheme of CDUs in the liquid cooling system shall be verified, and the reasonable range of "N" in the N+1 architecture and the CDU power level shall be analyzed to achieve a balance among reliability, availability, and cost-effectiveness. The system architecture shall ensure the redundancy of key components such as pumps and shall enable fault isolation and online maintenance (see Appendix A.1).

3.3 Pain Points of CDU Product Application

Low standardization: Internationally, industry standards are primarily led and driven by upstream chip giants and large cloud service providers (CSPs). The SuperPod architecture and CDU specifications they have established have formed a relatively unified market consensus. Domestically, however, the technical standards across various links of the industry chain are not yet fully unified. This leads to significant challenges in matching and compatibility between CDUs and components such as liquid-cooled servers from different vendors, including differences in rack flow and resistance, and requirements for working medium compatibility. This significantly increases the complexity and overall cost of system integration.

Energy saving challenges: Energy saving shall be primarily considered from the overall design of the liquid cooling system. The main approaches include: first, configuring high-efficiency water pumps; second, reducing the chip inlet water temperature to directly improve computing energy efficiency; third, optimizing the CDU heat exchange performance to reduce dependency on the primary side cooling sources and chillers. The core measure is to promote the CDU approach temperature from the traditional 4–5 °C to 3 °C or even lower.

High O&M complexity: The liquid cooling system involves multiple professional fields, such as water, electricity, and chemistry, imposing high requirements on the cross-domain capabilities of O&M personnel. Currently, there is a lack of mature intelligent O&M tools and standard processes, resulting in difficult fault locating, slow response, and safety risks in maintenance operations.

4 Definition of Key CDU Specifications

Liquid cooling CDUs can be classified into air-to-liquid CDUs (L2A) and liquid-to-liquid CDUs (L2L) based on the heat exchange principle. Based on the layout, CDUs can be classified into distributed CDUs and centralized CDUs. This document focuses on the single-phase centralized liquid-to-liquid CDU.

4.1 General Requirements

1. The internal layout of the liquid cooling CDU shall be reasonable, and the maintenance and repair convenience of components such as circulating pumps, filters, valves, and sensors shall be fully considered. In addition, the CDU shall separate water from electricity internally.
2. The materials of the liquid contact components in the CDU shall be fully considered for compatibility to ensure that the CDU can operate reliably for a long time in the designed operating conditions.
3. The CDU shall meet the design and stable operation requirements of the liquid cooling system. Under different load rates of the liquid cooling system, the temperature control precision on the

secondary side shall be ≤ ± 1 °C. In steady-state operating conditions, the temperature control precision shall be ≤ ±0.5 °C.

4.2 Performance Requirements

4.2.1 Heat Exchange Performance

1. Approach temperature: In rated working conditions, the difference between the outlet temperature of the coolant on the secondary side and the inlet temperature of the cooling source on the primary side of the CDU should be no greater than 3 °C. For high-performance applications and future energy-saving scenarios, the approach should reach 2 °C.

   Note: The approach is a core indicator for measuring the heat exchange efficiency of the CDU. A smaller value indicates better heat exchange performance. In this case, the supply water temperature required by the cooling source on the primary side (such as the cooling tower or chiller) can be increased accordingly, significantly increasing the time for utilizing free cooling on the cooling source side and improving the overall energy efficiency (reducing the PUE). The traditional design is usually ≥ 4 °C. The requirement of ≤ 3 °C in this document is proposed based on the high standards in the industry and traditional solutions, aiming to improve the energy efficiency benchmark of the industry. The target of ≤ 2 °C is proposed based on the performance limitation of plate heat exchangers and system design, providing a technical evolution direction for high-performance data centers.

2. Secondary side supply/return fluid temperature: The secondary side temperature range of the supply and return liquid (liquid cooling medium, compatible with water-based and 25 % volume concentration alcohol-based) for the CDU shall be determined based on the heat dissipation characteristics of the server cold plates. The temperature difference between the supply and return liquid shall be designed as 10 °C (or the flow rate on the secondary side shall be 1.54 LPM/kW).

   Note: The secondary side temperature range shall first meet the heat dissipation performance requirements of the server cold plates. On this basis, the design of the temperature difference between the supply and return liquid shall consider the balance between the cold plate flow rate and the pump energy consumption. Generally, a larger temperature difference (e.g., 20 °C) is beneficial for reducing the circulating flow rate and pump power, but imposes higher requirements on the cold plate design. A smaller temperature difference (e.g., 5 °C) is more conducive to achieving precise and uniform control of the chip temperature. Considering engineering practices and energy efficiency balance, the standard temperature difference of 10 °C shall be used for design.

3. Primary side supply/return fluid temperature: The primary side temperature difference between the supply and return fluid (softened water) for the CDU shall be designed as 8 °C.

4.2.2 Hydraulic Performance

1. Available head: The built-in circulating pump of the CDU shall provide sufficient head to meet the resistance requirements of the system pipe system and server racks. The specific value shall be determined based on the system design. Considering the development of high-heat-flux racks, the available head shall be designed to be ≥ 25 m.

   Note: As the power density of a single rack evolves to 100 kW or even higher, the flow channel design inside the server cold plates becomes more complex and compact, resulting in a significant increase in the flow resistance of the entire server rack and the entire secondary side circulation piping system. If the pump head margin is insufficient, the actual flow rate in the system will not meet the requirements, leading to insufficient heat dissipation capacity and affecting the safe operation of IT equipment. Therefore, the specific design value shall be determined after the flow resistance of each part of the system is calculated in detail. Considering the current development trend of high-heat-flux racks, to reserve sufficient safety margin for the design of cold plates with higher resistance and more complex pipe layout, the pump selection and system design shall be performed based on the available head of ≥ 25 m (meters of water column). This recommended

value is intended to ensure the reliability and adaptability of the system during future upgrades and high-load operation.

2. Flow rate adjustment: The secondary side circulating system of the CDU shall be capable of adjusting the flow rate. The flow rate adjustment range in rated operating conditions shall be 10 % to 100 %.
3. Motor energy efficiency: When a three-phase asynchronous motor is used for the CDU circulating pump, the motor shall meet the level-2 energy efficiency requirements specified in GB 18613-2020 "Minimum Allowable Values of Energy Efficiency and Values of Efficiency Grades for Motors", which is equivalent to the IE4 level specified in IEC 60034-30-1:2014. When a permanent-magnet synchronous motor is used, the motor shall meet the level-2 energy efficiency requirements specified in GB 30253-2024 "Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades for Permanent Magnet Synchronous Motors". The motor selection shall also comply with the relevant energy-saving regulations in the project location.

4.3 Design Requirements

4.3.1 Connections and Monitoring Devices

1. Piping connection: The CDU shall specify the types of connections (such as flange and clamp) on the primary and secondary sides. For pipes with a nominal diameter of less than or equal to DN80, the hygienic clamp that complies with ISO 2852 or DIN 32676 may be used. For the main circulating pipe and pipes with a nominal diameter greater than DN80, flange connection should be used. If the clamp connection is used due to space constraints, heavy-duty clamps shall be used to ensure the reliability of the connection.

   Note: Specifying the connection type is the basis for implementing standardized and modular deployment and interchangeability of the system in later maintenance. Flange connection features high pressure bearing capacity, reliable sealing, and repeated disassembly and assembly, but requires large installation and operation space. Clamp connection features quick installation and small space occupation, and is especially suitable for scenarios where racks are densely arranged or pipes are complexly deployed. Heavy-duty clamps (such as double-bolt clamps) should be used to cope with possible pressure fluctuation, temperature change, and slight vibration during the operation of the liquid cooling system, preventing connections from loosening or leakage. This is critical to ensuring long-term stable operation of the system and reducing the risk of coolant leakage.
2. Electrical connection: The power system type shall be specified. The CDU shall support dual power inputs, and the dual power module redundancy solution should be used. In case of a fault, the faulty power module can be replaced without shutting down the system. It supports a wide-range input voltage compatible with 3-phase AC 380–415 V AC±10% (steady-state operating line voltage: 342–456.5 V AC) and 50/60 Hz±3 Hz (steady-state operating frequency: 47–63 Hz).

   Note: As the core power unit of the liquid cooling system, the CDU shall be treated with the same power supply reliability as IT equipment. It shall support two independent power inputs to eliminate single points of failures (SPOFs) in the power supply chain. A dual power module redundancy scheme should be adopted, where the CDU integrates two independent, hot-swappable power modules operating in parallel current sharing. When either module fails, the other module shall be able to seamlessly carry the full load, and the faulty module can be replaced without powering off the system, thereby achieving the highest availability and maintainability. Compared with the traditional automatic transfer switch (ATS) solution, this solution completely avoids the risk of switching interruption and the SPOF of the ATS itself. Furthermore, the power modules shall have a wide input range capability and should be compatible with 380 VAC to 415 VAC, 50/60 Hz, to automatically adapt to mainstream global grid standards such as 380 V, 400 V, 415 V, and 480 V (as required), facilitating global deployment and O&M of the product.
3. Sensor connection: Sensors for temperature and pressure shall support online maintenance to ensure reliable monitoring and efficient O&M of the liquid cooling system. Note: The process connection components of the temperature sensor should uniformly use internal threads such as

G1/4, G3/8, and G1/2, and shall be integrated with an installation sleeve. This structure allows the sensor to be isolated and replaced online without draining the liquid while the system is running normally. To improve the consistency of temperature readings within the system, the temperature sensors used in the same CDU should have the same precision deviation direction (positive or negative). It is recommended that the sensors be paired or selected for consistency during manufacturing.

4. CDU control panel: The size should be ≥ 10 inches, and the panel shall support Chinese and English display, local parameter setting, running status monitoring, fault alarm reporting, and data export functions.

4.3.2 Dimensions and Power

1. Dimensions: The external dimensions of the CDU shall meet the layout requirements of standard racks or micro modules. The width should be designed in multiples of 1, 1.5, 2, 2.5, or 3 times the width of a standard rack. The depth should be 1200 mm or 1400 mm.
2. Power: The power level classification should be designed based on the networking mode and architecture, with levels such as 425 kW, 650 kW, 850 kW, 1300 kW, or 2550 kW.

4.3.3 Filtration Precision

A filter with a filtration precision of no more than 300 μm should be installed in the primary loop.

The secondary loop shall be equipped with a high-flow and low-resistance filter with a filtration precision of no more than 50 μm and a filtration ratio $\beta_{50} \geq 75$ (which should be verified by the ISO16889 multi-pass test). In addition, a bypass filter with a filtration precision of no more than 5 μm should be installed to protect precision components such as the cold plate of the server.

4.3.4 Auxiliary Devices

1. The CDU shall be integrated with an automatic or manual liquid refill device. A filter screen shall be installed at the liquid refill port to prevent impurities from entering the system.
2. The CDU shall be equipped with a built-in fluid make-up tank. The capacity of the tank shall be determined based on the total system volume, evaporation and leakage volume, and O&M requirements. A clear liquid level indicator and high/low liquid level alarm function shall be provided.
3. The CDU shall be equipped with a built-in automatic constant-pressure fluid make-up device. The expansion tank (constant-pressure tank) shall be able to accommodate the water volume expanded due to system temperature changes. The flow rate of the internal make-up pump shall meet the liquid refill requirements during normal system operation, and the rated head should be no less than 1.6 bar. The constant pressure value of the system shall meet the requirements of the pump NPSH, and the recommended value is 0.5 bar to 1 bar. If the CDU is equipped with an external fill pump (liquid injection pump), the flow rate of the external liquid refill pump shall not be less than that of the internal make-up pump.
4. A safety pressure relief device shall be installed, with a relief pressure of ≤ 0.5 MPa, to prevent high-pressure risks.
5. The system shall be integrated with automatic and manual exhaust devices. The exhaust devices shall be installed at the highest point of the system and shall be capable of continuously exhausting non-condensable gases from the secondary loop.
6. If the CDU uses different working media on the primary and secondary sides, the drip tray should be physically separated to independently divide the water collection areas for the primary and secondary working media.

Appendix A

A.1 Networking Architecture Analysis - CDU Performance Specification Derivation

Deriving the load power capacity from the transformer perspective

Category	Unit	Specification Requirement/Example Value	Recommended Value
Transformer power	kVA	2500	-
Power factor	/	97.0%	-
Load rate	/	100.0%	-
Power supply efficiency	/	97.2%	-
Transformer derating factor (power factor × load rate × power supply efficiency)	/	94.3%	-
Derated load power capacity	kW	2357	Power > derated UPS load capacity

Deriving the load power capacity from the UPS perspective

Category	Unit	Specification Requirement/Example Value	Recommended Value
Power factor	/	97.00%	-
Load rate	/	95%	-
Power supply efficiency	/	99.80%	-
UPS derating factor (power factor × load rate × power supply efficiency)	/	91.97%	-
Configured power capacity of 5 × 500 kW UPS system	kW	2500	-
Configured power capacity of 4 × 600 kW UPS system	kW	2400	-
Derated UPS load capacity of 5 × 500 kW UPS system	kW	2299	Adopts the stringent value of 2300.
Derated UPS load capacity of 4 x 600 kW UPS system	kW	2207	

According to the derivation of the transformer and UPS, the load power capacity is 2300 kW.

Category	**Unit**	**Specification Requirement/Example Value**	**Recommended Value**
IT load power value based on integrated transformer and ups configuration calculation	kW	2300	Limited by the UPS configuration, the derated UPS load capacity adopts the most stringent value
Liquid cooling ratio	/	100%	Calculated based on full liquid cooling infrastructure to complement future development trends
Liquid cooling load	kW	2300	-
Redundancy factor	/	10%	-
Liquid cooling capacity demand	kW	2530	-
Specifications of a single CDU - 1+1	kW	2530	**2550**
Single CDU specifications: 2+1	kW	1265	**1300**
Single CDU specifications: 3+1	kW	843	**850**
Single CDU specifications: 2+1 & 2+1 (two modules)	kW	633	**650**
Single CDU Specifications - 3+1 & 3+1 (Two Modules)	kW	422	**425**

A.2 Example of Key CDU Specification Parameters

Category	Parameter	Unit	Specification Requirement/Example Value	Remarks
Performance Requirements	Approach temperature	°C	≤ 3	≤ 2 (better)
	Secondary-side coolant supply temperature range	°C	20~50	Configurable
	Available head	m	≥25	
	Secondary side supply/return fluid temperature difference	°C	10	Or secondary side flow rate of 1.54 LPM/kW
	Primary side supply/return fluid temperature difference	°C	8	6–8 °C, 8 °C recommended
Design Requirements	Primary side connection	/	Clamp/Flange type	
	Secondary connection	/	Clamp/Flange type	
	Primary-side filtration precision	μm	≤300	
	Secondary-side filtration precision	μm	≤50	Optional 5 μm bypass filter
	Power system	/	380 VAC 50/60 Hz 3PE	Compatible with 400 V 50/60 Hz 3P and 415 V 50/60 Hz 3P
	Dimensions (W x D)	mm	Width: 600/900/1200/1500 Depth: 1200/1400	Adapts to standard rack positions
	Power level	kW	425/650/850/1300/2550	Compatible with standard rack slots
Reliability Requirements	Pump redundancy configuration	/	Supports N	Optional N+1
	Electrical redundancy configuration	/	Supports dual power input	Optional ATS solution, dual power module solution recommended

Category	Parameter	Unit	Specification Requirement/Example Value	Remarks
	Liquid-contact materials	/	Compliant with the GCC dual-zero initiative: test methods for coolant and material compatibility in single-phase cold plate liquid cooling	
	Design life	Year	≥10	

A.3 Example of key specifications of the CDU -850 kW

Category	**Parameter**	**Unit**	**Specification Requirement/Example Value**	**Remarks**
Performance Requirements	Heat exchange capacity of the CDU	kW	≥850	
	Approach temperature	°C	≤3	≤ 2 (better)
	Secondary side supply temperature range	°C	20~50	Configurable
	Available head	m	≥ 25	
	Primary-side working medium	/	Softened water	
	Secondary-side working medium	/	PG25/EG25/pure water liquid cooling working medium	Coolant with inhibitors and biocide
	Secondary side supply/return temperature difference	°C	10	
	Secondary side supply/return fluid flow rate	LPM	≥1309	
	Primary side supply/return fluid temperature difference	℃	8	
	Primary side supply/return fluid flow rate	LPM	≥1518	
Design Requirements	Primary connection	/	4.5" clamp/DN100 flange	The clamp shall match the heavy-duty clamp.
	Secondary connection	/	4.5" clamp/DN100 flange	The clamp shall match the heavy-duty clamp.
	Primary side filtration precision	μm	≤300	
	Secondary side filtration precision	μm	≤50	Optional 5 μm bypass filter
	Fluid make-up	L	≥30	

Category	Parameter	Unit	Specification Requirement/Example Value	Remarks
	tank			
	Expansion tank	L	≥36	
	Internal make-up pump	LPM@bar	2.5@1.6	
	Power system	/	380 VAC 50/60 Hz 3PE	Compatible with 400 V 50/60 Hz 3P, and 415 V 50/60 Hz 3P recommended
	Control panel	in	≥10	
	Dimensions (W x D x H)	mm	Width: ≤ 1500 mm Depth: ≤ 1400 mm Height: ≤ 2250 mm	Compatible with standard rack slots
Reliability Requirements	Pump redundancy configuration	/	Supports N	Optional N+1
	Electrical redundancy configuration	/	Supports dual power input	Optional ATS solution, dual power module solution recommended
	Liquid-contact materials	/	Compliant with the GCC dual-zero initiative: test methods for coolant and material compatibility in single-phase cold plate liquid cooling	
	Design life	Year	≥10	

A.4 Example of key specifications of the CDU -1300 kW

Category	**Parameter**	**Unit**	**Specification Requirement/Example Value**	**Remarks**
Performance Requirements	Heat exchange capacity of the CDU	kW	≥1300	
	Approach temperature	°C	≤3	≤2 (better)
	Secondary side supply temperature range	°C	20~50	Configurable
	Available head	m	≥25	
	Primary-side working medium	/	Softened water	
	Secondary-side working medium	/	PG25/EG25/pure water liquid cooling working medium	Coolant with inhibitors and biocide
	Secondary side supply/return temperature difference	℃	10	
	Secondary side supply/return fluid flow rate	LPM	≥2002	
	Primary side supply/return fluid temperature difference	℃	8	
	Primary side supply/return fluid flow rate	LPM	≥2322	
Design Requirements	Primary connection	/	≥5" clamp/DN125 flange	The clamp shall match the heavy-duty clamp.
	Secondary connection	/	≥5" clamp/DN125 flange	The clamp shall match the heavy-duty clamp.
	Primary-side filtration precision	μm	≤300	
	Secondary side filtration precision	μm	≤50	Optional 5 μm bypass filter
	Fluid make-up	L	≥30	

Category	Parameter	Unit	Specification Requirement/Example Value	Remarks
	tank			
	Expansion tank	L	≥36	
	Internal make-up pump	LPM@bar	2.5@1.6	
	Power system	/	380 VAC 50/60 Hz 3PE	Compatible with 400 V 50/60 Hz 3P, and 415 V 50/60 Hz 3P recommended
	Control panel	in	≥10	
	Dimensions (W x D x H)	mm	Width: ≤ 1500 mm Depth: ≤ 1400 mm height: ≤ 2250 mm	Compatible with standard rack slots
Reliability Requirements	Pump redundancy configuration	/	Supports N	Optional N+1
	Electrical redundancy configuration	/	Supports dual power input	Optional ATS solution, dual power module solution recommended
	Liquid-contact materials	/	Compliant with the GCC dual-zero initiative: test methods for coolant and material compatibility in single-phase cold plate liquid cooling	
	Design life	Year	≥10	

References

[1] GB 18613-2020: Minimum Allowable Values of Energy Efficiency and Values of Efficiency Grades for Motors

[2] GB 30253-2024: Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades for Permanent Magnet Synchronous Motors

[3] IEC 60034-30-1:2014 Rotating Electrical Machines - Part 30-1: Efficiency Classes of Line Operated AC Motors (IE Code)

[4] ISO 2852:1993 Stainless Steel Clamp Pipe Couplings for the Food Industry

[5] DIN 32676:2022 Stainless Steel Components for Hygienic and Aseptic Applications in the Food, the Chemical and the Pharmaceutical Industries - Clamp Connections with Molded Seals

[6] ISO 16889:2022 Hydraulic Fluid Power — Filters — Multi-pass Method for Evaluating Filtration Performance of a Filter Element