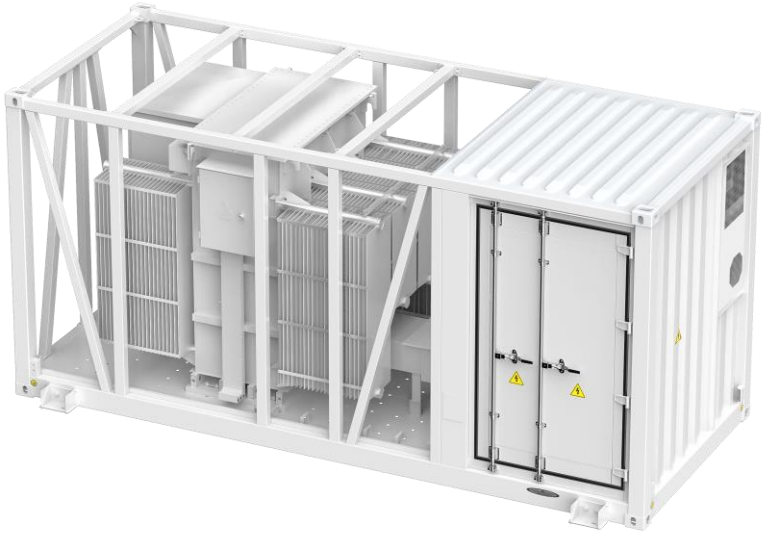
Midea Industrial Tech.

NE-(4000,5000)-MV-UL
User Manual



Revision History

Version	Revision content	Revision date
V0	Initial release	2025-11-01
V1	Added the model of NE-4000-MV-UL.	2025-12-24
V2	Updated 4.1.1 Model Description.	2026-01-04

Contents

1 About This Manual

1.1 Preface

Thank you for choosing the medium voltage substation (hereinafter referred to as the MVS) developed and manufactured by Shenzhen CLOU Electronics Co., Ltd. To ensure the optimal performance of the equipment during installation, commissioning, and operation, and to guarantee the safety of personnel and equipment, it is imperative to read this manual carefully before operating the product.

This manual, provided as a technical document with the equipment, covers all aspects from installation, operation to maintenance, and serves as a critical reference for proper use of the equipment. Please keep this manual in good condition during use, for reference during subsequent maintenance or troubleshooting.

In order to continuously improve customer satisfaction, this product manual is in the process of continuous improvement and upgrade. All illustrations in this manual are for reference only. The actual product received shall prevail.

1.2 Applicable Product

This manual applies to the following product models:

- NE-4000-MV-UL
- NE-5000-MV-UL

1.3 Applicable Personnel

This manual is intended for personnel who have some installation and maintenance experience with this product or similar products. Installation personnel must have a certain level of electrical, electrical wiring, and mechanical expertise to ensure they can perform the correct operations as guided by this manual.

1.4 Symbol Conventions

To ensure the personal and property safety of users during the installation of this product, the manual provides relevant installation information and uses appropriate symbols to highlight and emphasize these points. The following is a list of symbols that may be used in this manual. Please read them carefully to better utilize this manual.

	Indicates a highly potential hazard, which, if not avoided, can result in death or serious injury.
	Indicates a moderate potential hazard, which, if not avoided, could lead to personnel death or serious injury.
	Indicates a low potential hazard, which, if not avoided, could lead to personnel moderate or minor injury.

Please pay attention to the danger warning labels affixed to the product, which are explained as follows:

	Indicates that high voltage exists within the equipment; touching it may result in electric shock danger.
	Indicates that the temperature here exceeds the human body's acceptable range; do not touch at will to avoid personnel injury.
	Indicates the protective grounding (PE) terminal, which must be securely grounded to ensure the safety of the operating personnel.

2 Safety Guidelines

2.1 General Safety

 Danger	This equipment operates under high voltage conditions, presenting risks of fatal contact voltage and high energy storage, which can be released instantaneously. If operated improperly, it may result in severe electric shock, lethal arc flash burns, explosion, fire, or equipment damage. Strict attention must be paid to the following risks: ● High voltage exposure risk: High voltage risks persist (including after the equipment is powered off, energy storage components may still retain dangerous voltages). Any unauthorized or non-compliant operations may lead to severe bodily injury or even death. ● Medium voltage cabinet risk: If the medium voltage cabinet and its internal components are damaged, it may cause electric shock or fire.

 Warning	**Operational safety requirements:** ● Operate only when the technical conditions and safety status of the equipment allow it. ● Regularly inspect the integrity of all external connection devices and the equipment enclosure. ● Before performing any operation that may involve contact with live parts or that could lead to accidental equipment start-up, strictly follow the de-energized work process (see section 2.4.2). ● Do not touch, bypass, or disable safety interlock devices in any form. ● Do not modify the equipment control program, safety parameter settings, logic, or firmware without authorization. ● Do not insert or remove electrical connectors while energized; live operations are only permitted under the stringent conditions specified in section 2.5.1. ● The work area must be equipped with robust physical barriers and clear, explicit warning signs prohibiting entry by unauthorized personnel. ● All equipment installation and operation must comply with local regulations and standards.

 Caution	**Operator training:** ● Operators must be familiar with specific risks associated with the equipment (such as thermal runaway, high short-circuit currents, etc.) and the corresponding emergency measures. ● Maintenance, operation, or repair personnel must be technically qualified personnel who have been professionally trained by the manufacturer or its authorized institution and have passed the assessment. It is recommended that they hold valid high-voltage electrical operation qualification certificates prescribed by the state or the industry.

2.2 Environment Requirements

To ensure that the installation and operating environment of the equipment meets the specification requirements, any use exceeding the environmental parameters listed below may result in equipment failure or risks. Please carefully refer to the recommended values provided in Table 2-1.

Table 2-1 System operating environment parameters

Model	**NE-4000-MV-UL**	**NE-5000-MV-UL**
Ambient temperature	–25°C to +45°C (> 45°C derating)	–30°C to +50°C (> 45°C derating)
Relative humidity	0%–100% (non-condensing)	
Altitude	2000 m; 3000 m (optional)	
Seismic rating	IEEE 693 moderate seismic level qualification IEEE 693 high seismic level qualification (optional)	

 Caution	If installed in areas with high salt mist, high dust, or extreme climates, dedicated corrosion-resistant and environmental control components must be selected.

2.3 Personal Protective Equipment (PPE)

Before transformer operation and maintenance, wear personal protective equipment which strictly meet insulation, mechanical protection, and emergency protection requirements. Key equipment and requirements are as follows:

- Insulation protection (core requirement: meeting insulation requirements for corresponding voltage levels)
  - Insulation safety helmet: Must comply with standards, have insulation properties, and prevent head electric shock and mechanical impact.
  - Insulation gloves: Check for no damage or air leakage before use, and ensure effective insulation.
  - Insulating shoes/boots: Ensure no cracks or wear on the insulating soles to prevent electrical shock.
- Mechanical/Physical protection
  - Cotton work uniform: Wear long-sleeved, long-legged pure cotton or flame-retardant work uniforms to avoid static electricity from synthetic fabrics, while also preventing contamination from equipment oil and cuts from sharp parts.
  - Protective eyewear/face shield: Wear in situations where electric arcs, oil mists (such as during oil release operations), or foreign objects may splash, to protect the eyes and face.
  - Anti-slip gloves: Used when handling parts and operating valves to enhance grip and prevent slipping.
- Emergency protection class
  - Seat belt: For high-altitude work (such as inspecting components on top of a transformer), a double-hook safety belt conforming to standards must be used to ensure a secure attachment point.
  - Voltage detector (auxiliary protective tool): Although not a direct wearable equipment, a qualified voltage detector must be used before operation and maintenance to confirm that the equipment is de-energized. This is a critical step in preliminary protection and should be used in conjunction with personal protective equipment.

2.4 Power-off, Electrical Testing, and Grounding

During transformer operation and maintenance, strictly follow the core principle of “power-off first, then electrical testing, and finally grounding”. The specific process is as follows:

1. Power-off (principle: load side first, then power side)

Step 1. Confirm that the load on the transformer under maintenance has been transferred or disconnected (such as disconnecting downstream distribution cabinet circuit breakers and other related load switches).

Step 2. Turn off the switches on the load side of the transformer (such as low-voltage side circuit breakers, isolating switches). After disconnection, check the switch position

indicator, and ensure that the power supply is completely cut off.

Step 3. Turn off the switches on the power side of the transformer (such as high-voltage side circuit breakers, isolating switches). After disconnection, check the switch disconnection indicator, and ensure that the power supply is completely cut off.

Step 4. Disconnect the control power and operation power on both sides of the transformer to prevent accidental operation.

2. Electrical testing (principle: low voltage side first, then high voltage side; power side first, then load side)

Step 1. Prepare a qualified voltage tester: Confirm that the voltage tester matches the voltage level of the maintenance equipment and is within its validity period (calibrated and conforming), first test for voltage on a known live device of the same voltage level to ensure the voltage tester is functioning properly.

Step 2. Before testing electricity, wear insulating gloves and insulating shoes, and maintain a safe distance (for example, the safety distance for 10 kV equipment should not be less than 0.7 meters).

Step 3. Conduct electrical testing by following the sequence below:

- Test the low-voltage side phases of the transformer first (such as the low-voltage busbar, outgoing terminals), then test the high-voltage side phases (such as the high-voltage bushings, incoming terminals).
- When testing for electricity on the same side, test the power supply side first, then the load side; When testing each phase, the contact head of the voltage detector must touch the conductive part of the equipment and remain in contact for more than 3 seconds to confirm there is no sound and light alarm (indicating no electricity).

3. Grounding (principle: the grounding electrode first, then the equipment terminal; low voltage first, then high voltage)

Step 1. Prepare a qualified grounding wire: Check that the cross-sectional area of the grounding wire, the insulating layer, and the line clamp are intact, with no broken strands or damage.

Step 2. Connect the grounding electrode: Securely connect the grounding terminal of the ground wire to the grounded grounding grid terminal (or dedicated grounding electrode), ensuring good contact (no looseness, rusting).

Step 3. Connect the equipment side (principle: low voltage first, then high voltage).

a. Connect the low-voltage side of the transformer first: Use the line clamp at the 'equipment end' of the ground wire (using an insulated operating rod) to securely clamp each phase conductive terminal of the low-voltage side, and lightly pull to confirm it is secure.

b. Connect the high-voltage side of the transformer: Similarly, use an insulated operating rod to securely clamp the ground wire to the conductive terminals of each phase on the high-voltage side, ensuring reliable grounding of each phase.

Step 4. After grounding is completed, check that the earthing wire is “straight, without tangling”, and the clamps are not loose, confirming that grounding is effective; if it involves multiple sets of earthing wires, proper markings should be made to avoid accidental disassembly.

2.4.1 Testing Equipment Requirements

- All measuring instruments must be calibrated periodically and have a clear CAT safety rating.
- Do not use damaged instruments, non-insulated probes, or equipment past its expiration date.
- Use testing instruments and accessories that meet the current region/national safety requirements and have insulation and arc protection capabilities.

2.4.2 No-voltage Working Procedures

Only when it has been confirmed that all equipment within the system is completely de-energized, the following operations can be performed:

1. Isolate all power sources:

Disconnect and lock out all possible live power sources (such as AC main power, DC bus, auxiliary power, etc.) to prevent accidental re-energization.

2. Verify no voltage:

Use test equipment that complies with standards (see 2.4.1) to perform multiple point tests to ensure no hazardous voltage is present.

 Warning	Live indicators are for auxiliary judgment only, and must not replace standard voltage verification procedures. After the system has stopped running, wait at least 15 minutes to ensure internal capacitors are fully discharged.

3. Ground and short circuit (if necessary):

- Install temporary grounding devices and ensure they are reliably connected to the protective earth conductor (PE).
- When grounding, connect the ground terminal first, then the conductor terminal.

4. Set up physical barriers and warnings:

- Install physical barriers at isolation points and hang conspicuous and secure warning

signs.

- Shelter or shield adjacent parts that may not be isolated to prevent accidental contact by personnel.

2.5 Safety Measures during Operation

2.5.1 Live Working Regulation

 Danger	Contact with live parts can cause arc flash explosions or fatal electric shock!

 Warning	When performing live work, ensure the work area is dry and use standard-compliant insulated tools, including but not limited to insulated gloves and goggles.

- Live operations are to be performed only by professionals who hold a high voltage work permit and are dressed in complete personal protective equipment (PPE).
- Before operation, verify the insulation condition of the equipment to ensure that the insulation resistance meets the current regional/national standards. During insulation testing, note the following:
  - Before testing, check the validity of the instrument, clean the surface of the equipment, and disconnect the circuit to discharge.
  - During testing, select the range according to the rated voltage, connect the test leads correctly, and read the data in a standardized manner.
  - After testing, disconnect the connections and fully discharge, then organize and properly store the tools.
- Operations should be conducted by two personnel working in coordination, one operating and one supervising.

2.5.2 Static Protection

 Warning	Electrostatic discharge may cause permanent damage to electronic components.

- Effective electrostatic discharge (ESD) protection measures should be taken for ESD-

sensitive areas such as the control unit and communication interface.

- Direct contact with sensitive electronic components using bare hands is prohibited; anti-static tools must be used.

2.6 Maintenance and High-risk Areas

2.6.1 Regular Inspection and Maintenance Requirements

	Neglecting ground testing can lead to the risk of electric shock, equipment damage, or fire. Before all operations, the effectiveness of the grounding system must be confirmed and it must comply with the current regional specification standards.

- Test the continuity of the protective conductor every 6 months, check that the connection points of the protective conductor are not loose, corroded, or damaged, and that the conductor's conductivity meets the specified requirements.
- Periodic insulation resistance testing is a critical component of a preventive maintenance plan. It is recommended that the test be performed at least annually, or according to the recommendations of NFPA 70B and the specific operating conditions of the equipment adjust the testing frequency. (NFPA 70B is specifically for the maintenance of electrical equipment, it outlines the frequency, methods, and acceptable values for various preventive maintenance tasks, including insulation resistance testing.) All tests should be conducted by qualified personnel using equipment that meets UL 61010 standards. (UL 61010 is an internationally recognized safety standard for electrical equipment, primarily governing the design, manufacture, and testing requirements for measuring, control, and laboratory equipment to ensure safety and global market access.)
- If abnormal noise, odor (such as a burnt smell), or local overheating (hot spots) is observed in electrical equipment or circuits, immediate emergency shutdown should be executed to identify the fault and take corrective actions before resuming operation.
- Remote sites should be equipped with safety equipment based on risk assessment, including but not limited to: fire extinguishing devices suitable for electrical fires, backup power systems to meet emergency power supply needs, and emergency communication devices to ensure communication remains open in emergencies, and regularly verify their functional effectiveness.

2.6.2 Hazardous Area Operation Permission and Unlock Control

	Before entering the high-voltage area, it is essential to confirm that the equipment is completely de-energized. Voltage absence verification must be conducted before unlocking (see 2.4.2).

Table 2-2 Area and unlocking conditions description

Area	Unlocking conditions description
Transformer compartment	High-voltage side isolating switch is open, there is no oil leakage, and the grounding connection is intact.
ACB compartment	All AC ports are disconnected, status indicator lights are off (QF1 is the switch of the AC system placed in the low-voltage cabinet, please check and confirm that this switch is open. For more specific switch designations and definitions, see 4.4.2.)
Low-voltage distribution cabinet	UPS is disconnected, and all feeders are de-energized.

2.6.3 Disposal Compliance

	Residual energy in batteries/capacitors may cause fires! Residual energy must be discharged before disassembly.

- Scrapped equipment should be dismantled and classified, with electronic components, metals, batteries, oils, etc., to be handled by qualified institutions respectively.
- All oil-absorbent materials, coolants, etc., should be recovered and handled by qualified institutions.
- It is strictly prohibited to dispose of or incinerate the equipment as a whole or its key components with household waste.

3 Scope of Supply

3.1 List of Equipment

Table 3-1 List of equipment for one set of the MVS

No.	Item	Quantity
1	Prefabricated container	1
2	Frame circuit breaker cabinet	2
3	Step-up transformer	1
4	4.5 kVA step-down auxiliary transformer (inside the distribution cabinet)	1
5	NEACC-4.5 distribution cabinet	1

3.2 List of Documents

Table 3-2 List of documents for one set of the MVS

No.	Item	Remarks
1	MVS user manual	/
2	Warranty card	/
3	QC sticker	/
4	Inspection report	/
5	MVS maintenance manual	This document provides the maintenance schedule, items, recommendations, and procedures for replacing wear parts of the medium voltage substation and its internal equipment.
6	Transformer user manual	This document provides instructions for the transformer.
7	Fire protection equipment maintenance manual	This document provides maintenance details for the fire protection components within the medium voltage substation.
8	9SX UPS user manual	This document provides instructions for the uninterruptible power supply (UPS).

4 Product Description

4.1 Product Overview

This product is a skid-mounted substation that can achieve bidirectional energy conversion between the power grid and batteries. The medium voltage substation has excellent anti-corrosion, fire resistance, water resistance, dust (sand) protection, and shock resistance, making it suitable for medium and large-scale energy storage power stations. The medium voltage substation stores grid electrical energy in the energy storage battery or converts battery direct current (DC) to alternating current (AC) synchronized with the grid, which is then fed into the grid through the distribution system.

4.1.1 Model Description

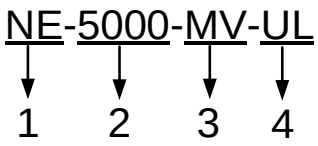


Figure 4-1 Model example

Table 4-1 Model description

No.	Designation	Description
1	Product category	NE: CLOU new energy
2	Power level	● 4000: a rated power of 4000 kVA ● 5000: a rated power of 5000 kVA
3	Voltage level	MV: medium voltage
4	Standard/region	UL: compliant with UL standards

4.1.2 Electrical System

The electrical system of the medium voltage substation is shown in the figure below. This is only an example; for specific details, refer to the relevant electrical diagrams.

NE-4000-MV-UL 12.47kV

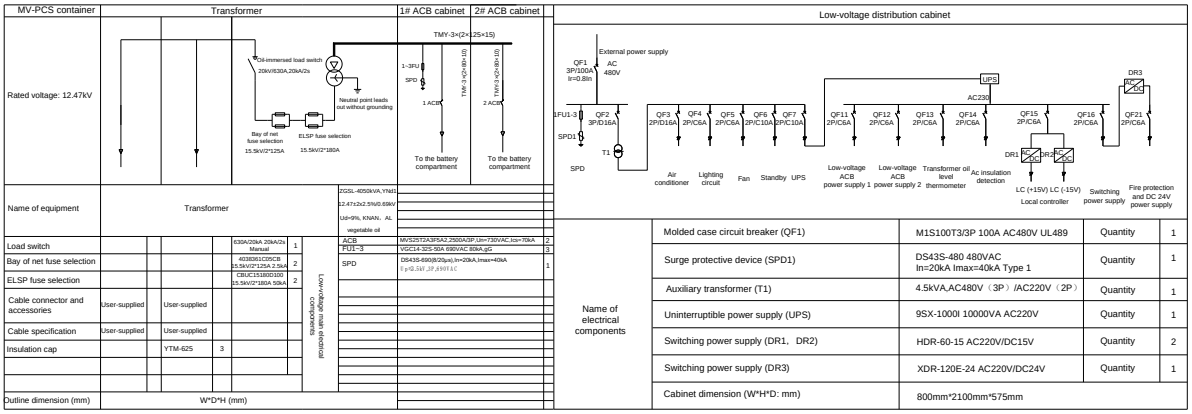


Figure 4-2 Electrical system diagram (NE-4000-MV-UL)

NE-5000-MV-UL 34.5 kV

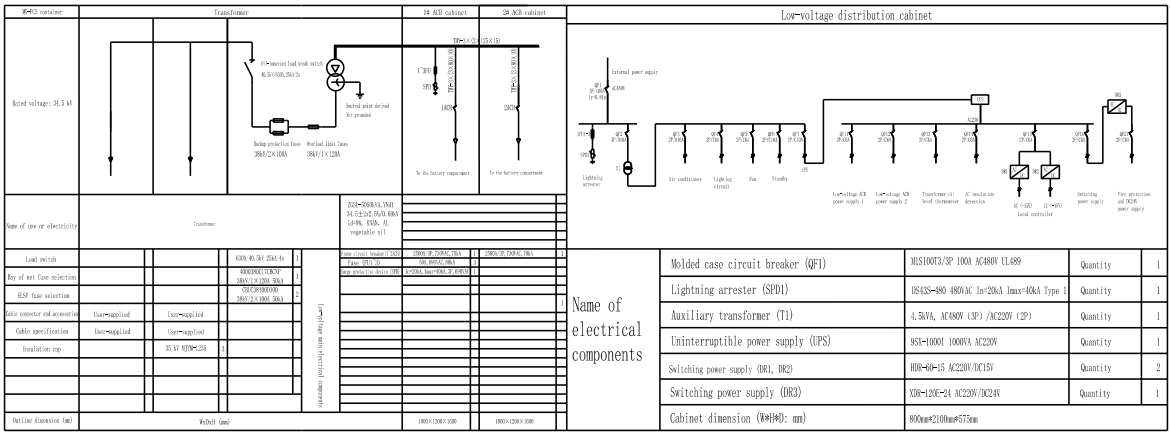


Figure 4-3 Electrical system diagram (NE-5000-MV-UL)

4.1.3 General Parameters

Table 4-2 General parameters of the MV system

Model	NE-4000-MV-UL	NE-5000-MV-UL
Dimension (W × D × H)	6058 × 2438 × 2896 mm	
Weight	≤ 15000 kg	≤ 19000 kg
Cable entry	Wiring in from bottom	
NEMA type	Type 3R Type 3S (optional)	
Anti-corrosion degree	C4 C5 (optional)	
Seismic level	IEEE 693 moderate seismic level qualification IEEE 693 high seismic level qualification (optional)	
Operating temperature range	–25°C to +45°C (> 45°C derating)	–30°C to +50°C (> 45°C derating)
Operating humidity range	0%–100% (non-condensing)	
Max. operating altitude	2000 m 3000 m (optional)	
Communication	RS485, CAN, Ethernet	
Standard compliance	UL 891, IEEE C57.12.00, IEEE C57.12.80, IEEE C57.12.90	

4.2 Product Overview

4.2.1 Appearance

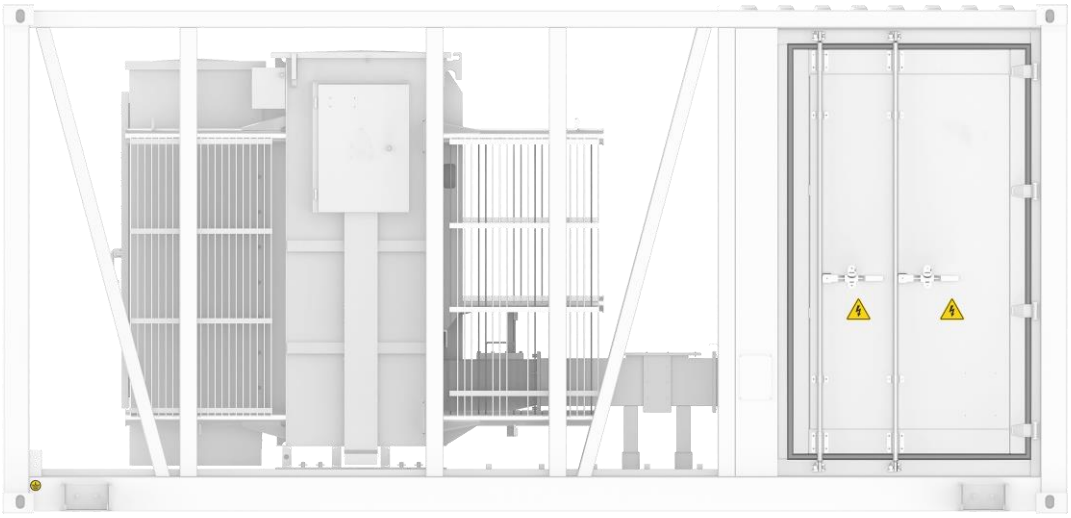


Figure 4-4 Appearance diagram (front view)

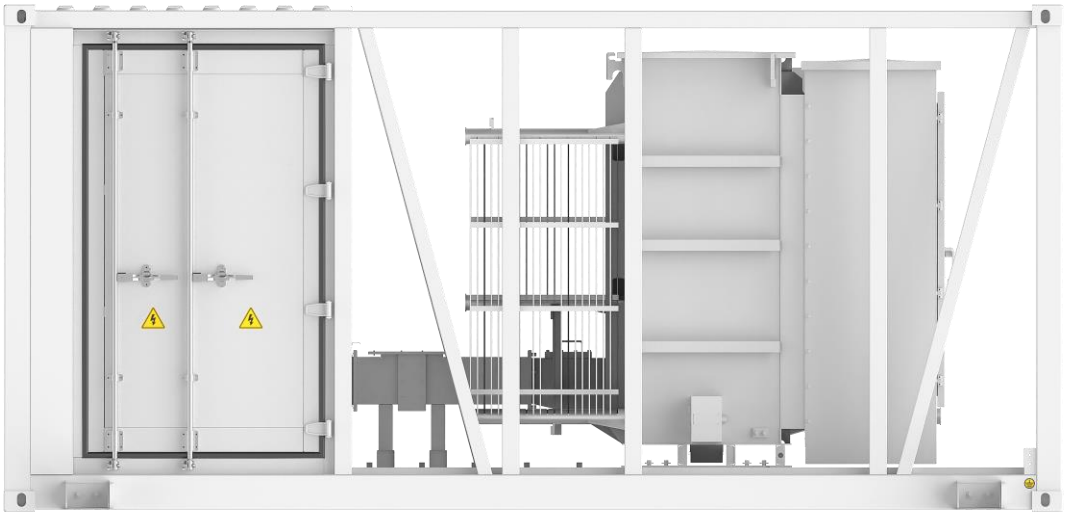


Figure 4-5 Appearance diagram (rear view)

Figure 4-6 Appearance diagram (side view)

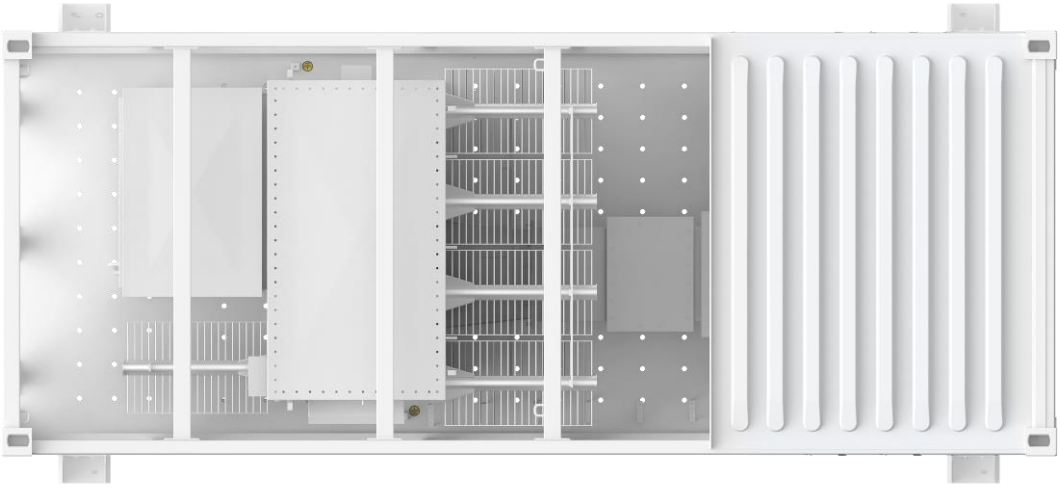


Figure 4-7 Appearance diagram (top view)

Note: The illustration is for reference only. The actual product's appearance might vary depending on the configurations.

4.2.2 Component Layout

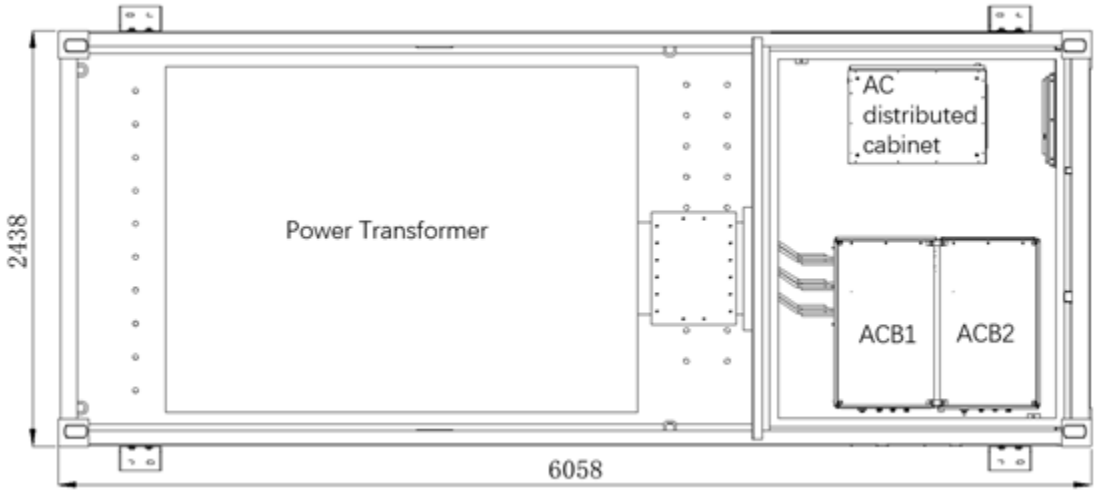
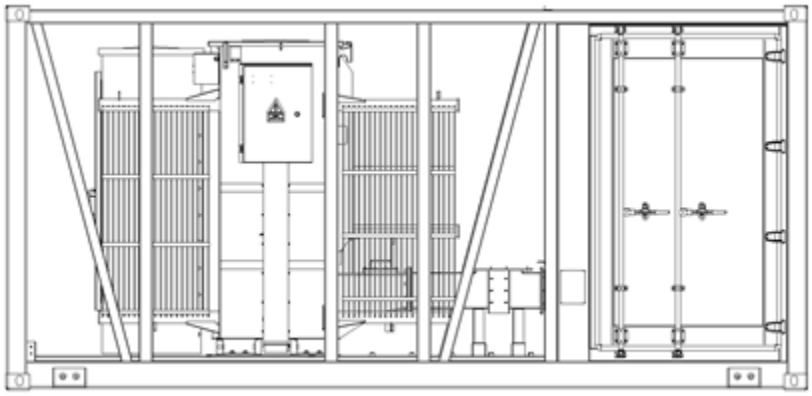


Figure 4-8 Component layout (top view, unit: mm)

4.3 External Design

4.3.1 Various Views and Descriptions

Views	Description
 **Front view**	The left side is the oil-immersed transformer, and the right side is the low-voltage compartment with a single door. After opening the compartment door, maintenance and other operations on the equipment can be performed.

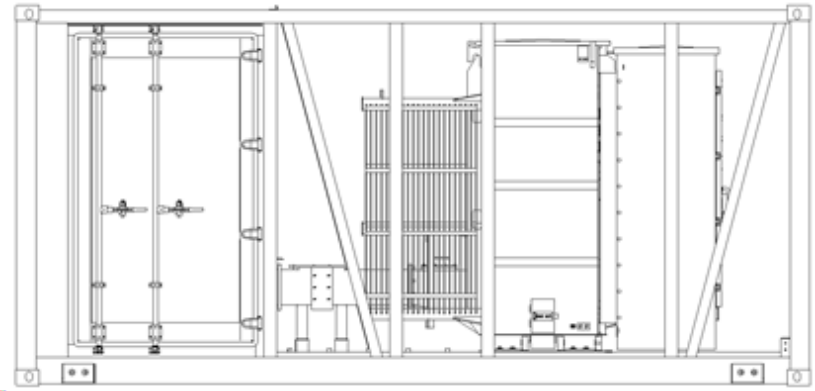
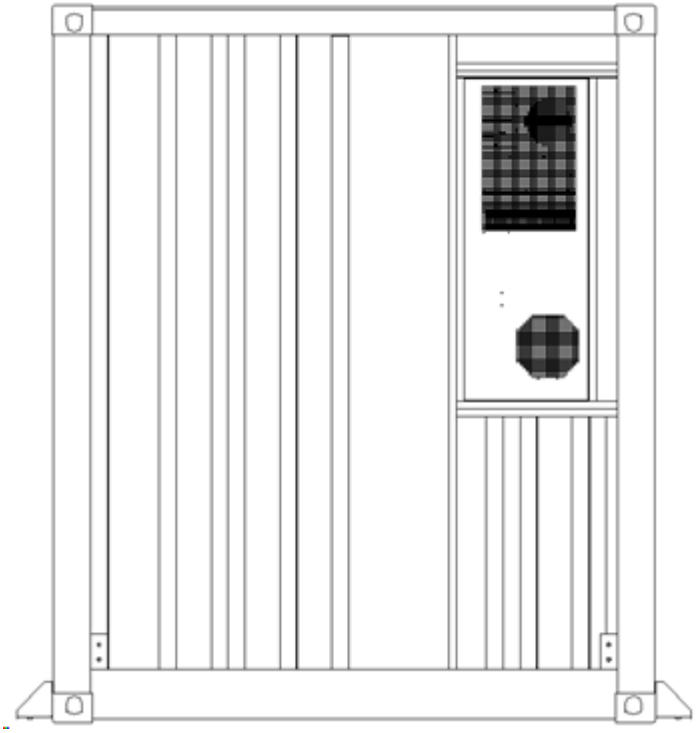
Views	Description
 **Rear view**	The right side is the oil-immersed transformer, and the left side is the low-voltage distribution cabinet with a single door. After opening the compartment door, maintenance and other operations on the equipment can be performed.
 **Left view**	The right side is the air conditioner and its air inlets and outlets. To ensure the normal operation of the equipment, please ensure that there are no obstacles blocking the air conditioner and its air inlets and outlets, and keep the ventilation unobstructed.

Figure 4-9 Views and description

4.3.2 Product Dimensions

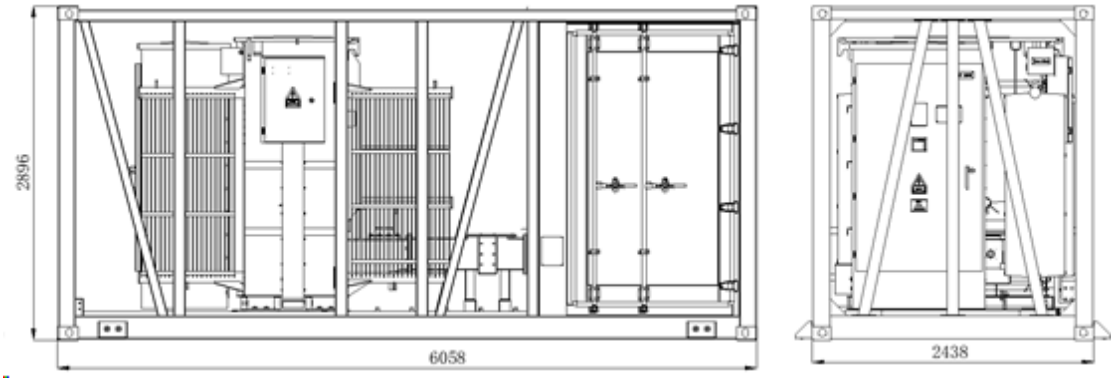


Figure 4-10 External dimensions (unit: mm)

Note: The illustration is for reference only. The actual product's appearance might vary depending on the configurations.

4.3.3 Clearance Requirements

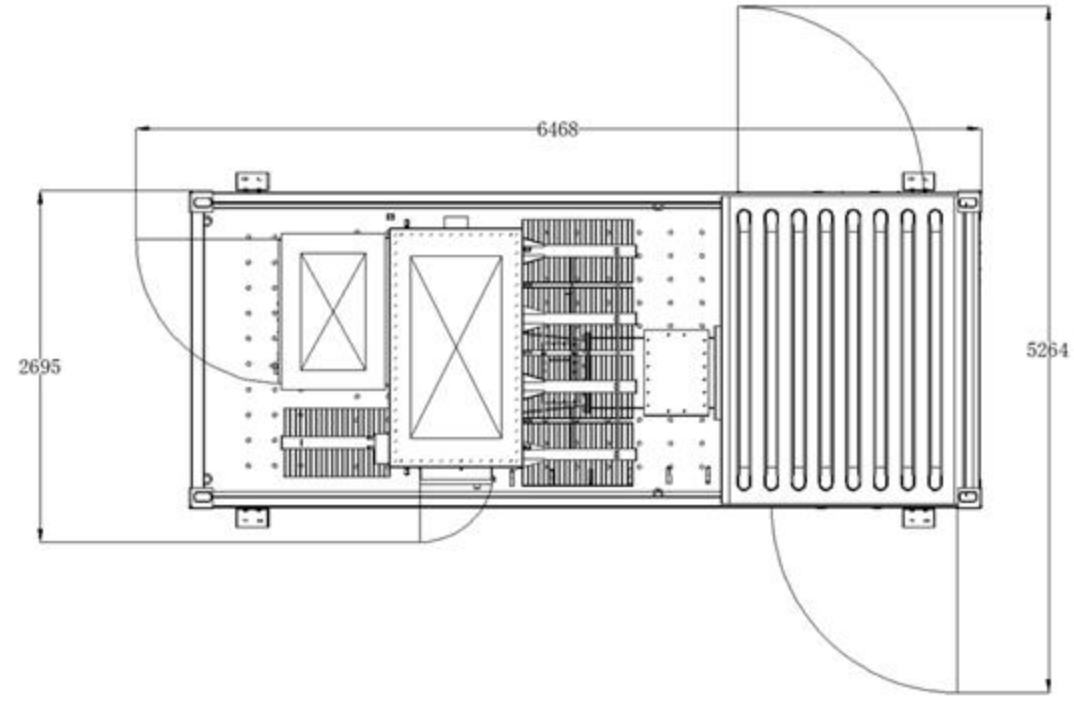


Figure 4-11 Clearance requirements to open the door (unit: mm)

Note: The illustration is for reference only. The actual product's appearance might vary depending on the configurations.

4.4 Internal Equipment

4.4.1 Transformer

4.4.1.1 Appearance

Transformer for NE-4000-MV-UL

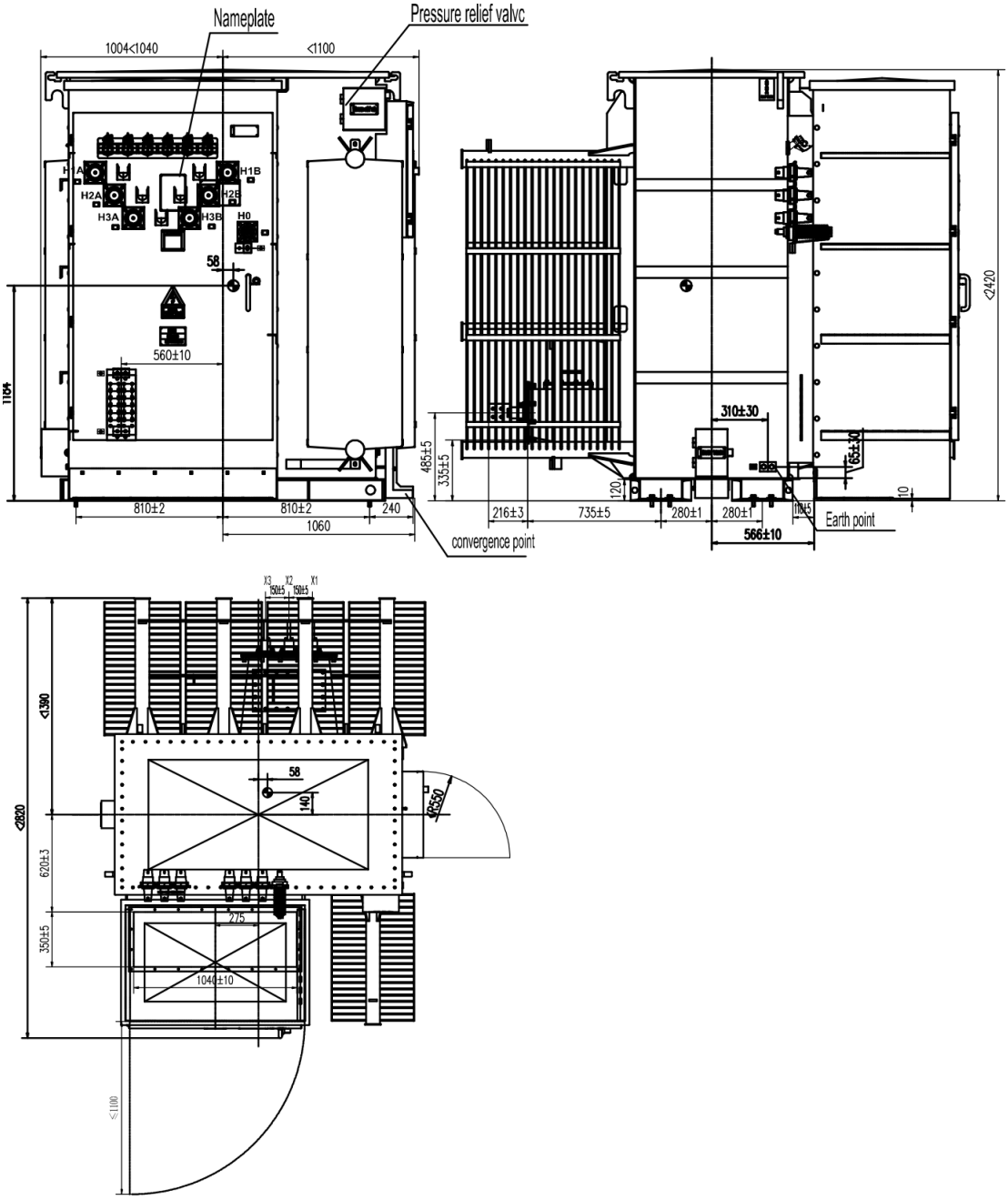


Figure 4-12 Dimensions of the transformer for NE-4000-MV-UL (unit: mm)

Transformer for NE-5000-MV-UL

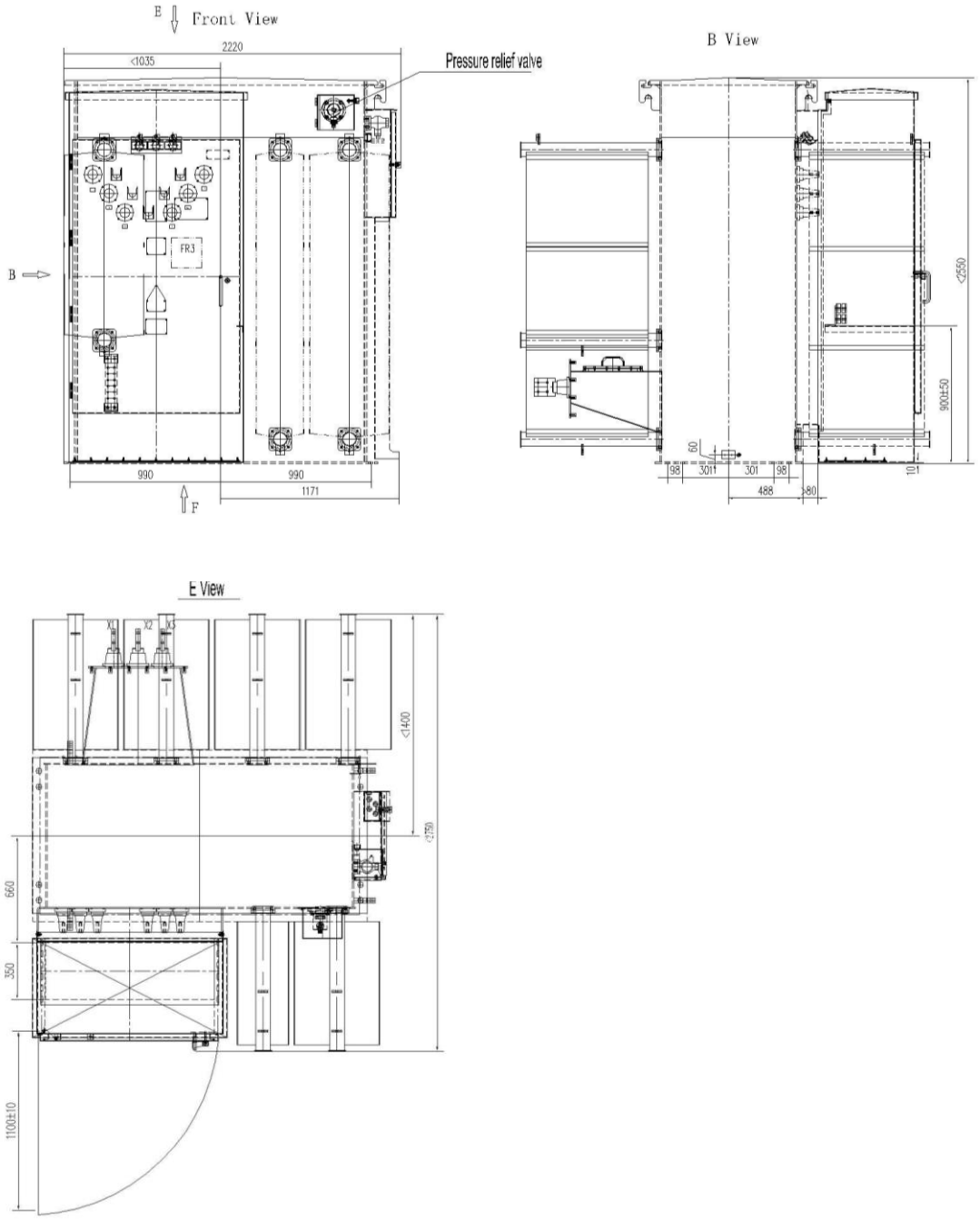


Figure 4-13 Dimensions of the transformer for NE-5000-MV-UL (unit: mm)

4.4.1.2 Technical Parameters

Table 4-3 Transformer technical parameters

Model	NE-4000-MV-UL	NE-5000-MV-UL
Transformer model	ZGSL-4050-12.47±2x2.5%/0.69	ZGSL-5050-34.5±2×2.5%/0.69kV
Operating temperature range	–25°C to +45°C	
Transformer performance	Oil-immersed, self-cooling, fully sealed, low loss, aluminum winding	
Rated capacity	≥ 4050 kVA (can run at 4050 kW when the power factor is 1)	≥ 5050 kVA (can run at 5050 kW when the power factor is 1)
Rated voltage	12.47±2×2.5%/0.69 kV	34.5±2×2.5%/0.69 kV
Maximum voltage of equipment	17 kV	36 kV
Rated frequency	60 Hz	
Vector group	YNd11, fully-insulated H0 neutral bushing ungrounded, factory default ungrounded (neutral point grounding Z-shaped copper par as spare parts upon factory dispatch, customers can choose whether to ground the neutral point according to their own needs.)	
Impedance voltage	9% (deviation: ±7.5%)	
Altitude	≤ 2000 m (> 2000 m derating)	
Protection level	IP54 (reservoir tank IP68)	
Anti-corrosion level	C4M	
Cooling method	KNAN (degradable oil)	
Insulation level	A	
Sound power level	≤ 70 db	
No-load current	0.55	
No-load loss	3400 W + 15%	4800 W + 15%
Load loss	37004 W + 15%	46210 W + 15%
Total loss	< 40909 W	< 51010 W
Efficiency	> 99%, full load when the power factor is 1	
Temperature rise	Top layer oil 60 K, winding 60 K (at rated capacity)	
Winding material	Aluminum	
Iron core	Oriented silicon steel	
Life	Not less than 25 years	
Transformer oil	Degradable oil	
Transformer total weight	8660 kg	11400 kg
Oil weight	2090 kg	2980 kg

Model	NE-4000-MV-UL	NE-5000-MV-UL
Oil volume	2272 L	3239 L
Insulation level	HV side: BIL 95/AC 34kV, HV neutral point HVN: BIL 95/AC 34kV LV side: BIL 35/AC 10 kV	HV side: BIL 150/AC 50 kV, HV neutral point HVN: BIL 125/AC 40 kV LV side: BIL 35/AC 10 kV
Overload capacity	1.1 times long-term overload at 35°C	
Color	RAL7035 matte	
Conditions of use	Outdoor	

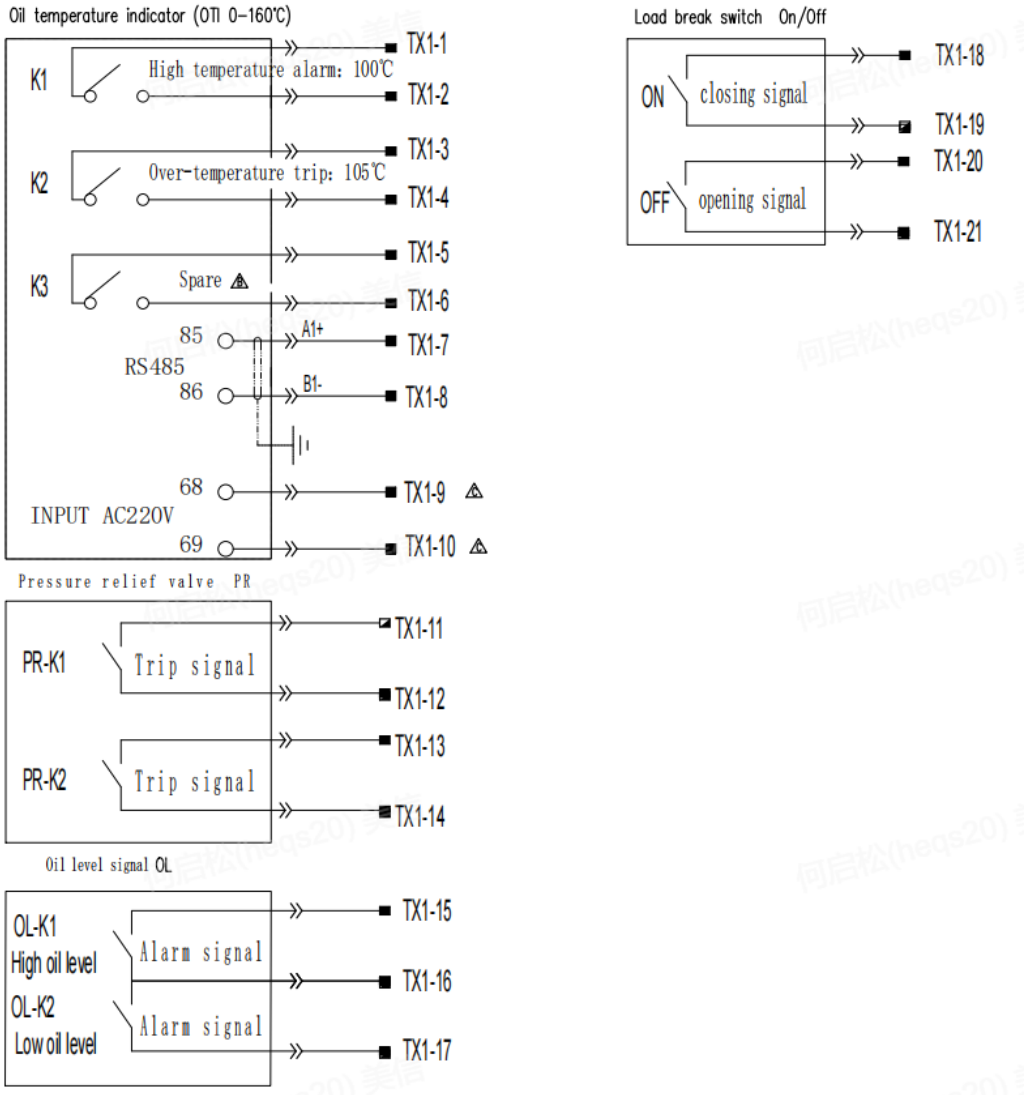


Figure 4-14 Secondary diagram of oil-immersed transformer

4.4.2 Distribution Cabinet

The primary wiring diagram of the distribution cabinet inside the medium voltage substation is shown in the figure below. This is only an example; for details, refer to the document of the primary wiring diagram of the distribution cabinet.

For detailed information about external wiring, refer to 7.5.2 Distribution Cabinet Connection.

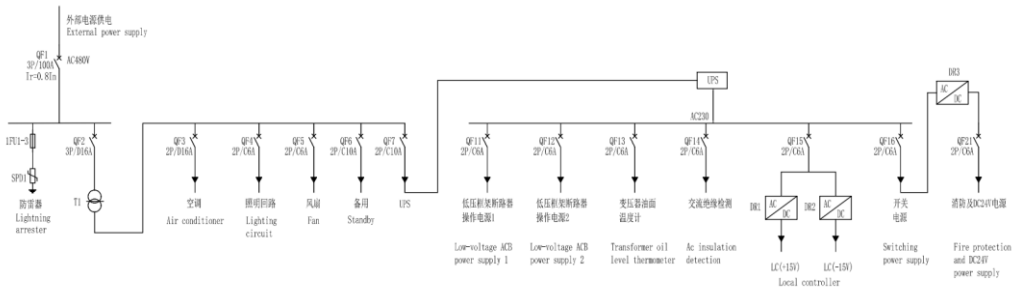


Figure 4-15 Primary wiring diagram of the distribution cabinet (unit: mm)

4.4.2.1 Appearance

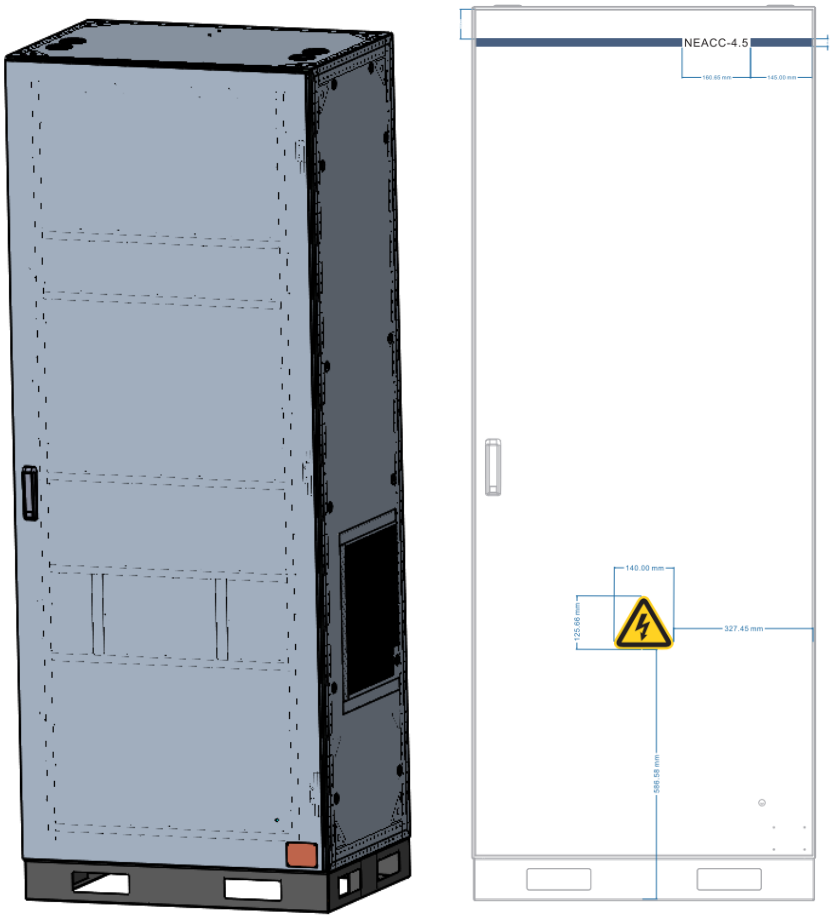


Figure 4-16 Appearance of the distribution cabinet

4.4.2.2 Components

Table 4-4 Component description

Designation	Purpose
QF1	Incoming molded case circuit breaker
QF2	Primary side switch of transformer
1FU1-3	Surge protective device backup protection
SPD1	Surge protective device
T1	Transformer
QF3	Air conditioner power supply
QF4	Lighting power supply
QF5	Fan power supply
QF6	Backup circuit
QF7	UPS input power supply
UPS	Uninterruptible power supply
QF11	Low voltage frame circuit breaker operating power 1
QF12	Low voltage frame circuit breaker operating power 2
QF13	Oil level temperature gauge power supply
QF14	AC insulation monitoring power supply
QF15	15 V switching power supply
QF16	24 V switching power supply
QF21	24 V load equipment power supply
QF31	UPS battery pack power supply protection switch

4.4.3 ACB Cabinet

4.4.3.1 Appearance

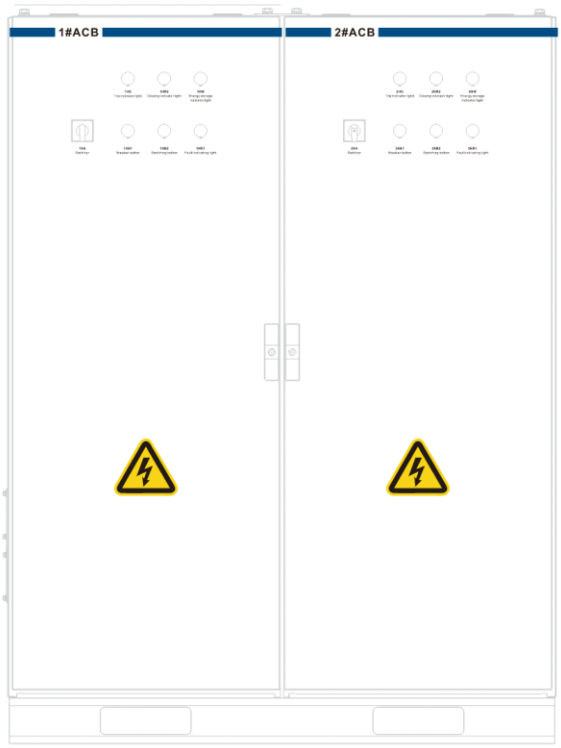


Figure 4-17 Appearance of the ACB cabinet

Table 4-5 Component description (For details, refer to Chapter 9)

Designation	Description
1HW, 2HW	The white lights in the first line
1HR1, 2HR1	The red lights in the second line
1HR2, 2HR2	The red lights in the first line
1HG, 2HG	The green lights in the first line
1SA, 2SA	The rotary switches in the second line
1SB1, 2SB1	The red buttons in the second line
1SB2, 2SB2	The green buttons in the second line

Local/Remote changeover switch 1SA and 2SA using instructions:

“1” indicates local operation, “2” indicates remote operation, and “0” indicates maintenance.

4.4.3.2 Electrical System

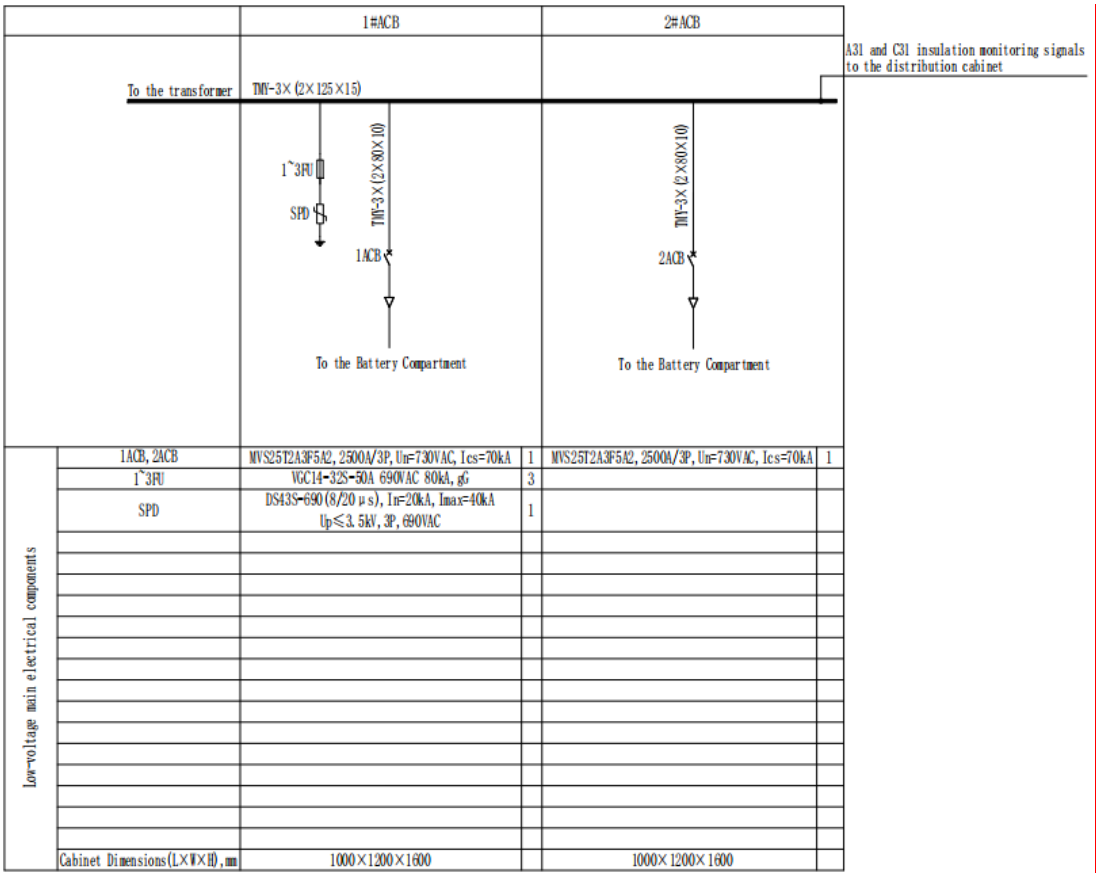


Figure 4-18 Electrical system

4.4.3.3 Technical Parameters

Table 4-6 Technical parameters of ACB cabinet

Item	Specification
Model	MVS25T2A3F5A2, 2500A/3P (fixed type)
AC connection method (isolation method)	Three-phase three-wire
Rated current (@40℃)	2500 A

Item	Specification
Rated voltage	730 V AC
Short circuit breaking capacity	70 kA
Breaking time	25 ms
Closing time	< 70 ms
Rated impulse withstand voltage	12 kV
Ambient temperature	–25°C to +70°C
Storage temperature	–40°C to +85°C
Operational altitude	2000 m (derated at 3000 m)
Mechanical life C/O cycles × 1000	20 (maintenance) / 10 (no maintenance)
Electrical life C/O cycles × 1000	6 (no maintenance)
Dimensions (H ×W ×D)	1600 × 1200 × 1000 mm
Impulse withstand voltage	12 kV
Rated insulation voltage	1250 V
Maximum rated operating voltage	730 V

4.4.4 Auxiliary Transformer

4.4.4.1 Appearance

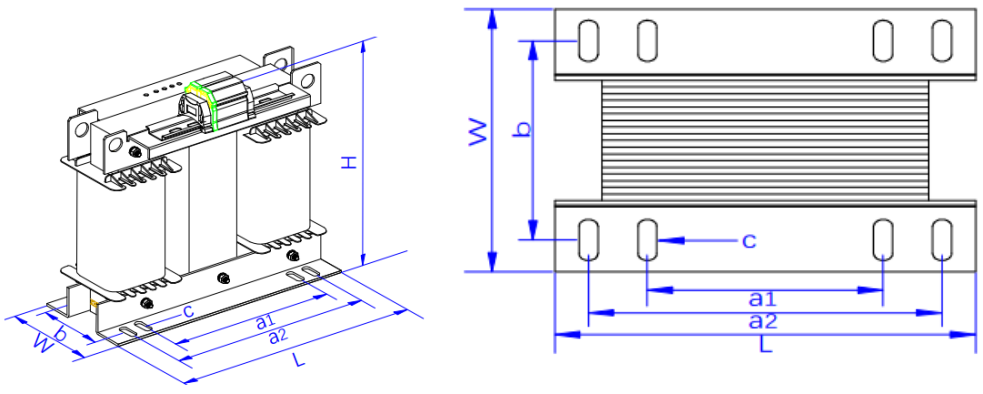


Figure 4-19 Appearance of the auxiliary transformer (unit: mm)

4.4.4.2 Technical Parameters

Table 4-7 Technical parameters of the auxiliary transformer

Item	Specification
Model	TT3 4500-3×480/2×220
Rated capacity	4.5 kVA
Frequency	50–60 HZ
Installation method	Indoor installation
Grid side voltage	2 × 220 V
Valve side voltage	3 × 480 V
Connection group	Vv
Rated grid side current	20.5 A
Rated valve side current	9.74 A
Harmonic current	/
Short circuit impedance	2.26%
Rated impulse voltage (current)	I^Inrush / I^nom-Factor≤19
Insulation temperature Rating	F
Temperature rise	< 95 K
Ingress protection (IP) rating	IP00
Cooling method	AF (cooling airflow 3 m/s)
Loss power	≤ 337.4 W
No-load loss	≤ 107.6 W
Load loss	≤ 229.8 W
Electrical clearance	≥ 7 mm
Creepage distance	≥ 9.6 mm
Noise	< 50 dB
Flammability rating	UL94 V0
Storage temperature	–40℃ to +80℃
Operating temperature	–25℃ to +45℃
Relative humidity	< 85%
Pollution level	P2--vacuum impregnation
Transportation conditions	Logistics

Item	Specification
Insulation resistance	≥ 5 MΩ
AC withstand voltage	Input–Output: 4800 V AC Input–Ground: 4800 V AC Output–Ground: 3000 V AC
Corrosion resistance rating	C3 (indoor installation)
Efficiency	95.82%
Weight	Approx. 75 kg

5 Transportation and Storage

5.1 Precautions

The medium voltage substation adopts a skid-mounted structure and is delivered by a professional freight company. Before transportation, it is necessary to communicate and confirm the unloading location and operation window with on-site personnel to ensure a smooth delivery process. The unloading of the equipment from the truck and its movement to the final installation position should be carried out by qualified construction personnel, unauthorized operation is strictly prohibited.

 Warning	Throughout the unloading and transportation process, the operation safety regulations of the project location must be strictly adhered to. ● All lifting equipment, tools, slings, etc., must be inspected beforehand and maintained in good condition. ● All personnel involved in handling and securing operations must receive corresponding safety operation training.

 Caution	If the equipment is damaged due to handling errors, moisture, impacts, etc., it may affect the validity of subsequent warranty services.

 Caution	During the transportation process, always keep in mind the basic mechanical parameters of the medium voltage substation: ● External dimensions (W×D×H): 6058 mm × 2438 mm × 2896 mm. ● Total weight: ≤ 19000 kg.

5.2 Lifting Requirements

5.2.1 Safety Instructions

 Warning	• The entire lifting process must strictly adhere to the crane's safety operating procedures. • No personnel should be present within 5m～10m of the operation area. In particular, no personnel should stand under the crane arm or beneath lifted or moving machinery to prevent personal injury accidents. • In case of adverse weather conditions, such as heavy rain, dense fog, strong winds, etc., crane operations should be halted.

When lifting the medium voltage substation, the following requirements must be met:

- Ensure on-site safety during the lifting process.
- During hoisting and installation operations, a professional should supervise the site throughout the process.
- The strength of the hoisting slings used should be sufficient to meet the requirement of lifting at least 20 tons.
- Ensure that all connections of the hoisting slings are safe and reliable, and that the slings connected to the corner fittings are of equal length.
- The length of the lifting sling can be appropriately adjusted according to the actual site requirements.
- During the entire lifting process, it must be ensured that the medium voltage substation remains stable and does not tilt.
- Please use the four top corner pieces of the medium voltage substation to carry out the lifting operation.
- Take all necessary auxiliary measures to ensure the safe and smooth lifting of the medium voltage substation.

Figure 5-1 provides a diagram illustrating the crane operation during the lifting process of the medium voltage substation. In the figure, the inner dotted circle indicates the crane's working area. When the crane is in operation, no one is allowed to stand within the outer solid circle!

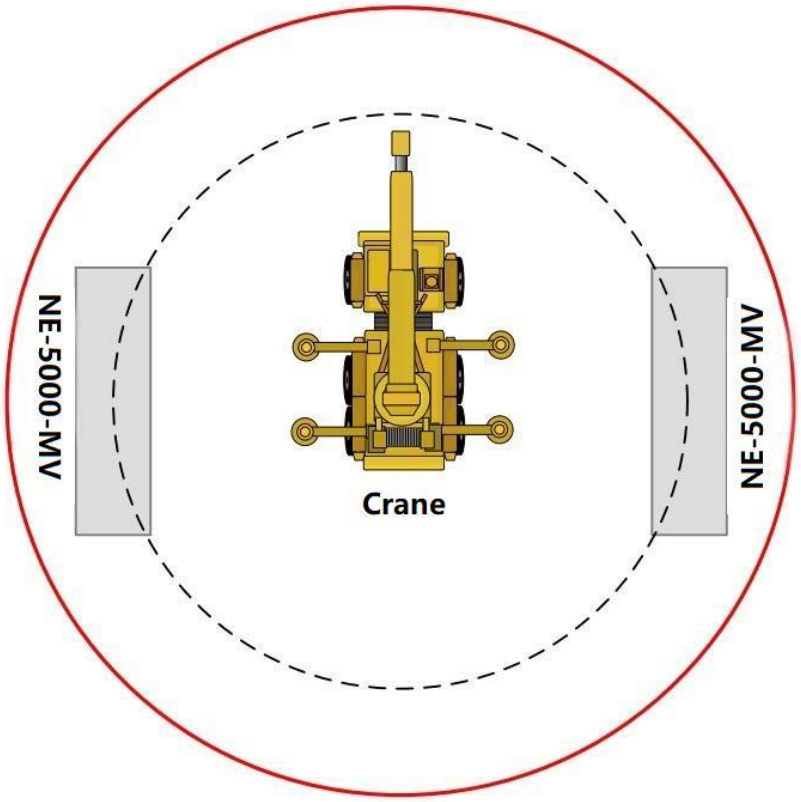


Figure 5-1 Crane operation diagram

5.2.2 Lifting Operations

During the lifting of the medium voltage substation, the operation stages should be carried out according to the following requirements:

- The medium voltage substation should be lifted vertically, and there should be no dragging along the ground or over the top of lower boxes during lifting. The medium voltage substation should not be pushed or dragged across any surface.
- After the medium voltage substation is lifted 300 mm off the support surface, it should be paused to check the connection between the lifting equipment and the medium voltage substation. Lifting may continue only after confirming that the connections are secure.
- After the medium voltage substation is in position, it should be gently lowered and placed steadily. It is strictly prohibited to place the medium voltage substation in areas other than the designated landing zone by swinging the lifting equipment.
- The site for placing the medium voltage substation should be solid and even, with good drainage, and free of obstructions or protrusions; on the site, the medium voltage substation should only be supported by the four bottom corner pieces.

Due to site conditions, use non-vertical force to lift the medium voltage substation through the top holes of the four top corner pieces, as shown in Figure 5-2.

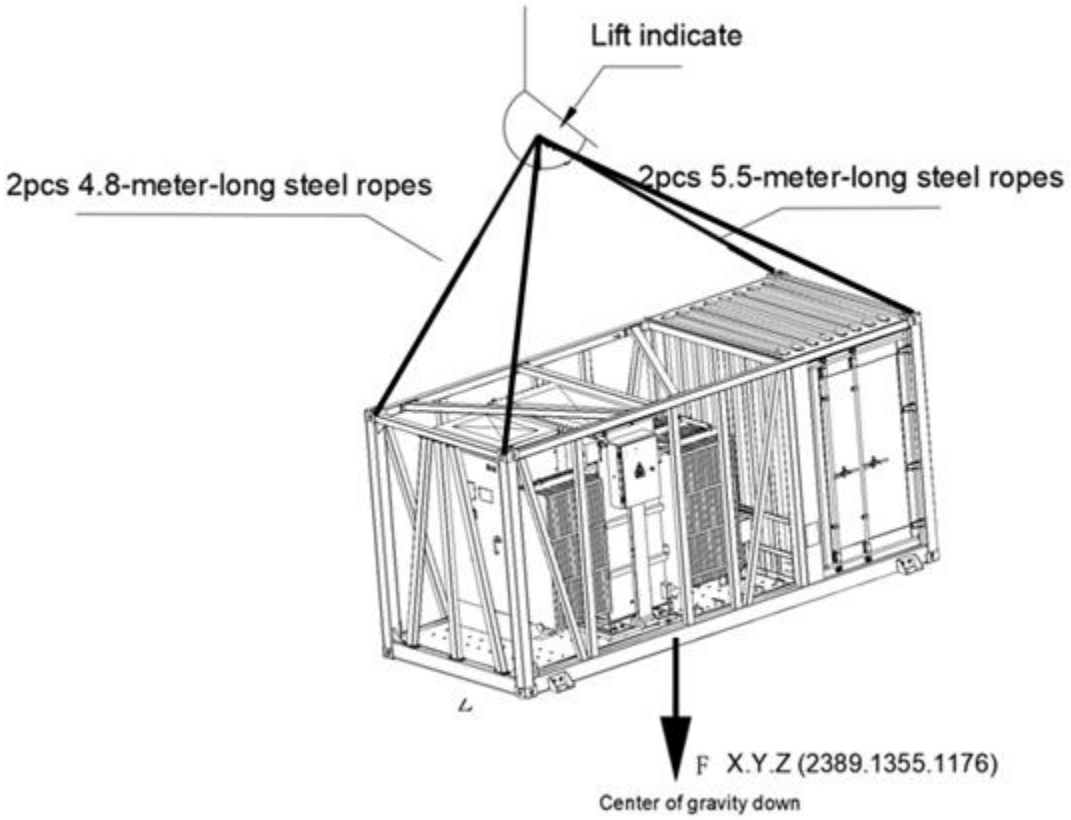


Figure 5-2 Lifting schematic diagram

Warning	Do not modify the lifting point positions or add unauthorized lifting tool interfaces without authorization!

5.2.3 Fastening of Connectors

Lifting operations can be performed on the medium voltage substation using slings with lifting hooks or U-bolts. The lifting device should be correctly connected to the medium voltage substation body, as shown in Figure 5-3.

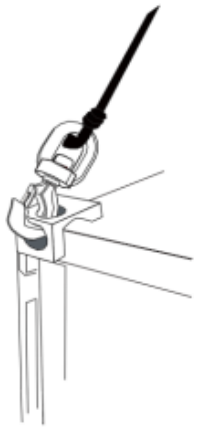
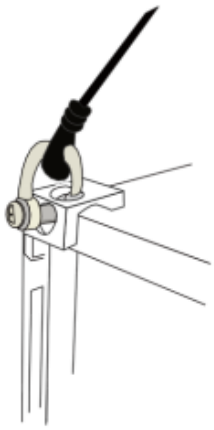
Lifting device	Hook	U-hook
Connections		
Notice	Insert the hook from inside to outside.	Lateral pin of the U-hook should be tightened.

Figure 5-3 Fastening of connectors

Warning	The equipment manufacturer shall not be liable for any personal injury or property damage caused by violation of relevant requirements or other safety regulations.

5.3 Transportation Requirements

Warning	● Transportation must strictly comply with all current national/regional safety operating standards and specifications. ● All personnel engaged in crane and transportation operations must receive safety training.

Caution	Transportation of the medium voltage substation should be carried out under better weather conditions as far as possible, avoiding operations in strong winds, heavy rain, and other extreme weather conditions.

Transportation and on-site handling must meet the following operating specifications:

- The equipment has been reinforced as a whole before leaving the factory, and the undercarriage structure has the strength for road transport;
- All compartment doors should be securely locked before shipment, and must not loosen;
- Select lifting equipment with suitable tonnage and lifting radius according to site conditions, the selected tools must have sufficient load-bearing capacity, boom length, and swing radius.

- Remove all obstacles that exist or may exist during transportation and movement, such as trees, cables, etc., to ensure the path is completely unobstructed.
- If the path has a slope, stable auxiliary equipment should be configured, such as pull ropes, wedges, or wheel blocks;
- Avoid transporting under extreme weather conditions such as strong winds, heavy rain, etc.
- The device must be labeled with complete markings, including but not limited to:
  - center of gravity position markings
  - lifting point warning markings
  - moisture-proof, anti-tilt, anti-vibration, etc., pictorial labels

5.4 Storage Conditions

If the device cannot be installed and operated immediately after delivery and on-site acceptance, it should be stored according to the following requirements to ensure its performance and structure are not damaged, and to meet the safety and long-term storage standards of the location.

 Caution	If the storage period is long, the uninterruptible power supply (UPS) must be inspected and maintained regularly, including but not limited to visual inspection, topping up battery charge. Refer to *Maintenance Manual* for detailed operations.

Table 5-1 Storage environment requirements

Item	Recommended
Temperature range	–30°C to +50°C
Relative humidity	≤ 90% RH, non-condensing
Floor requirements	Dry, level, with insulation properties, must not be conductive or damp
Storage requirements	Indoor or semi-enclosed structure with shading, rain protection, dust protection, and ventilation

- It is recommended to perform routine status inspections every 15 days, including but not limited to integrity of appearance, protective structure, signs of rust, and effectiveness of desiccant.
- For equipment stored long-term, the cabinet should be opened for an inspection before installation, and if necessary, insulation and electrical performance should be tested by a professional.

- The control cabinet comes pre-installed with a desiccant, which must be hung on the inside of the cabinet door or on the designated position on the side wall, away from electrical components.
- Check the desiccant condition every 30 days. If the indicator color shows that it has absorbed moisture to saturation, replace it immediately.
- During storage, avoid frequently opening and closing the cabinet door to prevent damage to the sealing structure and the introduction of moisture.

6 Mechanical Installation

This chapter describes the basic structural construction, environmental adaptation requirements, and mounting methods after the equipment has been installed on the ground, ensuring good structural stability and safety during system operation. For requirements related to transportation and lifting, please refer to Chapter 5, which are not detailed in this section.

The medium voltage substation is transported to the project site by a freight company, and the on-site management personnel will be notified in advance to arrange for delivery and unloading. After delivery, the movement of the medium voltage substation to its final position must be carried out by the on-site construction personnel.

6.1 Pre-installation Inspection

 Warning	Installation can only proceed after confirming that there is no damage, internal or external, to the medium voltage substation!

 Caution	● Before installation, please check the on-site installation list of the project to ensure that all delivered components are present. ● Verify that the cabinet received matches the ordered model. ● Inspect the external and internal equipment of the medium voltage substation to ensure there is no damage. If any problems are found or if there are any doubts, please contact the transporter or the equipment supplier promptly.

6.2 Foundation Construction Requirements

6.2.1 Site Requirements

When selecting an installation site, please follow at least the following principles:

- The climate environment and geological conditions (such as stress wave emission, groundwater level) of the medium voltage substation installation site should be fully considered.
- Stay away from residential areas to prevent noise interference or even vandalism.

- Choose a suitable installation location, and stay as far away as possible from hazardous sites where flammability, explosivity, or corrosion may occur, such as chemical plants, fireworks factories, etc.
- The soil at the installation site needs to have a certain level of compaction. It is recommended that the relative density of the installation site soil ≥98%. If the soil is loose, it is imperative to take measures to ensure the stability of the foundation.
- Fully consider the surrounding local environment; ensure there are no trees or sand nearby the installation position to prevent blockage of ventilation or fire protection pipes.

6.2.2 Foundation Requirements

 Warning	The medium voltage cabinet is heavy; before constructing the foundation, a detailed survey of the installation site's various conditions (primarily geological and climatic conditions) should be conducted. Only on this basis can the design and construction of the foundation begin.

When constructing the foundation, the following requirements must be met:

- The bottom of the foundation pit must be compacted and leveled (flatness ≤ 5 mm).
- The foundation must provide sufficient load-bearing support for the medium voltage cabinet.
- It is recommended to elevate the medium voltage cabinet to prevent rainwater from eroding the base and interior. The foundation height should be at least 600mm above ground level to accommodate the oil collection tray.
- Construct a cement foundation with sufficient cross-sectional area and height. The foundation height is determined by the construction party based on the site's geology.
- Consider cable routing when building the foundation.

6.2.3 Recommended Scheme

This section provides a foundation construction plan (as shown in Figure 6-1) for user reference.

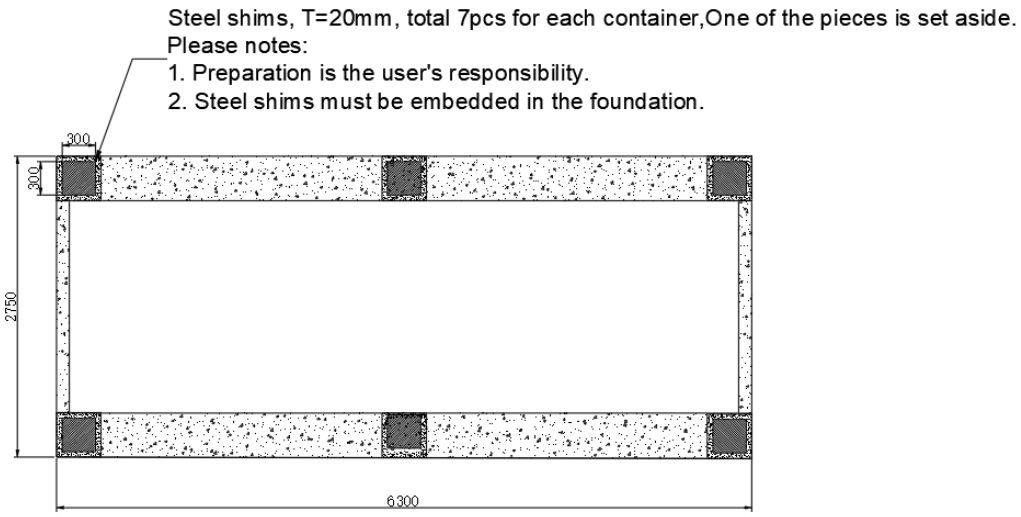


Figure 6-1 Foundation installation diagram (unit: mm)

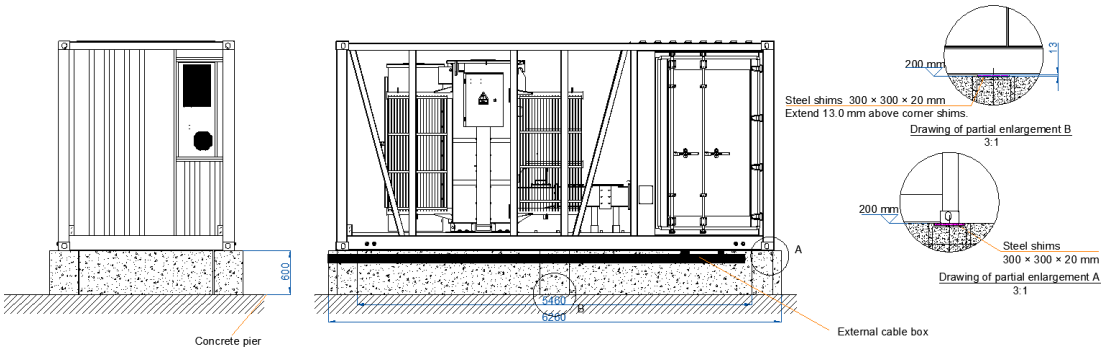


Figure 6-2 Foundation installation rendering (unit: mm)

Recommended foundation cross-sectional area (length × width): 6300 mm × 2800 mm.

- A maintenance platform should be built around the foundation to facilitate future maintenance and repair work. Recommended maintenance platform dimensions (length × width): 8500 mm × 5000 mm.
- Cables must enter and exit through the holes at the bottom of the medium voltage substation, based on their location and size. When constructing the foundation, reserve positions for AC and DC side cable trenches, and pre-bury the threading pipe.
  - Recommended cable trench dimensions (width × depth): 2650 mm × 1900 mm.
  - The specifications and quantity of the threading pipe should be determined based on the selected cable model and the number of incoming and outgoing lines.
- A steel plate no less than 300 mm × 300 mm (as shown in the foundation installation diagram) must be pre-buried in the foundation surface to weld the medium voltage

substation base to the foundation after mechanical installation. The pre-buried steel plate must be level with the rest of the foundation's upper surface. The pre-buried steel plate must be robust and reliable.

- The base should have a sump at the bottom with a dedicated drain-pipe installed.
- At the steel plate locations on the diagonal of the foundation, 50mm×5mm galvanized steel sheets should be pre-embedded as grounding bodies, with a recommended burial depth of 0.8m. One end of the steel plate is welded to the main grounding grid of the power station, and the other end is welded to the pre-embedded steel plate on the foundation. Ensure that both welds are secure.
- It is recommended to construct steps at the positions of the medium voltage substation maintenance door, escape door, and equipment installation and maintenance door to facilitate staff entry. Suggested step height: 150mm; depth: 300mm. The width and number of steps should be reasonably selected based on the site conditions.
- Both ends of all pre-buried pipes need to be temporarily sealed to prevent debris from entering, otherwise it will be unfavorable for subsequent cable laying.
- After all electrical connections are completed, the cable entry and exit points should be sealed to prevent small animals such as insects and rodents from entering.
- For other recommended dimensions, please refer to the above figure (Figure 6-1/2) and the drawings.

6.2.4 Environment Requirements

 Caution	**Environmental requirements:** ● Ambient temperature within a certain range (For details, refer to 4.1.3 General Parameters). ● Reserve sufficient space around the unit (top, bottom, left, right) to ensure ventilation and heat dissipation, installation and maintenance, and safe emergency egress.

 Caution	**Floor requirements:** ● The medium voltage substation should be installed on a flat surface made of fire-retardant material or on a channel steel support structure, and the ground must not show any concavities or tilts. ● The foundation must be solid and provide a reliable safety guarantee. It must have the load-bearing capacity to support the weight of the medium voltage substation. Always consider its weight when selecting the installation location.

6.2.5 Clearance Requirements

Caution	• When installing the medium voltage substation, an appropriate distance must be maintained between the walls or other equipment to meet the requirements for the narrowest maintenance passage, escape route, and ventilation. • There should be sufficient space around the installation location of the medium voltage substation to facilitate installation, heat dissipation, and maintenance. • Refer to the standard specifications NFPA 850, section 3-2.4.3 “Outdoor Oil-Insulated Transformer Separation Criteria” for clearance.

It is recommended to place the clearance in all directions as shown in the following figure:

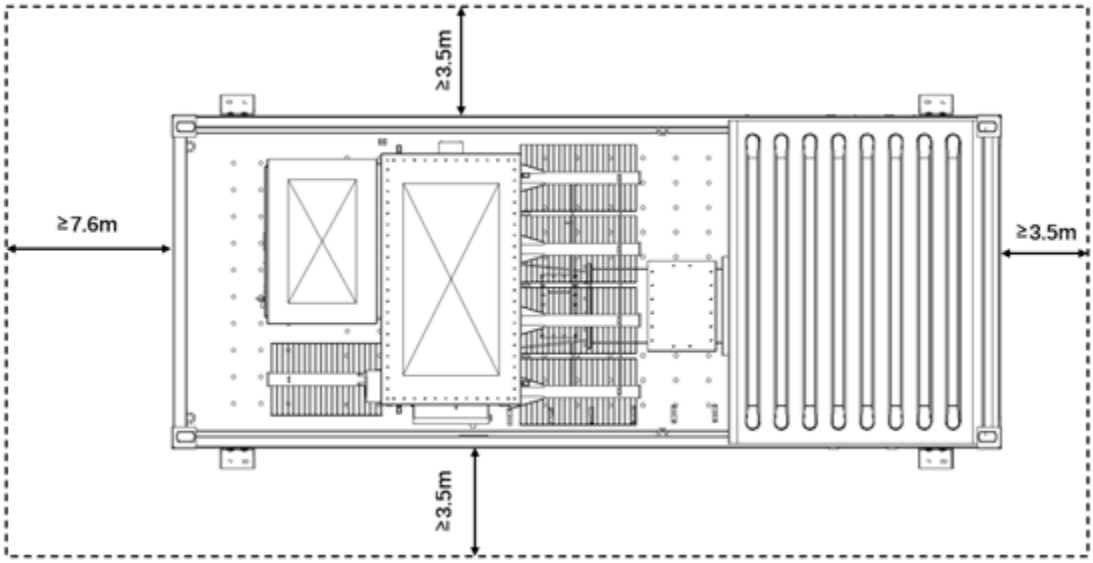


Figure 6-3 Clearance for single device installation (unit: mm)

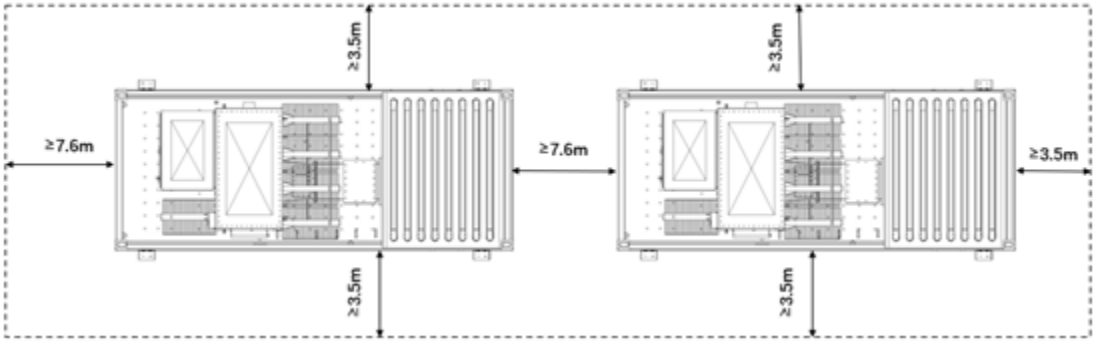


Figure 6-4 Clearance for multiple devices installed side by side (unit: mm)

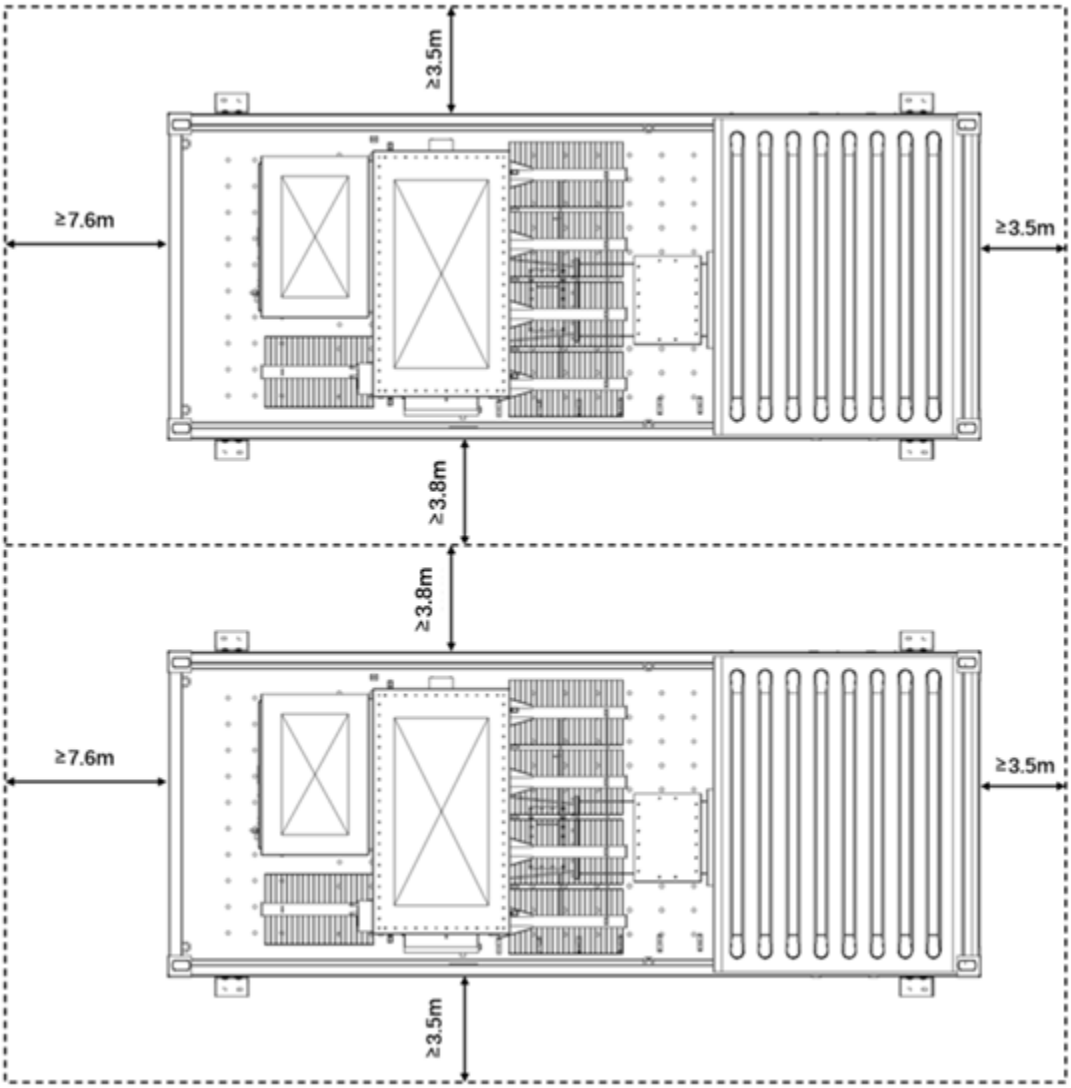


Figure 6-5 Clearance for multiple devices installed back to back (unit: mm)

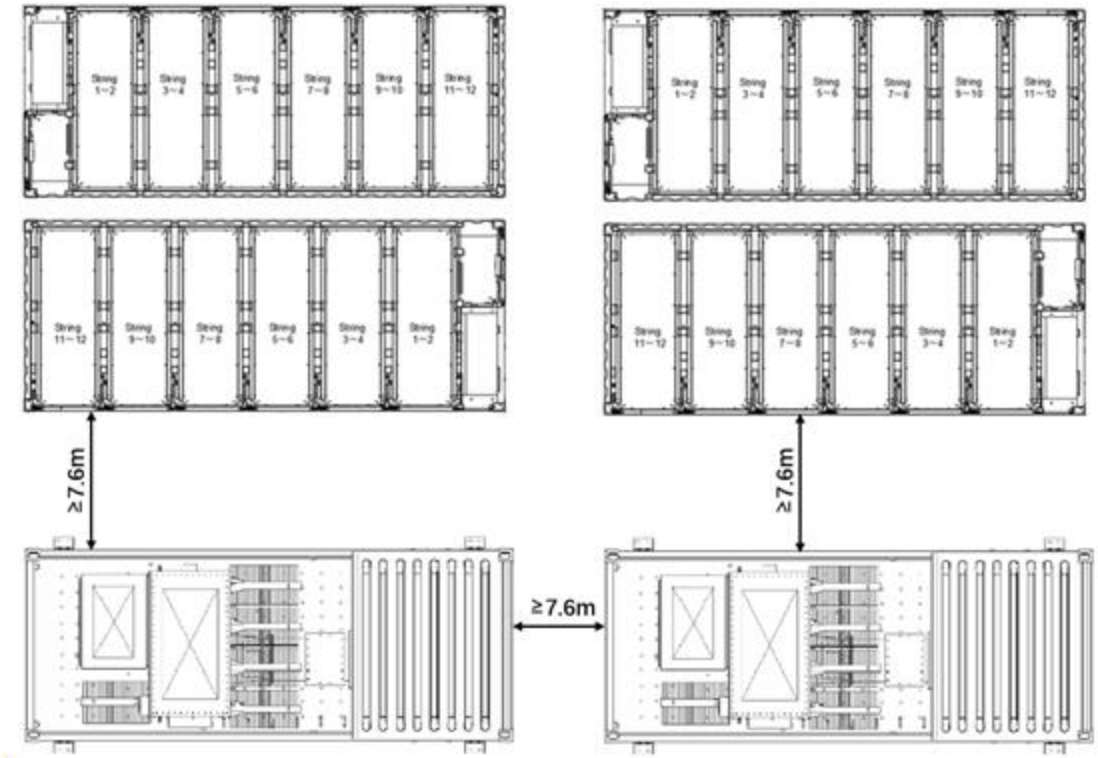


Figure 6-6 Suggested layout A for installation between BESS and MVS (unit: mm)

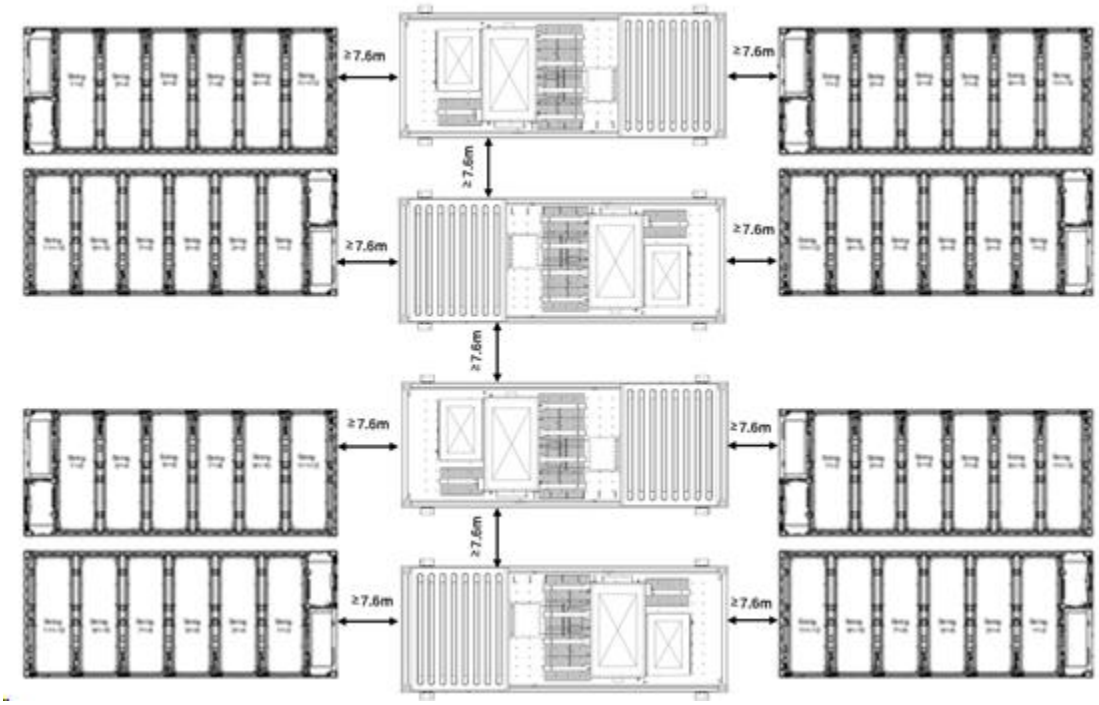


Figure 6-7 Suggested layout B for installation between BESS and MVS (unit: mm)

Caution	The above are suggested layout diagrams, which can be adjusted according to actual conditions, but please ensure compliance with local regulations.

6.3 Equipment Positioning and Fixing

6.3.1 Positioning and Placement

- After positioning the equipment, ensure that the anchor holes of the base are aligned with the foundation anchor bolts without any forced misalignment;
- After the lifting and installation are completed, professional personnel should guide to ensure vertical positioning and stable contact.

6.3.2 Leveling and Anchoring

- The maximum difference at the four corners should not exceed 5 mm; uneven areas can be leveled using gaskets or grouting.
- Recommended fixing method: high-strength expansion bolts or chemical anchors;
- Bolt tightening reference values: M16 (100–120 N·m), M20 (180–200 N·m);
- All exposed parts must have a corrosion protection level of C4 or higher.

6.3.3 Recommended Fixing Scheme

- Fixing scheme one

Weld the angle steel at the bottom of the medium voltage substation securely to the embedded steel plate on the foundation. After welding is completed, the interface between the underside of the medium voltage substation and the foundation should be sealed with suitable sealing material and treated for corrosion resistance, as shown in Figure 6-8.

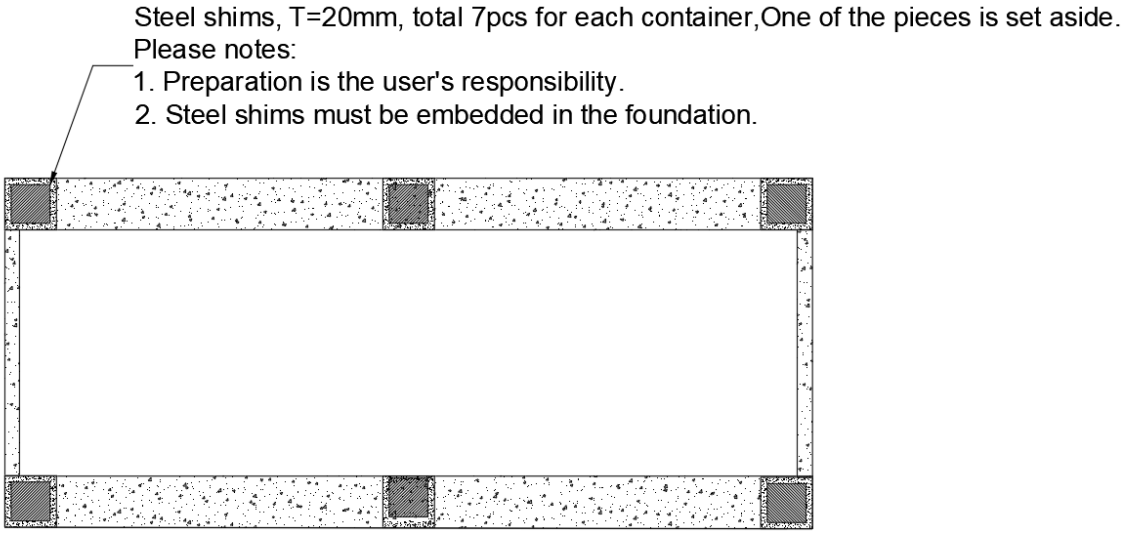


Figure 6-8 Schematic diagram of fixing plan one

- Fixing scheme two

Use M16 bolts to fix the medium voltage substation to the pre-buried foundation through the fixing slot holes on the base of the medium voltage substation. After fixation, the interface between the bottom surface of the medium voltage substation and the foundation should be sealed using appropriate sealing material and treated against corrosion, as shown in Figure 6-9 (unit: mm).

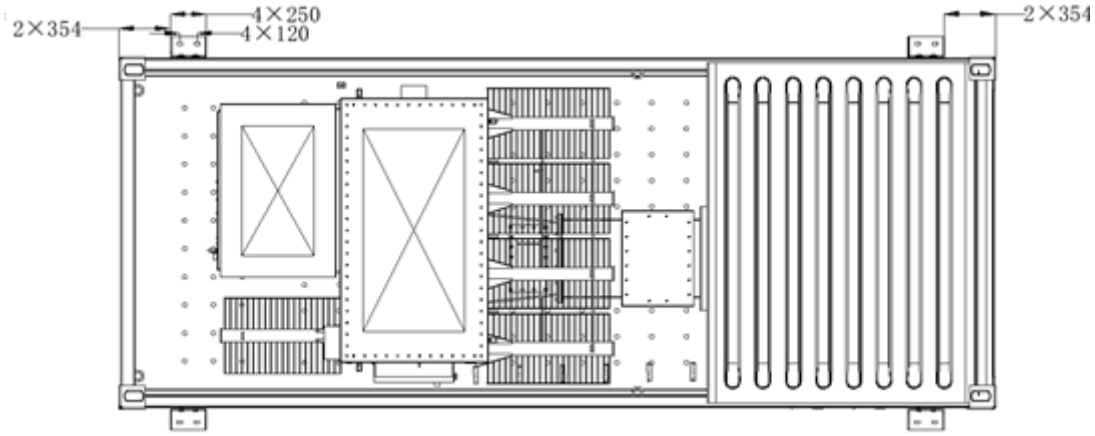


Figure 6-9 Schematic diagram of fixing plan two

6.4 Environmental Adaptability Design

After installation, check whether the ground around the equipment has a drainage slope. If there is a risk of rainwater accumulation at the site, additional measures such as drainage ditches, permeable layers, or collection wells should be added. Avoid the foundation being in a moist state for a long time, which can affect the structural stability and electrical grounding performance.

It is recommended to clear vegetation within a 500mm radius around the equipment foundation and lay root barrier fabric; cable openings should be sealed and fitted with a metal mesh cover to prevent small animals from entering; no temporary items or flammable materials should be piled up in the surrounding area.

Caution	After the equipment foundation is handed over, it must be jointly inspected by the civil construction unit, the installation party, and the supervisory engineer, focusing on checking the dimensional deviation, anchoring status, grounding resistance, and environmental treatment measures. After completion, the relevant documents should be filled out and archived.

7 Electrical Installation

7.1 Precautions

 Danger	**High voltage risk** The equipment contains high voltage components during operation, and some capacitors may still retain residual charge after power off. Failure to adequately discharge and confirm before wiring, or performing live wiring, can result in severe bodily injury. ● Before wiring, the main power supply and auxiliary circuits must be completely disconnected. ● Before operation, multiple-point voltage testing should be completed to ensure no residual voltage. ● Unauthorized personnel are strictly prohibited from entering the wiring area or touching the terminals.

 Danger	Before operation, please ensure that you thoroughly and carefully read the following precautions, and all content in Chapter 1 “Safety Guidelines”.

 Warning	**Qualifications and regulatory compliance** ● All electrical connection work must be performed by qualified electrical professionals only. ● You must comply with national and local electrical standards and regulations. ● Before connecting the system to the public power grid, authorization approval from the grid operating unit is required. ● Any wiring that does not conform to the manual specifications may lead to system malfunction or fire.

 Warning	**Environmental condition limitations** Poor construction environments can affect equipment performance and may even lead to safety incidents.

	● Electrical work is prohibited in high humidity (relative humidity > 95%) or sandy and dusty environments. ● All cable entry points and seams must be sealed to prevent moisture and foreign objects from entering.

 Warning	**Cable connection requirements** ● Wiring must be tightened to the specified torque; both too loose and too tight connections may cause overheating or poor contact. ● Power cables and communication cables should be laid separately to avoid electromagnetic interference. ● Cable laying paths should be fixed using supports or clamps to avoid suspension or mechanical tension. ● Do not use damaged or inferior cables; fire protection cables must use flame-retardant/fire-resistant cables.

 Warning	**Precautions for communication connections** ● All shielded cables should be grounded at one end at the equipment end, and must not be grounded at both ends. ● Do not plug or unplug terminal blocks while powered during wiring.

 Caution	**Preparations before wiring** ● Before wiring, ensure that the insulation of each cable is good and meets local specifications. ● All cables must be clearly marked according to the wiring diagram in this manual to avoid incorrect connections. ● Terminal lugs should be crimped with specialized tools and must comply with relevant standards and regulations.

 Caution	**Compliance responsibility** ● The installation and connection of this equipment must comply with local electrical codes and design drawings. ● If damage or malfunction of the equipment occurs due to non-compliance with the manual, the manufacturer will not be liable.

	● After construction, an inspection should be organized to verify the correctness of electrical connections, the effectiveness of grounding, and the compliance of insulation.

7.2 Wiring Area Diagram

The SPCS system provides standard wiring solutions according to different configurations (0.5C/0.25C). It is recommended to confirm the drawings and verify the site before installation. The recommended parameters in this section are given for 0.5CP as an example; if the system is 0.25CP, please refer to the relevant documentation provided with the shipment.

If you have any questions, please contact the equipment supplier.

7.2.1 System Wiring Diagram and Port Definition

The medium voltage substation consists of two ACB cabinets, one oil-immersed transformer (including a high-voltage oil-immersed load switch and high-voltage fuses), and one distribution cabinet. The detailed area division of each component is shown as follows.

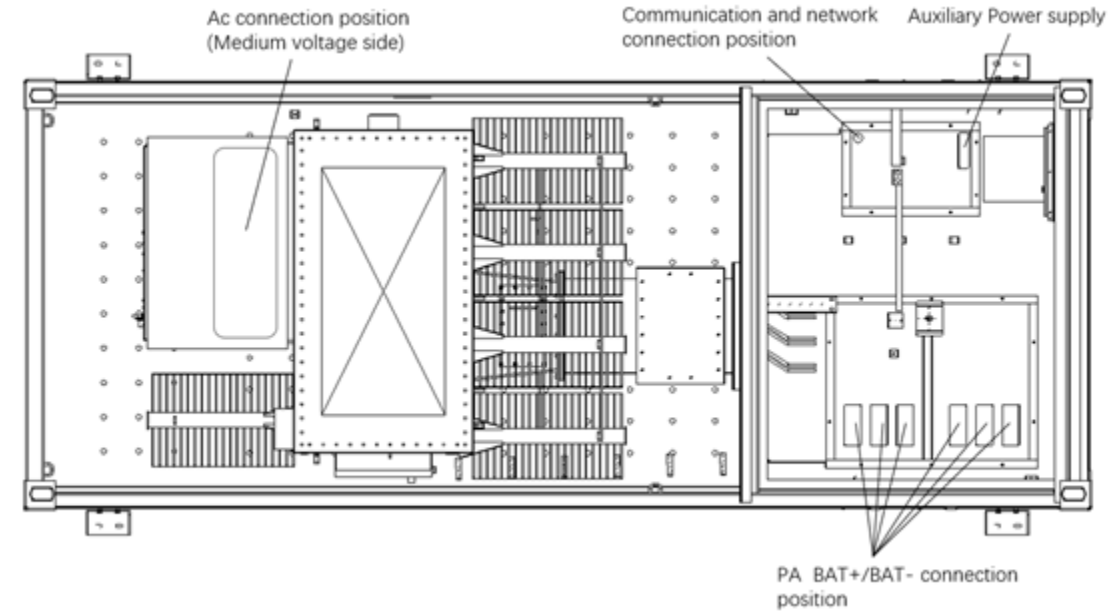


Figure 7-1 Layout of the medium voltage substation

Table 7-1 Wiring area connection methods (taking 0.5CP as an example)

Wiring area	Connection method	Cable/Copper busbar specifications
Energy storage box to ACB Cabinet	Cable connection	Each phase connects 8 wires of 600 kcmil. (For 0.25 CP system,

Wiring area	Connection method	Cable/Copper busbar specifications
		connects 4 wires per phase.)
ACB cabinet to transformer	Copper busbar connection	TMY-3×(2×125×15)
Customer power to low voltage distribution cabinet	Cable connection	According to actual conditions

7.2.2 Additional Explanation

Power Supply Method Selection

The low voltage distribution cabinet auxiliary power supply supports external power supply methods.

UPS Distribution Method

The internal UPS powers the following equipment/devices:

- PCU power
- Insulation monitoring power
- ACB cabinet operation power
- Main transformer oil level temperature gauge
- Fire protection equipment and 24V equipment

Cable selection recommendations:

- Power cable: Select installation method, wire cross-sectional area, and insulating sheath type based on site environmental conditions, and it is recommended to use multi-strand copper conductors.
- Communication cable: Use shielded industrial cable.

Interface cleaning and protection

All unused interfaces should be sealed with fireproof mud to prevent dust and moisture from entering and causing corrosion or short circuit risks.

7.3 Preparations before Wiring

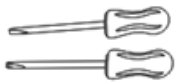
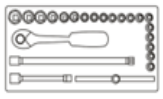
Caution	Before opening, please ensure that the door is not obstructed and wear necessary protective equipment. Please refer to the following steps for the specific door opening operation process: ● Confirm the door is in a locked state and there are no obstructions; ● Rotate the handle protective cover clockwise to expose the keyhole; ● Insert the dedicated door key and rotate it clockwise to the unlocked position; ● Rotate the handle counterclockwise until the front door opens, and use the limiter to secure the door in place.

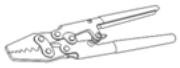
7.3.1 Installation Tools Preparation

Caution	All tools should be calibrated and have an appropriate insulation protection rating; damaged, rusted, or untested equipment and tools must not be used.

Caution	The tools listed in Table 7-2 are for reference only; the selection and use of specific tools should be adjusted according to actual working conditions.

Table 7-2 Installation tool preparation checklist

No.	Tool	Description	Purpose
1		Slotted/Phillips screwdriver	Removing, installing screws
2		Hex key wrench set	Installing, removing screws
3		Socket wrench set	Installing, removing screws

No.	Tool	Description	Purpose
4		Wire stripper	Stripping wire
5		Torque wrench	Torque inspection
6		Crimping pliers	Crimping cable terminals
7		Wire cutters	Cutting wire
8		Multimeter	Measuring voltage, current, and resistance
9		Marker	Drilling, Marking Numbers
10		Tape measure	Cabinet Positioning
11		Hammer	Installing Expansion Bolt
12		Motorized/manual pallet jack	Transporting Equipment
13		Insulating gloves	Electric Shock Protection
14		Insulating withstand voltage tester	Testing the Dielectric Strength of Equipment Insulation

7.3.2 Cable Preparation

 Warning	If the cable is damaged, incorrectly selected, or improperly connected, it may cause a short circuit, overheating, or communication abnormalities, posing safety hazards. Please use only qualified cables that meet the requirements and have the relevant operations performed by a professional electrician.

 Warning	Please strictly follow the specified sequence for wiring, otherwise, it is easy to have an accident. The wiring steps are as follows: Ground wire connection→AC cable connection→BESS connection→communication cable connection.

For detailed cable connection relationships, quantities, recommended models, and cross-sectional areas, please refer to the document “Cable List”.

7.3.3 Cable Entry Design

To ensure the safety and reliability of the equipment, all external cables must be introduced through the pre-set openings at the bottom of the device (see Figure 7-2), and the site should reasonably arrange and protect the cables based on the actual number of cables and the routing direction.

 Warning	● Prohibit cables from crossing the wiring ports in suspension. All holes should be accurately processed according to the external diameter of the cables and equipped with necessary sealing measures to prevent water vapor, dust, or small animals from entering the interior of the equipment. ● All cables must be introduced from the bottom of the equipment; it is prohibited to route them from the sides or top.

 Caution	● If multi-core cables are used, they should be routed reasonably to avoid crossing and overlapping, ensuring that each cable has no compression points or excessive bending after energization. ● On-site, holes should be positioned and drilled according to the cable specifications and quantities, ensuring the locations are appropriate and do not interfere with internal structures.

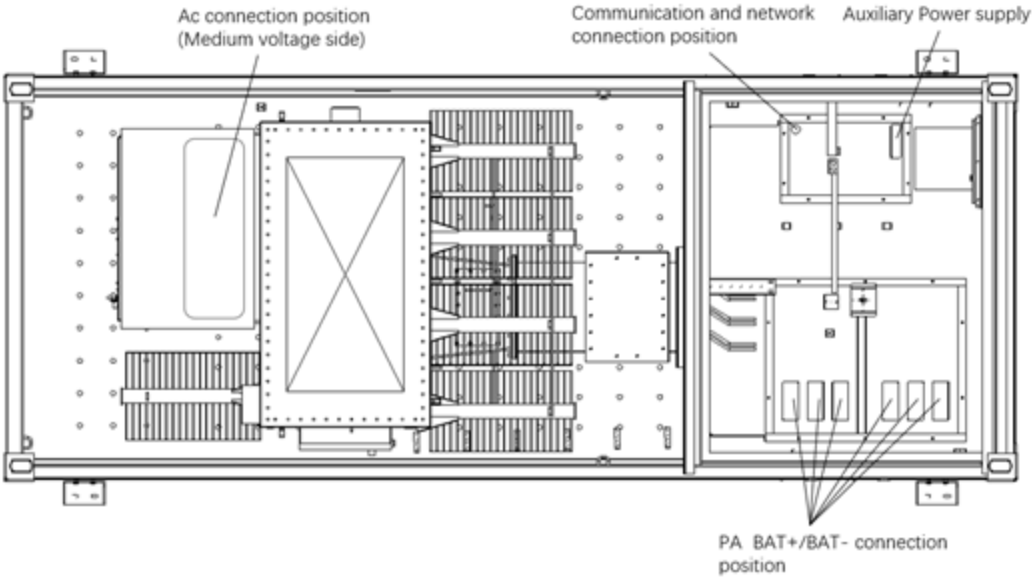


Figure 7-2 Cable inlets/outlets at the bottom of the medium voltage substation (unit: mm)

7.4 Grounding and Equipotential Bonding

Danger	● Poor grounding can lead to energized equipment enclosures, abnormal communication, and even personnel electrocution; all grounding operations must strictly follow the specifications. ● Construction should be carried out by personnel with electrical qualifications.

Warning	Unauthorized changes to grounding methods or omissions in anti-corrosion treatment can lead to equipment failure; the manufacturer does not assume responsibility for any consequences arising therefrom.

Caution	● At the foundation stage, grounding electrodes or flat steel should be embedded. ● For high-resistance soils, it is recommended to install a ring grounding network. ● Grounding weld points require anti-corrosion treatment, such as hot-dip galvanizing or anti-corrosion coatings.

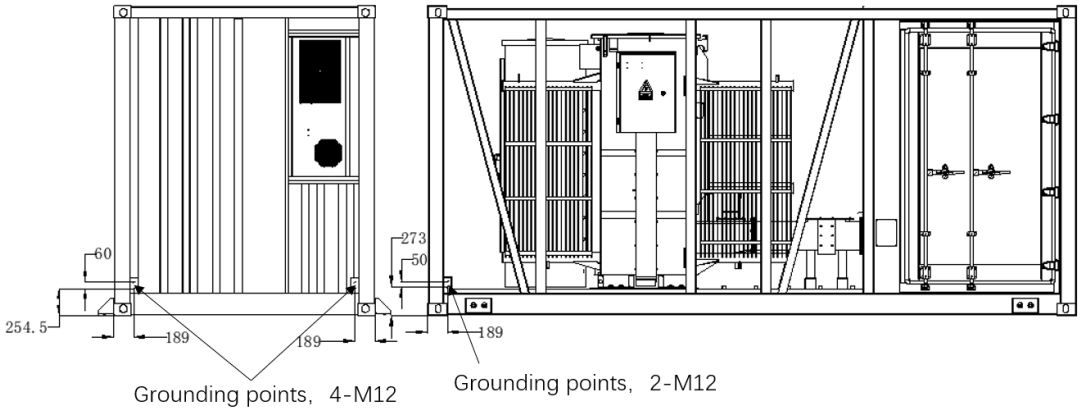


Figure 7-3 Schematic diagram of front grounding points (unit: mm)

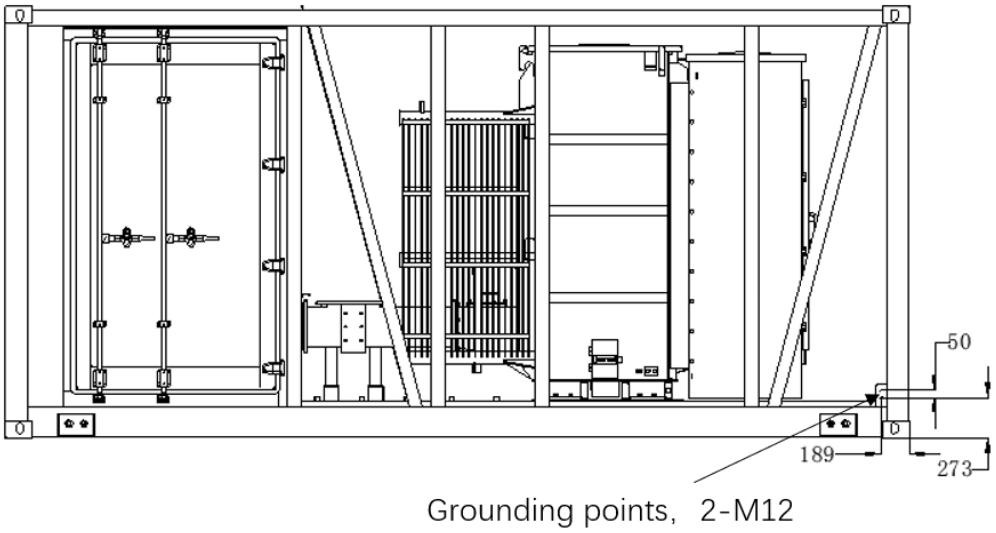


Figure 7-4 Schematic diagram of rear grounding points (unit: mm)

7.5 Low Voltage Side Connection

The low-voltage side connection is used to electrically connect the AC output of the energy storage system to the medium voltage equipment and to power the internal auxiliary systems. The operation must be performed by qualified electricians, and the specific requirements for each module are as follows.

Danger	• Any power supply connection operations must not be performed while live. • Operations must be conducted by personnel with electrical qualifications.

Warning	• All main power cables must be connected according to the L1/L2/L3 phase sequence; connection sequence must not be reversed. • All terminations should be completed with insulation testing and phase sequence verification to ensure accuracy before energizing.

7.5.1 ACB Cabinet Connection

The ACB cabinet, also known as the molded case circuit breaker cabinet, is referred to simply as the ACB cabinet. It aggregates power from multiple energy storage boxes via three-phase alternating current cables. Each set of power lines should correspond to the molded case circuit breaker module inside the ACB cabinet and be connected according to phase sequence requirements. Figure 7-5 shows the specific wiring positions within the ACB cabinet.

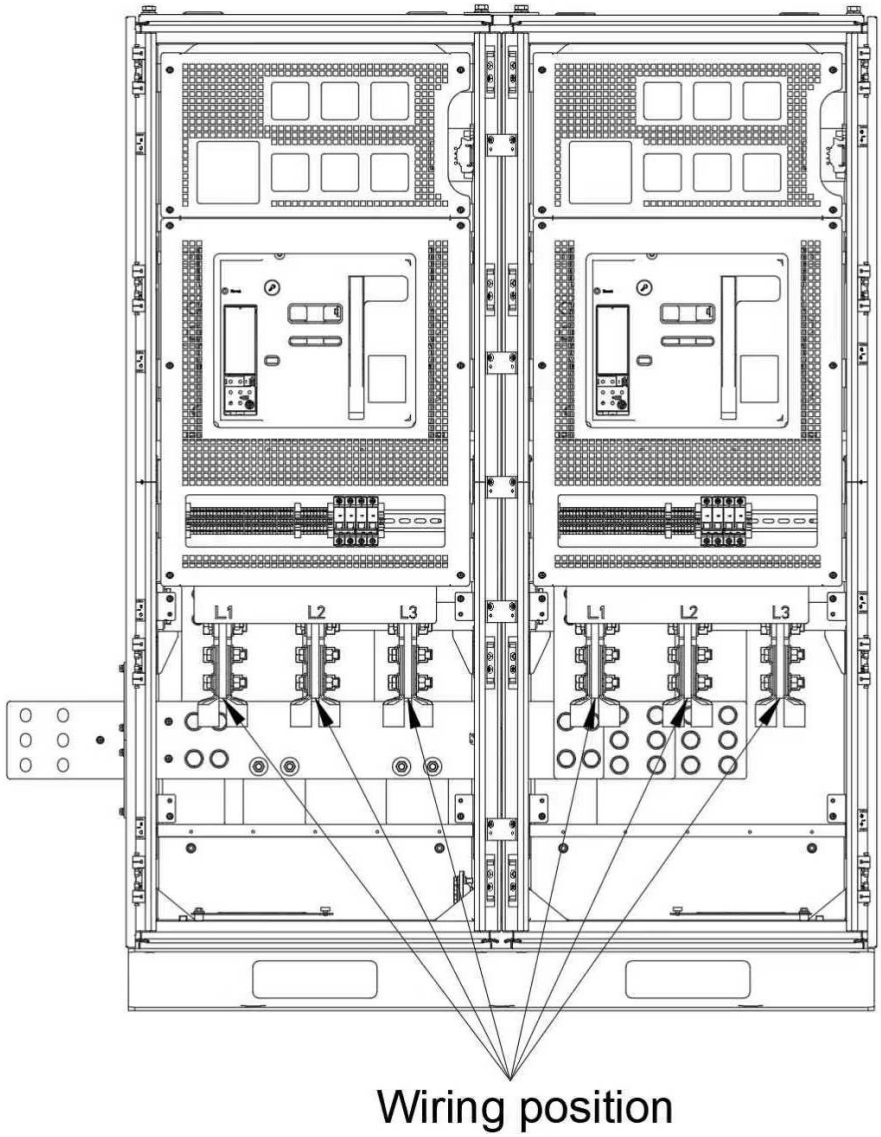


Figure 7-5 Schematic diagram of ACB cabinet wiring area

Table 7-3 Recommendations for external wiring of ACB cabinet

Corresponding wiring position	Connection method	Recommended specifications	Busbar terminal hole specifications
Energy storage box to ACB cabinet	Cable connection	Connect 4-8 copper wires of 600 kcmil per phase.	/
ACB cabinet to transformer	Copper busbar connection	TMY-3×(2×125×15)	/

When wiring, it is recommended to follow the steps below:

Step 1. Route the main power cable through the bottom cable entry hole to the wiring area, and mark the L1/L2/L3 phases accordingly.

Step 2. Use a wire stripper to remove the cable insulation, leaving an appropriate length of bare copper conductor.

Step 3. Crimp DT-type terminals, refer to 7.3.2 Cable Preparation for detailed instructions.

Step 4. Connect the terminal to the corresponding terminal strip, and tighten the M12 bolt with a torque of 61–94 N·m.

Step 5. After completing the wiring, it is necessary to recheck and confirm that the connections are secure and that the reserved cable length meets the requirements.

7.5.2 Distribution Cabinet Connection

 Caution	For the external wiring cables in the distribution cabinet, the cable laying factor, environmental temperature factor, and cable material must be considered based on the design conditions.

 Caution	Communication wiring and power lines must be laid separately to avoid electromagnetic interference affecting communication quality.

The schematic of the external wiring for the distribution cabinet is as follows:

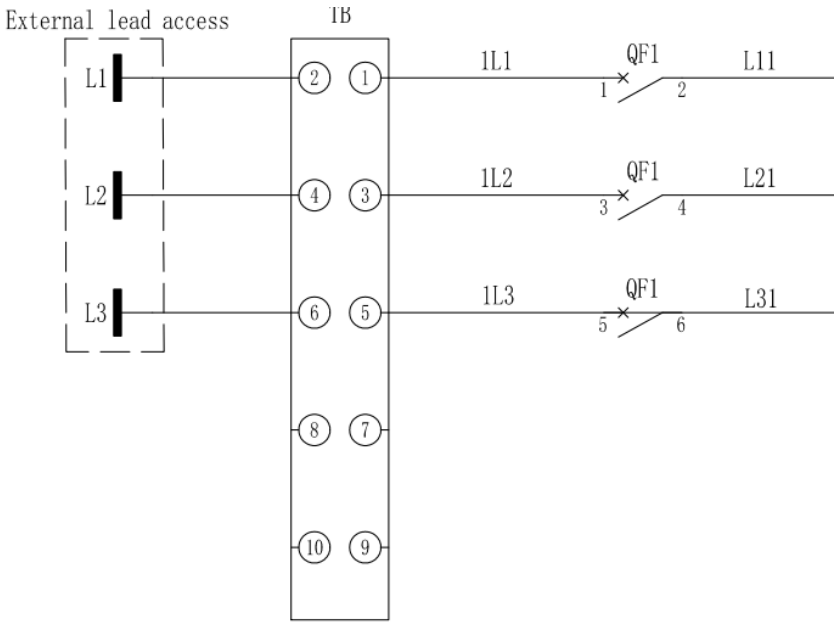


Figure 7-6 Electrical schematic of external wiring for the distribution cabinet

Table 7-4 Recommendations for external wiring of the distribution cabinet

Corresponding wiring position	Cable specifications recommendations	Busbar terminal hole specifications
TB:2 (L1)	It is recommended to use copper wire with a cross-sectional area of no less than 25 mm².	
TB:4 (L2)	It is recommended to use copper wire with a cross-sectional area of no less than 25 mm².	
TB:6 (L3)	It is recommended to use copper wire with a cross-sectional area of no less than 25 mm².	

The power supply line for the low-voltage distribution cabinet is introduced from the outside, as detailed in the following table:

Table 7-5 Power supply modes for the distribution cabinet

Power supply mode	Power source description	On-site connection required
External power supply	The customer provides a three-phase 480Vac power supply, which is connected to the internal TB terminal block of the low-voltage distribution cabinet	Yes

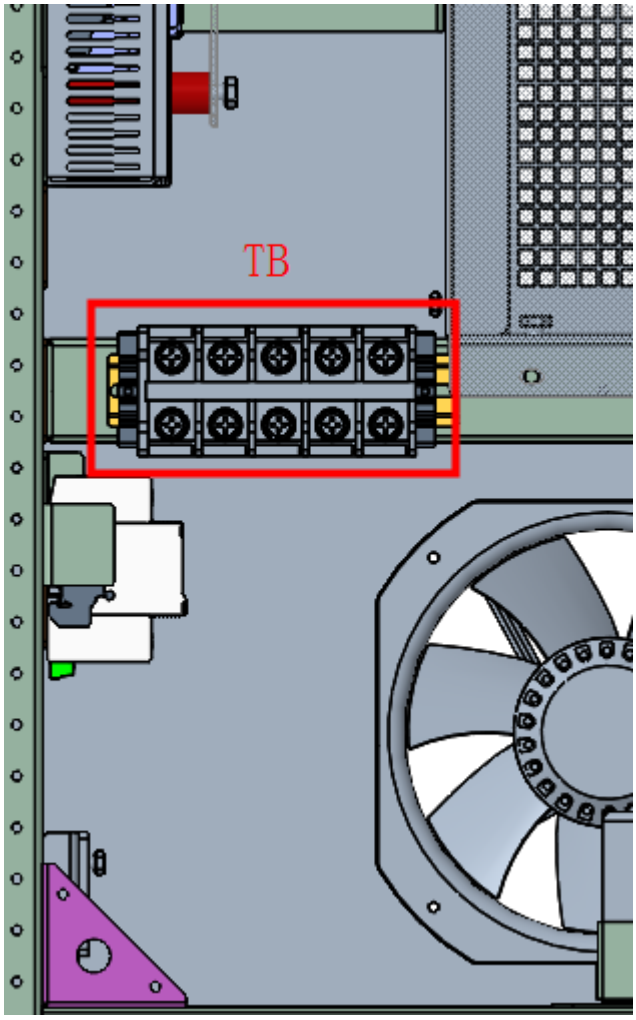


Figure 7-7 Schematic of external power supply connection point for distribution cabinet

The low-voltage distribution cabinet provides auxiliary power to the medium voltage substation, which mainly supplies power to air conditioning, fans, lighting, electricity meters, operation power, etc.

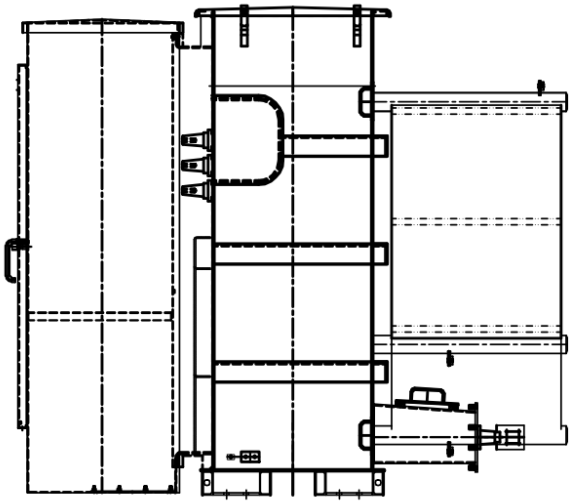
7.6 Medium Voltage Side Connection

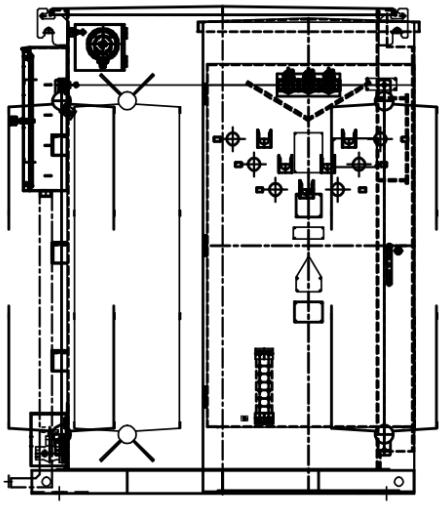
Warning	Medium voltage connections must be performed by personnel with a medium voltage operation certificate.

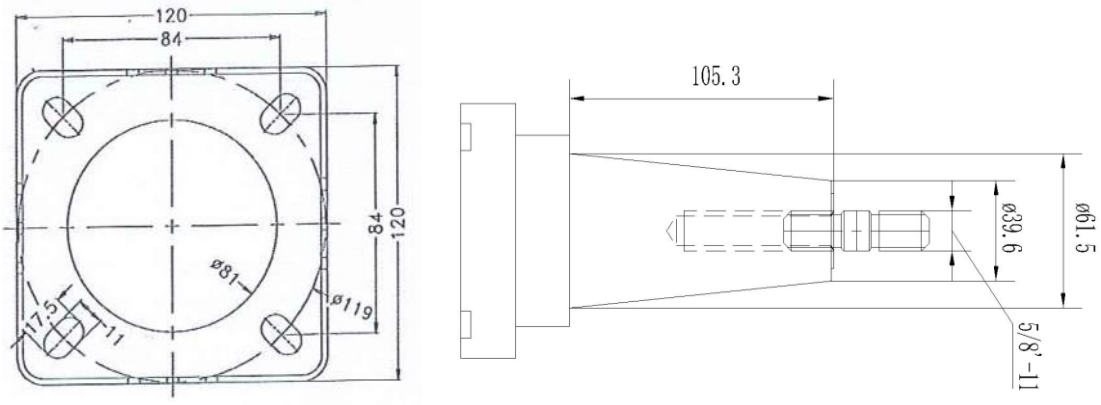
This chapter primarily introduces the location of the cable terminal connections and the recommended cable specifications.

7.6.1 Connection Area

The connection area for medium voltage cables is shown in the figure below.







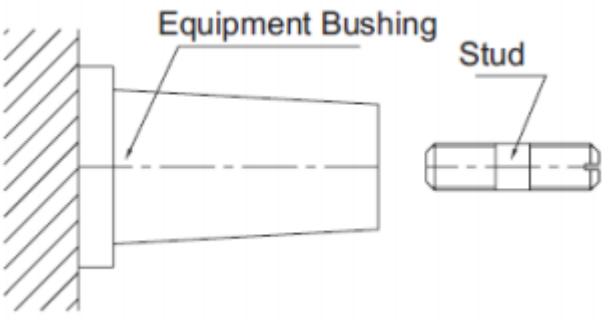
Note: The connection bolts for the insulator are 5/8 inch-11UNC-28, made of copper. It is recommended to use copper materials when connecting the insulator.

7.6.2 Connection Requirements

Medium voltage cables must be equipped with type C connection plugs.

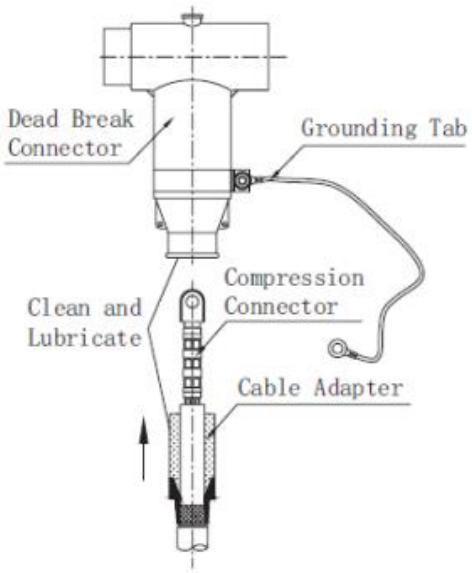
7.6.3 Installation Procedure

Step 1. Screw the threaded stud into the insulator nut hole until the bottom.

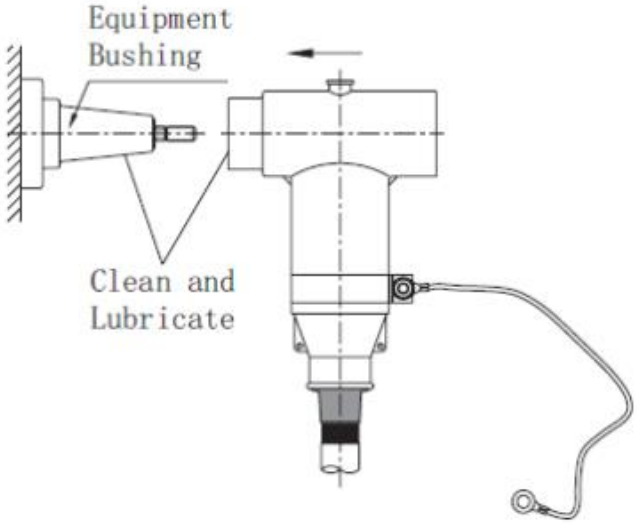


Note: The double-ended studs are made of copper and have a tin plating coating.

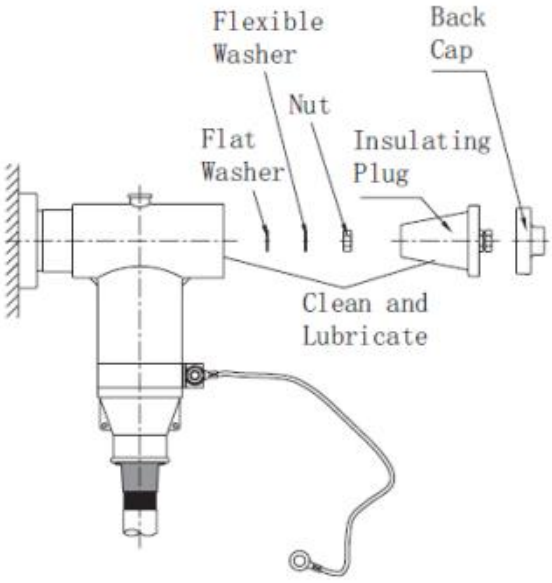
Step 2. Clean the cable adapter and the deadbreak connector. Lubricate the outer surface of the cable adapter and the inner surface of the deadbreak connector. Insert the compression connector into the deadbreak connector until the compression connector opening is centered on the deadbreak connector.



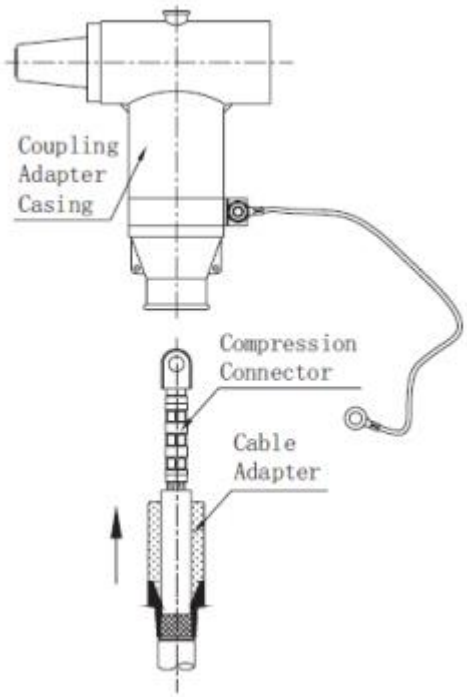
Step 3. Clean and lubricate the bushing, then install the deadbreak connector.



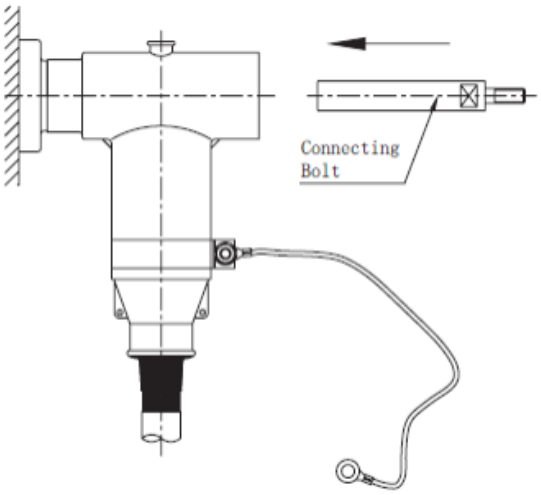
Step 4. Install the back cover.



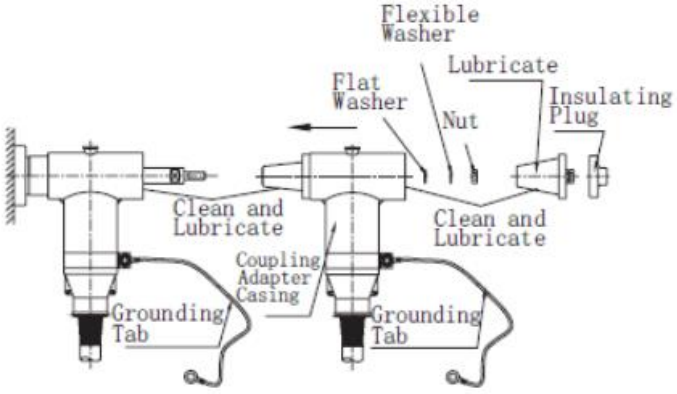
Step 5. Connect the coupling adapter housing to the cable adapter.

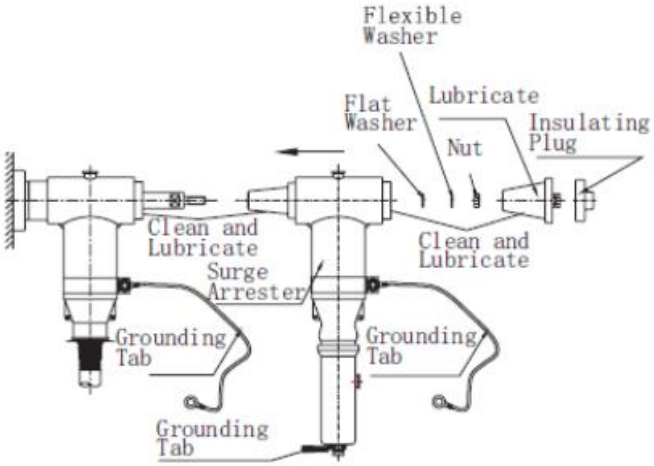


Step 6. Install the connection bolts.



Step 7. Clean and lubricate the deadbreak connector, coupling adapter, and insulation plug, then connect them.


Flexible Washer
Lubricate
Flat Washer
Insulating Plug
Nut
Clean and Lubricate
Clean and Lubricate
Coupling Adapter Casing
Grounding Tab
Grounding Tab


Flexible Washer
Flat Washer
Lubricate
Insulating Plug
Nut
Clean and Lubricate
Clean and Lubricate
Surge Arrester
Grounding Tab
Grounding Tab
Grounding Tab

7.7 Communication Port Connection

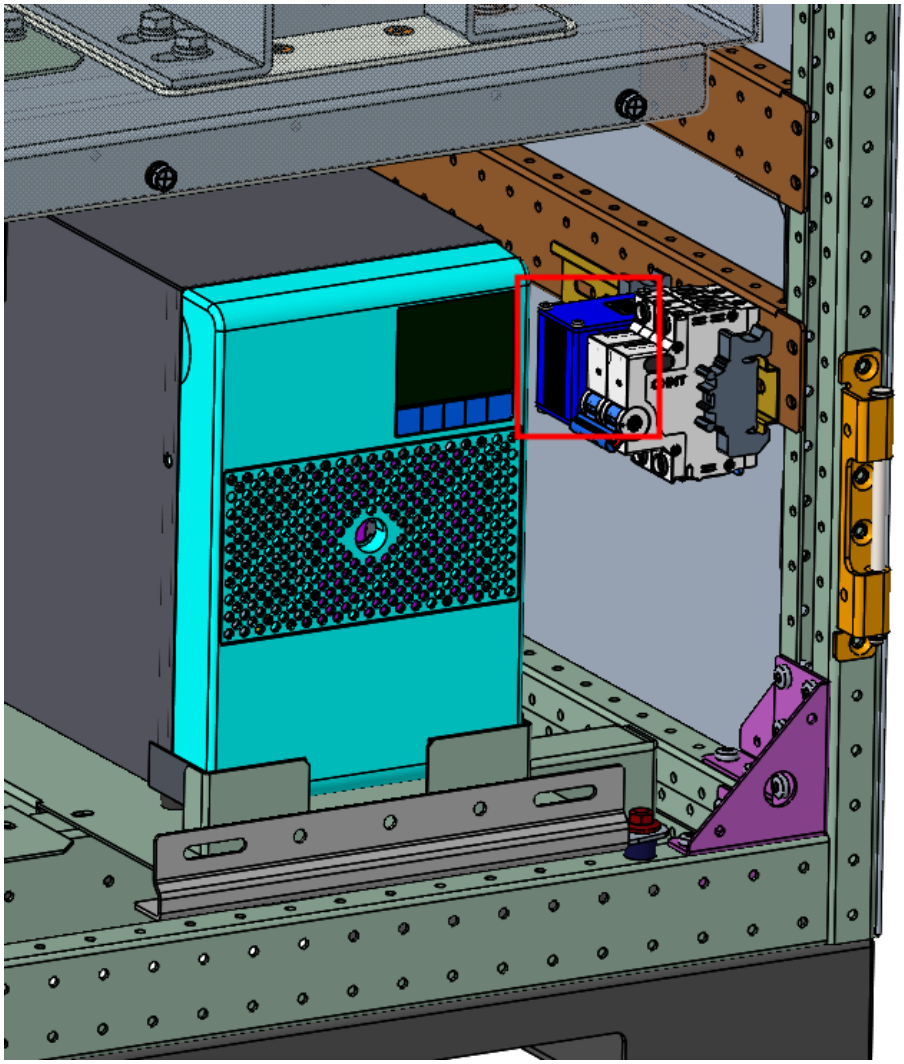


Figure 7-8 Communication interface schematic

Caution	• To prevent external interference, it is recommended to use shielded network cables; • The connector must be securely locked to prevent loosening; • It is recommended to use industrial-grade switching equipment and interface modules.

7.8 UPS Module and Battery

Figure 7-9 UPS module

Caution	● The UPS module is a consumable component; if it remains under-voltage for a long period, it may fail. It is recommended to establish a regular maintenance schedule. ● Before and after installation, if the UPS remains powered off for a long time, it must be powered on for 24 hours, and this should be done at least once every 6 months (under normal storage conditions with a temperature below 25℃). This action will charge the UPS battery, thus preventing possible irreversible damage. ● It is recommended to check the UPS status monthly and to connect it to an external AC power source for recharging and maintenance.

For more details on UPS usage methods, operational restrictions, and inspection and maintenance cycles, please refer to the maintenance manual and UPS user manual.

7.9 Procedures after Electrical Wiring

After all communication and power wiring is completed, to ensure the safe operation of the equipment and environmental sealing, users must perform the following checks and sealing procedures.

	If the wiring area is poorly sealed, it may cause the following risks, which can affect the stability of the equipment's operation and even pose serious safety hazards: ● Moisture intrusion, leading to corrosion of electrical connections. ● Rodent intrusion, which can chew through cables or cause short circuits.

7.9.1 Wiring Area Inspection

- All connection terminals should be fully tightened, check for no looseness, misconnections, or omissions.
- Cable distribution should be clear and tied neatly, to avoid loosening of connections due to tensile stress.
- All cables should maintain adequate clearance from adjacent connectors, meeting safety insulation distance requirements.
- Unused interfaces must be blocked, to prevent moisture or foreign objects from entering.

7.9.2 Sealing and Protection Treatment

- Seal cable entry/exit holes using fire clay or waterproof sealing tape.
- Check that air inlet/outlet ports are not blocked, ensuring smooth equipment ventilation.
- If a waterproof connector is used, make sure the thread lock is properly tightened.
- Clear any foreign objects from the wiring area to avoid accumulation that could affect subsequent operations or heat dissipation.
- Reinstall all protective covers to ensure they are properly installed and securely fastened.

7.9.3 Sealing Procedure

- Reinstall the protective cover in the reverse order of disassembly.
- Ensure all screws are tightened, and there are no obvious gaps between the cover plate and the case.
- Close the box door and lock it, remove the key and keep it properly.

 Caution	Before closing the door, make sure to check that the sealing strip is intact and not folded or curled to prevent seal failure.

8 Commissioning and Operation

8.1 Pre-commissioning Checklist

After completing the installation of the medium voltage substation, a systematic inspection must be carried out to ensure that it meets the safety operation requirements and can be reliably put into use, including:

- a general inspection of the appearance and overall condition of the equipment
- verification of the robustness and fit of mechanical connections
- inspection of the completeness, accuracy, and standardization of electrical wiring
- testing of insulation withstand voltage performance to confirm that insulation indicators meet standards
- ground continuity tests to ensure the effectiveness of the grounding system
- inspections of the internal conditions of various components

Through the comprehensive testing mentioned above, potential hazards are fundamentally eliminated, providing assurance for the safe and stable operation of the equipment.

8.1.1 General Inspection

Table 8-1 General inspection checklist

Equipment	Check item	Criteria	Inspection method	Result
Medium voltage cabinet	Internal lighting inspection	Lighting fixtures are properly installed, with no damage or looseness.	Visual inspection	
	Cable glands sealing	Fire seal at cable entry points on the bottom of the cabinet is intact.	Visual inspection	
	Neatness	The interior of the cabinet should be kept neat, free from clutter.	Visual inspection	
Frame circuit breaker cabinet	Cabinet door check	Doors of the cabinet and enclosure open and close smoothly, protective panels are installed, and power cables and copper bars cannot be touched directly.	Visual inspection	

Equipment	Check item	Criteria	Inspection method	Result
Low-voltage distribution cabinet	Internal protective panels	Protective panels are installed, and power cables and copper bars cannot be touched directly.	Visual inspection	
Transformer	Overall inspection	For details on inspection items and requirements, see 8.1.5 Transformer Inspection.	Test	

8.1.2 Mechanical Connection Inspection

Table 8-2 Mechanical connection verification checklist

Equipment	Check item	Criteria	Inspection method
Medium voltage cabinet	Appearance	No noticeable scratches, no distortion, no damage, device LOGO/plate markings meet requirements	Visual Inspection
	Cabinet sealing	Sealing strips around the cabinet are well adhered without gaps, damage, aging, or lifting, meeting IP protection rating, no water leakage/light leakage	Visual, Airtightness Test
	Equipment installation fixation	Levelness ≤ 5mm/m	Level
		Base bolt torque meets requirements	Torque wrench retest
	Cooling duct	Keep clear, no obstructions blocking	Visual inspection
	Door lock mechanism inspection	Box door hinge rotates normally without obstruction	Manual inspection

8.1.3 Electrical Connection Inspection

- The connection phase sequence between the medium voltage substation oil-immersed transformer and the power grid is correct, and the tightening torque at the connection points meets requirements.

- The connection phase sequence between the medium voltage substation ACB cabinet and the battery compartment is correct, and the tightening torque at the connection points meets requirements.
- The grounding of the medium voltage substation is complete, secure, and reliable.
- The cable specifications and models comply with design drawings, the wiring phase sequence and polarity are correct, the cable connection points tightening torque meets requirements, and the wiring installation is standard.
- Cable labels are present at both ends, and the labels are correct, clear.
- Communication and dry contact feedback signal lines are connected correctly, and are maintained at a certain distance from the power lines.
- Control cable shield layer grounding: single point connection to the equipotential bonding strip (multiple grounding points are prohibited).
- Communication wiring is correct, and is maintained at a certain distance from other cables.
- Insulation protection cover is complete and reliable, and danger warning labels are clear and securely attached.

8.1.4 Insulation/Withstand Voltage Inspection

The insulation resistance and dielectric withstand test of the oil-immersed transformer must comply with IEEE C57.12.00 standards and related specifications.

8.1.5 Transformer Inspection

Before connecting the medium voltage primary power supply, the following inspection tasks should be performed on the oil-immersed transformer:

- The door of the transformer room is closed and locked.
- There are no cracks, concavities, or scratches on the surface of the transformer.
- There is no oil leakage or blockage in the transformer, and the oil level gauge indicates the lower limit of the normal operation range.
- Inspect the insulation of the transformer to ground, measuring the insulation clearance between the live parts of each voltage level bushing and the grounded components (including the cabinet, frame, etc.), and confirm that it meets the safe operating threshold.
- Verify the clean air clearance between the live parts of different voltage level bushings to ensure compliance with design and standard specifications.
- Remove the locking device from the pressure relief valve.

- The tap changer position indicator of the transformer should match the actual position.

8.2 System Power On/Off

 Warning	Insulating gloves must be worn when energizing or de-energizing!

8.2.1 Power-on Procedure

 Caution	If a circuit breaker trips during energization, stop closing other circuit breakers and immediately check if a short circuit has occurred in the downstream load of the tripped circuit breaker.

Sequence for energizing and low-voltage distribution cabinets:

Step 1. The UPS battery pack switch QF31 shall not be operated under load (equipped with a padlock, which should be installed when no closing or opening operations are being performed to prevent accidental operation by personnel).

Step 2. Close QF1, QF2, and QF3 to QF7 in sequence.

Step 3. Close QF11 to QF16, and QF21 in sequence.

Step 4. Close QF31.

8.2.2 Power-off Procedure

Step 1. Disconnect QF21, and QF11 to QF16 in sequence.

Step 2. Disconnect QF3 to QF7, QF2, and QF1 in sequence.

Step 3. Disconnect QF31.

8.3 Signal Collection and Protection Function Design

8.3.1 Signal Collection

Table 8-3 Signal acquisition information

No.	Acquisition type	Acquisition object	
1	RS485 communication	Transformer oil temperature gauge	Temperature value
		Air conditioner	Temperature/humidity, telemetry, telecontrol
2	Signal acquisition	Oil transformer signal	High oil temperature, heavy gas, light gas, pressure release, oil level, etc.
		ACB cabinet signal	Circuit breaker status, remote status
		Other signals	Door signal, smoke detector Y1/Y2 alarm, UPS alarm, low-voltage cabinet temperature and humidity controller alarm, insulation monitoring fault, auxiliary transformer temperature alarm

8.3.2 Relay Protection Function Design

Table 8-4 Relay protection function design

No.	Fault type	Protection functions corresponding to configuration	Protection type	Range of protection action
1	Internal short circuit	Heavy gas trip	Non-electrical quantity	Trip transformer
		Light gas alarm	Non-electrical quantity	Alarm
		Pressure release trip	Non-electrical quantity	Trip transformer
2	High oil level	High oil level alarm	Non-electrical quantity	Alarm
3	Low oil level	High oil level alarm	Non-electrical	Alarm

No.	Fault type	Protection functions corresponding to configuration	Protection type	Range of protection action
			quantity	
4	High oil temperature	High oil temperature trip	Non-electrical quantity	Trip transformer
		High oil temperature alarm	Non-electrical quantity	Alarm

8.3.3 Air Conditioner Control

The distribution cabinet and ACB cabinet are separate sealed compartments, isolated from the external environment, with the internal environmental temperature controlled by the air conditioner on the side wall of the medium voltage substation. The air conditioner has cooling, heating, and dehumidification modes, which can adjust the operating mode according to the real-time temperature and humidity inside the compartment.

- Cooling mode: Start when the monitoring point temperature > 30°C, stop when < 20°C.
- Heating mode: Start when the monitoring point temperature > 0°C, stop when < 10°C.
- Dehumidification mode: Start when the monitoring point humidity > 75%RH, stop when < 65%RH.

8.3.4 Auxiliary Transformer Temperature Control

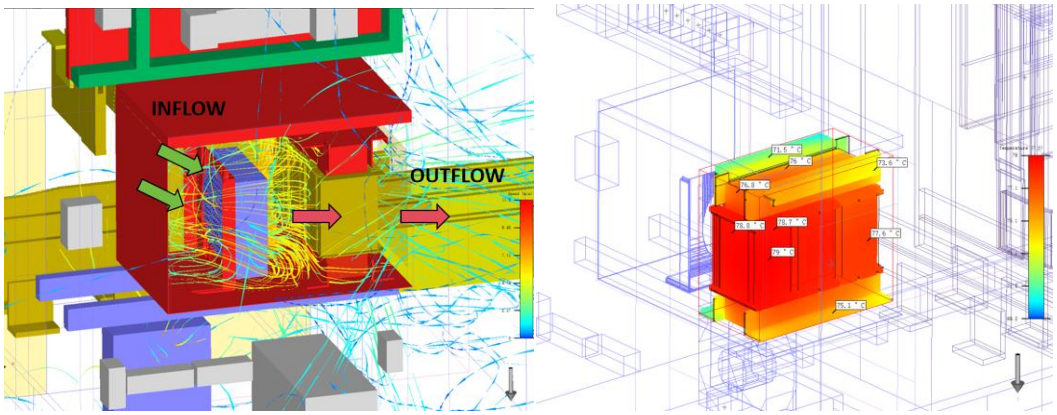


Figure 8-1 Auxiliary transformer flow field and temperature distribution

The auxiliary transformer has a relatively low overall loss and a high environmental adaptability. The design employs internal air conditioning cooling and forced convection cooling. At an ambient temperature of 45°C, the overall temperature rise of the auxiliary transformer is low, with the highest temperature point being 79°C.

A temperature sensor is installed at the highest internal temperature point of the auxiliary

transformer to monitor the transformer temperature and determine the operation of the cooling fan. When the ambient temperature is low, the fan is turned off. If the temperature at the transformer monitoring point exceeds the set value, the fan is activated to lower the temperature, ensuring that the transformer temperature rise operates within the design range.

9 Panel Operation

Caution	• Do not perform multiple operations simultaneously, as this may trigger unintended operations. • Use touch operations: Only one operator control on the screen should be touched at any time. • Use keyboard operations: Do not press more than two keys simultaneously.

The distribution of the indicators on the panel of the ACB cabinet is shown as follows.

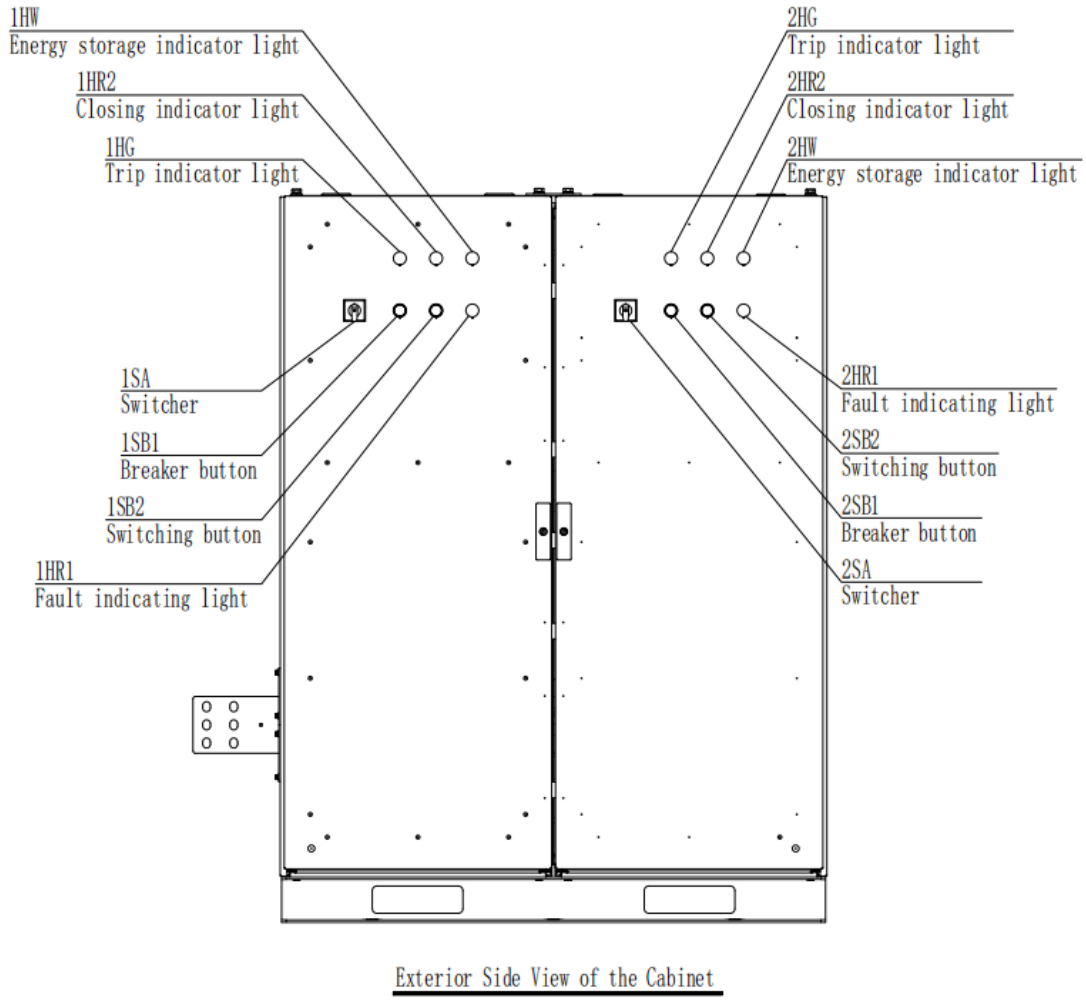


Figure 9-1 Indicators on the panel of the ACB cabinet

Table 9-1 Function descriptions

Code	Description
1HW, 2HW	Energy storage indicator light
1HR1, 2HR1	Fault indicating light

Code	Description
1HR2, 2HR2	Closing indicator light
1HG, 2HG	Trip indicator light
1SA, 2SA	Switcher
1SB1, 2SB1	Breaker button
1SB2, 2SB2	Switching button

10 Fault and Verification

10.1 Fault Response Principles

 Caution	The content of this chapter is based on typical usage scenarios. It is recommended to adjust it in conjunction with the configuration and operating policies delivered for the project.

During equipment operation, if alarms, trips, performance degradation, or other abnormalities occur, the following principles should be followed for investigation and handling:

- Priority should be given to checking the PCU device interface for real-time status, alarm codes, and node signals.
- Ensure the equipment is powered off and grounded before performing physical inspections.
- Record the time of failure, operating conditions, and environmental factors to assist in analysis.
- Users are not advised to modify system configurations or bypass safety interlocks on their own; if the issue falls outside the scope of this manual, please contact the manufacturer promptly.

10.2 Control System Integration Process

The step-up compartment connects the PCU device to the battery compartment. For the system integration process and software-related commissioning procedures and instructions, please refer to the relevant documentation for the battery compartment.

10.3 Fault Classification and Handling Suggestions

10.3.1 Temperature-Related Faults

Applicable nodes

Oil-immersed transformer, control compartment, etc.

Typical phenomena

Oil temperature trip, forced shutdown

Handling suggestions

- Check for prolonged full load, insufficient environmental ventilation, or abnormal cooling fans.
- If the oil temperature continues to rise above 105℃, it is recommended to immediately shut down the unit and investigate for internal faults or oil degradation.
- Inspect whether the pressure relief valve has actuated, and perform oil sampling tests if necessary.

10.3.2 Abnormal Oil Level and Oil Pressure

Applicable nodes

Transformer compartment

Typical phenomena

High/Low oil level alarm, pressure trip

Handling suggestions

- Check if the oil level gauge and oil pressure gauge are reading abnormally.
- Inspect the area around the equipment for any signs of leakage.
- Confirm that the signal sensor cables are not open circuit or incorrectly connected.
- If the oil pressure fluctuates significantly, consider draining oil for inspection or replacing the seal.

10.3.3 Safety Interlocks and Physical Protection-Related Alarms

Applicable nodes

Control cabinet door, smoke sensor, etc.

Typical phenomena

Door open alarm, false smoke alarm

Handling suggestions

- Check if the door travel switch is damp or stuck;
- If frequent alarms occur in high wind or dusty environments, consider enhancing physical sealing or replacing the sensor;
- After all protection devices are reset, re-energize or clear the alarm information.

10.3.4 Main Circuit Protection Action

Applicable nodes

Main circuit breaker QF1, QF2, surge protector (SPD), etc.

Typical phenomena

Circuit breaker tripping, system unable to connect to the grid, surge alarm

Handling suggestions

- Determine whether the circuit breaker tripping is due to manual operation by personnel or system protection actions.
- Check if the protection setting values are reasonable.
- Inspect whether the surge protector's action window has changed color or shows signs of degradation.
- If tripping occurs frequently, it is recommended to combine operational logs to assess whether there are issues with grid interference or potential short circuit hazards.