0.5P EnerOne+ Outdoor Liquid Cooling Rack Product Specification

Version	Date	Changes
1.0	Feb. 03, 2023	First Release
2.0	Aug.22,2023	Update based on product development

Contents

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1 General Introduction

1.1 Confidentiality

This product specification is intended to be seen only by persons directly involved in this project. Transfer to other parties, especially to partners without the approval of CATL, has to be coordinated by the person in charge of this project in CATL and is governed by declarations relating confidentiality in the development contract.

1.2 Purpose of Document

This document is a product specification for Battery Energy Storage System developed by Contemporary Amperex Technology Company Limited (CATL). It describes and stipulates the performance index, basic functions, interface and communication, key parameters, safety characteristics of this product, as well as matters needing attention of users and relevant legal statements.

The specifications of the product are provided in this document. If the contract parties find any inadequacies, they shall inform us so as to develop better products.

CATL possesses the right to update and clarify this document.

1.3 Definitions and Abbreviations

1.3.1 Definitions

BESS: Battery Energy Storage System, using electrochemical cells to storage electrical energy.

Frequency Modulation: The BESS provide the active power to modulate the frequency of grid when some uncontrol events disturbed the frequency .

Voltage Modulation: The BESS provide the reactive power to modulate the voltage of grid when some uncontrol events especially the inductive load and capacitive load will disturb the voltage.

Peak shifting: Battery absorb or release the energy when the power plants generate more or less energy than the demand.

PV: Photovoltaic power generation.

Wind power: Power get from the rotation blade driven by wind.

Modbus TCP: The Modbus protocol including three kinds of messages: ASCII, RTU, TCP. Modbus TCP is a

kind of communication protocol which is widely used in the industrial field.

Rack: The Rack for the battery energy storage system.

Module: A mechanically integrated arrangement of cells connected in series and/or parallel, complete with packaging, thermal management, output DC connections, and associated cell sensing.

Cell: The smallest non-divisible component of the EnerOne+ System, assembled into a battery module in series and parallel arrays.

RTE: Round-trip Efficiency, defined as the discharging energy of the system from 100% SOC to 0% SOC divided by charging energy of the system from 0% SOC to 100% SOC. The Round-trip DC-DC energy efficiency shall be measured at the DC terminals of the Rack.

1.3.2 Abbreviations

BMS: Battery Management System.

TMS: Thermal Management System.

CAN: Controller Area Communication.

FSS: Fire Suppression System.

PCS: Power Conversion System.

BOL: Beginning of Life.

EOL: End of Life.

SOC: State of Charge.

SOH: State of Health.

CSC: Cell Supervision Circuit， the base unit of battery management.

SBMU: Slave Battery Management Unit, collects and analyses the data from CSC, and uploads to the MBMU.

MBMU: Main Battery Management Unit. The core control unit of the Rack.

EMS: Energy Management System. Monitoring and manage the charge and discharge of the BESS.

Master Control Box: Including the SBMU fuse isolation switch and other components.

2 System Description

2.1 Application

The EnerOne+ Rack is a modular fully integrated product , consisting of rechargeable lithium-ion batteries, with the characteristics of high energy density, long service life, high efficiency. The EnerOne+ Energy Storage product is capable of various on-grid applications, such as frequency regulation, voltage regulation, arbitrage, peak shaving and valley filling, and demand response. Furthermore, the EnerOne+ Rack can be used for PV storage integration and Wind storage integration. The system can also operate as a microgrid to support backup and islanded systems.

2.2 Overview

The overview of the Rack is shown in Figure 1 and Figure 2. The detailed information can be found in the following chapters.

Figure 1 EnerOne+ Liquid Cooling Energy Storage Rack – Sideview

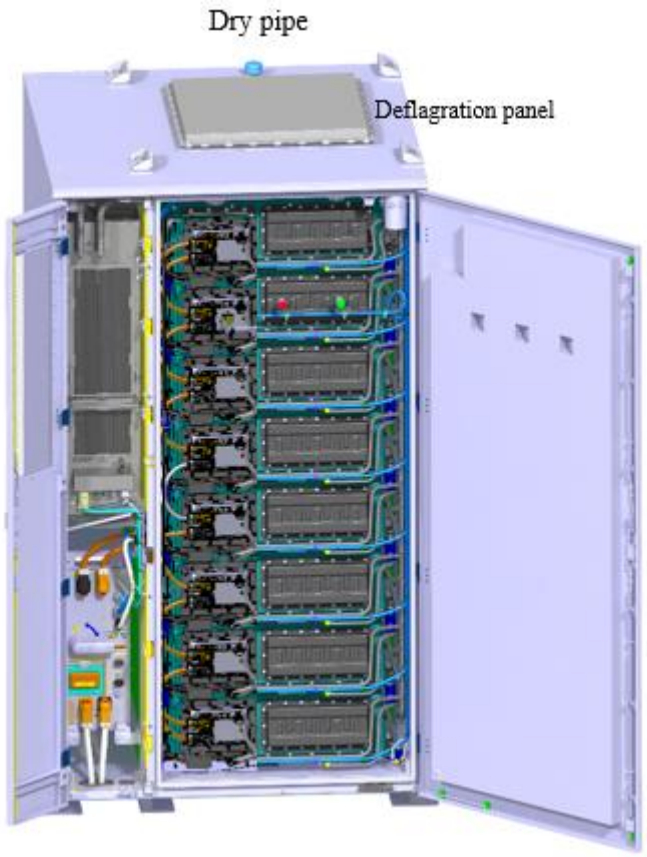


Figure 2 EnerOne+ Liquid Cooling Energy Storage Rack – Sideview Open the Door (deflagration panel/dry pipe are optional)

*For reference only, subject to final product

The EnerOne+ Rack consists of following parts: batteries, BMS, FSS and TMS, which are integrated together to keep the normal working of the Rack.

2.2.1 Battery

The capacity of cell is 306Ah, 1P52S cells integrated in one module, 8 modules integrated into one Rack. As the core of the energy storage system, the battery releases and stores energy.

2.2.2 BMS

BMS adopts the distributed scheme, through the three-level (CSC--SBMU--MBMU) architecture to control the BESS, and ensure the stable operation of the energy storage system. It can manage energy absorption and release, the thermal management system and auxiliary power supply according to the detected

information: battery voltage, current and temperature. It can monitor high voltage DC/AC security, diagnosis and analysis faults according information from various detectors and dry-contacts. And it can keep communication with PCS and EMS through CAN.

2.2.3 FSS

FSS consists of smoke detector and heat detector(Or heat detector and gas detector) , the aerosol, the dry pipe(optional). FSS undertakes functions : monitor the thermal run-away risks of Rack through the detectors, extinguish the thermal run away in an early stage, and control the loss to minimum. The FSS is independent with any other system and it is the security guard of EnerOne+ Rack.

2.2.4 TMS

TMS consists of one powerful chiller, one PTC heater and the liquid cooling pipe distributed in each battery module. The TMS will keep the battery work at best state and reach longest life.

2.2.5 Control box

Control box mainly includes detection device, protection device and AC/DC power supply. The structure is shown as follows.

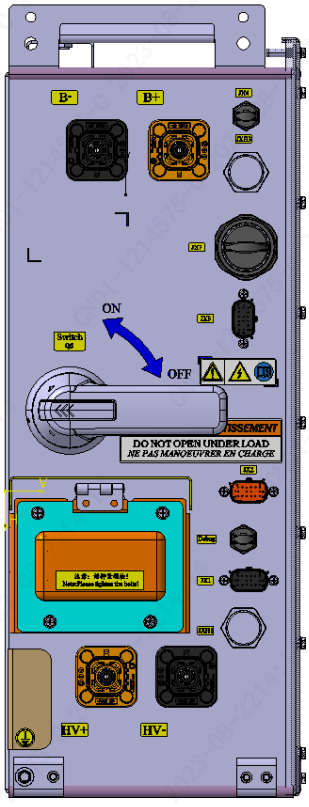


Figure 3 EnerOne+ Liquid Cooling Energy Storage Rack – Control Box

3 System Specifications

In this chapter, the systems specifications will be introduced in detail. For the BESS, the system specifications included the power and energy, electrical specifications, the environmental specifications, the mechanical specifications and certification standards. The product model is R08306P05L31

3.1 Power and Energy

Table 1 Power and Energy of EnerOne+

DC Side Data		
Product Model	R08306P05L31	**Remark**
P-Rate	0.5P	
Cell		
Cell type	LFP	
Cell capacity	306Ah	
Cell Voltage range	2.5-3.65V	
Cell rated Energy	979.2Wh	
System		
Configuration	1P416S	
Rated Energy	407.34 kWh	
Rated Voltage	1331.2 VDC	
Voltage Range	1040~1500 VDC	
Rated Charging Current	153A	
Maximum Charging Current	195.8A, <1min	
Rated Charging Power	203.67kW	
Rated Discharging Current	153A	
Maximum Discharging Current	195.8A,<1min	
Rated Discharging Power	203.67kW	

3.2 Electrical Specifications

Table 2 Electrical specifications of EnerOne+

Auxiliary Power & Communication			
Product Model		R08306P05L31	**Remark**
P-Rate		0.5P	
Auxiliary Power 1 for BMS	**Voltage Range**	L+N+PE /220V/110V ±10%，50/60HZ	
	Power	Max. 135W	
	Rated Current	2.3A	

	Inrush Current	≤6A, < 1S	
Auxiliary Power 2 for cooling unit	**Voltage Range**	L+N+PE /220V ±20%，50/60HZ	
	Power	Max. 3kW (Continuous)	
	Rated Current	10A	
	Inrush Current	⩽32A， < 1ms	
Auxiliary Power 3 for Fire FSS	**Voltage Range**	24VDC	
	Power	0.003W（Standby state） 27.3W（Alarm status）	
	Current	0.125mA（Standby state） 1.1375A（Alarm status）	
Communication Protocol		CAN, Modbus/TCP	

3.3 Mechanical Specifications

Table 3 Mechanical Data of EnerOne+

Mechanical Data		
Product Model	R08306P05L31	**Remark**
Transportation	Land or sea transportation	
Size	2348mm(H)*1390mm(W)* 1344.1mm(D)	
Weight	3600±100 kg	
Color	RAL7035	
IP Level	IP56 (Battery Room)	
	IP23 (Electrical Room)	
	IP66 (Control Box)	
	IP67 (Battery Modules)	
	IP26 (Chiller Unit)	

3.4 Environmental Specifications

Table 4 Environmental Specifications of EnerOne+

Environment condition		
Charge Temperature Range	-25℃…+55 ℃	Remark
Discharge Temperature Range	-25℃…+55 ℃	
Storage Temperature Range	-30℃…+60℃	
Application Altitude	≤4000m	
Relative Humidity	0 ~ 95 % (non-condensing)	
Degree of Anti-corrosion of Battery Unit	C5	
Seismic Level	IEEE 693-2018 Moderate design level	

3.5 Certification Standard

Table 5 Certification Standard

Standards & Certificates		
Rack	UL1973	Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications
	NFPA855	Standard for the Installation of Stationary Energy Storage Systems
	UL9540A	Energy Storage Systems and Equipment
	UL9540	Battery Energy Storage System (ESS) Test Method
	IEC 62477	Safety requirements for power electronic converter systems and equipment – Part 1: General
	IEC 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications
	IEC 62933-5-2	Electrical energy storage (EES) systems – Part 5-2: Safety requirements for grid-integrated EES systems – Electrochemical-based systems
	IEC 61000-6-2 IEC 61000-6-4	Generic standards – Industrial Environmental Immunity Generic standards – Emission standard for industrial environments

	UN38.3	Transportation Testing for Lithium Batteries and Cells
	NEMA 3R	Resistant to ingress of water, rain, ice formation, sleet, and snow
	RoHS 2011/ 65 EU	Directive 2011/65/EU of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment
	REACH 1907/2006 EC	Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
	UKCA EMC	Electromagnetic Compatibility Regulations 2016: Great Britain
	UKCA LVD	Low Voltage Directive 2014/35/EU

4 Battery Management System(BMS)

4.1 BMS Overview

BMS is used in energy storage system, which can monitor the battery voltage, current, temperature, managing energy absorption and release, thermal management, low voltage power supply, high voltage security monitoring, fault diagnosis and management, external communication with EMS and ensure the stable operation of the energy storage system.

4.2 BMS Architecture

BMS includes three-level constructure, there are 1 unit of SBMU, 8 units of CSCs in one rack and 1 unit of MBMU, 1 unit of IMM(optional),and 1 unit of ETH of one system(block/bank). This is the architecture that one PCS connected to n Racks.

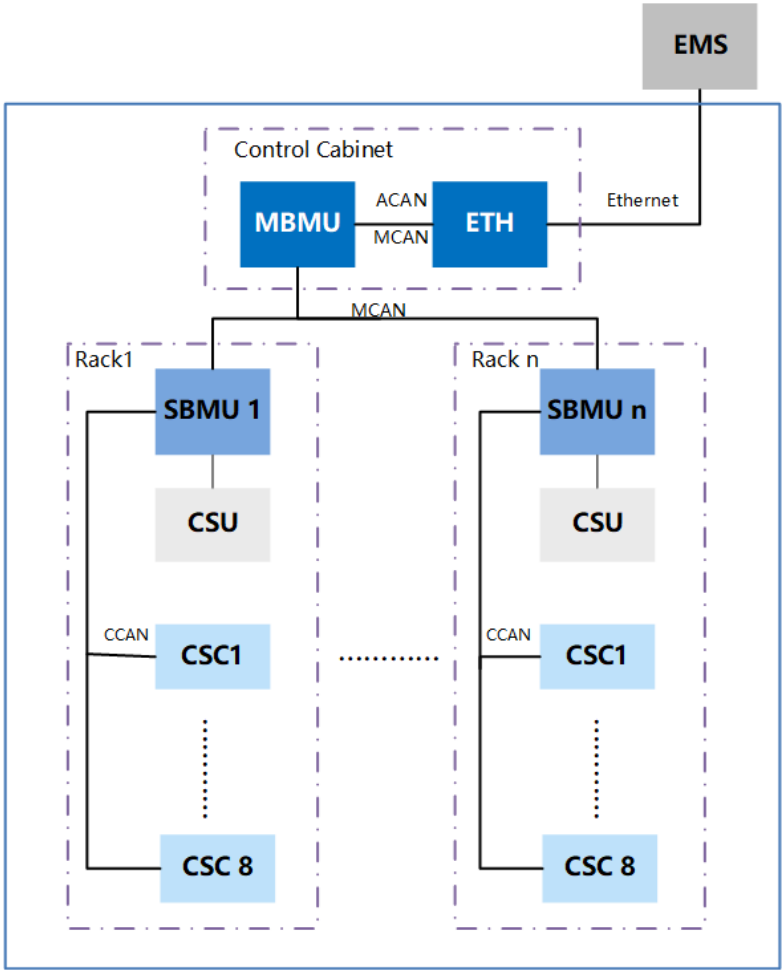


Figure 4 Three-Level BMS Architecture for n Racks in Parallel

4.3 BMS Function

The detailed information of BMS can be seen in Table 6. The parameters including: Cell voltage sampling, Cell temperature sampling, Current sampling, HV sampling, Ambient temperature detection, Insulation detection and other important parameters.

Table 6 Detailed Performance Parameters of BMS

Item	Performance Parameters	Value	Note
Working voltage	Range	20V~26V	
Cell voltage sampling	Range	1V~4.85V	
	Accuracy	±5mV	0℃ ~ +60℃
		±10mV	-30℃ ~ 0℃
Cell temperature sampling	Range	-40℃ ~ +125℃	
	Accuracy	±1℃	-20℃ ~+60℃
		±2℃	-30℃~-20℃
Current sampling	Range	± 500A	
	Sampling period	10ms	
	Accuracy	<0.5%FSR	-30℃ ~ 60℃
HV sampling	Range	0V ~ 1500V	
	Accuracy	1%FSR	
Cell balance	Current	100mA@3.2V	Opened in all channels
SOC	Accuracy	＜± 5%	LFP, according to specific conditions
SOH	Accuracy	＜± 5%	
Ambient temperature detection	Range	-40℃ ~ +85℃	
	Range	±3℃	
Insulation detection	Range	0 ~ 10MΩ	
	Accuracy	-30% ~ 0%	
	Detection Time	≤10s	Y capacitor<0.47μF (for single side)

4.3.1 Battery Status Monitoring

1) BMS monitors the battery's parameters, including cell voltage, module temperature, battery module current and total battery module voltage.

2) BMS detects or calculates the battery status(SOX): such as State of Charge (SOC), State of health (SOH), state of energy(SOE) and state of power (SOP).

3) BMS functions as a safety management system in such cases as under voltage, over discharge, over voltage, over temperature, and over current of the battery. In case of failure, the system will give an alarm to the supervisory equipment, limit the charge and discharge current or power, and control the disconnection of all HV contactors. This can protect the battery while safeguarding the power systems security.

4) BMS shall provide battery information (including data recording and fault waveform recording) to EMS.

4.3.2 Charging/Discharging Management

1) BMS controls and monitors the high voltage main contactors, auxiliary relays and low voltage coils.
2) BMS has pre-charge control within the parallel connection among racks.
3) BMS works in the management of charge and discharge. It will calculate the charge and discharge power limit according to the existing status of the battery (temperature, SOC) and electrical components and then report to EMS.
4) BMS has the function of balance management to extend the energy efficiency of the battery system.

4.3.3 Thermal Management

1) BMS has the function of sample collecting of battery cell temperature and chiller operating status.
2) BMS controls the liquid cooling TMS system based on cell & coolant's temperature.

4.3.4 Program Refreshing

BMS can be flashed on site using the host computer through MCAN, or remotely via Ethernet, or through EMS, including the flashing of MBMU, SBMU, IMM, CSC and ETH software.

4.3.5 High Voltage Safety Monitoring

1) BMS has the function of system insulation detection.
2) BMS has the function of high voltage sampling (collecting data of the main positive voltage).
3) BMS supports the detection of the dry contact of MSD, Fuse and Switch, as well as the auxiliary contact of the primary loop contactor.

4.3.6 Peripheral Monitoring and Control Management

1) BMS has the function of ambient temperature sampling,which matches according to project requirements

2) BMS has multiple high-side drivers and can drive and control peripheral devices according to project requirements.

3) BMS has multiple dry contact interfaces and can monitor external signals according to project requirements.

4.4 Communication

The Communication Architecture of the System is showen as below as Figure 5.

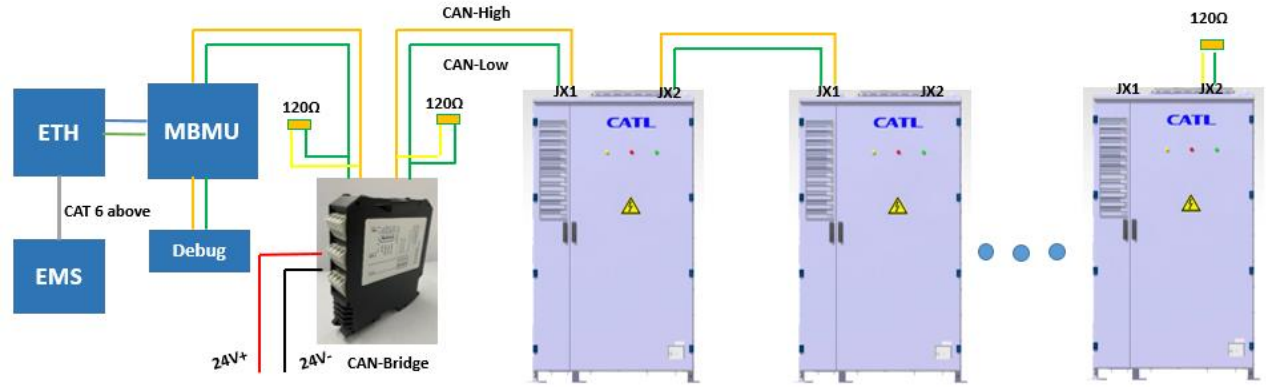


Figure 5 The Communication Architecture of the System

1. The installation position of MBMU and ETH are not in the Battery Rack, so the customer needs to reserve the installation position (e.g. control cabinet on customer side) and provide auxiliary power supply of 22 ~ 26V DC.

2. The cables between ETH and EMS (Or network switch) should be CAT 6A or above.

3. The data record requirements of EMS: The 7 days' data can be backtracked after alarm occurs , and the alarm data record interval is 5s . General data record interval is 10s.

5 Fire Suppression System(FSS)

5.1 FSS Overview

As an outdoor liquid cooling battery energy storage system, EnerOne + provides a perfect set of fire suppression system solutions with detection, explosion control and fire extinguishing functions. The fire extinguishing control strategy is divided into four levels:

- **Level I, alarm warning and cut off high voltage automaticly;**
- **Level II, aerosol is released to extinguish the initial fire;**
- **Level III, dry pipe spraying to control the fire; (Optional)**
- **Level IV, deflagration panel works to release the pressure.(Optional)**

5.2 FSS Function

The fire suppression system is divided into three parts: detection system, deflagration system and fire extinguishing system. The control logic is shown in the following Figure 6.

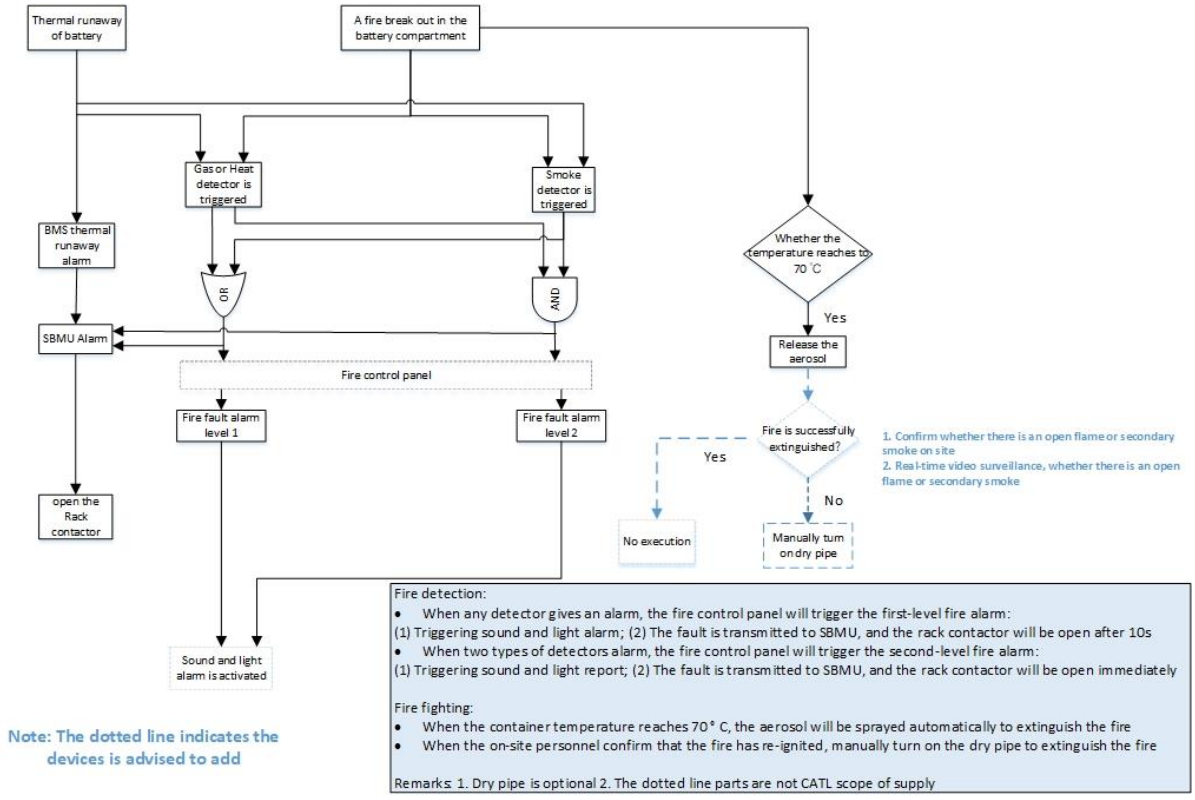


Figure 6 Control logic of FSS

*Note: 1. The dotted line indicates the devices is advised to add.

2. Three ways to tell if the fire is successfully extinguished:

1) The temperature sensor displays the temperature rise in real time

2) Confirm whether there is an open flame or secondary smoke on site

3) Real-time video surveillance, whether there is an open flame or secondary smoke

The fire suppression system detect fire incidents as following two levels:

- **When any detector gives an alarm, the first-level fire alarm will be triggered:**

① Triggering sound and light alarm;

② The fault is transmitted to EMS, and the contactors will be open after 10s

- **When two types of detectors alarm, the second-level fire alarm will be triggered:**

① Triggering sound and light report;

② The fault is transmitted to EMS, and the contactors will be open immediately

When the temperature reaches 70 ° C, the aerosol will be triggered automatically to extinguish the fire. When the on-site personnel confirm that the fire has re-ignited, manually turn on the dry pipe system to extinguish the fire.

5.2.1 Detection System

The detection system has three types of detectors for option, the number and installation position of which are shown in Table 7 and Figure 7. All detection signals are received and processed by the fire control panel, and the aresol is trigger by electrical signal from fire control panel or itself(by detecting the temperature in the rack).

Table 7 Detector Type and Position Description

No	type	quantity	remarks
1	Heat detector	1	Detection of temperature
2	Smoke detector	1	Detection of smoke particles
3	Gas detector	1	Detection of gas in the battery room (optional, replace the Heat detector)

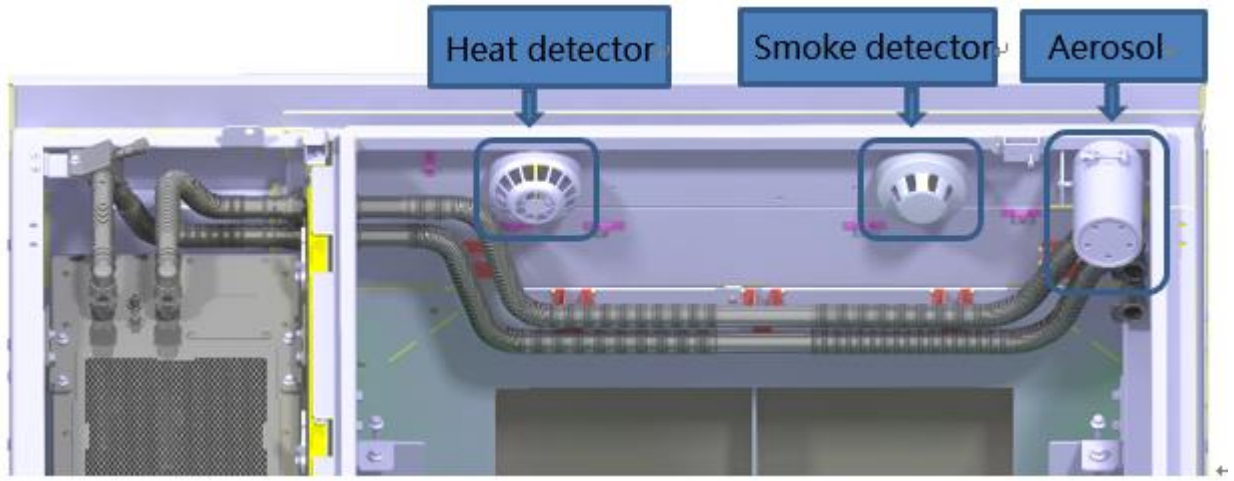


Figure 7 Type and Location of Detectors

*For reference only, subject to final product

5.2.2 Deflagration System

Deflagration system meets NFPA855 (NFPA 68) standardand has the ATEX certification. When the pressure in the rack reaches the set value, the cabinet door or deflagration panel at the top of rack will bounce off to prevent explosion in the cabinet. There are two options for deflagration system, which are shown in Figure 9.

Figure 8 Venting deflagration system

*For reference only, subject to final product

5.2.3 Fire Extinguishing System

5.2.3.1 Aerosol

There are electronically controlled and temperature controlled two type of aerosols.When the detectors are triggered at the same time or the temperature raises to a certain level, and the fire extinguishing system will automatically release the aerosol. The fixed position of aerosol is shown in Figure 7.

5.2.3.2 Dry pipe

As the last fire extinguishing measure,, the dry pipe can effectively control the spread of fire, which is shown in Figure 9.

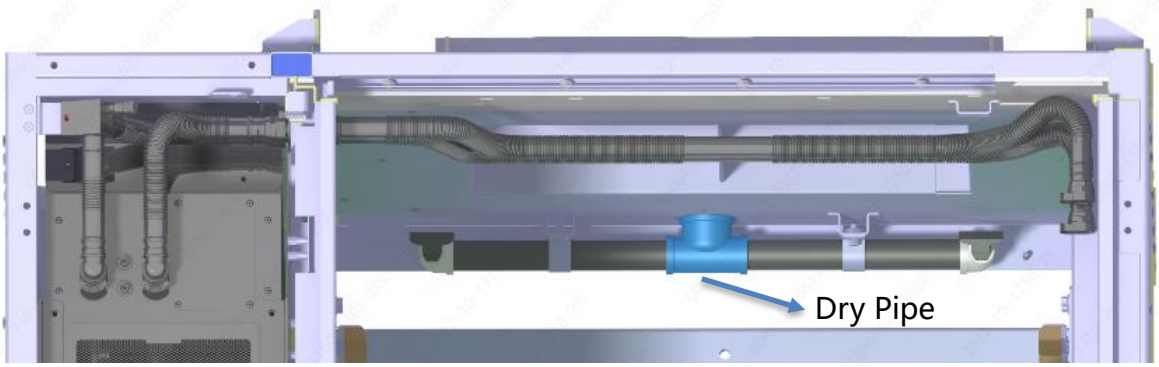


Figure 9 Dry pipe System

* Dry pipe is optional configuration

The dry pipe at the top of battery cabinet is divided into two roads and installed with one nozzle respectively after entering the cabinet body. The water through the outside pipeline and injected into the battery cabinet to realize the fire extinguishing.

6 Thermal Management System(TMS)

6.1 TMS Overview

The cooling strategy of EnerOne+ is liquid cooling, which can maintain the temperature of the battery system to the best operating temperature range. Thus, the battery shall work at the best conditions, adsorb and release the maximum energy, and achieve the longest life.

The TMS is composed with a high-efficiency liquid cooling unit, the liquid cooling pipe under the bottom of battery and the PTC (The positive temperature co-efficiency resistance)heater. The TMS works under the control of BMS, by following the signals to achieve the heat exchange under different working mode. Detailed information is described below.

6.2 TMS architecture

The overview of cooling unit has been listed in figure 11. TMS architecture can be described below (Figure 12).

The composites parts are listed below:

a) **Compressor.** The function of compressor is to compress the low temperature and low pressure refrigerant gas into high temperature and high pressure refrigerant gas. Then the gas flow to the condenser through the pipe.

b) **Condenser.** The function of condenser is condensing the high temperature and high pressure refrigerant gas into ambient temperature and high pressure refrigerant liquid. The excess heat of liquefaction will be taken away by the fan. Then the liquid flow to the chiller through the pipe.

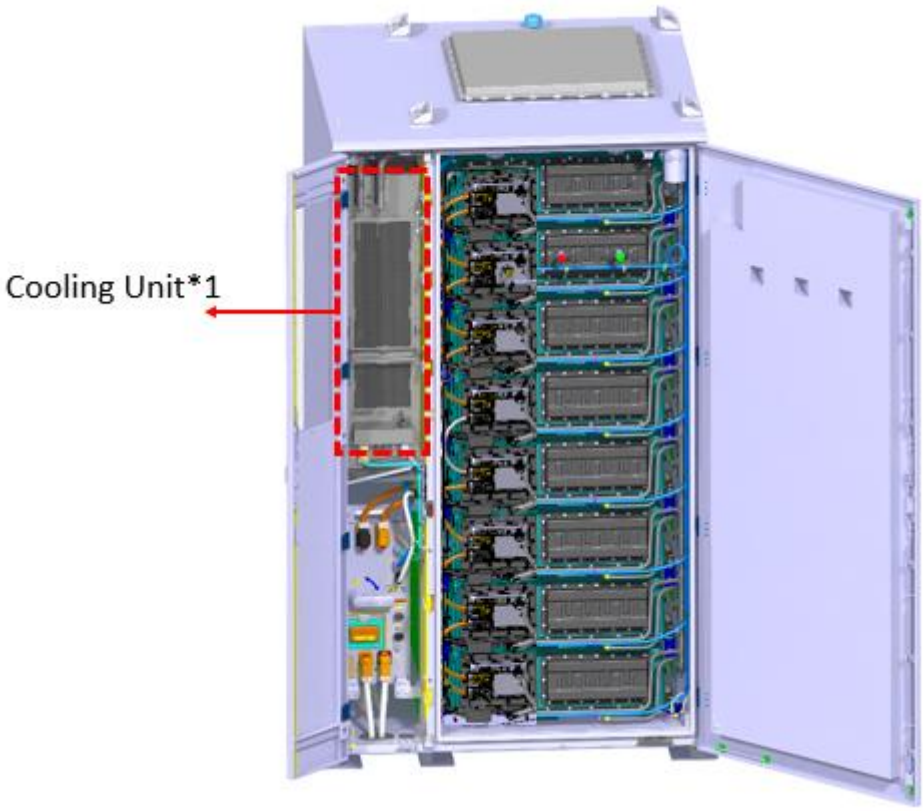


Figure 10 Overview of the cooling unit of EnerOne+

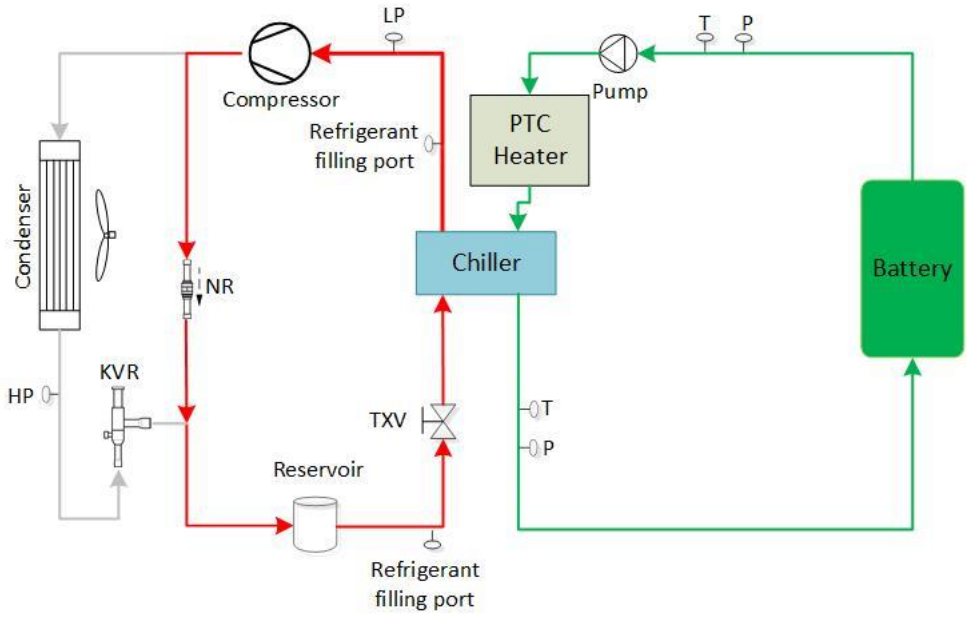


Figure 11 Architecture of Thermal Management System

c) **Chiller.** The function of chiller is to exchange the heat from the refrigerant liquid with the coolant. The ambient temperature and high pressure refrigerant liquid will evaporate into low temperature and low pressure refrigerant gas. The heat will transfer from the coolant to the refrigerant liquid.

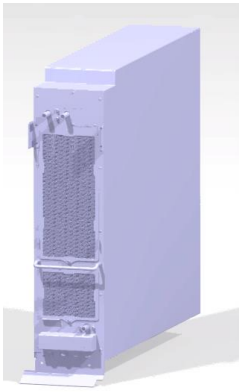
The low temperature coolant will flow to the cooling plate to cool the batteries while the refrigerant gas return to the compressor.

d) **Heating**. The PTC will heat the coolant when the TMS get signals that the temperature of coolant is below the setting value. Then the coolant will be heated until the temperature increases to the setting value. The battery will be warmed up by the coolant.

e) **Pump.** The pump will force the coolant into circulating in the pipe.

6.3 TMS Specification

Table 8 Specification of Thermal Management System

	Refrigerant Type: R134a
	Max. ambient temperature: 55°C
	Power supply: 1AC 220V
	Maximum 3kW Cooling capacity for 0.5P System
	Cooling capacity is auto-adjustable according to ambient temperature & discharge/charge status

The main features of TMS are listed above, which is shown in Table . The TMS will work under the ambient temperature range from -25℃ to 55℃. The cooling power is auto-adjustable according to ambient temperature & discharge/charge status. There are four operating modes for the TMS, including , cooling mode, heating mode, self-circulation mode and stand-by mode.

Table 9 Power Consumption of Thermal Management System

Type of EnerOne+	**0.5P System**
Cooling Capacity	3kW
Maximum Electric power for heating	3.0kW
Maximum Electric power of refrigeration	2.1kW
EER	>2.76@35℃, >1.7@45℃

7 Product installation

7.1 Site and environmental requirements

The requirements for ground flatness are as follows:

1. Ground level deviation≤±10mm

2. Ground flatness deviation≤±4mm/2m

7.2 Foot Margin

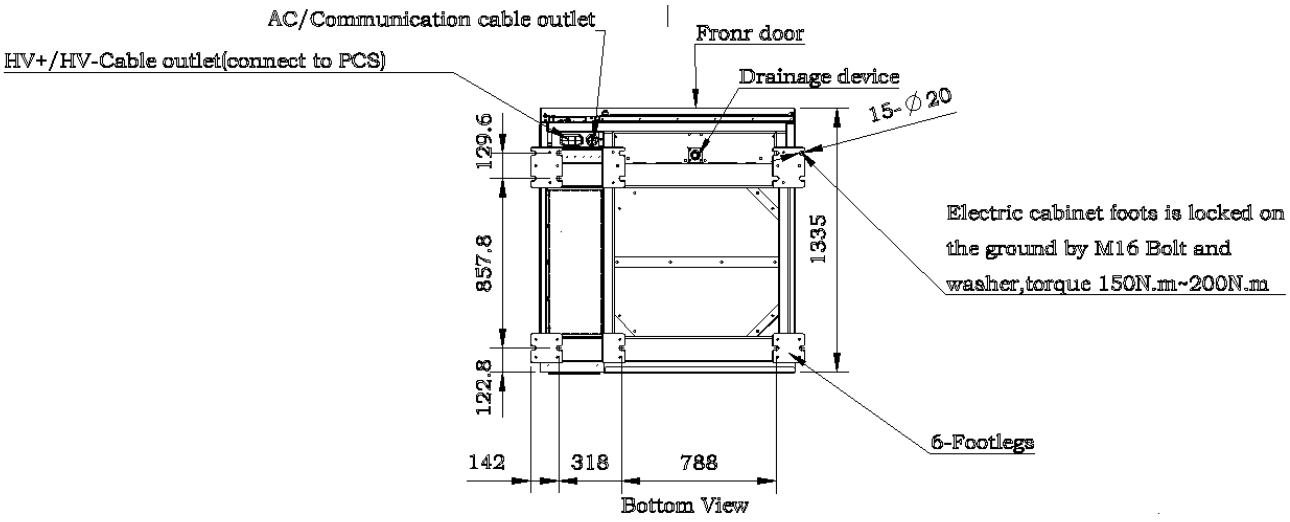


Figure 12 Foot margin

7.3 Layout of the rack

Varied layouts of the rack are presented in the figures below:

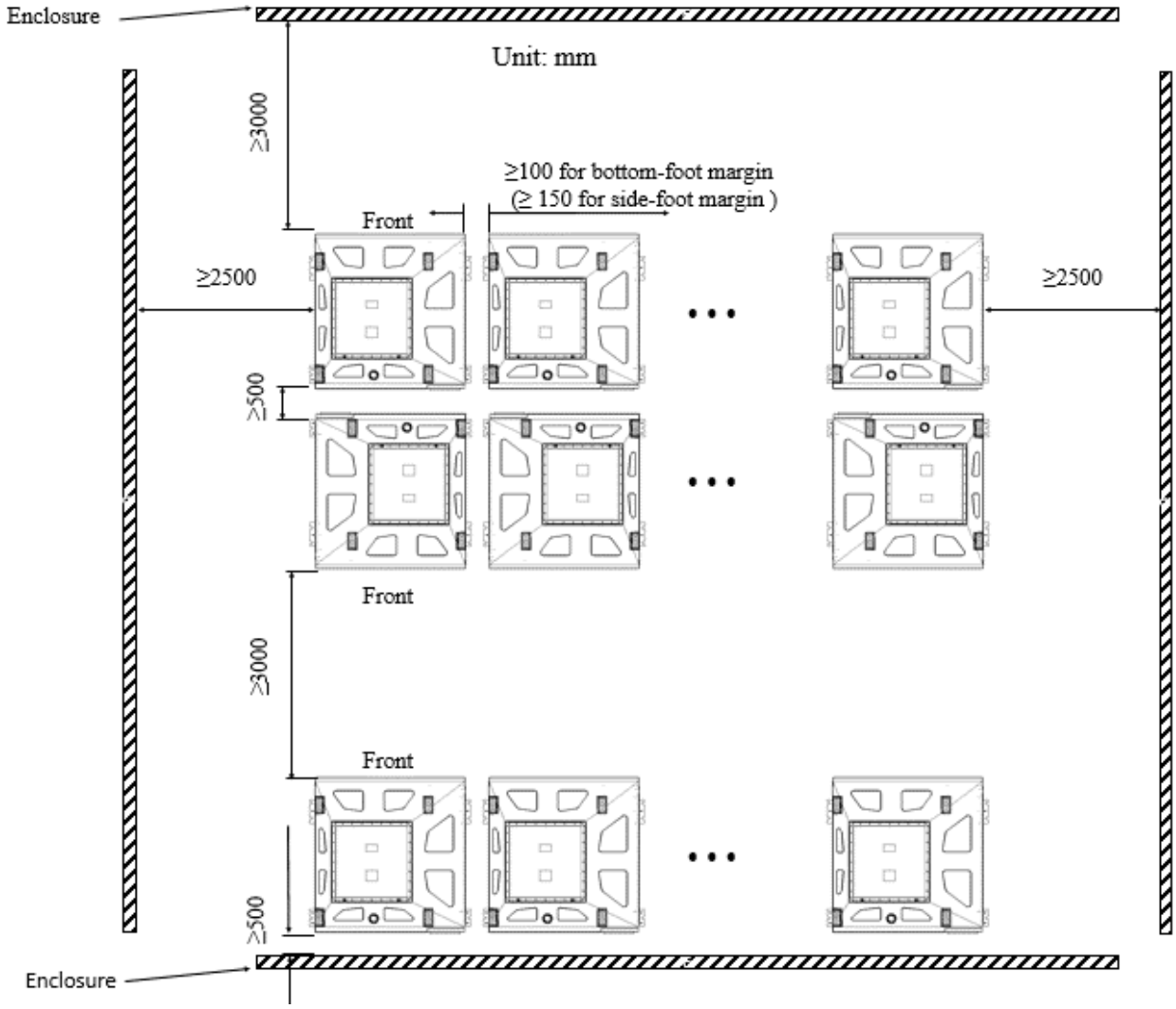


Figure 13 Layout of the rack

For back-to-back arrangement, the minimum clearance between battery racks is 500mm, and the recommended clearance between the front side of the two rack is 3000mm.

For back-to-enclosure arrangement, the minimum clearance between the back side of rack and the enclosure is 500mm, and the recommended clearance between the front side of rack and the enclosure is 3000mm. (For installation and maintenance).

For side-to-side arrangement, the minimum clearance between battery racks is 100mm(Foot margin install on the bottom) or 150mm(Foot margin install on the side).

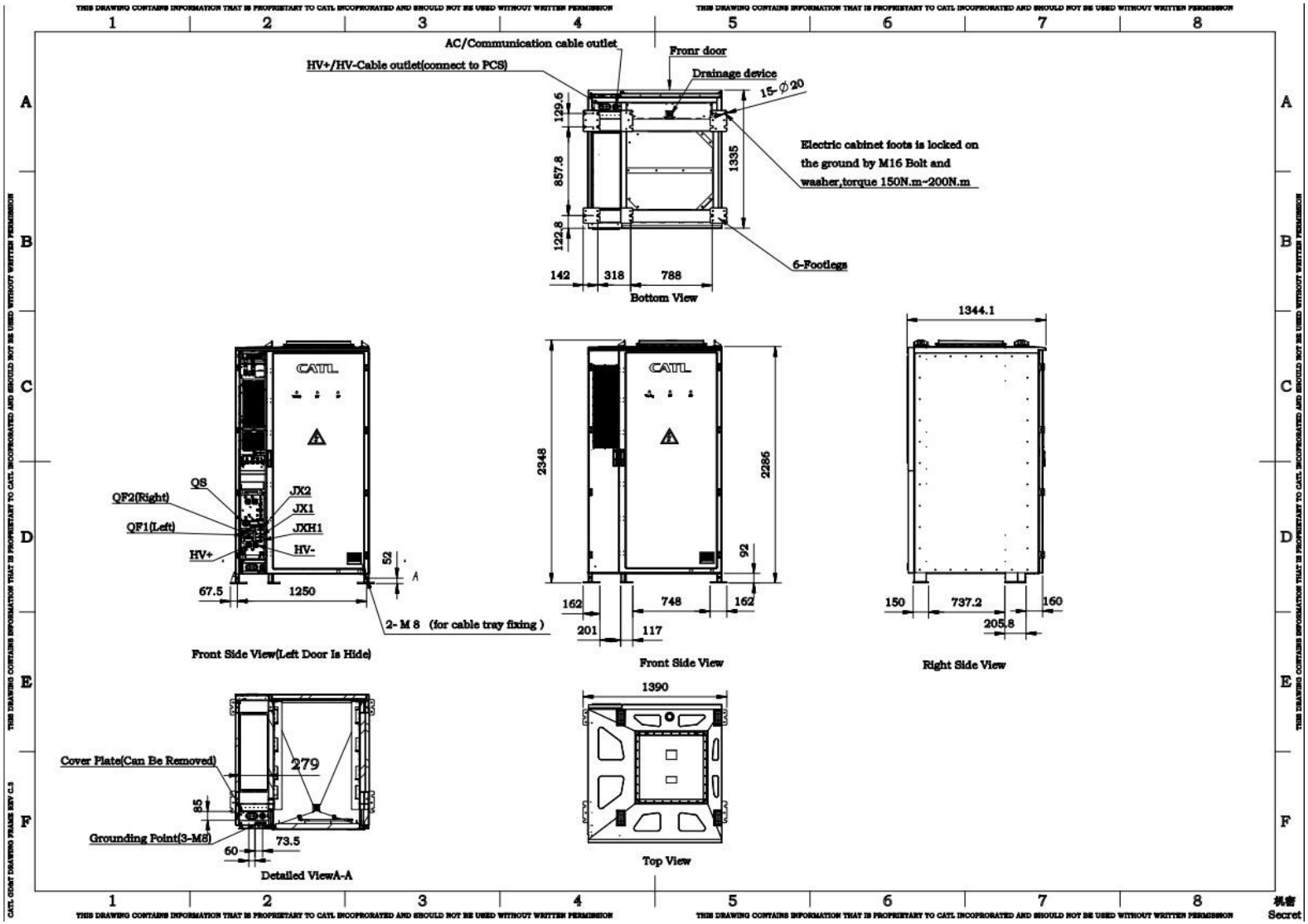


Figure 14 Enerone+ three-view drawing

8 Appendix

The attached is the triple view and the dimensions of EnerOne+. The front view, the side view, the top view. The detailed installation information can be found in the users' manual.

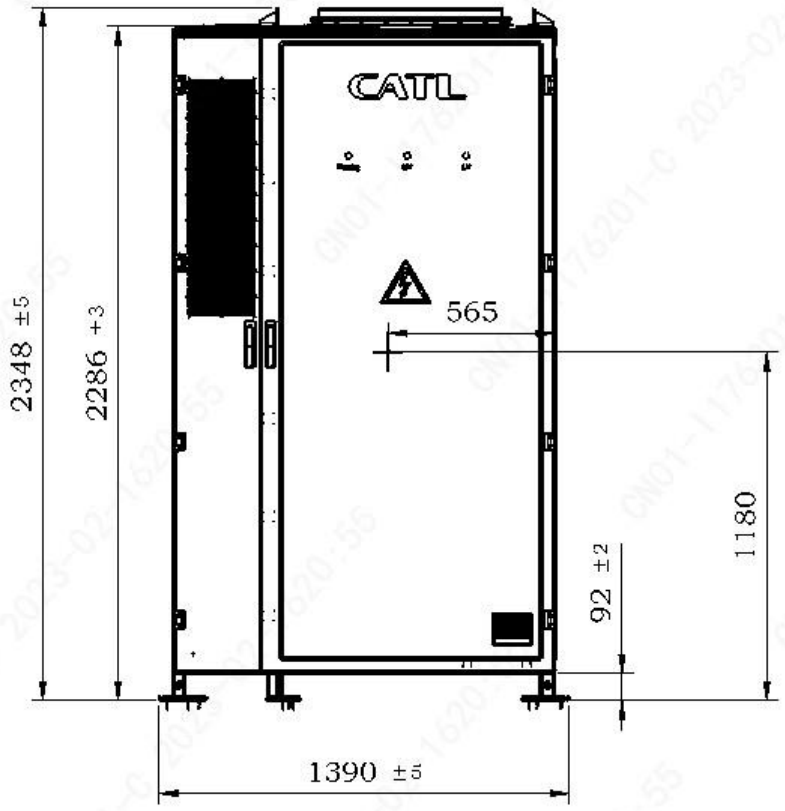


Figure 15 The Front View and Dimensions of EnerOne+

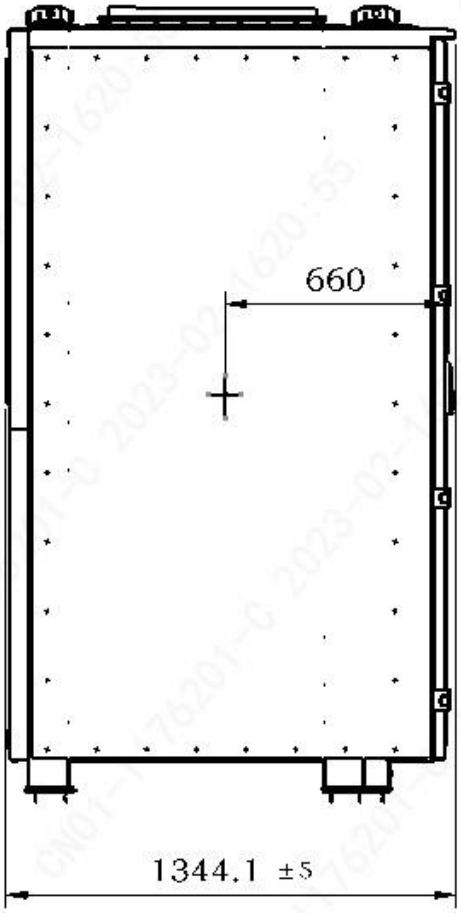


Figure 16 The Side View and Dimensions of EnerOne+

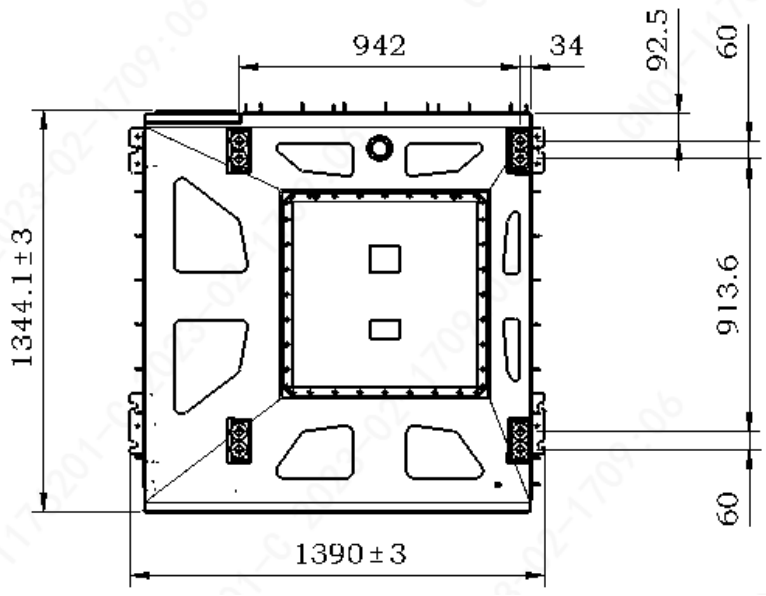


Figure 17 The Top View and Dimensions of EnerOne+

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