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Research Paper

Structure and Anti-corrosion coatings for a large capacity lead acid emergency power supply

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ABSTRACT: In this paper, a large capacity lead acid emergency power supply composed of lead acid battery has been designed and UPS uninterruptible power supply has been used. Working parameters and structure of the lead acid emergency power supply are designed, and the auxiliary functions of the lead acid emergency power supply are introduced. This large capacity emergency power supply has no emission and noise pollution when it is used in case of sudden power failure, and can guarantee power supply in sufficient time. It has broad market prospect. This design carries on the lead acid emergency power supply battery group choice, carries on the structural design. At last, choose the anti-corrosion coatings for this emergency power supply.

KEYWORDS: Large Capacity, Lead Acid, Emergency Power Supply

I. INTRODUCTION

The requirements for the stable operation of the power system are increasing with the process acceleration of the information society. We are increasingly inseparable from the application of various electrical and electronic equipment. Most of the industrial production control information and other important data need electronic information system to process and store.

Without exception, all electronic devices need stable power supply, when the sudden stop of power supply, every aspect of our life will be affected by more or less. In order to avoid this situation, the emergency power supply system is developed, it can continuous production and life for the people to provide security and backup or emergency power supply for the purpose of operation. Therefore, lead-acid battery is widely used in the energy storage system of emergency power supply equipment. In this way, even if there is a sudden power failure, the backup or emergency power supply composed of batteries can be used to provide sufficient reaction time and processing time, so as to avoid the occurrence of major accidents. Therefore, no matter from which situation, the importance of the battery will be reflected in all aspects of safety and power system.

The current development direction of lead acid emergency power supply is still focused on energy density and service life. The most effective method is still to use new materials such as carbon to replace the traditional lead electrode to increase the reaction area lead utilization rate and charging rate. However, the working parameters and structure design of the emergency power supply also have a great influence on the performance of the lead acid emergency power supply. This work focuses on the design of the working parameters and structure of the lead acid emergency power supply to ensure the stable work of the emergency power supply. At last, the anti-corrosion coatings was be chosen.

II. DESIGN OF UPS SYSTEM FOR LEAD-ACID EMERGENCY POWER SUPPLY

2.1 Components of the UPS system

The UPS system outputs three-phase or single-phase power to the external system for emergency uninterruptible power supply for laboratory or home environments. Lead-acid emergency power supply system is mainly composed of a variety of systems working together. The UPS uninterruptible power supply host and lead-acid battery group constitute the energy supply system, the dual power conversion device (ATS) is to convert the battery use, and the intelligent battery protection switch cabinet plays a role in protecting the battery under high load.

2.2 Diagram of UPS system principle

The AC input side of the UPS power supply is supported by the independent power supply of the dual-system power supply, and the automatic switching function of the UPS power supply is adjusted by the dual-power conversion device. In this way, the dual-power supply and dual-system automatic switching function of the UPS power supply is realized.

UPS battery requirements are determined by the required input and output voltage. In most cases, lead-acid battery will be used as energy storage module. When there is a power failure, UPS uninterruptible power supply will enable the battery module, battery electric flow into alternating current to the output, the power supply fault judgment is based on the input side power supply stops working. UPS uninterruptible power supply in the whole process always stay in working state, so the power switch time is very short.

UPS uninterruptible power supply takes a separate control method for each power supply, and each circuit is equipped with high-score circuit breaker, which ensures the stability, safety and reliability of UPS uninterruptible power supply working environment. The DC power supply system also uses the opening and closing handle to protect the circuit. This handle can realize the mechanical self-lock to prevent damage to the equipment caused by misoperation.

2.3 The power supply of UPS

In this paper, it is required that the total capacity of UPS uninterruptible power supply is 200kVA, and the output voltage is stable for at least 30 minutes. Multiple output modes are required to ensure the stable operation of lead-acid emergency power supply. The input voltage is 220*V*, the input power factor is 0.8, the input frequency is 50 *Hz*, the output voltage is 220 *V*, the output power factor is 0.8, and the output frequency is also 0.8, 50 *Hz*. Therefore, choose Eaton 930E-300k*VA* uninterruptible power supply host, this UPS uninterruptible power supply host with online backup and seamless switching mode, suitable for maintenance and installation.

III. CALCULATION OF WORKING PARAMETERS OF LEAD-ACID EMERGENCY POWER SUPPLY

Calculation basis: The working environment is required to be 25℃, the total output capacity of power supply is 200k*VA*, and the power supply duration is 0.5 *h*. The DC system does not have terminal batteries. At the end of the accident discharge, the voltage of each battery is 1.80*V*, the floating charging voltage is 2.15*V*, and the balanced charging voltage is 2.33*V*.

$$Quantity = \frac{V_L}{V_E} = \frac{202 \times 0.85}{1.80} = 104$$

Quantity: battery quantity, *VL*:the lowest allowable DC curve voltage,*VE*:end-discharge voltage. In the formula, 0.85 indicates that the lowest allowable DC curve voltage is 85% for single-line load.

Voltage check required for DC bus at floating charge voltage(V_f):

$$104 \times V_f = 104 \times 2.15 = 223.6(V)$$

Voltage check required for DC bus in equalizing charging voltage(V_e): $104 \times V_e = 104 \times 2.33 = 242.3(V)$

Voltage verification required for DC bus at constant initial charging voltage(V_i), which is known to be 2.4 *V*:

$$104 \times V_i = 104 \times 2.4 = 249.6(V)$$

After calculation, the DC bus can be used normally under the above conditions.

Calculation of battery parameters: assume that the initial load of the accident is 500 *A*, the sustained load is 250 *A*, and the impact load is 150 *A*.

①Preliminary calculation

GFD-800 battery was selected based on the current and accident discharge capacity of the DC load meter. The battery was composed of 8 positive electrodes and 9 negative electrodes of 100 *A·h*, and the discharge characteristic curve was used as Fig 1.

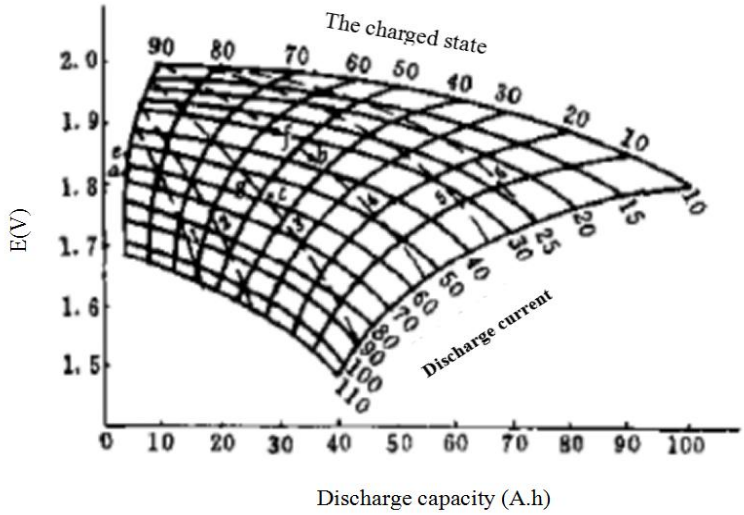

Fig 1 Electrode discharge characteristic curve of 100A.h

Initial accident load: $\frac{500A}{8} = 62.5A$ (A load current is carried on each electrode).

The intersection point *a* was obtained from discharge curve 62.5 *A* and 90% of charged state. The ordinate voltage corresponding to point *a* was 1.825 *V*, and the discharge charge on the abscissa was 5 *A·h*.

Accident sustained load: $\frac{250A}{8} = 31.25A$

According to the calculation basis given, the duration is 0.5 *h*, 30 *min*, and the storied discharge power is follow:

$$31.25 \times \frac{30}{60} = 15.625(A.h)$$

Since the battery had discharged 5 *A·h* power at the beginning of the accident, the total discharge when the accident continued was 5+15.625=20.625 (*A·h*). When the discharge is 20.625*A·h*, refer to Fig 1, corresponding to 30 minutes is point *b*, at this point, the discharge state relative to the total capacity of point *b* is 46%, the voltage is 1.855*V*, and the discharge current is 37*A*.

Shock loading： $\frac{150A}{8} = 18.75A$

After stacking, 37*A*+18.75*A*=55.75*A*, point *c* is point *b* downward along the 46% curve of charge state and intersects with the discharge current curve of 55.4 *A*. The coordinate voltage of point *c* is 1.79 *V*, lower than the required 1.80 *V* voltage at the end of the accident, so it needs to be selected again.

②Recalculate battery parameters

GFD-1000 battery is selected. This lead-acid battery consists of 11 negative electrodes and 10 positive plates with 100 *A·h*. Fig 1 discharge characteristic curve is used.

Initial accident load: $\frac{500A}{10} = 50A$

Point ***e*** is the intersection point of 90% of 50 *A* discharge curve and charged state in Fig 1. The voltage coordinate corresponding to point *e* is 1.86 *V* and the discharge quantity is 5*A·h*.

Power failure continuous load: $\frac{250A}{10} = 25A$

The duration is 0.5 *h*, discharge energy: $\frac{25\times 30}{60} = 12.5A.h$ 。

The total discharge power at the initial stage of the accident and the sustained load of the accident is 5 *A·h*+12.5 *A·h*=17.5 *A·h*. The intersection point of 1*h* discharge curve and 17.5*A·h* of discharge lighting is *f*, and the voltage at point *f* can be seen from Fig 1 that is 1.90 *V*, the charged state is 58 %, and the discharge current is 30 *A*.

Shock loading: $\frac{150}{10} = 15A$

After stacking, the total current is 15*A*+30*A*=45*A*. The discharge current of 45 *A* intersects 58% of the curve of the charged state at point *g*, and the voltage coordinate of the corresponding point *g* is 1.85 *V*, which can meet the requirements of the end of the accident (that is, the voltage of each battery is not less than 1.80 *V*). Therefore, it is reasonable to select the battery capacity *FEIFAN 12XL205* colloidal lead-acid battery can meet the calculation of lead-acid battery demand data before, so choose this lead-acid battery.

According to the requirements of 220 *V* input voltage, 200 *kVA* capacity and 25℃ ambient temperature, the cut-off voltage of a single lead-acid battery is 11.9 *V* by using the constant power calculation method 1.70 *V*, considering that the input voltage of UPS uninterruptible power supply has redundancy requirements and lead-acid battery will have a small amount of heat loss when working, the number of lead-acid battery set in series is estimated to be 20 single.Table 1 shows the calculation of lead acid battery parameters:

Table 1 Calculation of lead acid battery parameters

Number	Paramater	Quantitative Value
a	UPS host capacity of uninterruptible power supply	200k *VA*
b	Output power factor	0.8
c	Inverter efficiency	0.95
d	Cut-off voltage of a single battery	11.9 *V* (single: 1.70 *V*)
e	Emergency power supply time requirement: at least stable output	0.5 *h*
f	Number of lead-acid batteries connected in series in each group	20 singles
g	Lead acid battery constant power discharge meter	Show as table 2

Table 2 25℃12XL205 battery discharge power at 1.7 *V* cut-off voltage

Time(*min*)	5	10	15	20	30	40	45	60	90
12XL205	824	664	564	476	366	300	274	224	168

W= S×cosφ /(η×N×n) = (200000× 0.8) /(0.95×20× 7) = 1203 *W*

S: rated capacity of UPS uninterruptible power supply (*VA* or *W*); *Cos φ*: power factor of load, take

0.8; *η*: inverter efficiency, the UPS uninterruptible power efficiency is 95%; *N*:UPS uninterruptible power supply matching lead acid battery group to 12 *V* each to calculate the number of lead-acid batteries needed in series; *N* :12 *V* number of lead acid batteries with 1.7 *V* cut-off voltage in a single battery. *W*: constant power discharge of one 12 *V* lead-acid battery (seven batteries with cut-off voltage of 1.7 *V*).

As can be seen from Table 2, the discharge power of 12XL205 lead-acid battery is 366 *W* when the cut-off voltage of the battery is 1.7 *V* and the discharge time is 30 *min*. Since the constant discharge power demand is 1203 *W*, there are three groups in total which are larger than our calculation requirements. So distribution scheme for lead-acid batteries, UPS uninterruptible power supply each host configuration three groups (each group consists of 20 series, but because of the lead-acid battery installation operators need to consider the overall weight and the problems of installation and maintenance, two symmetrical placed 60 lead-acid storage batteries, the battery holder wiring for the three groups, each group 20 lead-acid battery) 12XL205 type battery. Figure 2 shows the battery. Figure 3 shows the single batteries.

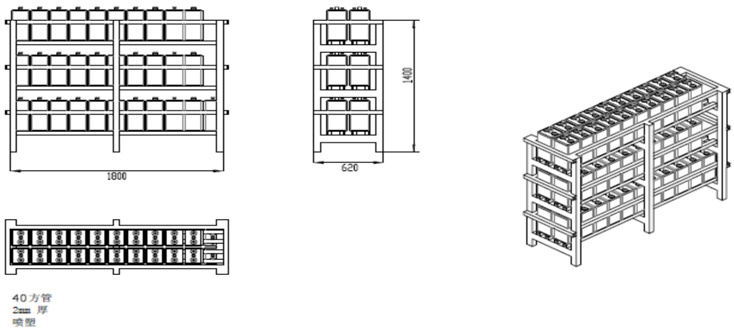

Fig 2. Emergency power diagram

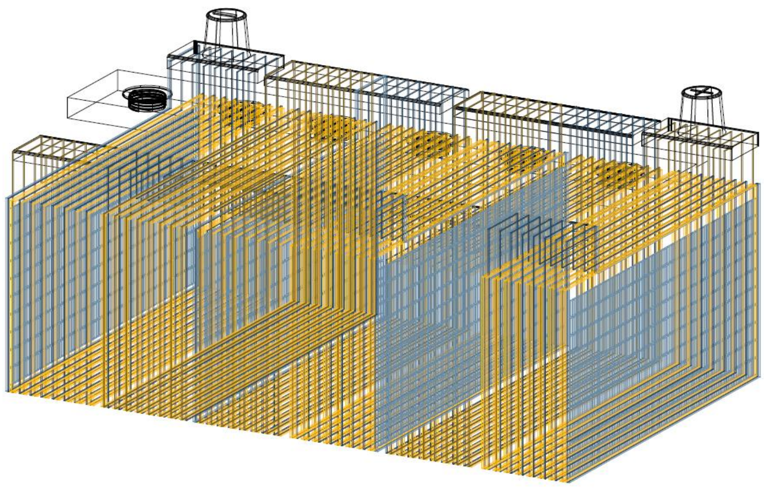

Fig 3.Single battery diagram

IV. STRUCTURAL DESIGN OF LEAD-ACID TYPE EMERGENDY POWER SUPPLY

4.1 Overall structure design of lead-acid emergency power supply

The structure design of lead-acid emergency power supply as Fig 4.

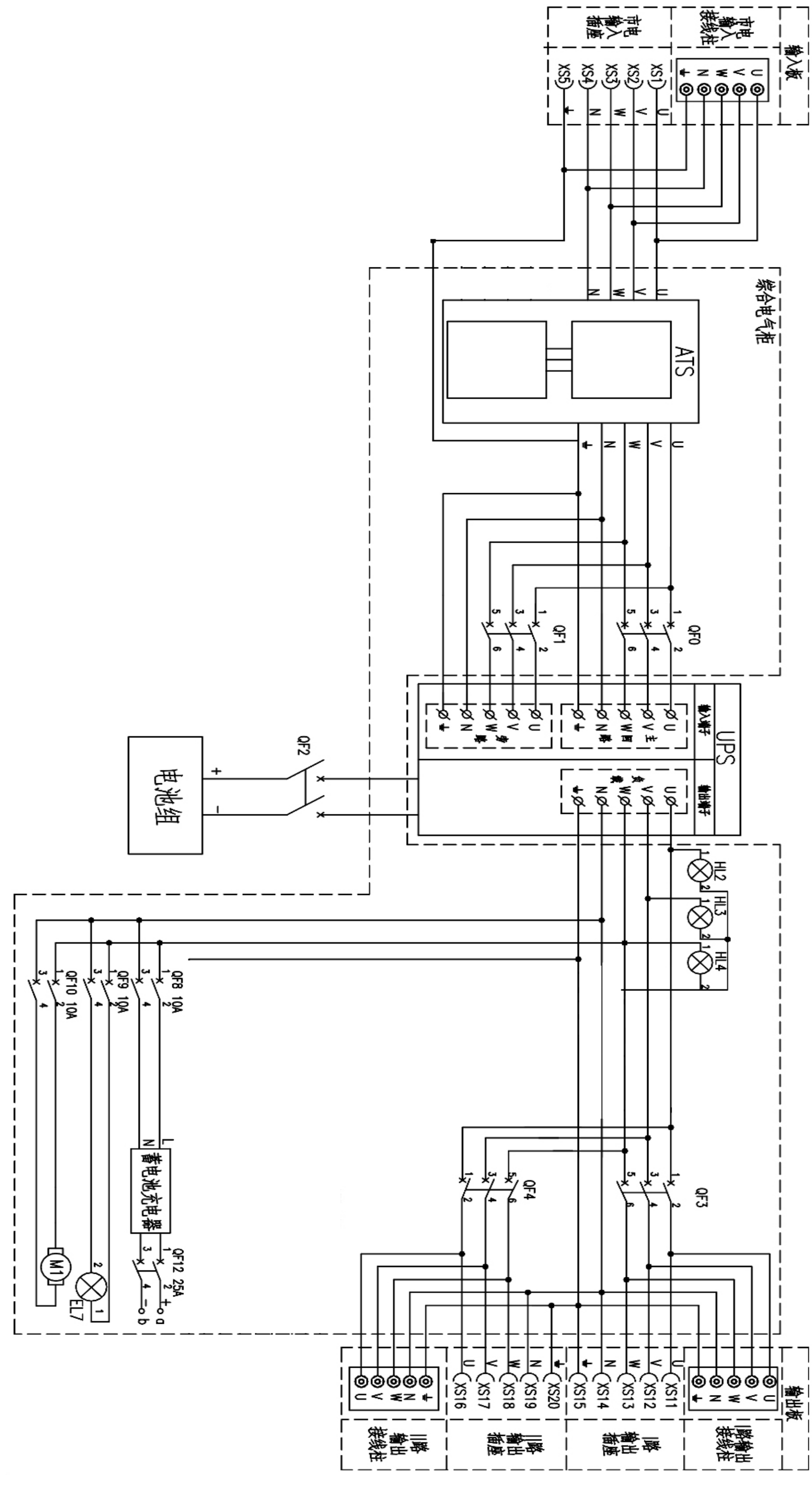

Fig 4.The structure design of lead-acid emergency power supply

4.2 Design of integrated power distribution cabine

Because of the lead acid type emergency power joined the independent dual power switching device (*ATS*) input and output bypass switch cabinet, the equipment relative to the previous old equipment take up more space, so the part of the high voltage function simplified design into the integrated distribution cabinets integrated power distribution cabinet has two area, the upper part of functional areas, integrated with the charger Multifunctional instrument *ATS* controller; The lower part integrates the incoming circuit breaker for the control area, UPS uninterruptible power supply controller. The integrated power distribution cabinet adopts the form of fixed switch cabinet, and is equipped with double power conversion device (*ATS*), circuit breaker, multi-functional intelligent meter, *AC/DC* micro-break, *DC* charger, lightning protection module indicator, etc. It is show as in Fig 5.

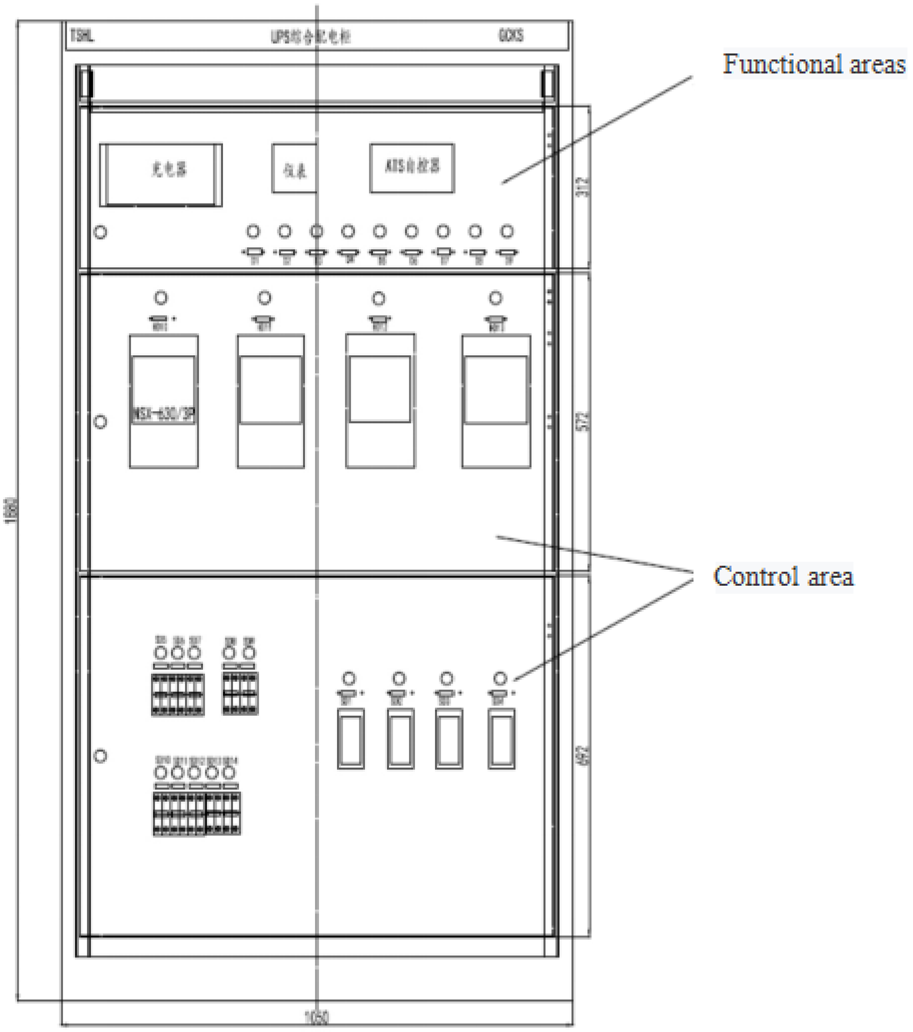

Fig 5 Integrated PDC operation area

4.3 *I/O* interface design

Input interface for wiring terminal or quick access plug socket. It is show as in Fig 6 and Fig 7.

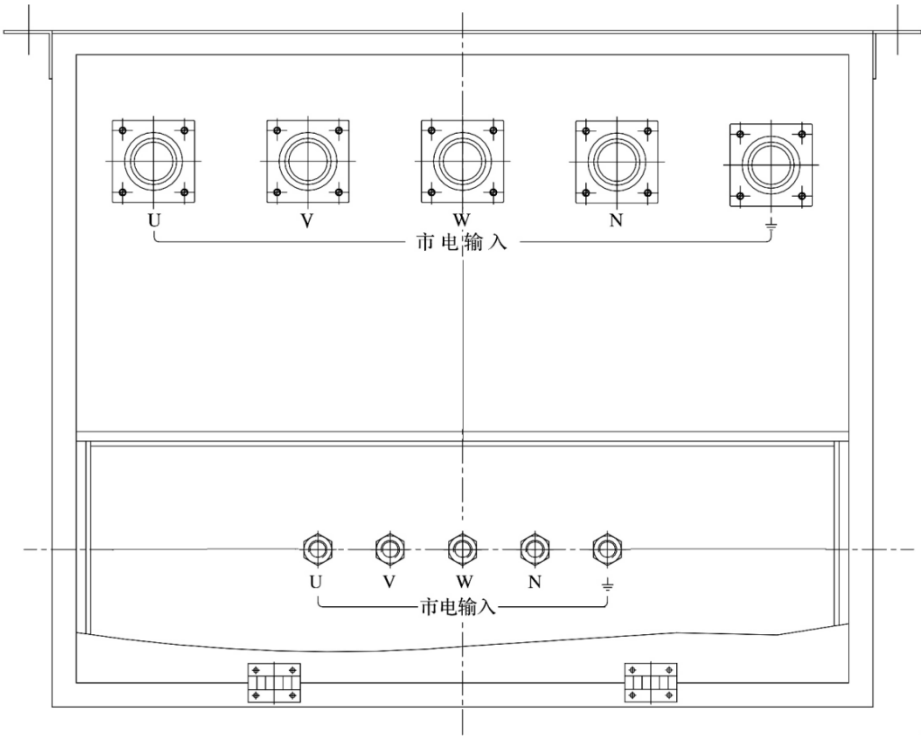

Fig 6 Power input interface

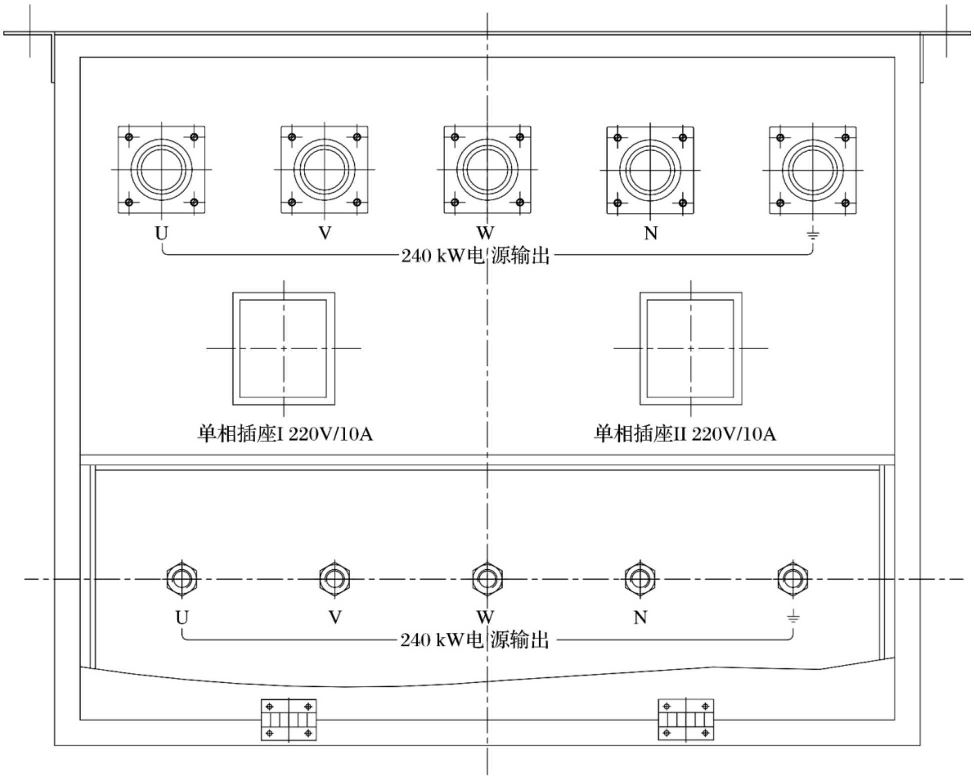

Fig 7 Power output interface

V. CHOICE OF ANTI-CORROSION COATING

5.1 Physical properties of polyurea coating

Spraying polyurea has many advantages. Table 3 lists the performance gap in spraying polyurea material. As can be seen from Table 3, the tensile strength of the new domestic spraying polyurea material is up to 47.5 *MPa*, and its performance is better than that of similar foreign products.

Table 3 Physical properties of spray polyurea

Item	Spray polyurea *A*	Spray polyurea *B*
The tensile strength/*MPa*	22~28	18~47.5
Elongation at break/%	＞450	＞450
tearing strength/$kN.m^{-1}$	43~124	43~166
Shore hardness	A50~D85	A60~D85
100%modulus/*MPa*	3.44~13.8	3.44~13.8
Low temperature flexibility	-40℃, no cracking	-40℃,no cracking
Abrasive resistance/[(750*g*/500*r*)/*mg*]	≤40	≤30

5.2 Waterproof and corrosion resistance of polyurea coating

As show in table 4, the resistance of the new spray polyurea and the waterproof membrane coating in various media are compared. It can be seen that the spray polyurea is impervious to water for up to 120 *min* under 0.4 *MPa* water pressure, and has excellent waterproof performance in seawater salt acid. In a variety of complex corrosive media such as alkali, spraying polyurea plays an excellent role in performance and has a better development space compared with traditional materials, indicating that polyurea has an excellent application prospect in corrosion protection in different scenarios.

Table 4. Comparison of corrosion resistance of three materials

Test condition		Waterproof roll	Waterproof paint	New spray polyurea
Watertightness		0.3MPa，2hWaterproof	0.3MPa，2hWaterproof	0.3MPa，2hWaterproof
Corroding solution	Seawater	Well	Well	Good
	Saturated salt solution	Good	Well	Good
	10% HCl	Good	Well	Good
	20% H_2SO_4	Good	Fair	Good
	20% $NH_3.H_2O$	Fair	Fair	Good
	Raw petroleum	Bad	Bad	Good

5.3 Adhesion of polyurea coating

Spraying polyurea shows good adhesion on the substrate such as steel and aluminum concrete. Table 5 shows the comparison between the adhesion of new high-performance polyurea with different substrates and the requirements of GB/T 23446-2009 spraying polyurea waterproof coating.

Table 5 Adhesion of new spray polyurea on different substrates

Substrate	New spray polyurea(*MPa*)	Standard request(*MPa*)
Steel (Sa2.5)	24	≥10
Al/stainless steel	15~18	≥10
Beton	4.86	≥2.5
Plywood	≥1.75	--
Chloroprene rubber	≥8.9	--

5.4 Durability of polyurea coating

Spray polyurea is often to be used as exposed, the appearance of polyurea material aging resistance is often used as one of the evaluation indicators, the difference in aging resistance is due to the selection of raw materials and formula design level. Table 6 lists the performance of the new spray polyurea before and after the aging resistance test. It can be seen that the difference between the polyurea before and after artificial aging is not obvious or within the acceptable range. After artificial aging, the main performance retention rate is more than 90%.

Table 6 Comparison of properties of new spray polyurea before and after aging

Item	BEFORE AGING	AFTER AGING
Tensile strength /*MPa*	22.6	20.8
Elongation at break /%	524	502
Tearing strength/$kN.m^{-1}$	72	66
Hardness（Shore A）	89	90
Low temperature flexibility	-40℃, no cracking	-40℃, no cracking

VI. CONCLUSIONS

This paper has designed a lead-acid emergency power supply, according to the requirements of the selection of lead-acid battery parameters, this lead-acid emergency power supply selected *Eaton 933E-300KVA* UPS power supply host, selected three groups of 20 *12XL205* lead-acid batteries as the energy storage system and added some necessary power protection function. For this design of the external structure of the lead-acid emergency power supply, the type of the riveted nut is selected and the anti-corrosion coating is selected for the calculation of the compression and shear resistance of the nut. However, this coating is expensive and economical, so it needs further research and development by researchers to improve it.

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