Community Specifications

Artificial Intelligence Data Center (AIDC) Infrastructure Specification (Version 1.0)

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Version Change History

Version	Description	Contributor
V0.8	Public release	As above
V1.0	1. Section 5.1: Regarding the requirement for the lower limit of load-bearing capacity for data halls in newly built AIDCs, the load-bearing capacity should not be less than 20 kN/m² and shall not be less than 16 kN/m². 2. Section 7: The upper limit of power per rack for air cooling should be 20 kW to 40 kW, meeting the air cooling demand of high-power AI racks. For details, see the GCC's *AIDC Air-Cooling Terminal Equipment Specifications and Evolution Roadmap*. 3. Section 7.1.2.1: The cooling capacity of the CDU should be greater than or equal to 450 kW and comply with the GCC's *Key Specifications and Evolution Roadmap for Coolant Distribution Unit (CDU)*. 4. Section 7.1.2.3: The specifications of the coolant on the secondary side shall meet the requirements in the *Technical Requirements and Test Methods for Coolant for Cold Plate Liquid Cooling* (in preparation, to be published). 5. Section 9.2.2: The check interval of the liquid cooling system should be determined according to the GCC's *Cold Plate Liquid Cooling System Intelligent Operation and Maintenance Technical Specification*. 6. Section 9: Added the simulation precision requirements. 7. Section 7.1.2.1: CDU harmonic requirements can be considered based on the power distribution system. CDU harmonics can be managed locally or in a centralized manner. 8. Section 6: Optimized descriptions about the power supply mode and UPS load rate.	As above, with these contributors added: Wang Guojun, Zhang Pengfei, Ding Jiaqi, Zhou Haitao, Wu Tianqing, Zeng Xianlong, Zhang Jiabin, Xiong Xin, Yu Maoping, Gao Shengtao, Cai Yuelin, Deng Zhihe, Wang Yuanyue, Zhang Yu, Liu Kui, Shi Junhua, Li Yajun, Wang Anlin, Yang Rui, Fan Ting, Wang Shaopu, etc.

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AIDC Infrastructure Specification

1 Scope

This document is intended for artificial intelligence data centers (AIDC). To support the continuous development of the AI industry, data center infrastructure planning should be forward-looking. Its design and construction should be moderately ahead of its time and possess high elasticity and scalability, meeting the development demand for power per rack to scale up to approximately 300 kW within the next three to five years. Specifically, it covers the overall requirements, environmental requirements, building requirements, power supply and distribution systems, cooling systems, cabling, delivery, and operations and maintenance (O&M). It features a decoupled design between equipment rooms and IT racks, supporting the evolution across two to three generations of AI liquid-cooled racks.

2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB 20052 Minimum allowable values of energy efficiency and the energy efficiency grades for power transformers

GB/T 2820.1-2022 Reciprocating internal combustion engine driven alternating current generating sets—Part 1: Application, ratings and performance

GB/T 29044 Water quality for heating and air conditioning system

GB/T 45393.1-2025 Information technology—Building information model (BIM) software

GB 50174 Code for design of data centers

GB 50236-2011 Code for construction and acceptance of field equipment and industrial piping

GB 50300-2013 Unified standard for constructional quality acceptance of building engineering

GB 50311-2016 Code for engineering design of generic cabling system

GB 50316-2008 Code for design of industrial metallic piping

GB 50462-2015 Code for construction and acceptance of data center infrastructure

GB 50736 Design code for heating, ventilation and air conditioning of civil buildings

GB 50944 Code for construction and quality acceptance of antistatic engineering

GB/T 51212-2016 Unified standard for building information modeling

GB/T 51269-2017 Standard for classification and coding of building information model

GB 55030-2022 General code for waterproofing of building and municipal engineering

HJ 93-2026 Technical specifications and test procedures for ambient air sampler for PM10 and PM2.5

3 General Requirements

The rapid evolution of AI liquid-cooled racks presents significant challenges to AIDC building structure, power supply and distribution and cooling systems, and integrated network cabling, impacting design and planning from the campuses down to buildings and floors. Therefore, AIDC planning and

construction must be coordinated with the generational evolution of computing equipment. Facility design shall feature flexible compatibility across different generations.

Table 1 Rack power levels

Level	**Level 1**	**Level 2**	**Level 3**
Power per rack	~100 kW	~200 kW	~300 kW
Power supply mode (AC)	380 V AC 32 A IEC 60309-2 industrial connector (6+6), or 380 V AC 63 A industrial connector (3+3)	380 V AC 63 A IEC 60309-2 industrial connector (6+6)	380 V AC 63 A IEC 60309-2 industrial connector (10+10)

Building structure: As power per rack evolves to 300 kW, the requirements of cooling, power supply, and networking on space height and load-bearing design increase. Accordingly, the facilities shall evolve to meet the rack weight and floor height requirements over the next three to five years.

Power supply system: To accommodate the evolution of total power per SuperPod toward 1–10 MW and power per cluster toward hundreds of MW, a data hall will expand from 1–2 MW gradually toward 10–20 MW, a building will expand from tens of MW to hundreds of MW, and the total power of a campus will reach the GW level. Therefore, it is essential to build an end-to-end, highly efficient power supply system to achieve optimal system energy efficiency.

Cooling system: To ensure compatibility with the changes in the air-to-liquid ratio of AI liquid-cooled racks, the facilities shall support flexible air-to-liquid ratios. The design of supplying coolant at low temperatures can be reserved to meet the requirements of supplying coolant at low temperatures for servers in the future.

Integrated cabling: For large-scale cluster facilities, it is advised to plan network cabling by layer from the campus to the building based on the maximum cluster deployment capacity while fully considering cabling space requirements and distance constraints.

Fast deployment: To shorten the facility readiness cycle, the construction process should be advanced as much as possible, and the electromechanical devices that are weakly coupled with intelligent computing devices should be constructed in advance. The electromechanical devices should be standardized, modularized, and prefabricated. AI computing and facilities shall be considered collaboratively with full-stack planning. Each module should be designed and verified in advance, and resources should be reserved through framework bidding to shorten the construction cycle of electromechanical devices.

Collaborative modeling and simulation verification: 3D digital technologies should be used to build a high-precision model of the AIDC facilities and IT devices. Collision simulation, hydraulic balance simulation, temperature field simulation, and energy efficiency simulation should be performed. For SuperPod scenarios, the networking and cabling should be jointly designed and optimized based on the overall modeling.

Intelligent operations: An intelligent management system shall be built to monitor the key operating parameters and IT load changes of the liquid cooling and power distribution systems online. AI technologies should be used to predict and diagnose exceptions and optimize system operations.

4 Environmental Requirements

4.1 Temperature and Humidity Requirements

1. The indoor temperature and humidity shall be controllable. The temperature in the cold aisle or air intake area of racks shall be 18°C to 27°C, the dew point temperature shall be 5.5°C to 15°C, and the relative humidity shall be less than or equal to 60%.
2. Condensation shall not occur in any part of the environment.
3. For other requirements, follow the relevant provisions of GB 50174 *Code for design of data centers*.

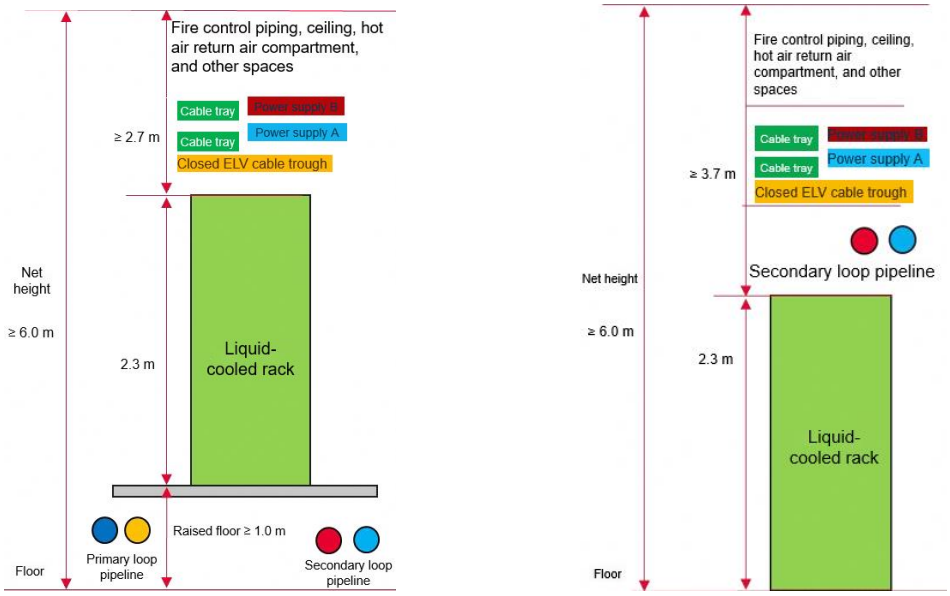
4.2 Air Cleanliness Requirements

1. Data center cleanliness shall meet ISO 14644-1 Class 8 requirements. The number of suspended particles with a diameter greater than or equal to 0.5 μm per cubic meter of air shall be less than 3,520,000 under static conditions.
2. There shall be no explosive, conductive, magnetic, or corrosive dust in the equipment rooms. Corrosivity shall conform to Severity Level G1, as defined in ANSI/ISA-71.04-2013.
   (a) For copper test coupons, the maximum growth rate of corrosion product thickness shall be less than or equal to 300 Å/month.
   (b) For silver test coupons, the maximum growth rate of corrosion product thickness shall be less than or equal to 200 Å/month.

5 Building Requirements

5.1 Design Principles

1. The AIDC building structure shall meet the deployment requirements of AI computing devices or AI SuperPod clusters.
2. The AIDC building floor plan and space layout shall be flexible, meeting the deployment requirements of multi-generation AI devices or AI SuperPod clusters.
3. The design of data halls for AI SuperPod clusters shall be based on the cluster network interconnect requirements. Multiple data halls in the same AI SuperPod cluster shall be designed adjacent to each other to minimize the cable length for network interconnects.
4. The net height of data halls shall be determined based on the height of AI racks, as well as the height requirements of the smart busbars for power supply and distribution, integrated cabling of the production network, liquid cooling pipes (overhead or underfloor), floor (or ceiling for return air), fresh air systems, fire extinguishing pipes, and lighting.
5. The net height of data halls in a new AIDC should be greater than or equal to 6.0 m. The live load of data halls shall be calculated based on the working weight of the AI racks, layout, liquid cooling pipes (underfloor), and transportation load. In addition, the load should not be less than 20 kN/m², and shall not be less than 16 kN/m². The requirements of rack power levels 1, 2, and 3 shall be met.



(a) Scenario with underfloor liquid cooling pipes (b) Scenario with overhead liquid cooling pipes

Figure 1 Net height of data halls

6. Scenario with underfloor liquid cooling pipes: The height of the raised floor in AIDC data halls should be greater than or equal to 1 m, which is determined based on the deployment requirements of liquid cooling pipes. The load-bearing capacity of the raised floor shall meet the installation requirements of AI liquid-cooled racks. The AI liquid-cooled racks shall be installed on dedicated bases. The design of the bases shall be determined based on the weight of the racks, position of the support legs, and requirements of the liquid cooling pipe ports. The raised floor in the area of secondary liquid cooling pipes can be a transparent glass floor.
7. Scenario with overhead liquid cooling pipes: Electrical, extra-low voltage (ELV), fire extinguishing, and liquid cooling pipes shall be arranged in a coordinated manner. To prevent condensate water or water leakage, water pans and leakage detection cables shall be installed under the pipes.
8. For existing data centers that are reconstructed, the cooling equipment (such as cooling towers) should be deployed as close as possible to the liquid-cooled room. If there is sufficient space on the roof, the liquid-cooled room should be preferentially deployed on a high floor. Otherwise, it should be preferentially deployed on a low floor. Centralized cooling equipment shall be deployed outdoors. Future capacity expansion requirements shall be considered during floor selection.
9. The load-bearing capacity of existing data center floors can be 10 kN/m², 12 kN/m², or 16 kN/m². The electromechanical system needs to be expanded and reconstructed based on the rack power level requirements and civil work resources. The details are as follows:

Table 2 Capacity expansion and reconstruction of existing data centers

Floor load-bearing capacity	10 kN/m^2	12 kN/m^2	16 kN/m^2

Suggestions on AI liquid-cooled rack deployment	Deployment is not recommended.	Consider reinforcement or increasing the deployment spacing for sparse deployment.	Expand electromechanical systems such as power distribution and cooling equipment on demand or adopt spare deployment. Consider local reinforcement measures.

10. The seismic fortification category of a newly built AIDC shall be key fortification (category B).
11. The suspended load of AIDC data halls shall be determined based on the requirements for cable hoisting of smart busbars or remote power panels, production network cabling, and liquid cooling pipe installation (overhead).
12. The waterproof level of data halls where AI liquid-cooled racks are deployed shall meet the waterproof level I requirements specified in GB 55030 *General code for waterproofing of building and municipal engineering*.
13. Waterproofing measures shall be taken around the area where water is likely to occur.
14. The liquid cooling pipes shall be secured to floor slabs or devices using supports or hangers. The load-bearing capacity of the floor slabs or devices shall be verified and meet the overall load-bearing requirements.
15. Before data center reconstruction design, the structure of the data center shall be inspected and evaluated, and the structure shall be reviewed according to the new load-bearing requirements.
16. The fire resistance rating of AIDC shall be at least level 1. The design fire resistance limit of steel structure components shall be determined based on the fire resistance rating of the building and the component type.
17. For other requirements of structural design, follow the relevant provisions in GB 50174 *Code for design of data centers*.

5.2 People and Material Flows

1. The AIDC shall be designed with separate entrances and exits for people and materials.
2. The unloading platform of the AIDC shall meet the requirements for unloading standard containers. The platform shall have independent temporary storage space to meet the requirements for transporting racks.
3. The freight passage shall be free of slopes or have a local lifting platform. All passages for transporting racks (including freight elevator doors, passage doors, and room doors) shall be flat, without steps or thresholds. The height of the passages shall be at least 2.8 m, and the width shall be at least 2.4 m. The turning radius and elevator depth shall be at least 2 m. If a slope is required, the slope angle should be less than 5°, and the slope width should be greater than 2.2 m.
4. The load-bearing capacity of the elevator for transporting AI racks shall be at least 3000 kg, and preferably at least 5000 kg. The dimensions (W x D x H) of the elevator car shall be at least

   2000 mm x 2850 mm x 2900 mm. The door opening size shall be at least 1800 mm x 2800 mm.
5. During the transportation of AI racks in equipment rooms, a load distribution plate shall be used. The load distribution plate shall be made of stainless steel with a thickness of at least 5 mm, and the surface shall be smooth and free of protrusions.

5.3 Equipment Placement

1. All devices in the AIDC shall be deployed in line with the technical design to meet the requirements for system operation and maintenance, personnel operations and safety, device and material transportation, heat dissipation, installation, and maintenance.

2. The layout of compute node racks, high-speed network racks, and storage racks in the AIDC data halls shall be planned based on the technical requirements of AI SuperPods or AI clusters.
3. If rows of racks in a data hall are longer than 6 m, aisles shall be designed at both ends. If the distance between two aisles exceeds 15 m, an aisle shall be added in between. The width of an aisle should be at least 1 m, and can be 0.8 m in some areas.
4. The distance between the cold and hot aisles in the layout of AI liquid-cooled racks shall be determined based on factors such as the room load-bearing capacity, rack transportation, installation space of primary and secondary liquid cooling pipes, power per rack for air cooling, heat dissipation mode of air cooling, and O&M.
5. The width of the transportation aisle in a data hall should be at least 1.8 m.
6. The aisle containment and main equipment in a data hall shall be decoupled. The space between aisles and racks shall be sealed to meet the airflow organization and energy saving requirements for device operation.
7. When auxiliary devices are used for device installation and maintenance in data halls, the net width and height of the aisles shall be designed based on the clear working space of the auxiliary devices.

6 Power Supply and Distribution System

6.1 Design Principles

The power supply and distribution system shall consist of an active power supply system (medium- and low-voltage power distribution, uninterruptible power system, precision power distribution system, and grounding system) and a standby power supply system.

The power supply and distribution system shall meet the following requirements:

1. The design shall be based on the service characteristics, importance, load nature, computing evolution, and energy consumption capacity of the AIDC. The design shall meet the requirements for safety, reliability, cost-effectiveness, flexible deployment, reduced power loss, and easy maintenance and management.
2. AIDC workloads fluctuate greatly. The power supply and distribution system shall be designed in phases based on the workload conditions in extreme test working conditions and daily operation conditions, to fully utilize utility power resources.
3. If continuous cooling is required, the power supply and distribution system shall meet the demand for continuous cooling.
4. Dual power sources for systems and equipment shall be switched close to the devices. Their switchgears, wires, and cables shall be configured with fault tolerance. Mutually redundant equipment shall be arranged in different physical compartments, and mutually redundant conduits may be routed along different paths.
5. Unless otherwise specified, the electrical power system design shall comply with the relevant provisions of GB 50174 *Code for design of data centers* and related industry standards.

6.2 Final Power Distribution

Final power distribution can be implemented by using remote power panels or busways. The service characteristics, rack capacity allocation and scheduling, and future capacity expansion demands shall be considered when you select the power distribution mode. The final power distribution system shall take into account the following items:

1. The total power of a single data center module shall be less than or equal to 2500 kVA, and should not exceed the load capacity of a single transformer.

2. The current-carrying capacity of a branch output of the power distribution system shall meet the requirements of the power ports of racks. The following requirements shall be met:
   (a) The circuit breakers of the power distribution system shall have good heat dissipation and shall not be derated when the operating temperature reaches 40°C.
   (b) Heat dissipation gaps shall be reserved between the miniature circuit breakers (MCBs) of each branch output. The installation spacing shall be greater than or equal to 9 mm.
   (c) The cables and busways of the power distribution system shall have good heat dissipation, and the current-carrying capacity shall meet the requirements when the operating temperature reaches 35°C.
   (d) The overall derating coefficient of the circuit breakers shall be greater than or equal to 0.85.
3. Space shall be reserved for capacity expansion in final power distribution to meet subsequent capacity expansion and power upgrade requirements.
4. The power distribution loop of racks shall use products that support branch current detection, display, and monitoring.

6.2.1 Remote Power Panels for Power Distribution

When selecting remote power panels for power distribution, consider the following:

1. The remote power panels shall be deployed at the head and tail of rows.
2. The rated current of 400 A, 630 A, or 800 A should be adopted.
3. The cable trays for the cold aisle on the top of racks shall be cable ladders. Cables for power supplies A and B shall be routed in separate cable trays and shall not cross each other in the entire cable trays.
4. The width of a cable tray should be 600 mm or 800 mm. The number of cable layers shall be less than or equal to 2. The correction coefficient for multi-layer parallel cables shall comply with GB 50217 *Standard for design of cables of electric power engineering*.
5. The number of cable trays installed on the top of racks shall be less than or equal to 4. The number of three-phase 63 A industrial connectors available for a single rack shall be greater than or equal to 24.
6. The vertical distance between the cable trays for power supplies A and B shall be greater than or equal to 300 mm.

6.2.2 Busways for Power Distribution

When selecting busways for power distribution, consider the following:

1. The busways shall be deployed in the cold aisle space above the racks.
2. For a busway with a rated current less than or equal to 1250 A, a small busway should be used. For a busway with a rated current greater than or equal to 1600 A, a dense busway should be used.
3. The number of busways installed on the top of racks shall be less than or equal to 4. The number of three-phase 63 A industrial connectors available for a single rack shall be greater than or equal to 24.
4. The vertical distance between busways should be greater than or equal to 300 mm, and the horizontal distance should be greater than or equal to 600 mm.

6.3 Power Supply and Distribution for Equipment Rooms

The power load level and power supply requirements of equipment rooms shall be determined based on the service characteristics, construction level, rack power, and room processing requirements of the AIDC.

6.3.1 Power Quality of the Electrical Power System

1. The deviation of the AC input steady-state frequency (including the diesel generating set) shall be within ±0.5 Hz.
2. The deviation of the AC input steady-state voltage (including the diesel generating set) shall be within the range of +7% to –10%.
3. The THDi of the UPS input shall be less than 8%.
4. The THDv of the UPS output shall be less than or equal to 5%.
5. When electronic information devices are working properly, the input voltage waveform distortion shall be less than or equal to 5%.
6. The allowed power failure duration for electronic information devices is 0–10 ms.
7. When electronic information devices are powered by AC, the deviation of the output steady-state voltage of the UPS shall be less than or equal to ±1%, and the deviation of the output steady-state frequency shall be less than or equal to ±0.5 Hz.

6.3.2 Mains Power Input System

1. The capacity, voltage level, and number of loops of the mains power supply shall be determined based on the AIDC load calculation capacity, construction level, and related regulations of the local power supply department.
2. The mains power input system shall ensure power supply continuity and quality.
3. The electrical system should have two mains power inputs. If one power supply fails, the other power supply shall not fail at the same time. It is recommended that the two power supplies be from different transformer stations. If the upstream station is a 220 kV station, different busway sections in the same station can be used.
4. The cabling mode (overhead or underground) of the campus power supply lines for the electrical system can be determined based on the local conditions of the project.

6.3.3 Standby Power System

1. The standby power system shall be selected and configured based on the construction level of the AIDC.
2. The standby power system shall be interlocked with the mains power supply.
3. If the standby power system is a diesel generating set, the following requirements shall be met:
   (a) The power of the diesel generating set shall meet the requirements of extreme weather conditions and altitude. The performance level of the diesel generating set shall be at least G3 and the diesel generating set be selected based on the data center power (DCP), continuous power (COP), or primary power (PRP). The selection shall comply with the prevailing standards such as GB/T 2820.1 and GB 50174.
   (b) Necessary measures shall be taken to meet the requirements for quick startup of the diesel generating set. The diesel generating set shall be able to start automatically.
   (c) The time from mains failure to normal power supply by the standby diesel generating set shall be shorter than the backup time of the UPS battery system.
   (d) The time from mains failure to normal cooling supply by the cooling system shall be shorter than the time that the cooling system can maintain continuous cooling.
   (e) In the equipment room without continuous cooling equipment, IT infrastructure shall not break down due to temperature rise during the time from mains failure to normal cooling supply by the cooling system.

6.3.4 Low- and Medium-Voltage Power Distribution System

1. The medium-voltage power distribution system shall implement hierarchical protection. The selection principle is to ensure that when the power supply and distribution system is faulty, only the circuit breakers at the corresponding level are affected, and the power supply at other levels is not affected.
2. When the standby power supply is a medium-voltage diesel generating set, the short-circuit current capacity of the medium-voltage circuit breaker shall include the RMS value of the AC component and the RMS value of the DC component of the breaking current.
3. The transformer shall be an energy-saving transformer with low loss and noise, and shall meet the following requirements:
   (a) A dry-type transformer shall be used.
   (b) The energy efficiency level 1 specified in the GB 20052 standard shall be met.
   (c) The 2000 kVA or 2500 kVA model should be used. The 3150 kVA model can also be used.
   (d) In the case of extreme load, the overload of the transformer for mechanical equipment shall not exceed 10%.
   (e) In the case of unilateral loading of the transformer for IT equipment, the load rate covering the UPS charging power shall be less than or equal to 100%.
4. The low-voltage power distribution cabinet shall be a drawer-type or fixed metal-enclosed switchgear, and shall meet the following requirements:
   (a) The rated breaking current of the protective electrical device shall be greater than the short-circuit current of the loop.
   (b) For protective electrical devices with a setting current of 1000 A or higher, air circuit breakers (ACBs) shall be used. For protective electrical devices with a setting current of 800 A or lower, molded case circuit breakers (MCCBs) shall be used.
   (c) At least 10% of the circuits in the power distribution panel or power distribution cabinet shall be reserved for future use.
   (d) Power supply objects with different characteristics shall not be controlled in the same power distribution cabinet.
   (e) The power distribution cabinet shall be equipped with display instruments to check the voltage, current, frequency, power, and three-phase load balance status.
   (f) All switches, handles, and operation buttons in the power distribution cabinet shall be clearly labeled to prevent misoperations.

6.3.5 Uninterruptible Power System

1. The logical structure of the uninterruptible power system for IT and critical infrastructure should use the 2N architecture. The DR and RR architectures can be used to meet the requirements of different scenarios.
2. A static UPS should be used.
3. The input power factor shall be greater than or equal to 0.98.
4. Energy-saving products shall be used. The efficiency of the UPS in normal mode shall be greater than or equal to 95.5% (51%–100% resistive load rate) and greater than or equal to 96% (20%–50% resistive load rate).
5. If an AC uninterruptible power system is used, the high-efficiency static bypass mode shall be supported, and the efficiency shall be greater than or equal to 99% (51%–100% resistive load rate), and greater than or equal to 98% (20%–50% resistive load rate). The static bypass current imbalance of UPSs connected in parallel shall be less than 10%.

6. If an AC uninterruptible power system is used, the UPS shall provide a complete static bypass and external maintenance bypass.
7. The number of UPSs connected in parallel shall be less than or equal to four.
8. When UPSs are connected in parallel, the mains input and static bypass input of the UPSs shall share the same switch. When a single UPS is used, the mains input and static bypass input shall be configured with separate switches.
9. The UPS load rate should be less than or equal to 95%, and the load fluctuation requirements should be considered.
10. An integrated power system should be used. Space for installing integrated power system equipment shall be reserved for future power supply capacity.

6.3.6 Backup Battery System

1. The battery backup time for IT and critical infrastructure shall be at least 7 minutes at full load for a single side and at least 15 minutes at full load for a 2N architecture.
2. The battery charge power shall be greater than or equal to 5%.
3. The discharge current imbalance of battery strings shall be less than 5%.
4. The system shall provide online monitoring functions, and be able to detect the health status and charging status (including voltage, temperature, and internal resistance) of each battery.
5. If the uninterruptible power system uses lithium-ion batteries, lithium iron phosphate batteries shall be used instead of second-life batteries.

   The functions for monitoring capacity status, health status, and core temperature, and the functions for detecting insulation failure and leakage current shall be provided.
6. Batteries shall be kept away from electronic information devices and be installed in an independent physical compartment. The compartment shall be equipped with explosion-proof lights and switches.
7. If the uninterruptible power system uses lead-acid batteries, hydrogen detectors shall be installed and linked with the ventilation system. Insulation plates shall be installed on battery layers, and the number of parallel battery strings shall be less than or equal to 4.
8. The backup batteries and their switchgears shall be configured in fault tolerance mode and placed in different physical compartments. The cables shall be routed along different paths and physically separated if conditions permit.
9. If the uninterruptible power system uses lithium-ion batteries, the battery compartment can be deployed outdoors or on the roof. If the battery compartment is deployed indoors, the following requirements shall be met:
   (a) The battery room shall not be adjacent to rooms where people frequently stay. The lithium-ion battery room shall be separated from other areas by fire-resistant walls with a fire resistance rating of at least 2.0 hours and fire-resistant ceilings with a fire resistance rating of at least 1.5 hours. The doors of the lithium-ion battery room shall be Class A fire doors.
   (b) The capacity of batteries installed in a single battery room should not exceed 900 kWh. The battery room shall be equipped with an automatic fire sprinkler system, water spray system, or water mist system, and effective measures shall be taken to prevent fire propagation and reignition.
   (c) The lithium-ion battery room shall be equipped with a daily ventilation system and an emergency ventilation system. The emergency ventilation fans shall be powered by the power supply intended for fire extinguishing.

6.3.7 Power Distribution Requirements for the Cooling System

1. The power distribution requirements of the liquid cooling system shall not be lower than those of the computing node devices. If the computing node devices require delayed cooling after power

failure, the continuous cooling system shall be equipped with dual power supplies, and at least one uninterruptible power system shall be provided.

2. The air-cooled air conditioning system for computing nodes shall be powered by dual power supplies, and at least one uninterruptible power system shall be provided.
3. The battery backup time of the uninterruptible power system used by the cooling system shall not be shorter than the continuous cooling time, and should be greater than or equal to 15 minutes.

6.3.8 Monitoring and Management System for Power Supply and Distribution

The AIDC shall be equipped with an independent monitoring and management system for power supply and distribution based on the management characteristics of power supply and distribution systems. Such a system shall meet the following requirements:

1. The monitoring and management system shall cover all power distribution systems from the mains power input of the AIDC to the precision power distribution cabinets. The monitoring scope of the power distribution system based on small busways shall start from the general input unit to the power distribution unit (PDU).
2. The monitoring and management system shall use a redundancy architecture, and server redundancy shall be used for key parts such as real-time data, historical data, and alarms.
3. The monitoring and management system shall provide data analysis functions such as power quality monitoring and analysis, electrical device status, data center power distribution, and energy efficiency calculation.

6.3.9 Grounding System

The AIDC grounding design shall meet the requirements for personal safety and normal operation of the electronic information system, and comply with the applicable national standards and specifications. The grounding system shall meet the following requirements:

1. For electronic information devices using AC power, the TN-S grounding system shall be used.
2. The neutral point of the transformer or generator shall be grounded, and the PE cable and neutral wire (N) shall be separately routed.
3. The cross-sectional area of the neutral wire shall not be smaller than that of the phase wire. During normal operation of the system, the PE wire shall not carry periodic current.
4. All devices in the facilities, including the conductive metal enclosure, metal conduits, metal cable trays, and metal structures of the building, shall be equipotentially bonded and grounded.
5. The protective grounding and functional grounding of the facilities shall share the same grounding equipment, and the grounding resistance shall be less than or equal to 1 ohm.
6. Surge protective devices shall be installed at the corresponding positions of the power system to protect connected devices from damage.

6.3.10 Campus Power Supply

The campus power supply of the AIDC shall meet the requirements for the proportion of green electricity consumption and renewable energy utilization in the country. In regions with abundant renewable energy resources and a large scale of newly added intelligent computing loads, the integrated planning and construction of coordinated computing power and electric power should be carried out. The integrated planning requirements are as follows:

1. The principle of self-consumption and self-peak shaving shall be followed to avoid increasing the peak shaving pressure of the system.
2. The power supply, power grid, load, and energy storage systems shall be planned, constructed, and put into operation synchronously, and be able to participate in power trading as an operating entity.

3. The power supply solution shall be determined based on the new load scale and electricity consumption characteristics, as well as factors such as regional policies, resource characteristics, power generation characteristics, and construction and grid connection conditions. Renewable energy shall be preferentially used.
4. An integrated intelligent management and control platform shall be planned synchronously to receive unified dispatching commands from the public power grid. The management and control platform shall be able to dynamically match the electricity load with renewable energy generation, with long-term, short-term, and real-time optimization policies formulated for coordination between computing power and electric power.

7 Cooling System

Design principles:

1. The cooling system shall be planned and designed based on customer requirements and technology development. It should meet the heat dissipation requirements of 2 to 3 generations of AI liquid-cooled rack systems.
2. The cooling system design shall be compatible with different vendors' rack power levels to support flexible power deployment.
3. With fixed total power supply in a data hall building, the cooling system may adjust the mix of air and liquid cooling within a set range without changing the cooling source. This means both methods work together and can adapt as rack power changes.
4. The cooling system should use prefabricated modules such as integrated cooling sources and hydraulic modules to support rapid deployment and high-quality delivery.
5. The key devices and operating parameters of the cooling link shall be monitored. Sensors are installed to monitor the system online, including water temperature, pressure, and flow.
6. The upper limit of power per 600-mm-wide rack for air cooling in the AIDC should be 20 kW to 40 kW, meeting the air cooling demand of high-power AI racks. For details, see the GCC's *AIDC Air-Cooling Terminal Equipment Specifications and Evolution Roadmap*.

7.1 Liquid Cooling System

7.1.1 Primary-side Cooling Source System

1. The primary-side cooling source system may use various cooling sources, such as open cooling tower + plate heat exchanger, closed cooling tower, chilled water, air-cooled chiller, dry cooler, and refrigerant system. The cooling source system should flexibly accommodate a liquid cooling proportion of 70% to 90%+ for AI liquid-cooled racks.
2. The primary-side cooling source system may deploy low-temperature liquid supply designs, such as chilled water and DX cooling, to reserve future capability for supplying low-temperature liquid to servers.
3. The primary-side cooling source system should meet the requirements of AIDC liquid-cooled devices and air-cooled devices sharing the same cooling source, simplify air and liquid cooling planning, and adapt to the deployment of different liquid-cooled servers.

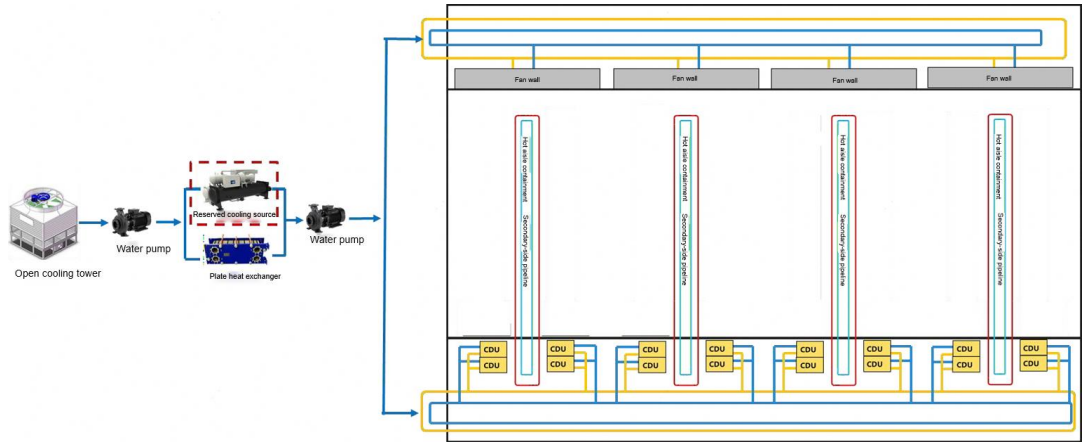


Figure 2 Design of liquid-cooled devices and air-cooled devices sharing the same cooling source

4. The water quality of the primary-side cooling source system shall comply with the *GB/T 29044 Water quality for heating and air conditioning systems,* which sets standards for circulating water and makeup water in the closed-loop circulating cooling water system used for indirect cooling in centralized air conditioning systems. Additionally, the water should include corrosion inhibitors, biocides, and scale inhibitors. The alcohol-based working fluid shall be utilized according to the specified requirements.
5. A filter shall be installed within the primary-side cooling source system, with pressure gauges positioned both upstream and downstream of the filter. This setup enables the detection of filter blockages, facilitating prompt replacement.

7.1.2 Secondary-side Liquid Cooling System

1. The design of the secondary-side cooling system shall be compatible with racks that have varying power levels, air-to-liquid ratios, and liquid supply flow rates. This allows the system to support liquid-cooled racks from different vendors and expand its capacity as needed.
2. The main liquid cooling pipe on the secondary side should accommodate a liquid cooling proportion of at least 90% for the AI liquid-cooled rack system.
3. The air cooling terminal air conditioners on the secondary side may be remote fan walls, local fan walls, or in-row units. They meet the cooling needs of the air-cooled section in the liquid-cooled rack system.
4. The design of the secondary-side branch ports should meet the port requirements of different AI liquid-cooled rack systems.
5. CDU ports should be reserved for secondary-side pipes. The CDU quantity is flexible and should be N+1+X ($1 < N+1+X \leq 5$).

   N: CDU quantity that meets the cooling requirement

   X (≤ 2): CDU quantity reserved for capacity expansion

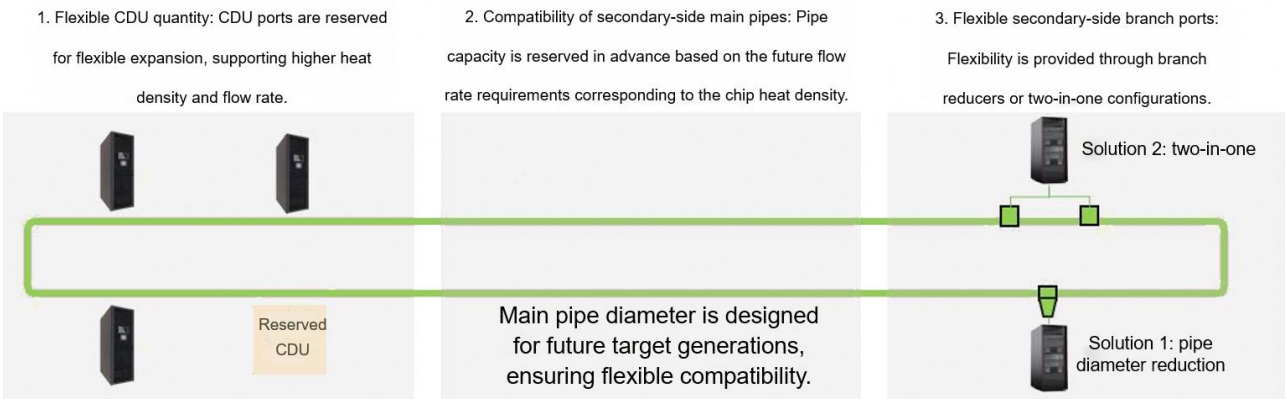
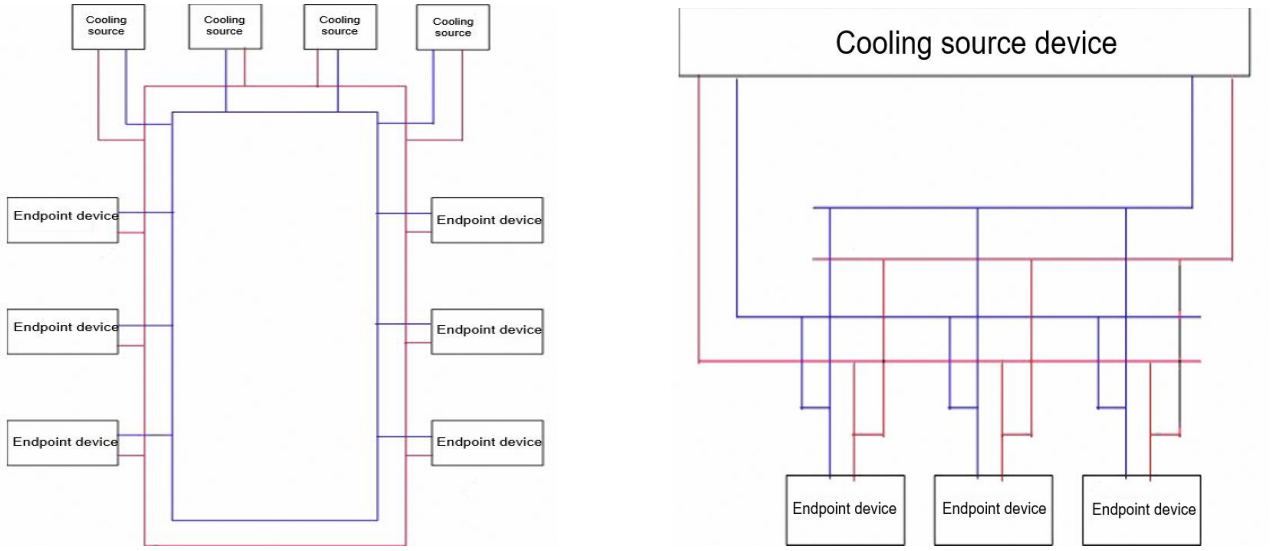


Figure 3 Elastic compatibility solution for the secondary-side liquid cooling system

6. The secondary pipe system shall adopt either a ring network or a dual-supply, dual-return (2N) setup.



(a) Ring pipe network (b) Dual-supply, dual-return setup

Figure 4 Secondary-side pipe design

7. The cooling capacity of the CDU should be greater than or equal to 450 kW, and should comply with the GCC's *Key Specifications and Evolution Roadmap for Coolant Distribution Unit (CDU)*.
8. The flow resistance of the secondary-side pipes—including the branch pipes from the CDU to the main pipe, the main pipe itself, and the branch pipes from the main pipe to the rack—shall not exceed 0.6 bar.
9. The flow resistance of the main pipe should not exceed 200 Pa/m.
10. It is recommended that the flow resistance of the liquid-cooled rack be set according to their power levels.

Table 3 Reference for flow resistance of the liquid-cooled rack

Power range	~100 kW	~200 kW	~300 kW

Flow resistance of the liquid-cooled rack	≤ 100 kPa	≤ 150 kPa	≤ 150 kPa (recommended), ≤ 180 kPa (mandatory)
Port specifications of the liquid-cooled rack	1 inch (50.5 mm clamp) or 2 inches (64 mm clamp)	≥ 2 inches (64 mm clamp)	≥ 2 inches (64 mm clamp)

11. The secondary-side pipes shall be made of stainless steel (grade 304 or higher). All materials in contact with the liquid shall pass liquid compatibility testing.

7.1.2.1 CDU Specifications

The CDU specifications shall meet the requirements specified in the GCC's *Key Specifications and Evolution Roadmap for Coolant Distribution Unit (CDU)*.

1. A CDU consists of but is not limited to the plate heat exchanger, secondary-side circulating pump, constant pressure liquid refill system, expansion tank, filter, valve, sensor, control system, display screen, power module, and leakage detection module.
2. The CDU shall be set to work in alternating mode, with the rotation period being adjustable. The initial setting is 24 hours x 7 days.
3. The heat exchanging capacity of the CDU shall be at least 1.1 times the IT liquid cooling power consumption. The total flow rate of the secondary-side ring network shall be 1.1 times the designed flow rate of the server.
4. Under stable operating conditions, the temperature control precision of the CDU's secondary-side liquid supply shall be maintained within ±1°C. During the CDU rotation, the temperature fluctuation range should be less than or equal to ±1°C. When the load changes, the temperature control precision of the CDU shall meet the temperature control requirements of the computing device.
5. The flow adjustment range for the secondary-side liquid supply shall span from 10% to 100%.
6. To ensure the long-term reliability of the liquid cooling system, the liquid supply pressure from the CDU should remain moderate. Specifically, the pressure of the liquid entering the liquid-cooled rack should not exceed 3 bar. The CDU shall feature pressure relief protection, and the pressure relief setpoint at the secondary-side outlet should be 5 bar or less.
7. Filters need to be installed in both the primary and secondary sides of the CDU. The filtration precision (pore size) shall not exceed 300 μm (50 meshes) for the primary side, and not exceed 50 μm (270 meshes, ≤ 25 μm recommended) for the secondary side. The filter should be made of sintered mesh.
8. The plate heat exchanger of the CDU shall meet the heat exchange performance requirements under the designed flow and temperature difference conditions on the primary and secondary sides. The approach of the heat exchanger should not exceed 3°C, and the temperature difference between the inlet and return water should be 6–10°C.
9. The internal flow resistance shall be no more than 1.5 bar on the secondary side and 1.2 bar on the primary side of the CDU.

Table 4 Available head of the CDU

Power range per rack	~100 kW	~200 kW	~300 kW
Available head of the CDU	≥ 200 kPa	≥ 250 kPa	≥ 250 kPa

10. All CDU materials in contact with the liquid shall pass the liquid compatibility testing, with a test report issued by an authoritative third party.
11. Harmonic requirements for the CDU can be evaluated in coordination with the power distribution system. Harmonics may be managed either locally or centrally.
12. The temperature and pressure sensors integrated into the control system shall be designed with fault-tolerance capabilities.
13. The one-click maximum cooling function should be available. This function can be enabled locally or remotely for rapid response in extreme cases.
14. The teamwork control feature should be available to automatically select the primary unit and rotate standby units.

7.1.2.2 Secondary-side Pipe Specifications

1. Reserve sufficient ports on the secondary-side branch pipes so they can adapt easily as high-density racks evolve.
2. Considering reliability and heat dissipation requirements of high-density racks, DN65 branch pipes are recommended for racks of 200 kW or higher, with the branch flow rate not exceeding 3 m/s.
3. The height and position of the hose at the terminal of the secondary-side branch pipe shall ensure operational accessibility and an adequate bending radius when the pipe is connected to the rack.
4. A shutdown valve shall be installed on the secondary-side branch pipe.
5. A bypass and a filter with at least 270 meshes can be installed on the inlet side of the rack for the secondary-side branch pipe. The filter shall support online maintenance.
6. A balancing valve can be installed on the secondary-side branch pipe as needed to meet the flow resistance requirements of different racks.
7. An exhaust valve shall be positioned at the highest point of the secondary-side supply and return pipes to fulfill the air venting requirements for these pipes.
8. The materials for the secondary-side pipes should be as uniform as possible. For metal pipes, 304 or 316 stainless steel or TU1/TU2 copper is recommended; non-metal pipe materials shall be EPDM or PTFE and shall pass working fluid compatibility testing.
9. The hose located at the terminal of the secondary-side branch pipe supports loopback flushing.

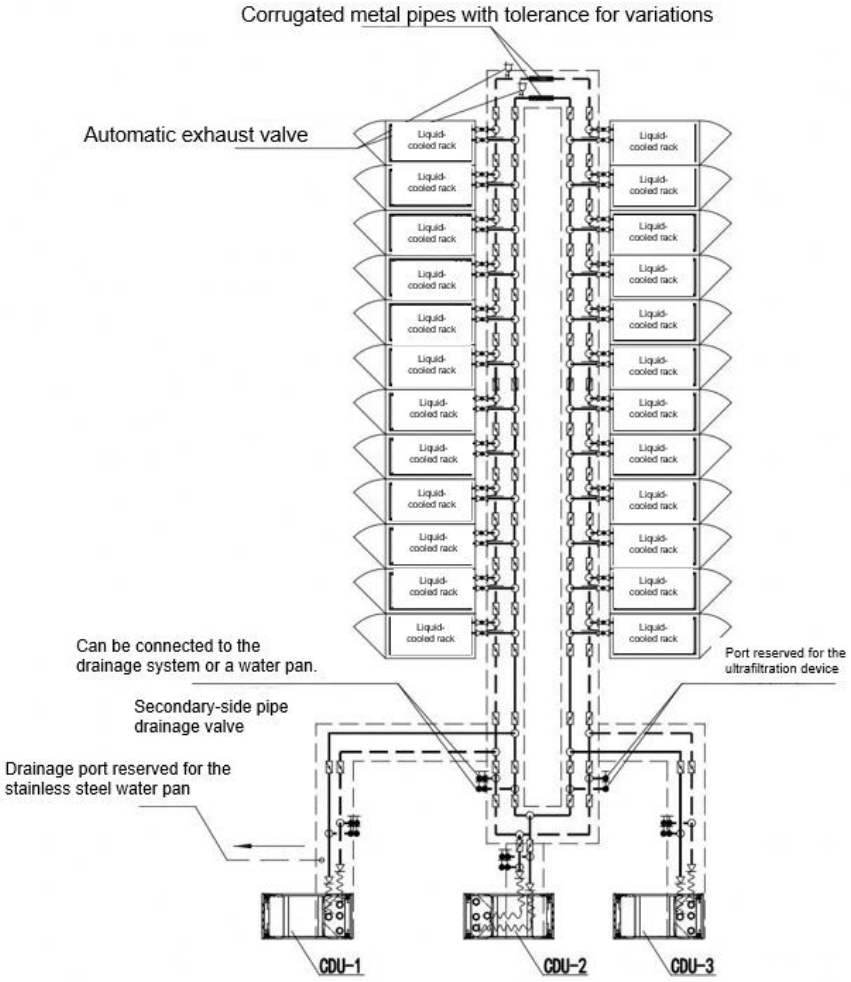


Figure 5 Secondary-side pipe design

10. When determining the size of the branch liquid cooling pipe on the secondary side, factors such as flow rate, pressure drop, capacity, connection method, and installation bending radius need to be taken into account.
11. With overhead liquid cooling pipes, the secondary-side ring network in the data hall shall have protective design to prevent water from being sprayed onto the racks. Install water pans and leakage detection sensors beneath the secondary-side ring network and its branch pipes in the data hall.

7.1.2.3 Working Fluid Specifications

1. The working fluid shall be compatible with all internal parts that are directly in contact with it during liquid pipe circulation—such as the cold plate assembly, pipes, and quick connectors—to ensure long-term reliability.
2. The coolant on the secondary side can be ethylene glycol solution, propylene glycol solution, or deionized water. The coolant specifications shall meet the requirements in the GCC's *Technical Requirements and Test Methods for Coolant for Cold Plate Liquid Cooling* (in preparation, to be published).
3. The compatibility testing methodology for wetted materials shall adhere to the *Compatibility Requirements and Testing Methodology for Wetted Materials in Single-Phase Cold Plate Liquid Cooling Systems* (in preparation, to be published).

4. To avoid impurities generated by the reaction of the working fluid, the working fluid shall not contain the following components (content ≤ 10 ppm): phosphate (PO_4^{3-}), silicate [SiO^{2-} (Si)], borate [BO_3^{3-} (B)], and nitrite (NO_2-).

7.1.2.4 Easy O&M Design of the Liquid Cooling System

1. The maintainability of the liquid cooling system shall be considered. The system shall be equipped with a liquid extraction port, a bypass port for the working fluid, and a port for the ultrafiltration system on secondary-side liquid cooling.
2. The secondary-side pipe, CDU, and rack liquid cooling system shall be capable of detecting leakage and generating related alarms.
3. With underfloor liquid cooling pipes, the floor height shall allow easy installation and O&M of the pipes.
4. With overhead liquid cooling pipes, each branch of the secondary-side pipe in the data hall shall be equipped with an interlocking ball valve or quick connector, which is capable of dual-end shut-off.
5. The in-room centralized CDU should be positioned against a wall or within an independent cooling equipment room. For the row-level centralized CDU, placement at either end of the rack row is recommended. During the design phase, reserve sufficient space for maintenance purposes to prevent any interference or collisions with external piping, walls, valve handles, and flanges.
6. An online pH sensor should be installed on the secondary side. For deionized water, additional online monitoring sensors, such as those for conductivity and turbidity, may be incorporated.
7. The number of shut-off valves in secondary-side pipes shall be determined by the system's criticality. During the maintenance or replacement of essential components, the impact area must be confined to one, two, or four racks.
8. Exhaust valves and filters shall be designed to support online maintenance or replacement, facilitating O&M operations and enhancing system reliability.

7.2 Air Cooling System

7.2.1 Cooling Source System

1. The meteorological parameters used for load calculation and equipment selection shall meet or exceed the 20-year extreme maximum dry-bulb and wet-bulb temperatures as outlined in the *GB 50019 Design code for heating ventilation and air conditioning of industrial buildings*. Equipment freeze protection needs to be designed based on the 20-year extreme minimum dry-bulb temperature.
2. The air cooling system may take different forms to meet part of the IT equipment heat dissipation needs that liquid cooling cannot cover. Consider compatibility to support scenarios featuring an increasing proportion of liquid cooling.
3. If a chilled water cooling system is employed, the supply water temperature shall be at least 18°C. The supply water temperature of the chilled water may be increased to improve the chiller coefficient of performance (COP), prolong the time of natural cooling and partial natural cooling, and reduce the annual power usage effectiveness (PUE).
4. The temperature difference between the supply and return chilled water should be at least 8°C, and may be set to 8–15°C, which can reduce the energy consumption of chilled water distribution and prolong the natural cooling time.
5. The cooling devices shall be able to work properly in the environment with the extreme maximum and minimum outdoor temperatures.
6. The air-cooled chiller, dry cooler, integrated refrigerant pump unit, and condenser should have energy-saving configurations such as wet films or sprays. Anti-corrosion coating should also be considered.

7. The design redundancy of key cooling devices (including but not limited to chillers, chilled water pumps, cooling water pumps, cooling towers, and plate heat exchangers) shall be greater than or equal to N+1.
8. When a single point of failure occurs, the air conditioning system shall operate continuously at full load for 15 minutes without reducing its cooling capacity or quality.
9. When a chilled water system is used as the critical cooling source, continuous cooling can be provided via chilled water storage or an uninterruptable power supply (UPS) for the cooling source system. An emergency cooling device can quickly supply backup cooling if the main system fails.

7.2.2 Air Cooling Terminal

1. The air cooling terminal shall include sufficient redundancy to support future installation of high-density liquid-cooled racks.
2. New AIDCs should contain local fan walls. In cases of partial reconstruction, in-row air conditioners, centralized fan walls, and air handling units (AHUs) are viable options.
3. The design and selection of some air-cooled devices in the data hall shall closely match the server's air cooling section in terms of heat dissipation power, heat exchange temperature difference (≤ 12°C), and air volume.
4. For in-room air conditioners (such as IDECs, integrated refrigerant pump units, split refrigerant pump units, precision air conditioners, and fan walls), if there are N primary air conditioners, N+1 redundancy shall be adopted when $N \leq 6$, N+2 redundancy when $6 < N \leq 12$, and N+3 redundancy when $12 < N \leq 18$, and so on. This represents the minimum requirement for redundancy. The number of redundant devices may be increased as needed.
5. Computational fluid dynamics (CFD) simulation should be performed to model the temperature fields and hot spots of the air cooling system.

8 Cabling

General principles: The design of the data center's cabling system shall adhere to the guidelines outlined in this document. Additionally, the cabling systems in auxiliary, support, and administrative areas shall comply with the current *GB 50311 Code for engineering design of generic cabling system*.

1. For AIDC cabling, follow the business needs, properly plan the cable tray route and width, choose suitable cable tray types, and reserve space for future capacity expansion.
2. Integrated cabling should employ overhead cabling above the racks to facilitate maintenance and upgrades.
3. The position of each SuperPod rack in the data hall shall be set by considering factors such as cooling, power supply, cable routing, and SuperPod cable length.
4. The AIDC should employ an intelligent electronic cabling management system.
5. Clear wear-resistant and heat-resistant labels shall be attached to both ends of all cables, distribution frames, and information outlets in the cabling system.
6. Cables of different colors, lengths, and port types shall be labeled according to the cabling plan, with proper planning for cable management, bundling, routing, and termination.
7. Cables shall be routed, laid onto the cable trays, and bound in advance. Before routing cables into the rack, bundle, sort, and distribute them based on the needs of the bus/network rack and the compute rack.
8. When cables are routed through a cable trough or cable tray, it shall not exceed 150 mm in height. Align the cable trough or cable tray with the decoration, electrical devices, air conditioners, and fire extinguishing systems in the building. If routing them below the main data hall ceiling, keep at least 300 mm between the top of the trough or tray and the ceiling or any obstructions.

9. The cable tray entering the data hall shall have at least two entries to accommodate dual or even more routes.
10. The optical fiber cable tray and network cable tray shall be separated. Two vertical main cable trays should be deployed to facilitate cross-rack cabling.
11. The cabling route in the rack shall not hinder subsequent maintenance or capacity expansion. Except power cables, no cable can be routed within 50 mm of the device fan vent, and redundant cables must not be coiled on the device.
12. Secure optical fibers inside the rack by binding them to the rack at an interval of no more than 250 mm.
13. The bending radius of an optical cable shall be at least 10 times the cable diameter, and that of a copper cable shall be at least 8 times the cable diameter.
14. Keep optical fibers at least 30 mm away from power cables, ground cables, and network cables. Connect each one-to-two optical fiber to the processor's odd- and even-numbered ports according to its label—port 1 for odd numbers and port 2 for even numbers.
15. Prioritize the termination of cables of the network and hosts associated with the management plane. Steps include cabling, routing cables into the rack, organizing the cables, terminating them appropriately, and pre-bundling as necessary.
16. Cabling consistency shall be checked to eliminate weak optical signals and facilitate the software commissioning, pressure testing, and verification of devices.
17. Network cables, optical fibers, and power cables in the rack shall be bound separately.
18. Power cables and network cables should be bound using nylon ties, while optical fibers should be bound using velcro straps.
19. Labels shall be attached to both ends of all cables.
20. All in-rack cables should be finished cables. Check their appearance and test their connectivity.
21. Network cables and jumpers shall be placed within a network cable tray, where they cannot be crossed or twisted.
22. During cabling, verify that the snap spring is properly fitted to the device port. If it is not, promptly replace the snap spring.
23. The cable length shall fit the distance between devices and the cable route. Route the cable with natural arcs so you can insert and remove it smoothly, and reserve some slack for the cable.
24. For network cables and jumpers that cannot be routed through a cable tray in the rack, you can bind them to the rack columns using nylon ties. The cables shall be secured in a manner that is even, neat, and visually appealing. Bending positions shall not include any dead bends.
25. Optical fibers and cross-rack cables shall be bound in opposite directions, leaving the excessive part at the top of the rack.

9 Delivery and O&M

9.1 Implementation of Delivery

9.1.1 Delivery Environment Requirements

A digital monitoring system should be available to monitor the cleanliness of the data hall in real time during the installation, flushing, commissioning, liquid filling, and rack installation of the CDU and secondary-side pipes. The key procedures of liquid cooling delivery can be digitally managed and traced.

1. During the installation and flushing of the secondary-side pipes, the data hall's environmental conditions shall comply with the *GB 50174 Code for design of data centers.* Specifically, the

concentration of suspended particles greater than or equal to 0.5 μm per cubic meter shall not exceed 17,600,000.

2. During the installation of IT equipment, the data hall's environmental conditions shall comply with the *ISO 14644-1 Class 8 – The Data Centre Cleaning Standard*. Specifically, the maximum particle concentrations per cubic meter shall meet the following limits: < 352,000 particles at 0.5 μm, < 832,000 particles at 1 μm, and < 29,300 particles at 5 μm.
3. Onsite welding, cutting, or fire operations are prohibited during the installation of the secondary-side pipes in the liquid-cooled data hall and following equipment delivery.
4. During the construction of the secondary-side liquid cooling pipe system, the particle concentration in the data hall should be remotely monitored 24/7 in real time. If the particle concentration exceeds the threshold, an alarm shall be reported.
5. The construction of prefabricated pipes in the factory shall comply with the *GB 50236 Code for construction and acceptance of field equipment, industrial pipe welding engineering and GB 50316 Design code for industrial metallic piping*.

9.1.2 Requirements for Prefabrication and Integration

1. Liquid cooling pipes shall be prefabricated in the factory and then assembled onsite using a modular approach. Onsite fabrication of these pipes within the data hall is strictly prohibited. During the prefabrication in the factory, the welding, acid cleaning and passivation, cleaning and drying, and valve assembly of the secondary-side pipes shall be strictly controlled. Argon arc welding shall be used for the secondary-side pipes.

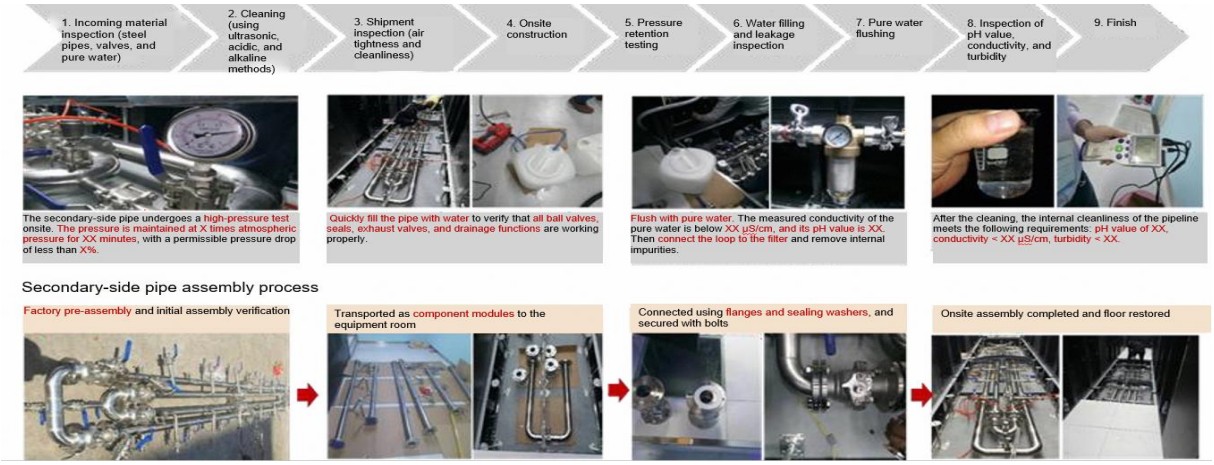


Figure 6 Process of secondary-side piping

2. The welding quality of the secondary-side pipes shall comply with the *GB/T 150.4 Pressure vessels—Part 4: Fabrication, inspection and testing, and acceptance*. No surface cracks, lack of penetration, lack of fusion, surface porosity, arc craters, underfill, slag inclusions, or spatter is allowed. The welds shall transition smoothly with the base metal. The fillet weld's profile shall be concave, with a smooth transition. The depth of undercut on the weld surface shall not exceed 0.5 mm. The continuous length of the undercut shall not exceed 100 mm, and the total length of undercuts on both sides of the weld shall not exceed 10% of the weld length.
3. After welding, cleaning, and passivation are complete, a weld specimen with shaped components shall be taken for a 48-hour neutral salt spray test (sampling) in accordance with the IEC 60068-2-11. After the test, no red rust spots are allowed.
4. Before prefabricating pipes, conduct a thorough site survey to ensure that the module layout in the data hall aligns with the design drawings. Based on the survey results and the secondary-side piping design outlined in the drawings, building information modeling (BIM) should be performed to

design and segment the secondary-side pipe network, and to complete the low level design (LLD) of each subunit. Pipes and valves shall be easy to maintain, with sufficient space to open and close the valve handles. Ensure that these parts do not block other pipes, walls, or floor supports.

5. The secondary-side pipes shall be prefabricated according to the approved secondary-side pipe design solution. These prefabricated segments shall be assembled into a complete ring pipe network. Pressure retention and leakage detection tests, welding seam detection, acid cleaning and passivation, ultrasonic cleaning, and deionized water flushing shall be performed in the factory. Once cleaning is completed, the pipes shall be dried, capped, and then covered with plastic film. Dust-proof caps may be used in this case.
6. The BIM design shall comply with the *GB/T 51212-2016 Unified standard for building information modeling, Standard for classification and coding of building information model, and GB/T 45393-2025 Information technology—Building information model (BIM) software*.
7. For factory prefabrication, production, and onsite installation, the following procedures shall be carried out: CDU pre-delivery check, CDU installation upon arrival, primary water quality monitoring, primary pipe connection to the CDU, and verification of the working fluid and secondary-side piping. Digital methods should be adopted for remote and real-time quality checks.
8. The recommended installation procedure for prefabricated pipes is as follows: onsite spot check → material unpacking → main pipe installation → hose installation → pipe pressure retention testing → pipe flushing in circulation mode → connection of pipes to devices → trial system running → water detection cable installation → project acceptance. To maintain pipe cleanliness, the dust covers should not be removed prematurely.
9. The prefabricated liquid cooling pipes on the secondary side should comply with the design drawing and be properly numbered. Exercise caution when transporting and installing the prefabricated liquid cooling pipes on the secondary side to ensure their safety and stability. Take care not to damage the pipes during O&M, as this could lead to issues with onsite connections and subsequent operations. Protect the pipes using flexible materials such as EPDM and PTFE.
10. The aisle, base, and CDU of the data center module, liquid cooling pipe on the secondary side, cable tray, busway or remote power panel (RPP), and end air conditioners should be prefabricated, modular, and designed to fit the compute rack ports.

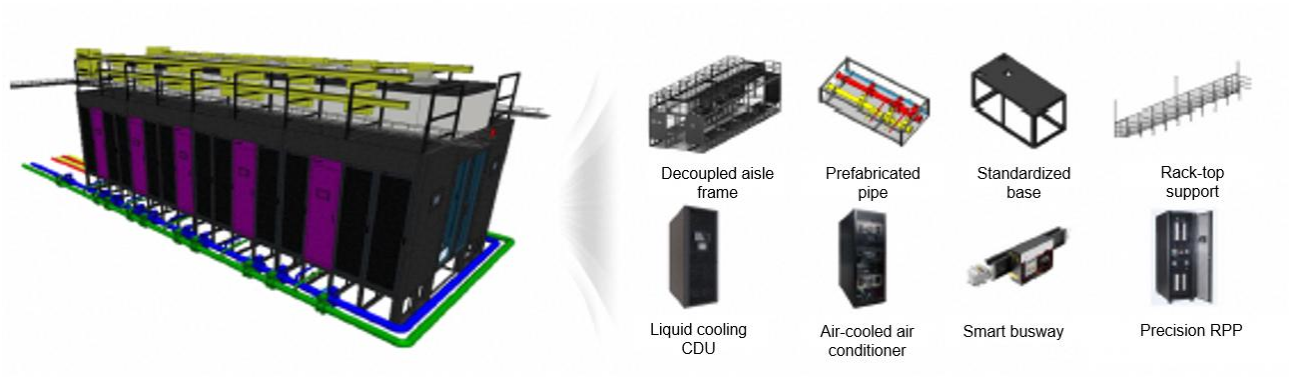


Figure 7 Integrated prefabricated liquid-cooled data center module

9.1.3 Delivery Requirements

1. Before implementing the project, all necessary resources—including both personnel and materials—shall be prepared. Each construction procedure shall adhere to relevant technical standards for quality control. Handover inspections shall be conducted and documented between interrelated procedures across disciplines.
2. The system installation plan shall be developed according to the design and detailed drawings to ensure the feasibility of the implementation strategy.

3. Upon arrival at the site, inspect all materials, including the CDU, secondary-side pipe, valve, and hose assembly. Verify the quantity, packaging, reports, appearance, and dimensions. Pay particular attention to the compatibility test reports for these materials, and check the welds and cleanliness of the secondary-side pipes.
4. Do not use sealing materials that may introduce granular contaminants, such as raw tape or thread sealants, when constructing the secondary-side liquid cooling pipes. Onsite activities shall be limited to basic pipe assembly, pressure testing, and flushing. Chemicals like lubricating oils and detergents shall not be stored onsite, nor shall any welding, cutting, or fire operations be performed. A pressure retention test shall be conducted following the installation of the secondary-side pipes.
5. Once the secondary-side pipes are installed, flush them thoroughly. After the flushing, verify that the water is free from contaminants, the surfaces are devoid of oil residues, the conductivity is less than or equal to 10 μs/cm, the turbidity is less than 10 NTU, and the pH ranges from 6.5 to 8. To prevent corrosion and bacterial risks, the interval between the start of flushing and the start of filling the working fluid shall not be longer than seven days. After the flushing is complete, the secondary-side working fluid shall continuously circulate. Do not allow the working fluid to stop circulating for a long time. Add working fluid agents as soon as possible to meet the working fluid specifications required for the operation of the liquid cooling system on the secondary side.
6. If a third-party dummy load test is required, the dummy load shall either provide a cleanliness test report or undergo onsite flushing with deionized water. Prior to and following the flushing, the water's conductivity shall be lower than 10 μs/cm. After the flushing, the water's pH level shall range from 6.5 to 8, and its turbidity shall be ≤ 10 NTU. Connection of the dummy load to the system is allowed only upon successful completion of the flushing process. Following the completion of the test, a sample of the working fluid shall be taken and analyzed prior to server installation. Installation may proceed only upon successful qualification of the test.
7. The construction quality shall comply with the relevant provisions outlined in the *GB 50462 Standard for construction and acceptance of data center infrastructure, GB 50300 Unified standard for constructional quality acceptance of building engineering, and GB 50944 Code for construction and quality acceptance of antistatic engineering.*

9.1.4 Acceptance Testing

1. The liquid cooling system shall be tested following project implementation but prior to O&M acceptance and delivery. Upon completion of the test, the project shall be ready for acceptance. It can only be launched into operation following successful acceptance.
2. The liquid cooling system testing process should be segmented into four distinct phases: the factory acceptance test, installation verification, functional assessment, and comprehensive system assessment.
3. The joint system commissioning shall be performed after the onsite installation test and standalone/single-system functionality test are completed. Before the joint system commissioning, the equipment parameters, such as the package nameplate parameters, shall be checked, and the standalone functionality, manual startup and shutdown, running logic, noise, dynamic balance, and welding process shall be tested for acceptance. The test and acceptance shall comply with the *GB 50236 Code for construction of field equipment, industrial pipe welding engineering, GB 50316 Design code for industrial metallic piping*, and *GBJ 93 Code for construction and quality acceptance of automation instrumentation engineering*.
4. The comprehensive testing shall be coordinated by key personnel from both the construction and supervisory teams. This overall testing shall comply with the provisions of the current *GB 50462 Standard for construction and acceptance of data center infrastructure*.
5. The operating conditions of the system load commissioning are set based on the design parameters. The system should be tested at various load levels—specifically, 25%, 50%, 75%, and 100% of the designed load—to ensure that the simulated load aligns with the cooling capacity and operates stably.

6. Before server installation, the working fluid shall be sampled for testing. Testing should cover several items, including appearance, pH level, turbidity, conductivity (for deionized water coolant), concentrations of critical ions (such as chloride, sulfate, total copper, total iron, total aluminum, total calcium, and total magnesium), and bacterial colony counts. Install the servers only after the test is passed. After the servers are installed, the working fluid on the secondary side shall be sampled for testing again to ensure that the indicators meet the requirements.
7. The acceptance process for the liquid cooling system should encompass four phases: preparation, system verification, trial operation, and final approval. During each phase, critical documents—including issue logs, drawings, and system status records—shall be organized and archived.

9.2 O&M

9.2.1 General O&M Services

1. Foundational O&M support services shall encompass O&M monitoring and O&M service management. O&M monitoring involves the detection, logging, filtering, and correlation of alarms. O&M support includes ticket handling, regular inspections, change assistance, and service reporting. O&M service management covers process oversight, staff and technical competency management, O&M service reporting, quality assurance, and continuous enhancement.
2. Implement emergency management and conduct regular drills to improve emergency response capabilities. Proactive prevention services should be provided. Develop tailored emergency plans based on the cluster status on the computing platform and potential issues after major events. This ensures devices on the platform recover quickly and run stably after a fault occurs.
3. Spare parts management services shall be provided, including designated storage areas and dedicated staff for managing the spare parts. Regular onsite stocktaking of spare parts is essential.
4. The intelligent computing O&M consulting service should be provided. The scope of the service should encompass the design of O&M specifications, the planning of O&M processes, the development of role and skill models for O&M, organizational structuring and responsibility allocation for O&M, as well as the design of performance indicators for computing O&M.
5. To ensure the seamless execution of critical model training and inference tasks during significant events, it is advisable to implement a key event assurance service. This service shall encompass an in-depth check of necessary resources and configurations, stress testing of equipment to identify potential issues, and validation that any previous issues have been rectified. Additionally, prioritizing essential and time-sensitive resources is strongly recommended.
6. The change management service should be provided to oversee changes to the AIDC infrastructure and IT devices. This includes developing change strategies and switchover policies, isolating resources, and managing and validating new resources after changes.
7. The proactive prevention service should be provided. By performing routine health checks on the cluster infrastructure and analyzing historical trends, the service can identify issues that may compromise service quality in advance and handle potential risks to reduce the probability of faults.
8. The O&M service indicators shall include the secure operation duration, fault response time, fault location and demarcation time, and fault recovery time.

9.2.2 Liquid Cooling System O&M

1. The cooling water of the cooling source shall be sampled for testing periodically. The test items shall include appearance, odor, pH level, conductivity, turbidity, calcium hardness, total alkalinity, chloride ion, iron ion, and organic phosphorus. When the cooling water system is out of service, stop the system and take measures for maintenance.
2. The coolant testing period should adhere to the GCC's *Cold Plate Liquid Cooling System Intelligent Operation and Maintenance Technical Specification*, while the coolant performance indicators shall follow the GCC's *Technical Requirements and Test Methods for Coolant for Cold Plate Liquid*

Cooling. When the coolant system is out of service, stop the system and take measures for maintenance.

3. When the system coolant fails to meet the specified standards and is deemed ineffective, it shall be promptly replaced. For Class B and Class C data centers, coolant replacement should be conducted during scheduled downtimes. In contrast, Class A data centers should perform coolant replacement without interruption.
4. The task of draining or recycling the coolant from the liquid cooling system shall be delegated to a qualified entity that possesses wastewater treatment credentials.
5. The CDU shall monitor operating parameters, including the operating status, fault, manual/automatic status, valve status, supply and return liquid temperatures, supply and return liquid pressures, and ambient temperature and humidity.
6. The routine inspection of the CDU shall encompass the control panel, rack, external ports, and connectors.
7. The CDU shall be subject to regular preventive maintenance, including the circulating pump, valve, sensor, controller, filter, and plate heat exchanger.

9.3 Operational Optimization

An intelligent operation management system should be deployed for the AIDC infrastructure. This system should be capable of collecting data from IT devices and cooling system devices (such as CDUs, plate heat exchangers, and cooling towers) via the network management system, power and environment monitoring system, and teamwork control system.

1. 3D digital technologies should be used to build high-precision models for the AIDC infrastructure and IT devices, and collaborative modeling of the infrastructure and IT devices should be implemented. The model precision should reach LOD 300 during the design phase, and LOD 400 in the detailed design, construction, and operational phases.
2. Digital simulation technology should be used to simulate the model parameters of the cooling system, power supply and distribution system, and IT system of the AIDC within the context of environmental changes and extensive large model training. The precision of these simulations should be at least 95%. To support operational optimization, it is recommended to collect AIDC energy consumption statistics for analysis, monitor and analyze energy efficiency indicators, and conduct simulations and predictions for energy usage and efficiency.
3. The system should optimize energy efficiency intelligently using algorithm training and inference. By training data from the AIDC environment and infrastructure, the system can build an energy consumption optimization model for intelligent computing centers and generate inference policies for different systems. These policies set parameters like supply cooling water temperature, supply (return) air temperature or temperature difference of the air conditioner, chip hibernation/frequency regulation, power supply unit (PSU) startup/shutdown and primary/standby mode, CDU liquid supply temperature, and supply-return water pressure or temperature difference of the CDU.
4. The system should be capable of intelligent global energy efficiency optimization, delivering energy efficiency optimization policy parameters to objects by interconnecting with the underlying control system or devices. Both automatic and manual modes are supported. Intelligent technologies or technologies that enable collaboration between infrastructure and IT devices are applied, improving energy efficiency by at least 12%.
5. The system shall collect and analyze energy consumption parameters before and after optimization, such as the energy consumption of the cooling/IT system and the PUE of the AIDC.
6. The intelligent operational management system of the AIDC infrastructure should set protection for the frequent startup and shutdown of cooling devices, and set the safe operating boundary for control parameters.

The system should predict exceptions in liquid cooling links. Specifically:

1. The system should monitor critical devices and parameters in liquid cooling links. It dynamically collects information like device type counts, operating status, bypass valve status, device connection modes, and operating conditions. This data feeds into a prediction model. The model can then be labeled and trained with preprocessed historical data. Inference policies for exception prediction can be generated to push exception information output by the model.
2. Status of exceptions in liquid cooling links, such as to be handled, being handled, false alarm, and closed, should be adjustable.
3. The full-link status can be displayed using the liquid cooling link energy consumption model. This helps evaluate system health, predict risks, and diagnose faults.

Appendix A

Acronyms/Abbreviations

AHU: air handling unit

AIDC: artificial intelligence data center

BIM: building information model/modeling

CDU: coolant distribution unit

COP: coefficient of performance

DX: direct expansion

EPDM: ethylene propylene diene monomer

IDEC: indirect-direct evaporative cooling

NTU: nephelometric turbidity unit

pH: potential of hydrogen

PSU: power supply unit

PTFE: polytetrafluoroethylene

PUE: power usage effectiveness

THDi: total harmonic distortion of current

UPS: uninterruptible power supply