Community Specification

Technical Specification for AIDC Air Cooling Terminal Equipment (Version 0.8)

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Version Change History

Version	Description	Contributor

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Technical Specification for AIDC Air Cooling Terminal Equipment

1 Scope

This document specifies the classification, application scenarios, power density limits, design and selection guidelines, and simulation verification methods for air cooling terminal equipment in the air-liquid fusion cooling system of an artificial intelligence data center (AIDC).

This document is applicable to the design and selection of air cooling terminal equipment in the air-liquid fusion cooling system of an AIDC with a single-rack power density ranging from 30 kW to 300 kW.

This document is prepared based on CFD simulation results and is version 0.8. It shall be supplemented and improved based on verification data from actual projects.

This document focuses on the capability boundaries and applicable conditions of four types of air cooling terminal equipment, including the air handling unit (AHU), in-row air conditioner, far-field fan wall, and near-field fan wall, in the air-liquid fusion cooling system, providing a technical basis for data center construction.

2 Normative References

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

GB 50174-2017 Code for Design of Data Centers

GB/T 1.1-2020 Directives for Standardization — Part 1: Rules for the Structure and Drafting of Standardizing Documents

GB/T 18836—2002 Ducted Air-Conditioning (Heat Pump) Units

GB/T 17758—2023 Unitary Air Conditioners

GB/T 19413—2024 Air Conditioning Unit for Data Center and Communication Room JB 14641-2022-T Indirect Evaporative Cooling Air Conditioning Units for Computer and Data Processing Room ASHRAE TC9.9—2016 Thermal Guidelines for Data Processing Environments, 4th Edition

3 Instructions Before Reading

1. The simulation result is only the maximum air-cooled IT power density of a single rack that can be achieved when the thermal field conditions are met in the specified scenario. It provides only an upper limit for the air-cooled IT power density of a single rack in the specified scenario. The simulation result does not consider the TCO comparison of the overall solution and therefore does not provide guidance for the overall project design. For details about the design and simulation conditions in specific scenarios, see Appendix A.
2. The simulation uses the standard air-cooled server in the simulation software. The simulation result is different from that of the liquid-cooled server.
3. The simulation assumes that the server can provide the air volume corresponding to its thermal load when the thermal field conditions are met.

4. The simulation result is obtained under ideal conditions and is for reference only. If the actual project scenario is inconsistent with the specified scenario, you are advised to perform simulation based on the actual project.
5. The external unit area is not considered in the calculation of air cooling IT load density. For example, if the AHU is placed on the rooftop, it does not occupy the side platform area. The external unit area is not considered for other types of devices.

4 Terms and Definitions

The following lists the terms and their definitions in this document:

4.1 Air-liquid fusion

A system that uses both air cooling and liquid cooling methods to efficiently dissipate heat by properly allocating the heat dissipation load.

4.2 Air cooling terminal equipment

A device in the air-liquid fusion cooling system that dissipates heat through air cooling, including but not limited to the AHU, in-row air conditioner, far-field fan wall, and near-field fan wall.

4.3 Air-to-liquid ratio

In the air-liquid fusion cooling system, the ratio of the heat dissipation load borne by the air cooling system to that borne by the liquid cooling system.

4.4 Cooling capacity of air cooling terminal equipment

Maximum cooling capacity that can be stably output by the air cooling terminal equipment under specific environmental conditions, in kW.

4.5 Air cooling IT load limit

Maximum load per rack when the air cooling terminal equipment meets the requirement of no overheating in the rack (air inlet temperature ≤ 27 °C) in specific scenarios, in kW/rack.

4.6 Performance utilization

Ratio of the actual IT load borne by the air cooling system to the rated cooling capacity of the air conditioner. The calculation formula is as follows:

$$U = \frac{Q_{IT}}{Q_{rated}} \times 100\%$$

Where:

- Q_{IT}: Total load of the equipment room (kW)
- Q_{rated}: Rated cooling capacity of the air conditioner (kW)

4.7 Air cooling IT load density

IT load borne by the air cooling system per unit area. The calculation formula is as follows:

$$D = \frac{Q_{IT}}{A}$$

Where:

- Q_{IT}: Total load of the equipment room (kW)
- A: Equipment room area (m²), excluding the area of the platform for placing outdoor units, such as the area of the AHU platform in the scenario design.

5 Classification and Application Scenarios of Air Cooling Terminal Equipment

5.1 Device Classification

Air cooling terminal equipment can be classified into the following four types based on the layout:

5.1.1 AHU air conditioning system (indirect evaporative cooling)

The air conditioners are centrally deployed on the equipment platform outside the equipment room. Cold air is delivered to the equipment room through air supply ducts for long-distance cooling, achieving overall cooling in large spaces.

5.1.2 In-row air conditioning system

The air conditioners are installed between rows of racks and close to heat sources. Air is drawn from the air supply side (cold aisle) and supplied horizontally to adjacent or opposite racks for cooling. This system features short airflow paths and high heat exchange efficiency.

5.1.3 Far-field fan wall system

The air conditioners are centrally deployed in an independent fan wall area on one or both sides of the equipment room. Cold air is pushed horizontally to the entire equipment room through large-area perforated panels or louvers, forming a push-pull air distribution.

5.1.4 Near-field fan wall system

The air conditioner fan wall is deployed close to the rack row. Using a "hot aisle containment with proximate return air" method, it directly captures the hot air exhausted from the rack row. After cooling, the air is sent back to the cold aisle, achieving precise local heat circulation control.

5.2 Application Scenarios

5.2.1 Old equipment room reconstruction scenario

This solution is applicable to the reconstruction of existing air cooling data centers into air-liquid fusion systems. The following features shall be considered:

- Space restrictions: Limitations on original aisle width, floor-to-floor height, and other conditions.
- Infrastructure: compatibility with existing power supply and water supply systems
- Migration path: The simulation results of a smooth transition from air cooling to air-liquid fusion cooling are as follows.

Equipment Type	Air Cooling IT Load Limit -Kw/Rack	Total Load of the Equipment Room -Kw	Rated Cooling Capacity of Air-Cooled Air Conditioners -Kw	Performance Utilization	Recommended Air-Liquid Ratio
AHU	30	375	1500	25%	3:7-5:5

Equipment Type	Air Cooling IT Load Limit -Kw/Rack	Total Load of the Equipment Room -Kw	Rated Cooling Capacity of Air-Cooled Air Conditioners -Kw	Performance Utilization	Recommended Air-Liquid Ratio
Far-field fan wall	30	150	750	20%	2:8-5:5
Near-field fan wall	30	375	1200	31%	3:7-5:5
In-row	30	375	1200	31%	3:7-5:5

5.2.2 New Equipment Room Scenario

This scenario is applicable to the construction of a new air-liquid fusion data center. The following aspects can be optimized:

- Aisle layout: Optimize the aisle dimensions based on the type of air cooling terminal equipment.
- Floor-to-floor height design: Reserve sufficient space for high-density cooling.
- Equipment selection: The simulation results of using each type of equipment with the highest cooling capacity from each air conditioner vendor are as follows:

Equipment Type	Air Cooling IT Load Limit -Kw/Rack	Total Load of the Equipment Room-Kw	Rated Cooling Capacity of Air-Cooled Air Conditioners-Kw	Performance Utilization	Room Area -M²	Air Cooling IT Load Density
AHU	35	1640	1800	91%	372.96	4.4
Far-field fan wall	35	1640	1800	91%	372.96	4.4
Near-field Fan Wall	35	2250	2400	94%	395.64	5.69
In-row	47	2970	3000	99%	436.8	6.8

6 Simulation Verification Method

6.1 CFD Simulation Requirements

To verify the capability limits of the air cooling terminal equipment, CFD simulation analysis shall be performed to meet the following requirements:

6.1.1 Model precision requirements

- Number of grids: ≥ 5 million cells
- Turbulence model: SST k-ω model
- Boundary conditions: consistent with actual operating conditions

- Convergence criteria: residual < 1×10^{-5}

6.1.2 Simulation scenario settings

- Design conditions of the equipment room:

  For details about the design conditions, see Appendix A.
- Design conditions of the air conditioner:

  Temperature control: average supply air, 25 °C, deadband 1 °C;

  air flow control: fixed RPM percentage

  Cold standby configuration: N+1/N+2
- Design conditions of the rack:

  Blank rack: closed vacant slots (If there is no server in the rack, the vacant slots are blocked by blind plates by default.)

  Rack leakage: typical small gaps

  Server layout: uniform load distribution (For example, if the total power of each rack is 15 kW deployed with 10 servers, the power of a single server is 1.5 kW.)
- Server design conditions: power utilization: 100%

  Flow definition: Power ratio, temperature-dependent. The flow curve is as shown in the table below.

Average Inlet Temperature	**Airflow CFM/W**
24	0.1198
25	0.1202
26	0.1278
27	0.136
28	0.1453
29	0.1559
30	0.168
31	0.1821
32	0.1986
33	0.2183
34	0.2422
35	0.2717

6.1.3 Simulation Result Analysis

- Temperature field distribution: Evaluate the hot spot locations and temperatures.
- Velocity field distribution: Evaluate the airflow uniformity.
- Pressure field distribution: Evaluate the pressure distribution in the equipment room.
- Cooling capacity output: Evaluate the actual effective cooling capacity.

6.2 Simulation Verification Process

The CFD simulation verification of the air cooling terminal equipment capability limit shall comply with the following process:

Start → Create 3D models

↓

Define boundary conditions and physical models

↓

Perform meshing and independence verification

↓

Perform Steady-state simulation (standard operating conditions)

↓

Analyze the result and evaluate the capacity

↓

Prepare the verification report

↓

End

6.3 Simulation verification indicators

The following key indicators shall be considered in CFD simulation verification:

Indicator	**Definition**	**Calculation Formula**	**Description**
Maximum rack inlet temperature	Maximum rack inlet temperature of all racks in the equipment room	/	Indicates whether there are hot spots in the rack. The maximum inlet temperature ≤ 27 °C
Air cooling IT load limit	Maximum power density per rack	/	When the maximum rack inlet temperature of all racks in the equipment room ≤ 27 °C
Temperature field	Airflow temperature field in the equipment room	/	Evaluates the hot spot location and temperature
Speed field	Airflow velocity field in the equipment room	/	Evaluates the airflow uniformity
Pressure field	Airflow pressure field in the equipment room	/	Reflects the pressure distribution in the equipment room

Indicator	Definition	Calculation Formula	Description
Performance utilization	Ratio of the actual IT load borne by the air cooling system to the maximum air cooling capability	$U = \frac{Q_{IT}}{Q_{rated}} \times 100\%$	Reflects the system utilization
Air cooling IT load density	IT load borne by the air cooling system per unit area	$D = \frac{Q_{IT}}{A}$	Reflects the space utilization efficiency

Note: This section describes the CFD simulation verification method. The actual test verification method shall be added later.

Appendix A

A.1.1 Overview

This appendix provides CFD simulation verification cases, showing the simulation verification process and results of the air cooling terminal equipment capability limits. The simulation results of multiple equipment vendors have been integrated. More simulation verification cases of other vendors shall be added later.

A.1.2 CFD Simulation Verification Cases

A.2.1 Simulation Conditions

- Air conditioner design conditions:

  Temperature control: average supply air, 25 °C, deadband 1 °C;

  air flow control: fixed RPM percentage at 100%

  Cold standby configuration: N+1/N+2
- Design conditions of the rack:

  Blank rack: closed vacant slots (If there is no server in the rack, the vacant slots are blocked by blind plates by default.)

  Rack leakage: typical small gaps

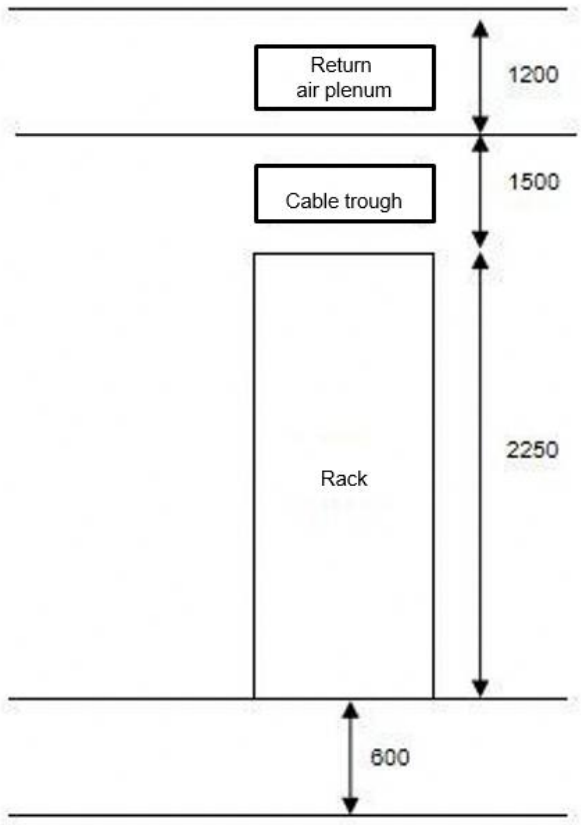
  Server layout: uniform load distribution (For example, if the total power of each rack is 15 kW deployed with 10 servers, the power of a single server is 1.5 kW.)
- Server design conditions: power utilization: 100%

  Flow definition: Power ratio, temperature-dependent. The flow curve is as shown in the table below.

Average Inlet Temperature	**Airflow CFM/W**
24	0.1198
25	0.1202
26	0.1278
27	0.136
28	0.1453
29	0.1559
30	0.168
31	0.1821
32	0.1986
33	0.2183
34	0.2422
35	0.2717

A.2.2 Old Equipment Room Reconstruction Scenario

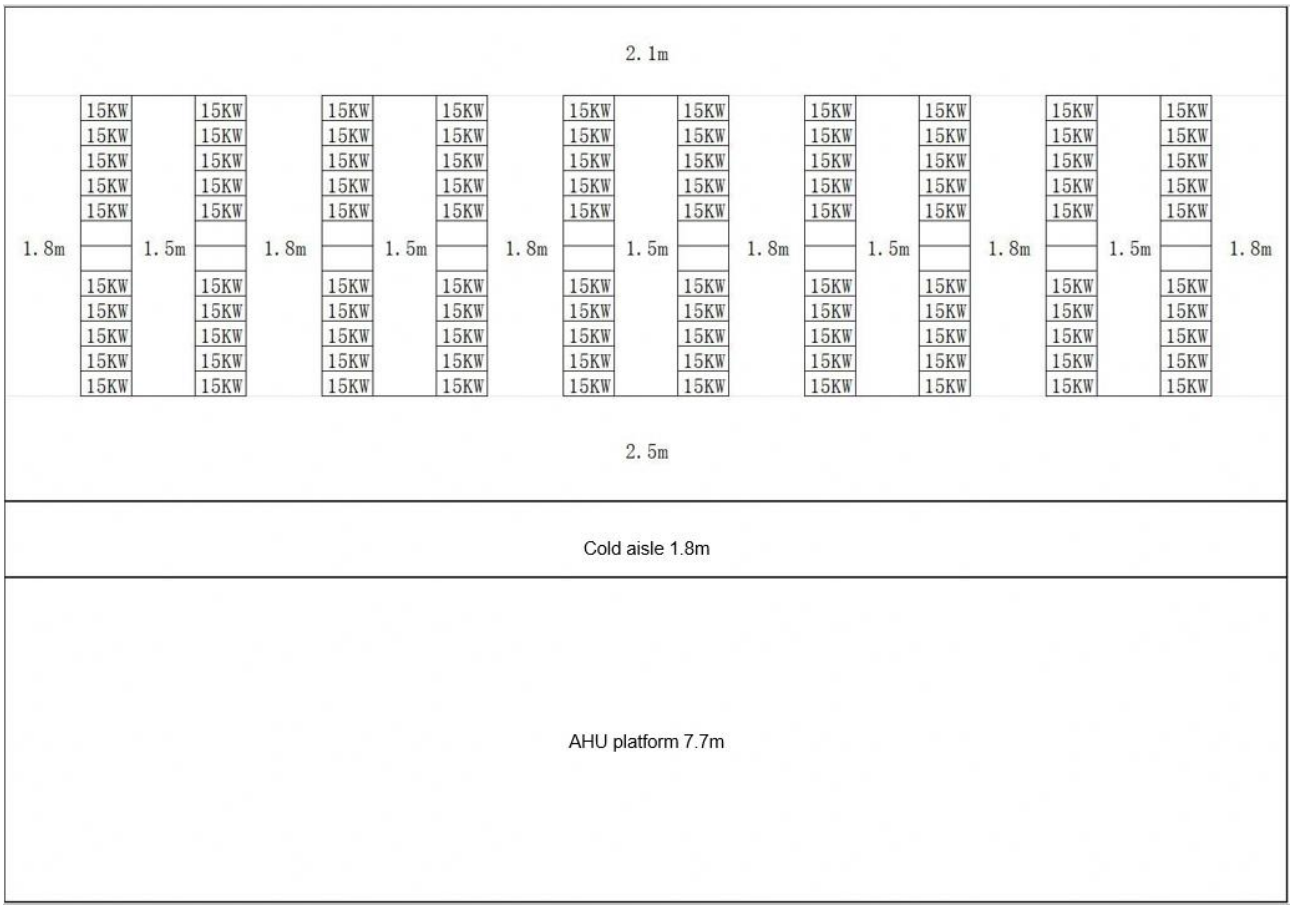
A.2.2.1 Equipment Room Side Layout Settings



Equipment room side layout diagram

A.2.2.2 AHU Scenario Configuration

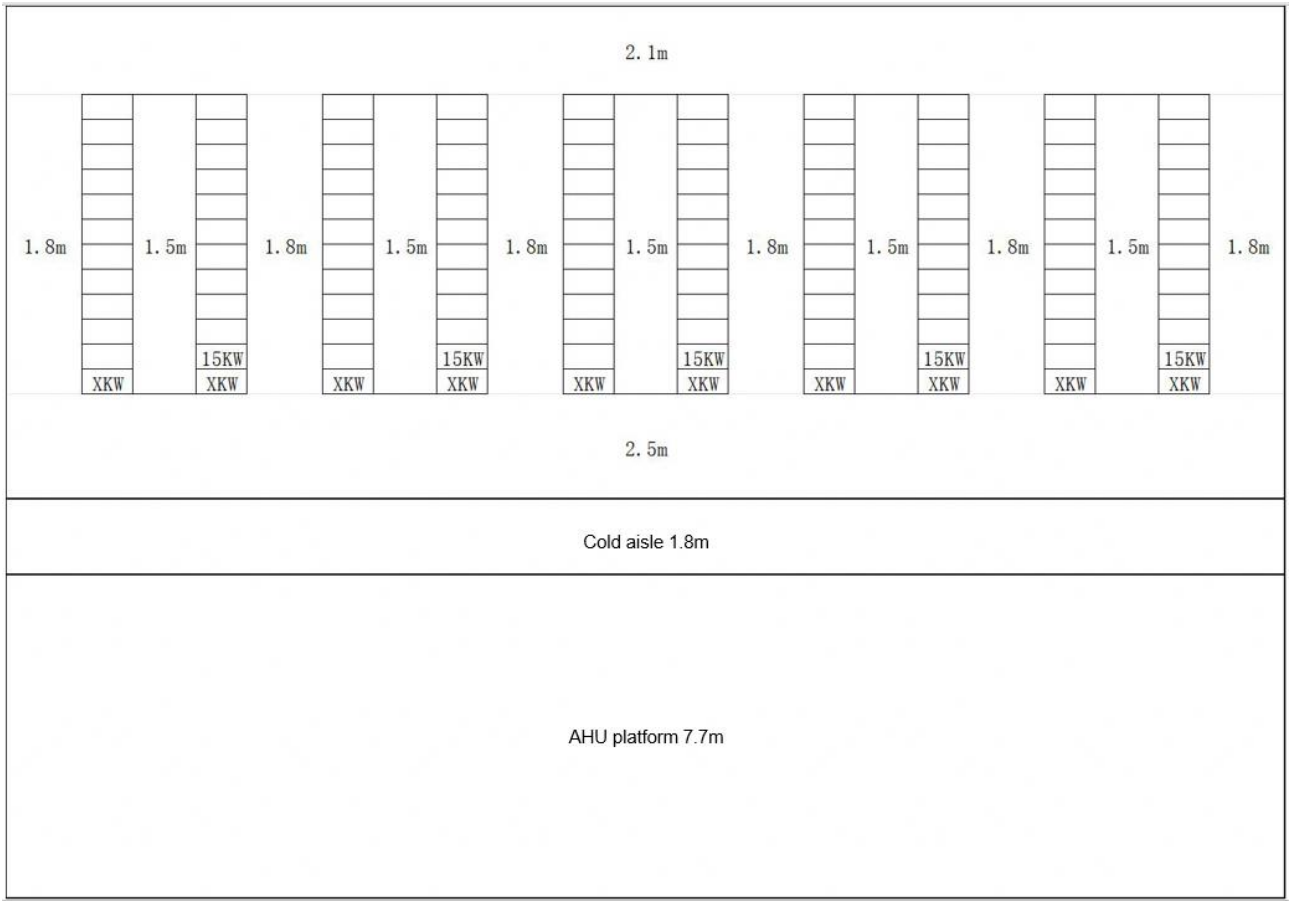
Original equipment room layout:



Equipment room layout diagram

Original Equipment Room Device Parameter Settings		Remarks
IT rack power density (kW/rack)	15	/
Number of racks	100	/
Total load of the equipment room (kW)	1500	/
Number of AHUs	5	5+1 backup
Cooling capacity of a single AHU (kW)	300	Supply/Return air conditions: 25/37°C

Equipment room parameters after reconstruction:

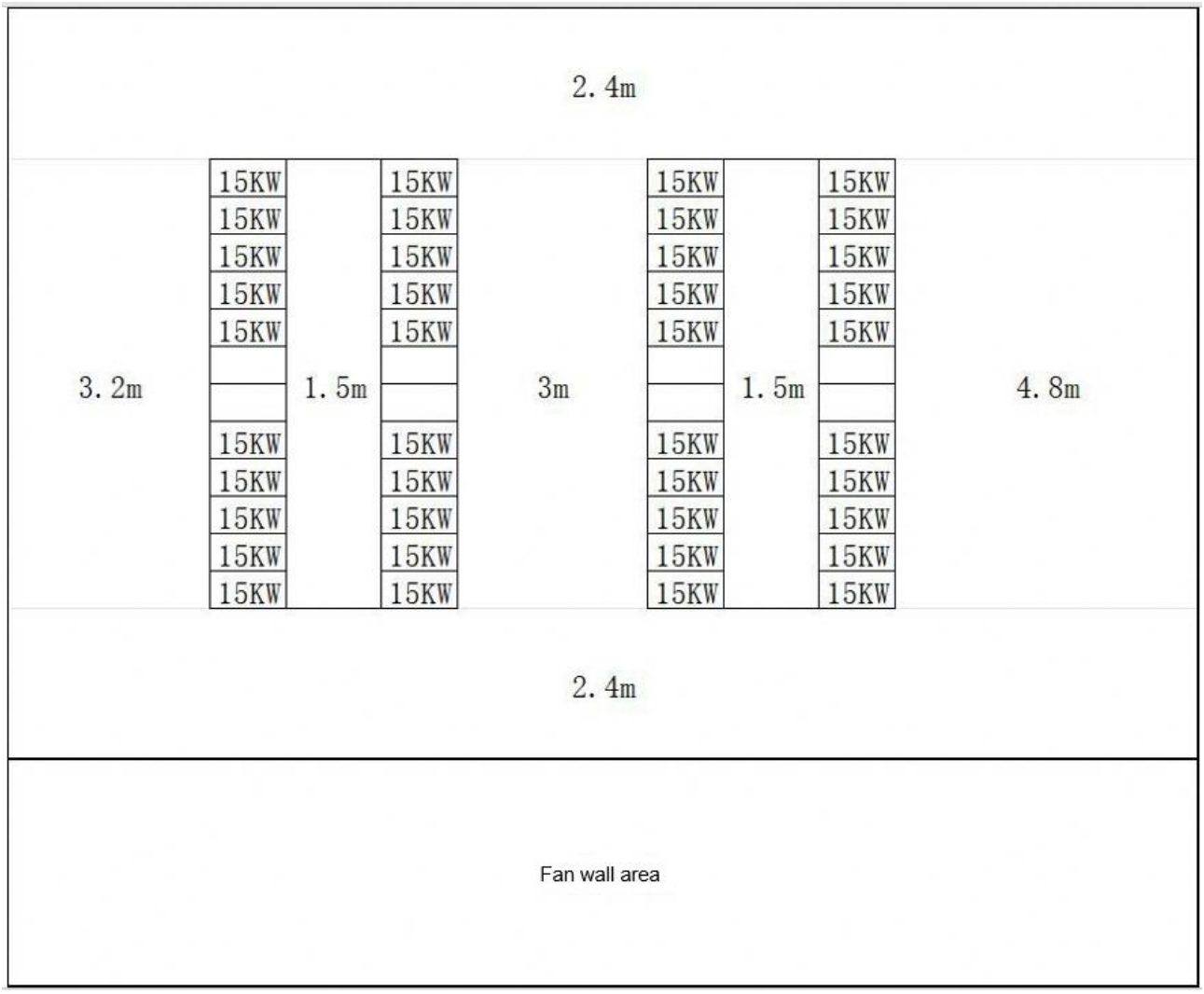


Equipment room layout diagram

Settings of Equipment Parameters in the Equipment Room After Reconstruction		Remarks
Power density of network racks (kW/rack)	15	/
Number of network racks	5	/
Power density of IT racks (kW/rack)	X	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	10	Blank indicates an empty rack where a blind plate is installed.
Total load of the equipment room (kW)	10*X+5*15	/
Number of AHUs	5	5+1 backup
Cooling capacity of a single AHU (kW)	300	Supply/Return air conditions: 25/37 °C

A.2.2.3 Far-Field Fan Wall Scenario Settings

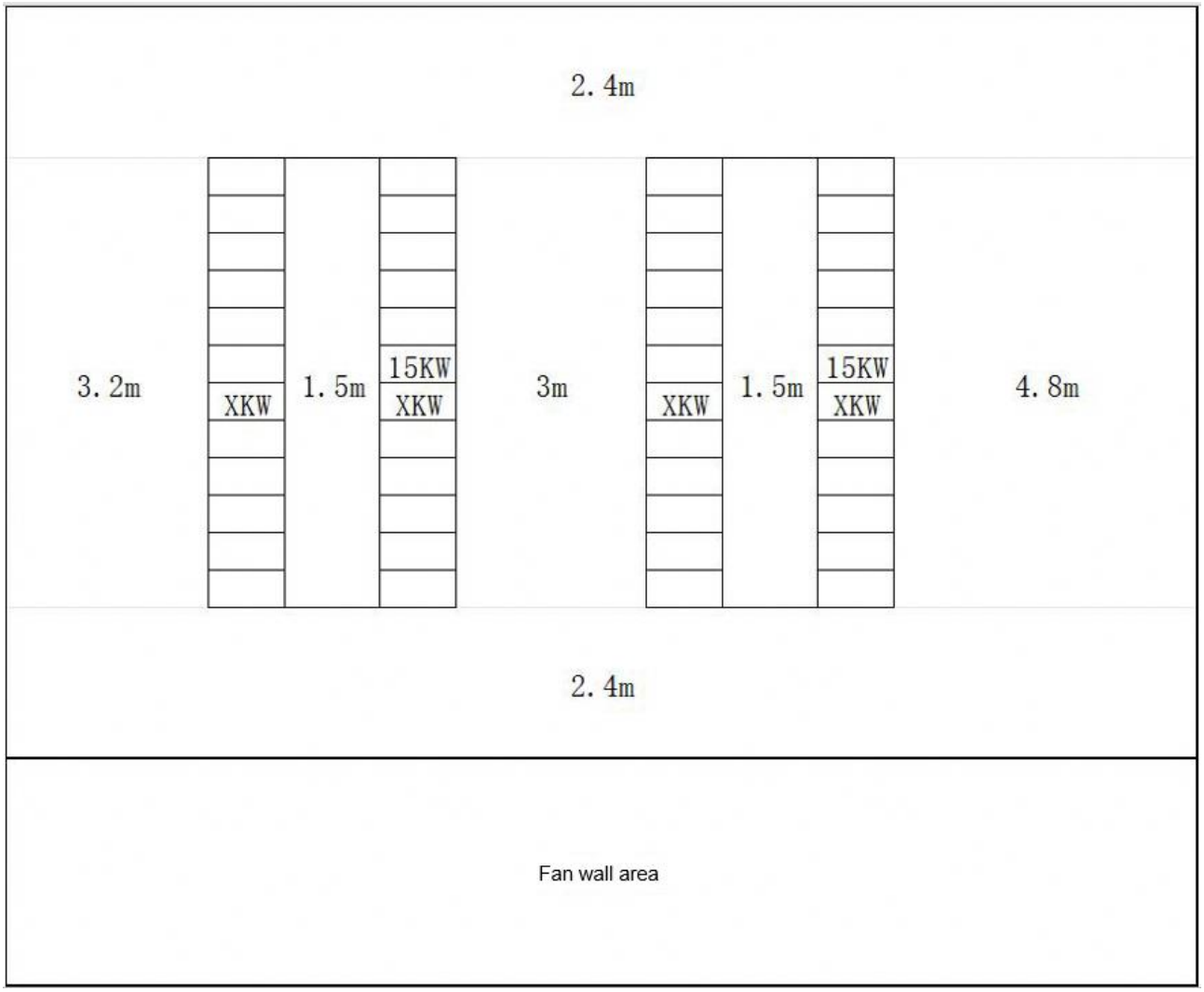
Original equipment room layout:



Equipment room layout diagram

Original Equipment Room Device Parameter Settings		Remarks
IT rack power density (kW/rack)	15	/
Number of racks	40	/
Total load of the equipment room (kW)	600	/
Number of far-field fan walls	5	5+1 backup
Cooling capacity of a single far-field fan wall (kW)	150	Supply/Return air conditions: 25 °C/37 °C

Equipment room parameters after reconstruction:



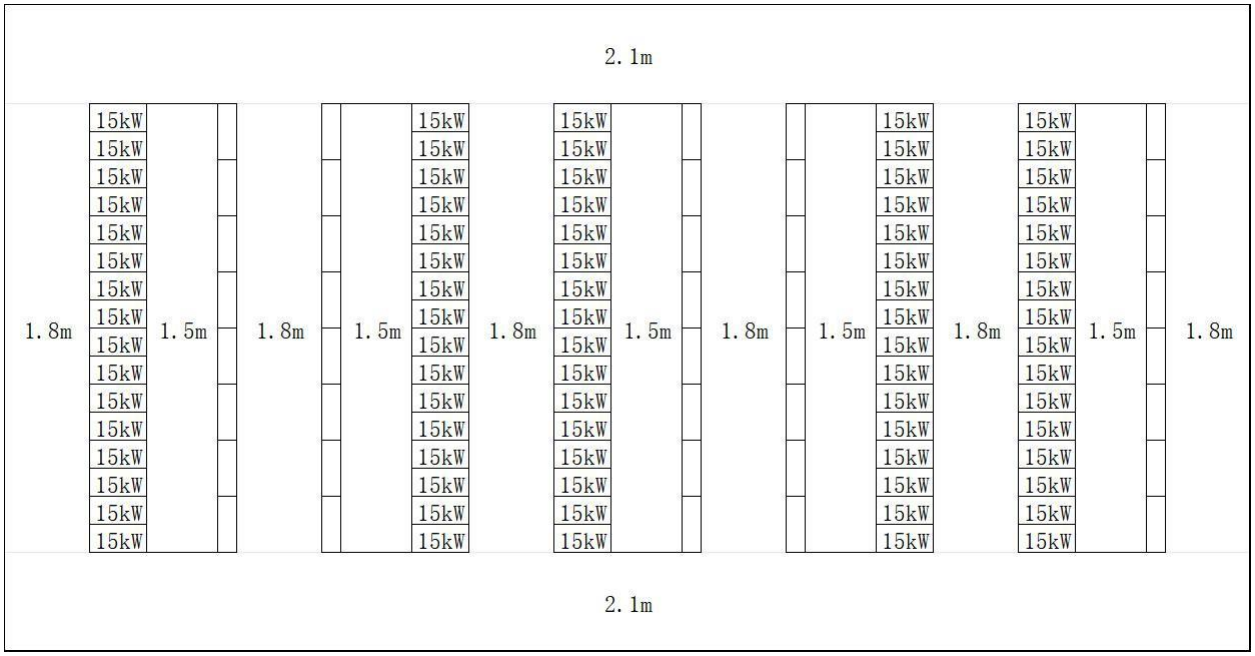
Equipment room layout diagram

Settings of Equipment Parameters in the Equipment Room After Reconstruction		Remarks
Power density of network racks (kW/rack)	15	/
Number of network racks	2	/
Power density of IT racks (kW/rack)	4	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	10	/
Total load of the equipment room (kW)	4*X+2*15	/
Number of far-field fan walls	5	5+1 backup

Cooling capacity of a single far-field fan wall (kW)	150	Supply/Return air conditions: 25/37 °C

A.2.2.4 Near-Field Fan Wall Scenario Settings

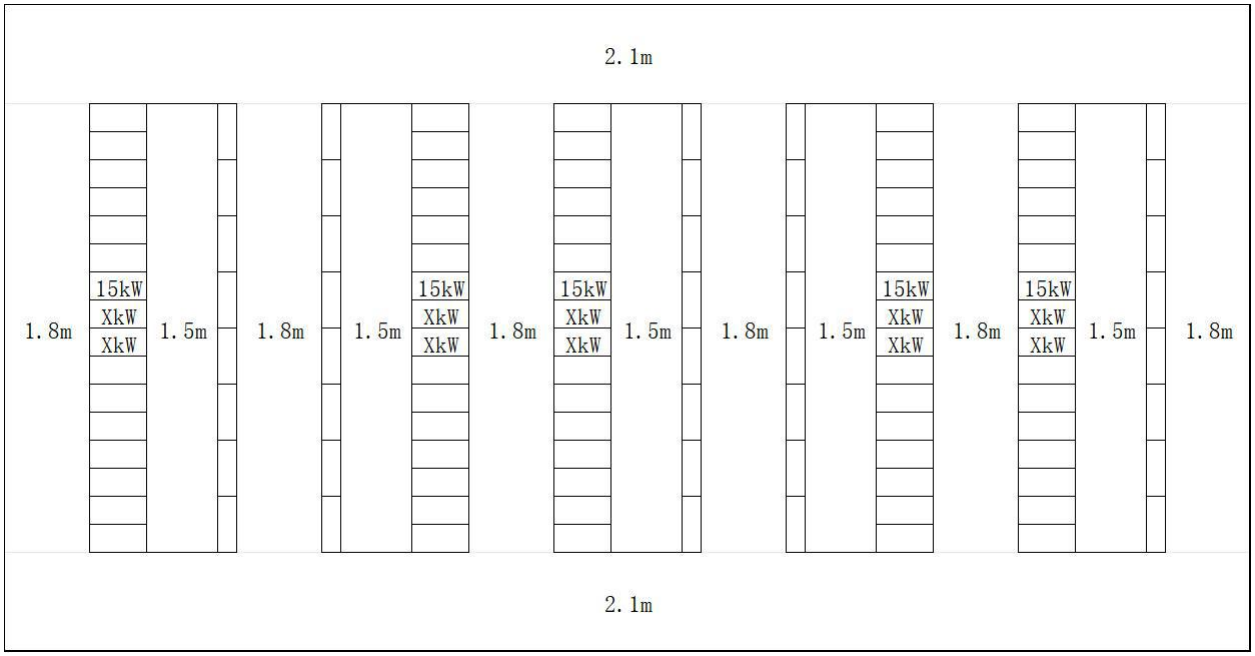
Original equipment room layout:



Equipment room layout diagram

Original Equipment Room Device Parameter Settings		Remarks
IT rack power density (kW/rack)	15	/
Number of racks	80	/
Total load of the equipment room (kW)	1200	/
Number of near-field fan walls	30	30 + 10 backup
Cooling capacity of a single near-field fan wall (kW)	40	Supply/Return air conditions: 25/37 °C

Equipment room parameters after reconstruction:

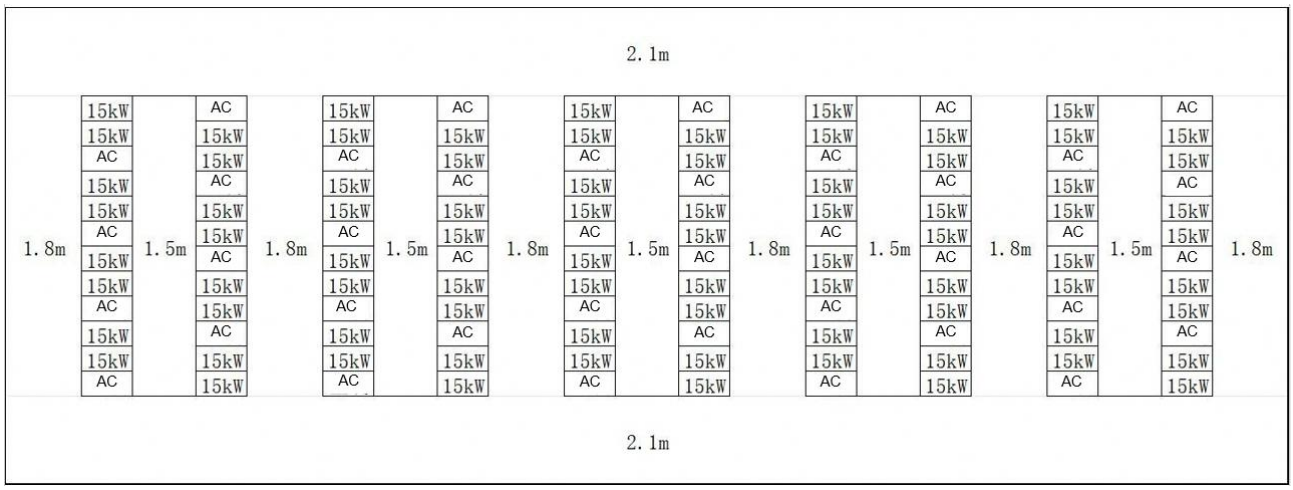


Equipment room layout diagram

Settings of Equipment Parameters in the Equipment Room After Reconstruction		Remarks
Power density of network racks (kW/rack)	15	/
Number of network racks	5	/
Power density of IT racks (kW/rack)	X	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	10	/
Total load of the equipment room (kW)	10*X+5*15	/
Number of near-field fan walls	30	30 + 10 backup
Cooling capacity of a single near-field fan wall (kW)	40	Supply/Return air conditions: 25°C/37°C

A.2.2.5 In-Row Scenario Settings

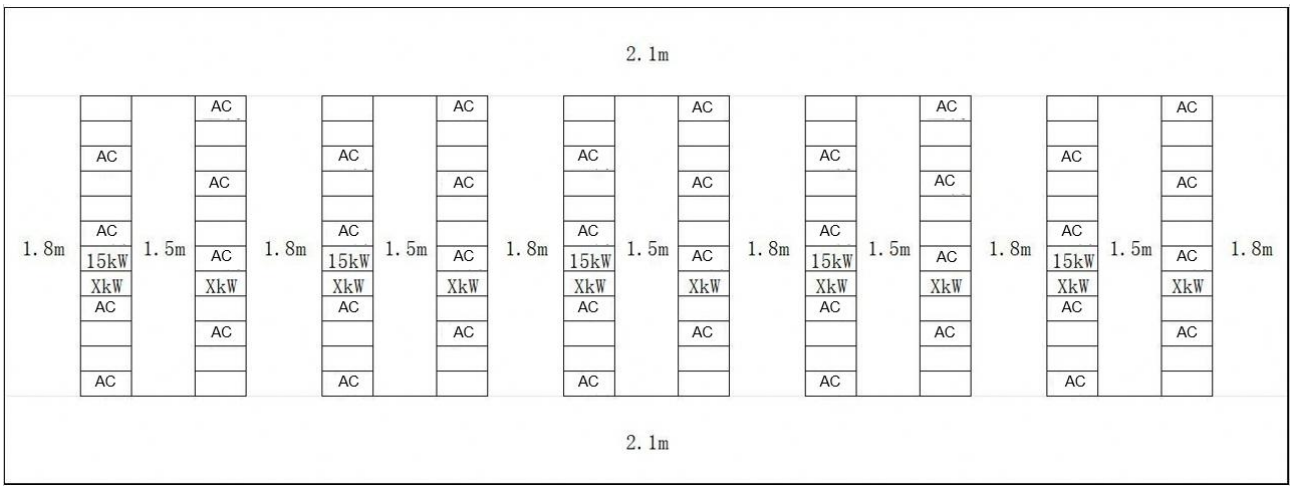
Original equipment room layout:



Equipment room layout diagram

Original Equipment Room Device Parameter Settings		Remarks
IT rack power density (kW/rack)	15	/
Number of racks	80	/
Total load of the equipment room (kW)	1200	/
Number of in-row units	30	30 + 10 backup
Cooling capacity of a single in-row unit (kW)	40	Supply/Return air conditions: 25/37 °C

Equipment room parameters after reconstruction:



Equipment room layout diagram

Settings of Equipment Parameters in the Equipment Room After Reconstruction		Remarks
Power density of network racks (kW/rack)	15	/
Number of network racks	5	/
Power density of IT racks (kW/rack)	X	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	10	/
Total load of the equipment room (kW)	10*X+5*15	/
Number of in-row units	30	30+10 backup
Cooling capacity of a single in-row unit (kW)	40	Supply/Return air conditions: 25/37 °C

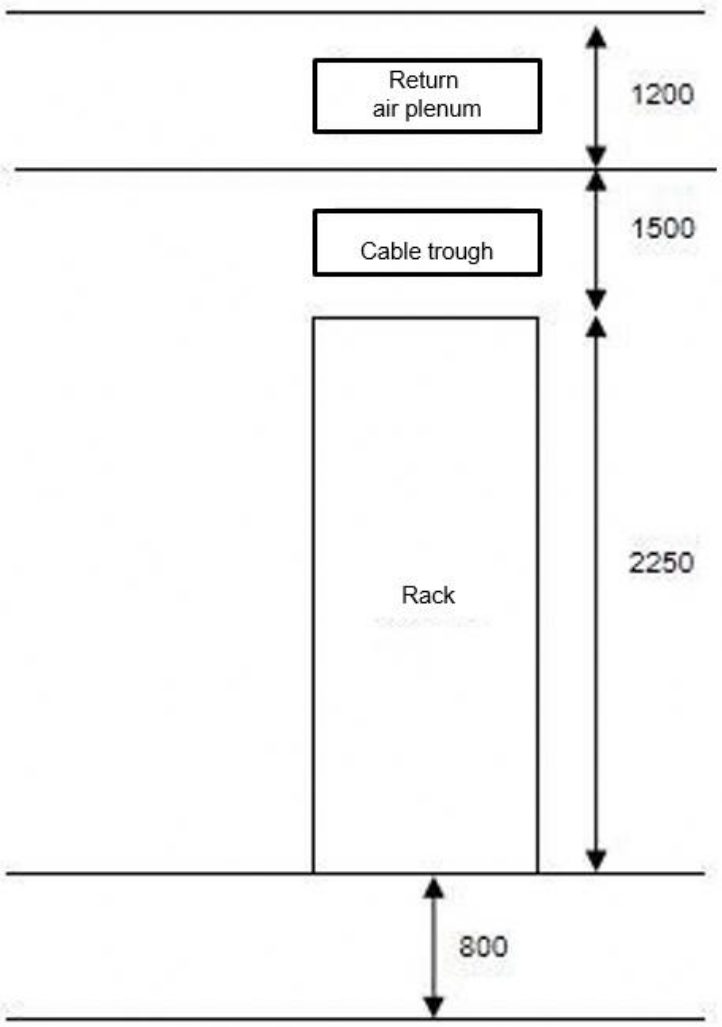
A.2.2.6 Summary of Simulation Results

Equipment Type	**Air Cooling IT Load Limit -Kw/Rack**	**Total Load of The Equipment Room-Kw**	**Rated Cooling Capacity of Air-Cooled Air Conditioners-Kw**	**Performance Utilization**	**Room Area - M²**	**Air Cooling IT Load Density**	**Recommended Air-to-Liquid Ratio**
AHU	30	375	1500	25%	645.39	0.58	3:7-5:5
Far-field fan wall	30	150	750	20%	293.28	0.51	2:8-5:5
Near-field fan wall	30	375	1200	31%	376.74	1	3:7-5:5

In-row	30	375	1200	31%	345.42	1.09	3:7-5:5

A.2.3 New Equipment Room Scenario

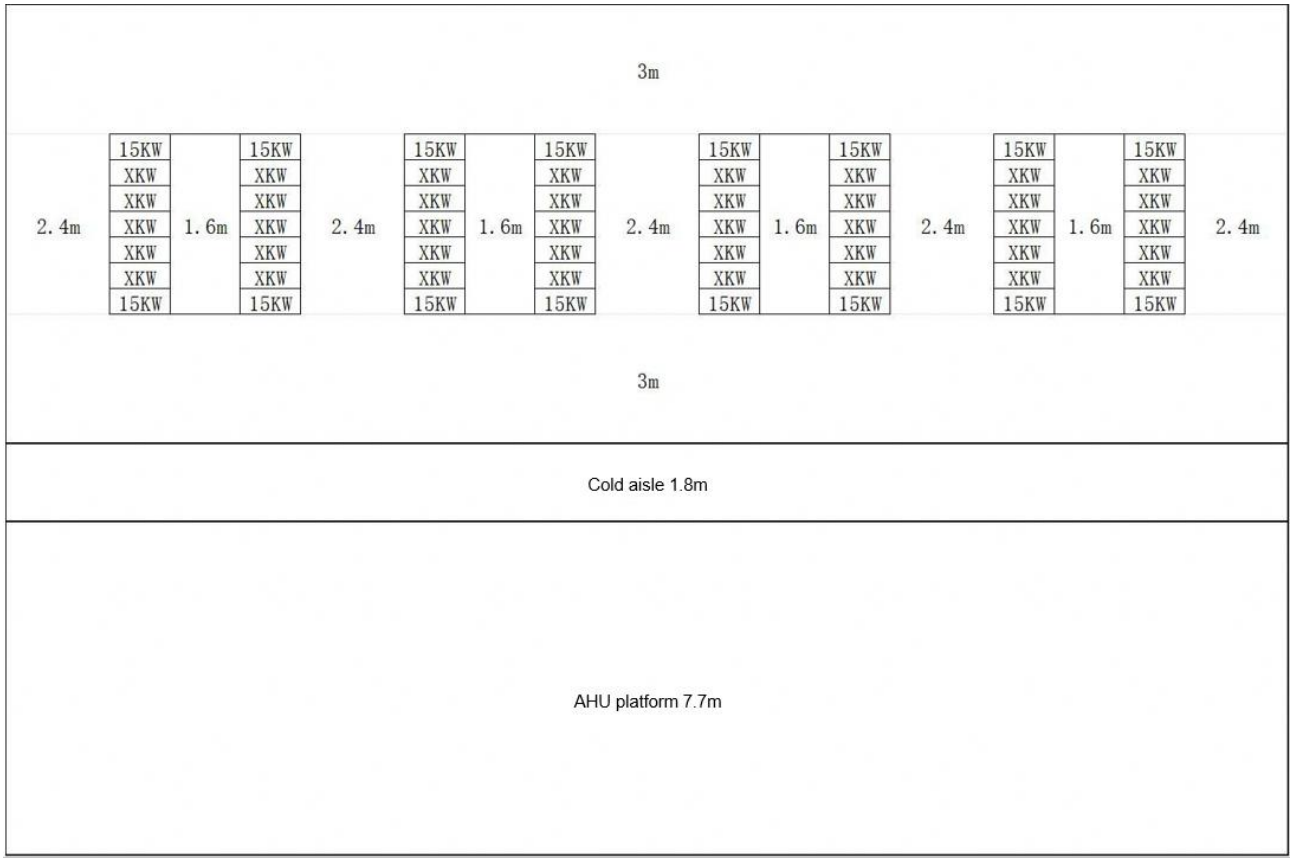
A.2.3.1 Equipment Room Side Layout Settings



Equipment room side layout diagram

A.2.3.2 AHU Scenario Settings

Equipment room layout:

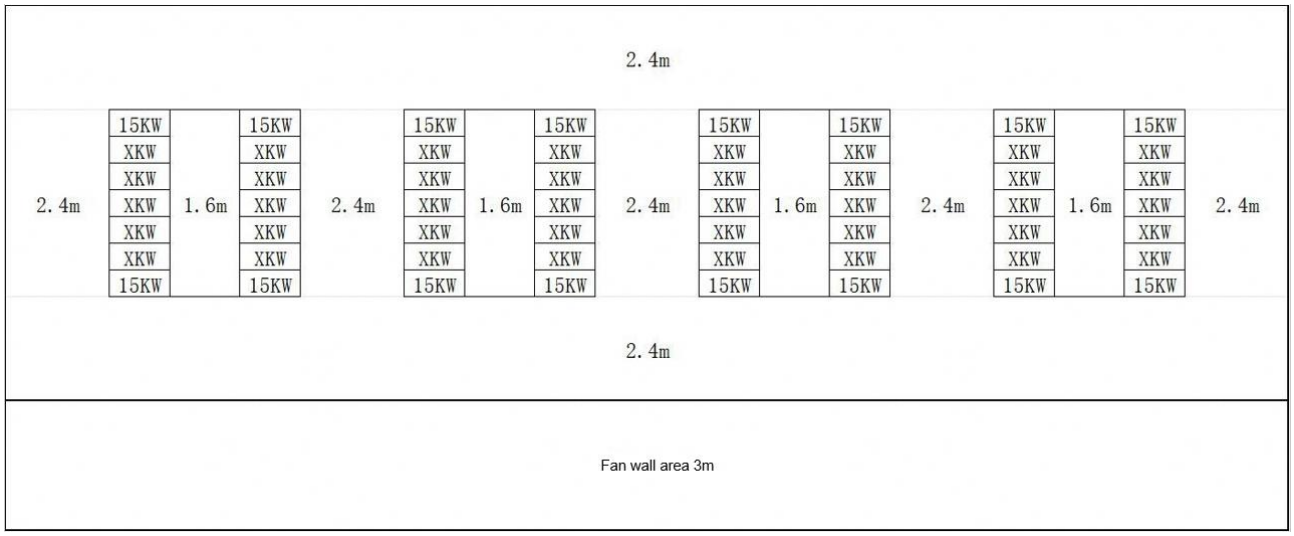


Equipment room layout diagram

Equipment Room Device Parameter Settings		Remarks
Power density of network racks (kW/rack)	15	/
Number of Network Racks	16	/
Power density of IT racks (kW/rack)	X	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	40	/
Total load of the equipment room (kW)	40*X+16*15	/
Number of AHUs	6	6+1 backup
Cooling capacity of a single AHU (kW)	300	Supply/Return air conditions: 25/37°C

A.2.3.3 Far-Field Fan Wall Scenario Settings

Equipment room layout:

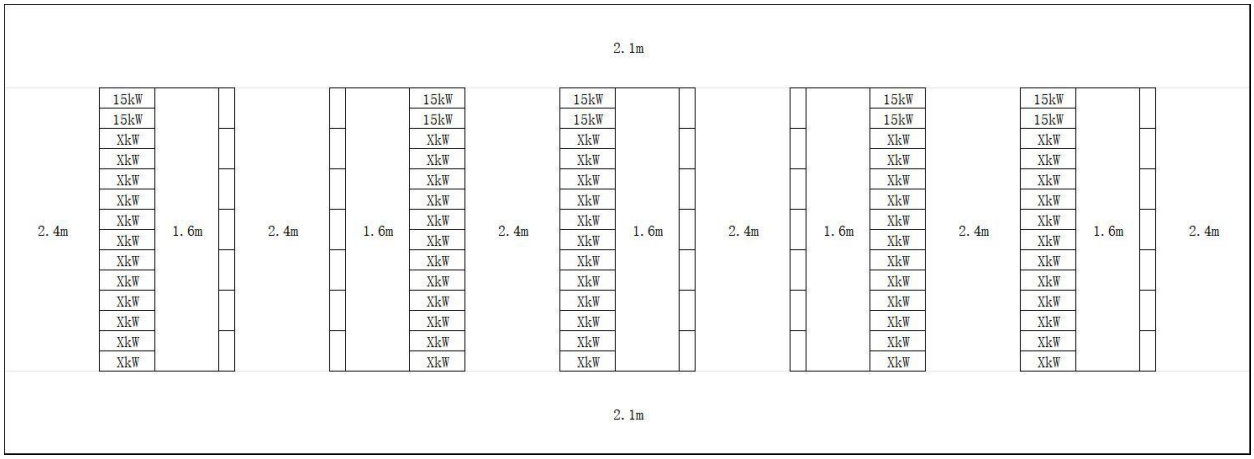


Equipment room layout diagram

Equipment Room Device Parameter Settings		Remarks
Power density of network racks (kW/rack)	15	/
Number of network racks	16	/
Power density of IT racks (kW/rack)	X	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	40	/
Total load of the equipment room (kW)	40*X+16*15	/
Number of far-field fan walls	6	6+1 backup
Cooling capacity of a single far-field fan wall (kW)	300	Supply/Return air conditions: 25/37°C

A.2.3.4 Near-Field Fan Wall Scenario Settings

Equipment room layout 1:

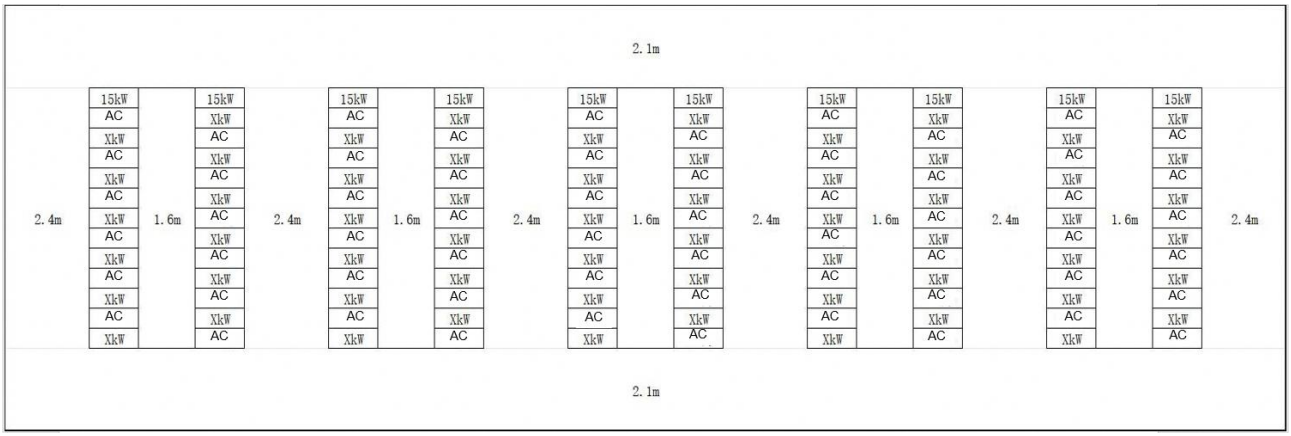


Equipment room layout diagram 1

Equipment Room Parameter Settings		Remarks
Power density of network racks (kW/rack)	15	/
Number of network racks	10	/
Power density of IT racks (kW/rack)	X	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	60	/
Total load of the equipment room (kW)	60*X+10*15	/
Number of near-field fan walls	30	30 + 5 backup
Cooling capacity of a single near-field fan wall (kW)	80	Supply/Return air conditions: 25/37°C

A.2.3.5 In-Row Scenario Settings

Equipment room layout:



Equipment room layout diagram

Equipment Room Device Parameter Settings		Remarks
Power density of network racks (kW/rack)	15	/
Number of network racks	10	/
Power density of IT racks (kW/rack)	X	X indicates that the power is unknown. The value is subject to the CFD simulation result.
Number of IT racks	60	/
Total load of the equipment room (kW)	60*X+10*15	/
Number of in-row units	50	50 + 10 backup
Cooling capacity of a single in-row unit (kW)	60	Supply/Return air conditions: 25/37 °C

A.2.3.6 Result Summary

Equipment Type	**Air Cooling IT Load Limit -Kw/Rack**	**Total Load of the Equipment Room -Kw**	**Rated Cooling Capacity of Air-Cooled Air Conditioners -Kw**	**Performance Utilization**	**Room Area -M²**	**Air Cooling IT Load Density**
AHU	35	1640	1800	91%	355.2	4.62
Far-field fan wall	35	1640	1800	91%	355.2	4.62

Near-field fan wall	35	2250	2400	94%	395.64	5.69
In-row	47	2970	3000	99%	436.8	6.8

Appendix B

References

[1] GB 50174—2017 Code for Design of Data Centers

[2] GB/T 1.1-2020 Directives for Standardization — Part 1: Rules for the Structure and Drafting of Standardizing Documents

[3] GB/T 18836—2002 Ducted Air-Conditioning (Heat Pump) Units

[4] GB/T 17758—2023 Unitary Air Conditioners

[5] GB/T 19413—2024 Air Conditioning Unit for Data Center and Communication Room

[6] JB 14641-2022-T Indirect Evaporative Cooling Air Conditioning Units for Computer and Data Processing Room

[7] ASHRAE TC 9.9—2016 Thermal Guidelines for Data Processing Environments, 4th Edition