±660kV HVDC Project from Matiari to Lahore in Pakistan

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Thyristor Valve water cooling system

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1. Project Overview

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Converter Valve Cooling System at Mediari Station of Mediari-Lahore ± 600kV DC Transmission Project in Pakistan. There are two valve halls in each of the Murtieri and Hahor converter stations, and each valve hall is equipped with an independent closed cycle valve cooling system.

The external cooling of the valve cooling system adopts the cooling mode of the cooling tower.

1. Project Overview

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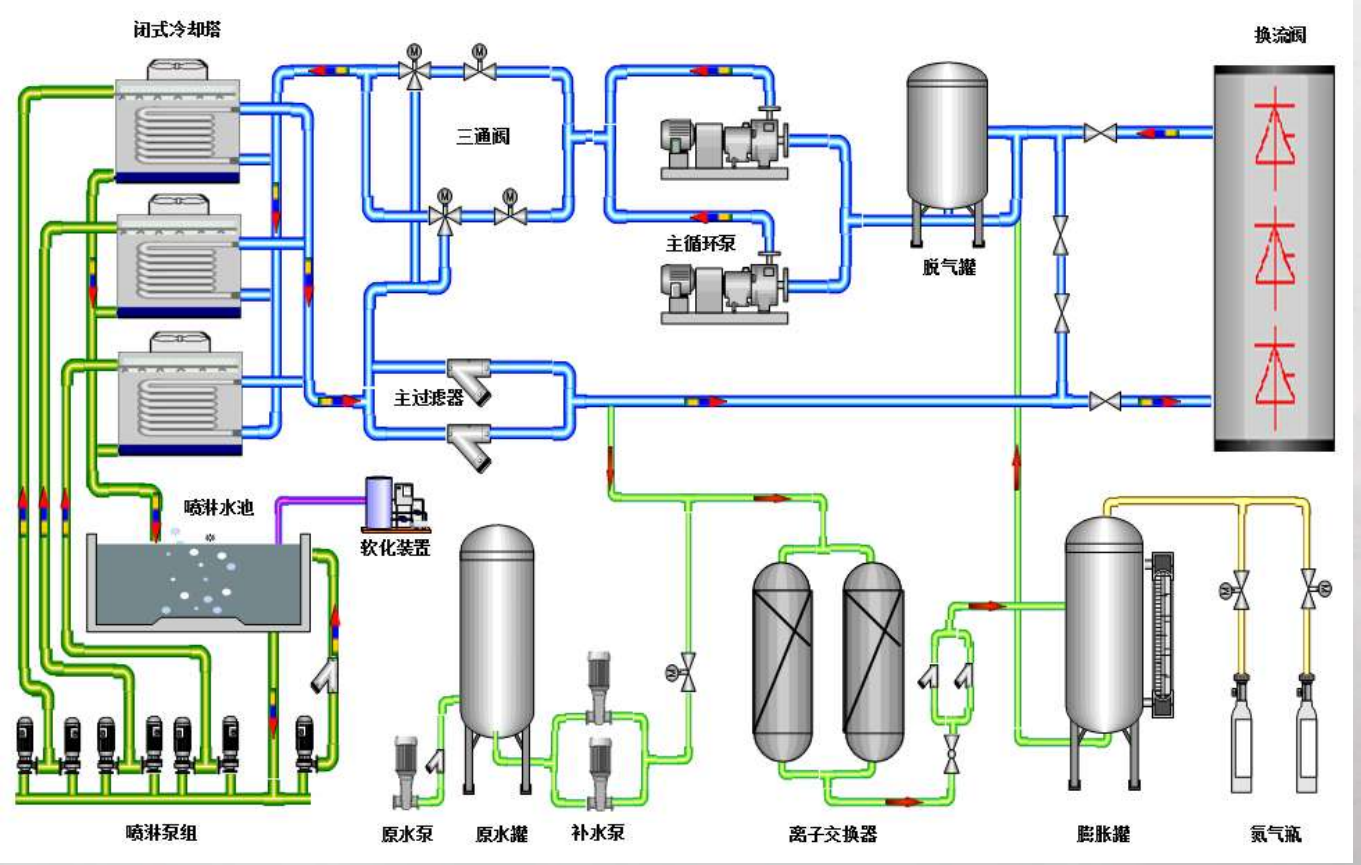

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1、Main Parameters of Converter Water Cooling System

Project Name: VAN BTB Substation	Parameter	Remarks
Rated cooling capacity	5900 kW	
Main cycle rated flow	119L/S	
Maximum converter inlet temperature	46℃	Warning temperature
Maximum converter inlet temperature	49 ℃	Trip temperature
Design pressure of converter internal cooling/external cooling	1.0 MPa/1.6 MPa	Internal cooling stainless steel part/external cooling tube bundle part
Test pressure of converter internal/external cooling	1.0 MPa/1.6 MPa	Internal cooling stainless steel part/external cooling tube bundle part
Main cycle filtration accuracy	100 μm	
Deionized water filtration accuracy	5 μm	

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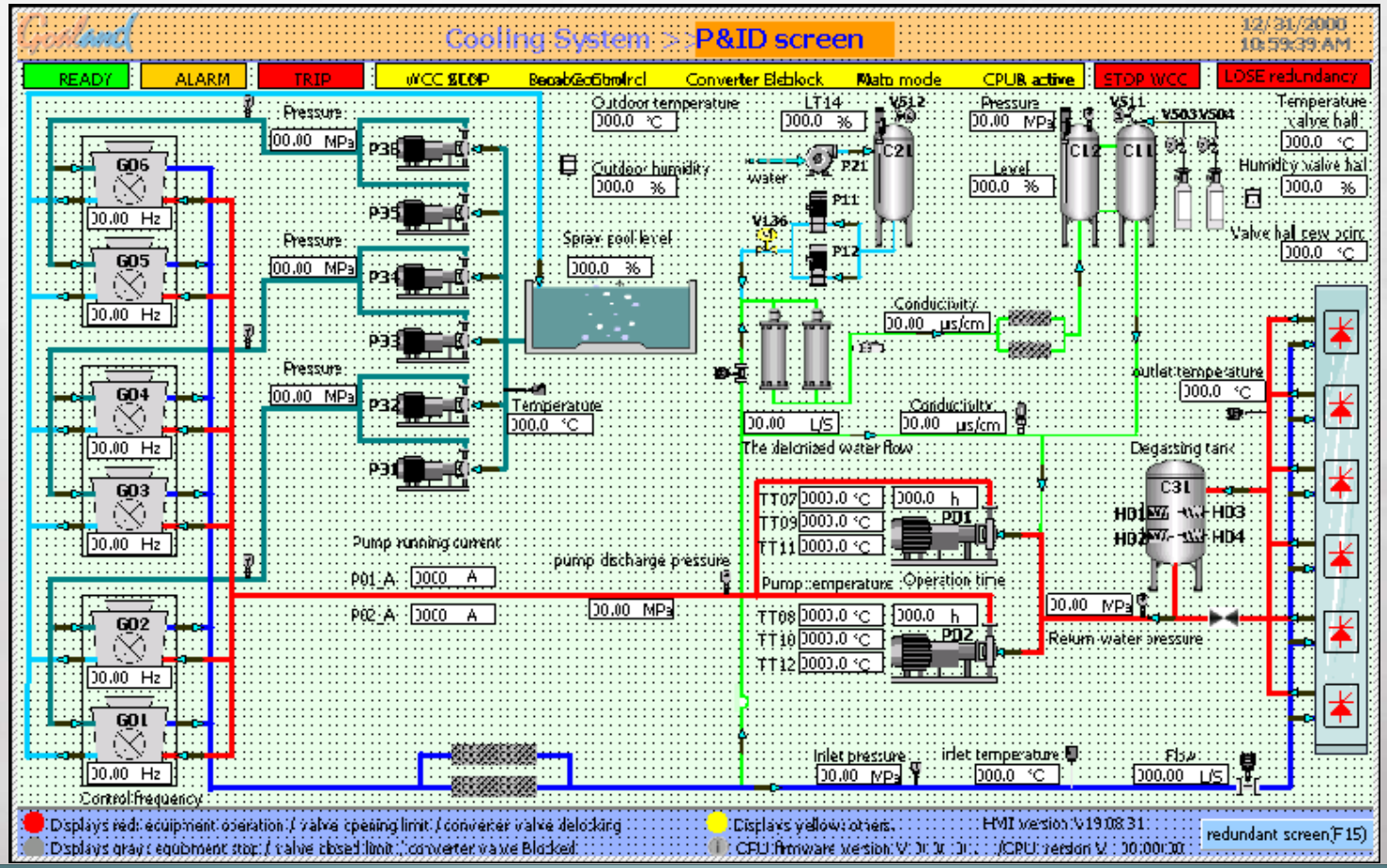
2. Process Flow Diagram of Converter Water Cooling System



3、Main Circulating Equipment of Converter Internal Cooling System

It is composed of a main pump, a filter, an electric heater and a degassing tank and relevant instruments and meters.

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4、Water Treatment Equipment for Converter Internal Cooling System

It comprises an expansion tank, a raw water tank, an ion exchanger, a refill pump, a raw water pump and relevant instruments and meters.

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5、Design of Converter Internal Cooling System-Main Pump

P01 and P02 main circulating water pumps are made of AISI 316 stainless steel, one for use and one as standby. Each pump has 100% capacity and is provided with overload and overheat protection (the motor has the temperature transmitter output signal function).

Both the water pump inlet and outlet are equipped with corrugated compensator to reduce vibration.

If the pump in operation has a failure or fails to provide the rated pressure, the standby pump shall be switched on immediately with an alarm signal set off. Meanwhile, the pump in operation will undergo an automatic switch after running continuously for a period of time (168 h), and the system flow and pressure will remain stable during switching.

Rated power ：110W

Total design flow：440m3/h

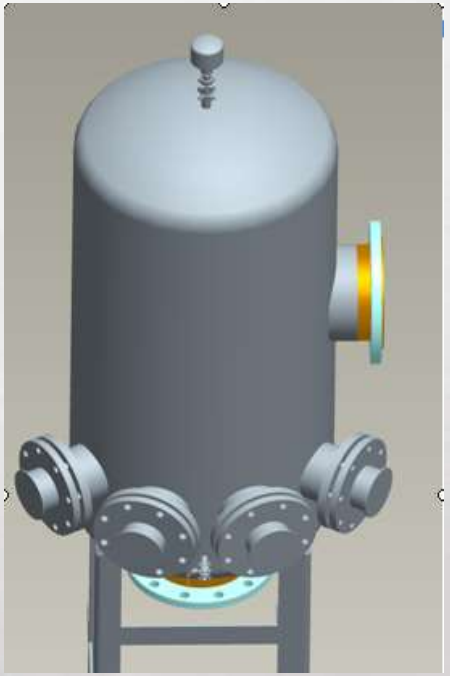
Lift：70m

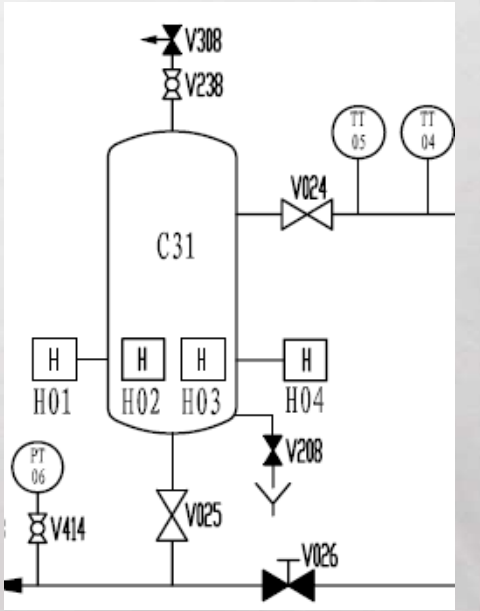
6、Design of Converter Internal Cooling System-Electric Heater

H01 and H02 electric heaters are placed in the degassing tank of the main circulating cooling water circuit for adjusting the temperature of cooling water in winter when the temperature is extremely low and the converter valve will be shut down, so as to prevent the cooling water temperature from being too low.

Four electric heaters shall be arranged according to the ambient temperature of the project site, and fault alarm shall be set off.

Power of electric heater 30kW/unit, 4 units in total.





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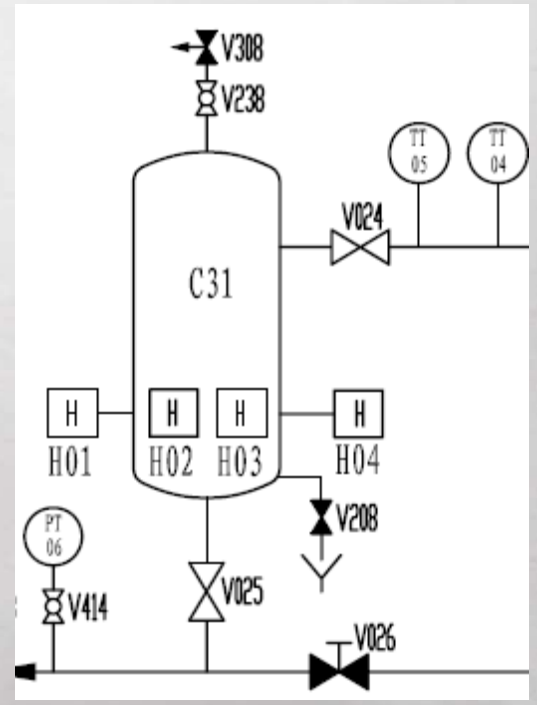
7、Design of Converter Internal Cooling System-Degassing Tank

C31 degassing tank is placed at the main pump inlet, and the top of the tank is equipped with an automatic exhaust valve, which can completely exhaust the gas in the cooling water.

The degassing tank can also be used as a heating tank, and the electric heater of the converter internal cooling system will be mounted in the degassing tank.

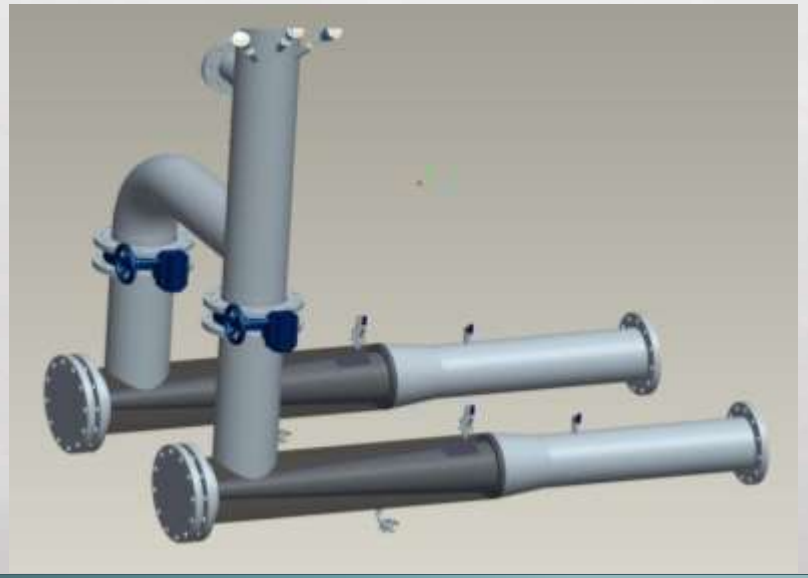


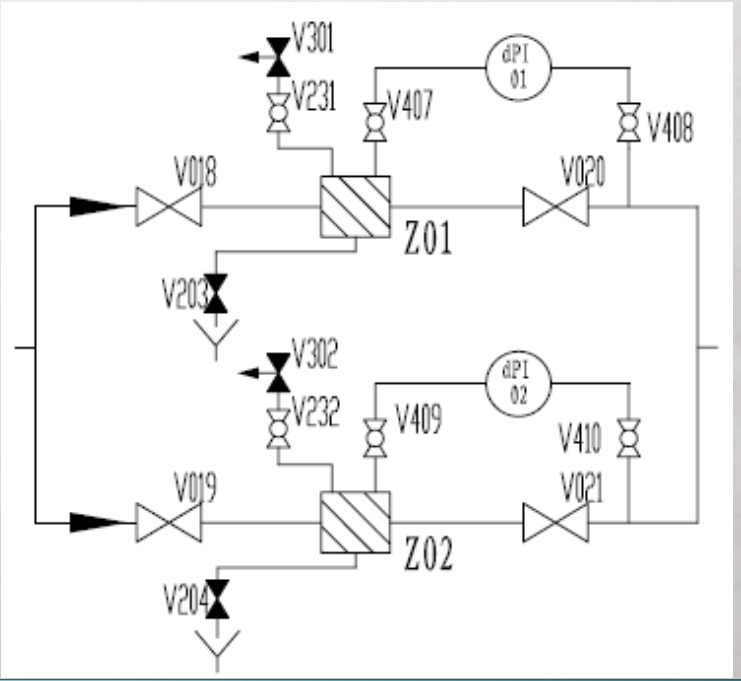
8、 Design of Converter Internal Cooling System-Main Filter

Z01 and Z02 main filters are placed at the water inlet of converter valve. Two sets of filters are arranged. Stainless steel cone filter elements are used. Maintenance valve, differential pressure meter and manual exhaust valve at the top are set up at the front and back of the filters.

In the process of normal operation, a single filter element can be cleaned online.

Filtering accuracy: 100μm

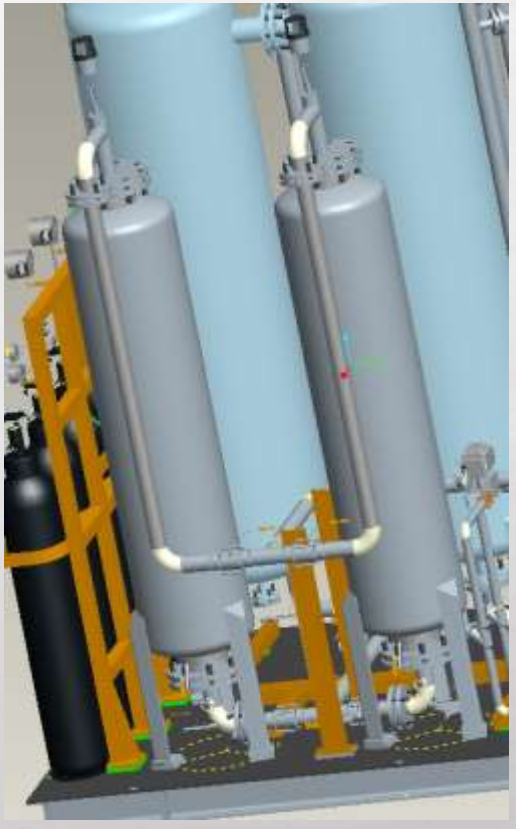


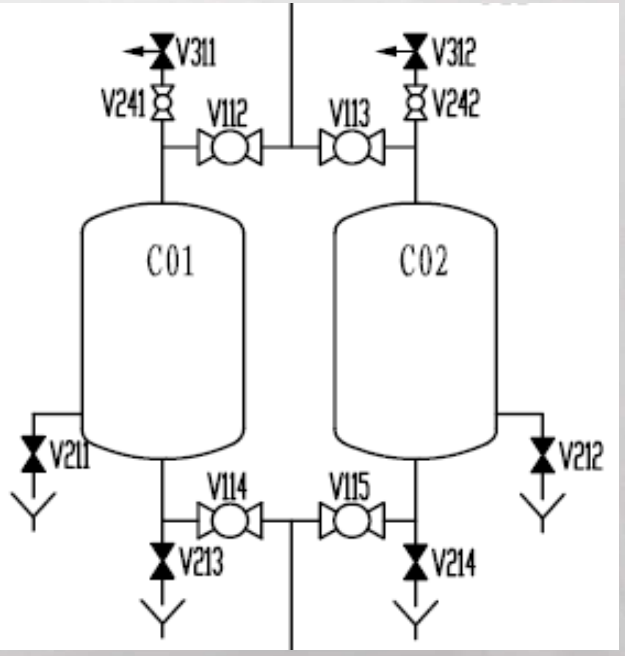


9、 Design of Converter Internal Cooling System-Ion Exchanger

C01 and C02 ion exchangers consist of a stainless steel ion tank, a filter, an ion exchange resin, etc. each.

2 sets of ion exchangers are provided, one for use and one as standby. When the resin in one of them fails, an alarm signal will be sent for prompt replacement of ion exchange resin. Material of ion exchanger: 440L





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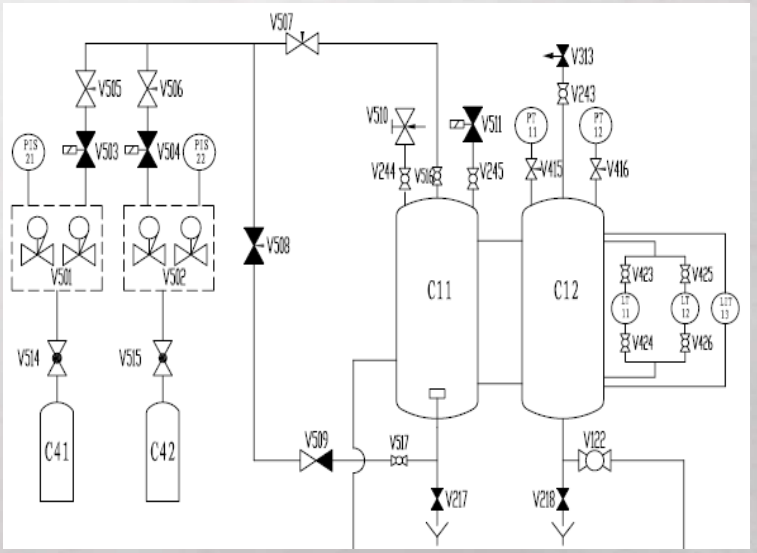
10、Design of Converter Internal Cooling System-Expansion Tank

The expansion tank is filled with high purity nitrogen with stable pressure on the top. When the cooling medium is lost due to a small amount of extravasation or electrolysis, the nitrogen automatically expands to press the cooling medium into the circulating pipeline system to keep the pipeline pressure constant and the cooling medium full.



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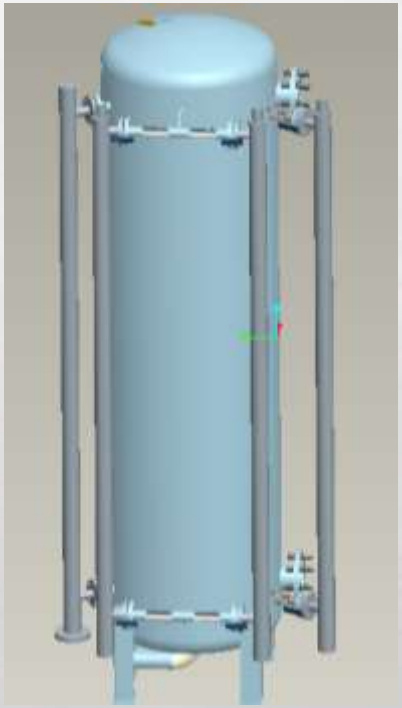
11、 Design of Converter Internal Cooling System-Expansion Tank

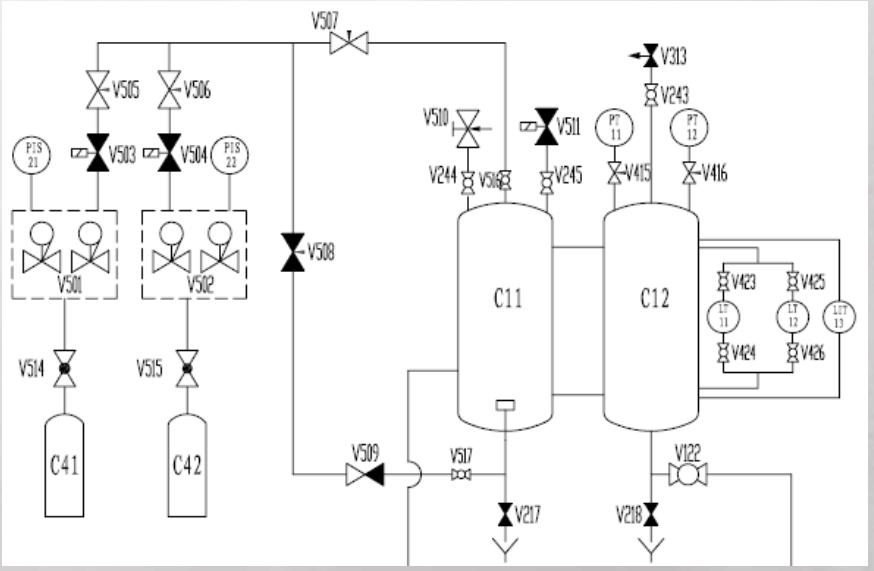
The expansion tank is installed with 3 sets of independent capacitive liquid level sensors and 1 set of magnetic

flap type liquid level sensor, which will be mounted outside the expansion tank and can display the liquid level in it.

When the liquid level of the expansion tank reaches the set low point, an alarm signal is set off,

and the refill pump will be started automatically to refill water before the alarm.





12、 Design of Converter Internal Cooling System - Refill Pump

There are P11 and P12 refill pumps, one for use and one as standby. They will be started automatically when the liquid level in the expansion tank drops to the required refill water level, and will be stopped automatically when the refill water level reaches the set pump stop level. In addition, the refill pumps are also provided with the local manual starting function.

The refill pump outlet is provided with pressure gauge and electric valve.

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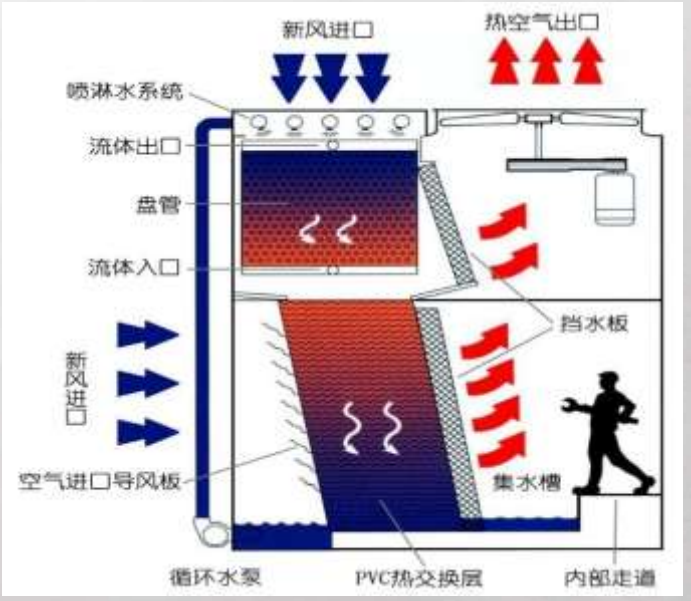
13、Design of Converter External Cooling System-Cooling Tower

The closed cooling tower is used as the outdoor heat exchange equipment of the water cooling system of the converter valve, which transfers the heat loss of the converter valve to the spray water and the atmosphere.



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III. Converter Water Cooling System Main Equipment Control

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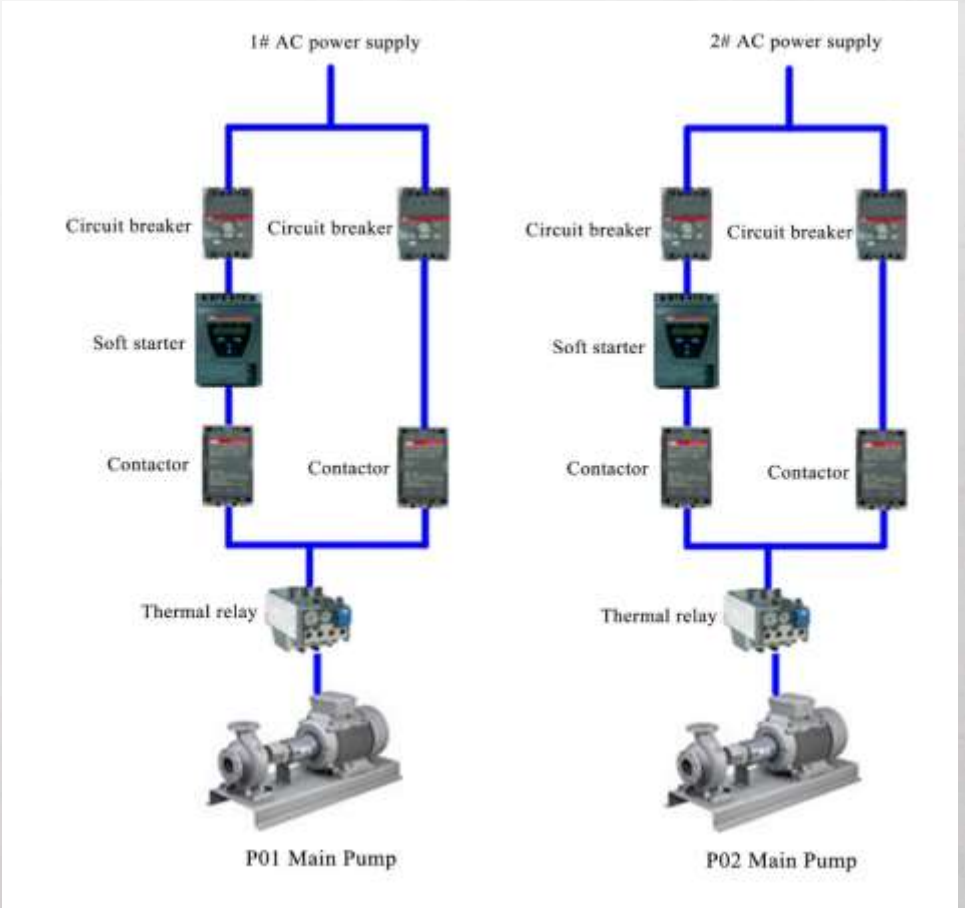
1、Main Pump

The converter water cooling system is equipped with two main pumps, which shall act as standby for each other. If the working pump circuit fails, it will automatically switch to the trouble-free standby pump. The primary circuit of the main pump motor is installed with a soft start and a power frequency circuit, which will be normally started by a soft starter and be switched to power frequency operation after soft start is completed.



2、Electrical Heater

(1) When the temperature of cooling water at the converter inlet is ≤H01 and H02, the electric heaters H01 and H02 will be started; when the temperature of cooling water at the converter inlet is > H01 and H02 electric heater stop temperature settings, the electric heaters H01 and H02 will stop.

(2) When the temperature of cooling water at the converter inlet is lower than/close to the dew point of valve hall by 1 ° C, 2 electric heaters will be forced to start.

(3) When the temperature at the converter inlet is > (converter inlet temperature high set value of-5 ° C), the electric heater will be forced to stop. This takes precedence over other conditions.

(4) The starting of the electric heater interlocks with the operation of the main pump and the cooling water flow low value.

3、Refill pump - Automatic Refill

(1) Automatic refill control can be realized when the converter water cooling system operates automatically. When the liquid level in the expansion tank drops to the automatic refill liquid level, the refill pump will start. When the liquid level in the expansion tank reaches the liquid level of the refill stop pump, the refill pump will stop.

(2) The automatic refill is a kind of intermittent refill, which will help prevent the system pressure from increasing rapidly due to too fast refill speed. The intermittent refill way is to automatically make up water for 2 min. and then stop circulating for 3 min. until the liquid level in the expansion tank reaches the pump stop level.

(3) When the liquid level of the raw water tank reaches the low level during automatic water refill, the system will forcibly stop the refill pump.

(4) The two refill pumps are featured by a configuration with one for use and one as standby, and only one of the refill pumps will be started during automatic water refill.

4、Nitrogen Stabilization

(1) There are two sets of air supply circuits, which are controlled by V503 solenoid valve and V504 solenoid valve respectively. V503 or V504 will be selected to be put into operation through the MP operation panel.

(2) When the expansion tank pressure is lower than the opening pressure of the air supply solenoid valve, the air supply solenoid valve will open the air supply action; when the expansion tank pressure reaches the closing pressure of the air supply solenoid valve, the air supply will stop.

(3) When the expansion tank pressure still does not reach the closing pressure of the air-supply solenoid valve after the air-supply solenoid valve continuously supplies air to reach the air-supply failure delay minutes, the solenoid valve failure will be reported and the solenoid valve will be switched to another solenoid valve for operation.

(4) The exhaust circuit is installed with a V511 solenoid valve. When the expansion tank pressure is higher than the opening pressure of the exhaust solenoid valve, the exhaust solenoid valve will open the exhaust; when the expansion tank pressure is lower than the closing pressure of the exhaust solenoid valve, the exhaust will stop.

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5、External Cooling cooling tower

A total of 3 cooling tower fans are divided into one group, G01, G03, and G05 are a group; when the inlet valve temperature exceeds 33 ° C, any set of fan frequency converters are started and PID adjustment is performed according to the inlet valve temperature change; If the temperature is lower than 29 ℃ and the frequency of the fan is lower than 20Hz, the fan will be stopped after 600S delay. At this time, the fans are stopped, and the start and stop are controlled according to the change of the inlet valve temperature. If a single fan has a variable frequency fault, it automatically switches to power frequency operation.

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IV. The control and protection instructions for converter water cooling system

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1、Control system introduction

The converter water cooling system adopts PLC of Siemens S7-400H series, and the CPU and I/O modules of the control system are redundantly configured.

The two CPUs are configured with synchronization templates and are connected by optical cables to achieve CPU hardware redundancy. The S7-400H adopts the principle of active redundancy in hot standby mode. When a failure occurs, it automatically switches without disturbance. When there is no failure, both subunits are in operation status. If a failure occurs, the subunit which is in normal operation can independently control the entire process.

The system consists of two independent PLC systems of S7-400H series, which can realize:

Redundancy of main rack power supply and backplane bus, etc.;

PROFIBUS fieldbus network redundancy (including communication interface, bus connector, bus cable);

Redundancy configuration of the communication interface module IM153-2 and all I/O modules of ET200M station.

The principle of relevant system configuration is as follows:

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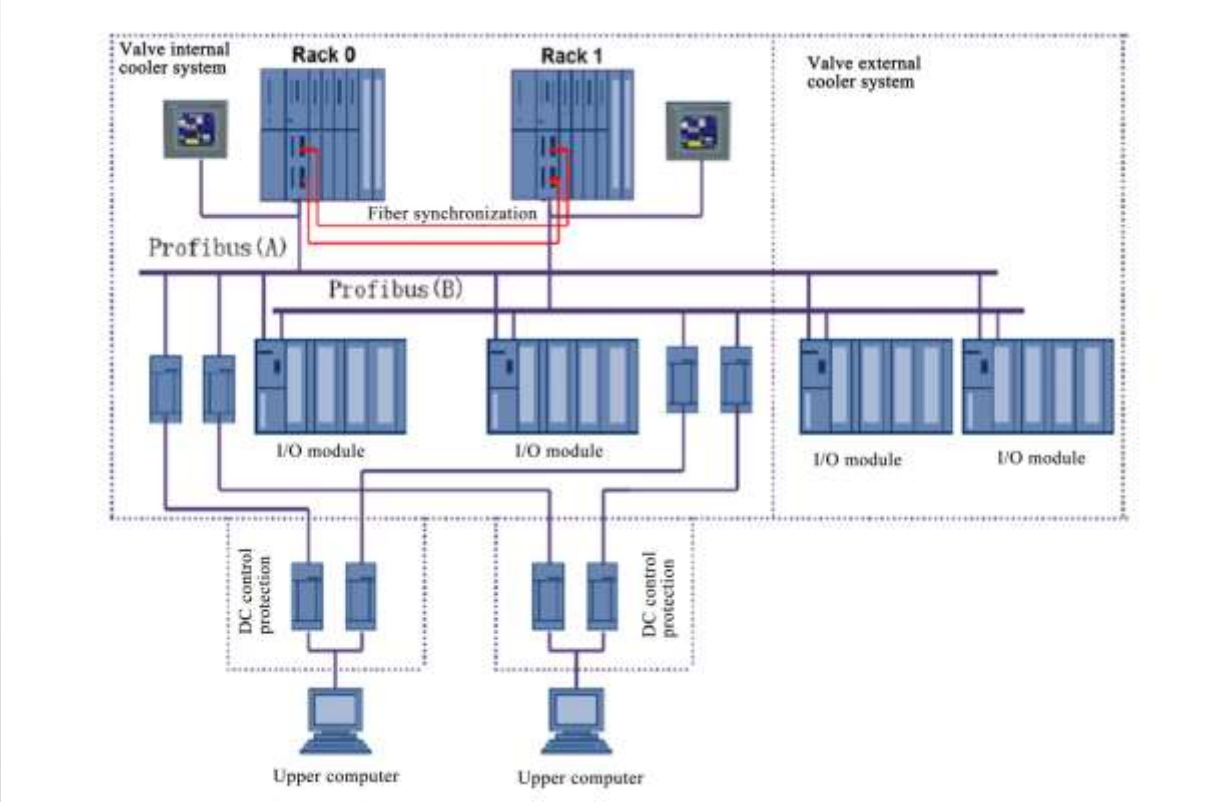

IV. The control and protection instructions for converter water cooling system

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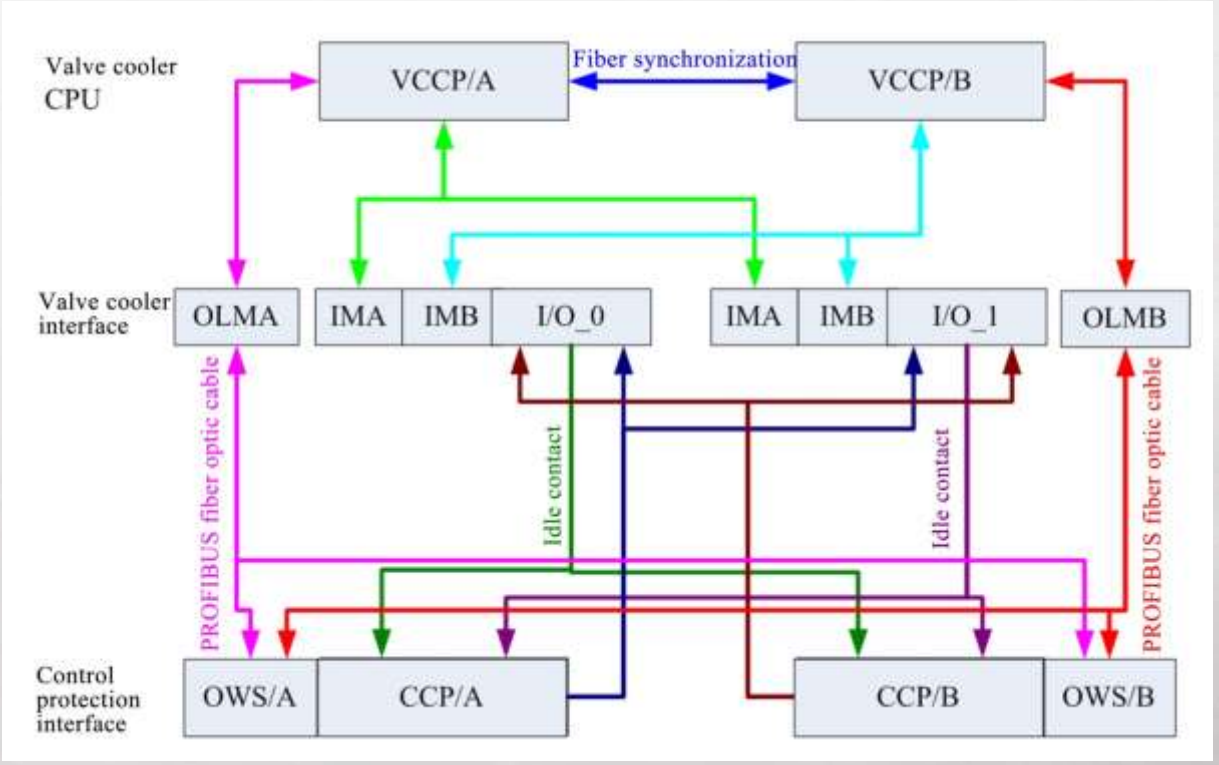

2、Sensor configuration

- In order to ensure the safe and stable operation of the system and prevent the converter valve from being stopped due to the instrument failure of the converter water cooling system, redundant instruments, which are mutual hot standby, are set for monitoring the important parameters such as the cooling water valve inlet temperature, cooling water conductivity and cooling water flow of the converter water cooling system.
- When any one of the redundant meters indicates that the value exceeds the warning limit, an early warning alarm is made to remind the operators to deal with it in time. When two of the redundant meters indicate that the values exceed the warning limit, a second-level alarm is made to remind the operators of the importance degree of the alarm.

7、Trip protection logic

- Trip for ultra-high upstream temperature
- Three sets of valve inlet temperatures trips due to the failure
- Trip due to ultralow flow rate + low valve inlet pressure (request to stop the converter water cooling system)
- Trip due to ultralow flow rate + high valve inlet pressure (request to stop the converter water cooling system)
- Trip due to low flow rate + ultralow valve inlet pressure (request to stop the converter water cooling system)
- Trip due to ultralow liquid level of the expansion tank (request to stop the converter water cooling system)
- Trip due to leakage (request to stop the converter water cooling system)
- Trip due to control system failure (power supplies failure/CPUs failure)

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V. Valve cooling system maintenance

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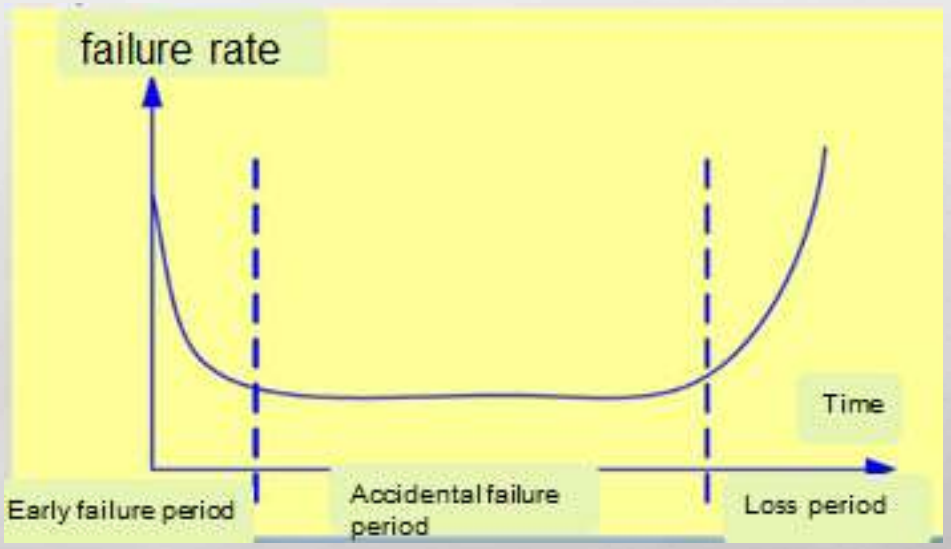
Generally refers to an event or phenomenon in which a device loses or reduces its specified function. It is manifested that some parts of the device lose their original accuracy or performance, causing the device to fail to operate normally and the technical performance to be degraded, resulting in interruption of production or efficiency of the device and affecting production. . Simply put, a device (or its parts) loses its function. Practice has proved that the failure rate of serviceable equipment has a graphical shape with time, which is the famous "bathtub curve".



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NO.	NAME of equipment	Maintenance project	Maintenance standard
1	Main circulation pump overhaul	Motor bearing	Good bearing lubrication, lubricating oil cleaning, filling lubricant
2		Fan inspection and cleaning	The fan is well fixed, the appearance is clean and the operation is normal.
3		Main circulation pump terminal inspection	Fastened wiring, no looseness
4		Pump winding insulation inspection of the outer casing	>10MΩ

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NO.	NAME of equipment	Maintenance project	Maintenance standard
5	Main circulation pump overhaul	Main pump bushing seal inspection	The sleeve is well sealed and has no water seepage
6		Vibration abnormality check	No abnormal vibration
7		Main pump and motor coaxiality check	≤0.1mm
8		Coupling inspection	No looseness, no damage
9		Bearing housing oil level check	Normal oil level
10		Pump motor running current check	≤ motor rated current

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Motor lubrication

Concentricity check

Coupling inspection

Leak check

Motor wiring check

Insulation inspection

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NO.	NAME of equipment	Maintenance project	Maintenance standard
1	heater overhaul	Electric heater cable insulation inspection	>10MΩ
2		Heater wiring check	Fastened wiring, no looseness
3	Valve check	All valve stem seal inspection	No leakage at the stem shaft seal
4		All valve position check	Correct valve position

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Electric heater cable insulation and wiring inspection

Valve stem seal and valve position check

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NO.	NAME of equipment	Maintenance project	Maintenance standard
1	Power circuit check	Power cable wiring nose	The cable connection is fastened, the tin block is not broken, the copper wire is not rusted, the conductivity is good, and the temperature measurement is good.
2		Power cable insulation inspection	>10MΩ
3	Cleaning	Screen cabinet cleaning	Clean appearance
4		Screen cabinet cooling filter cleaning	Cleaning filter`
5		Water-cooled pipelines, tank cleaning	Clean appearance

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Screen cabinet cleaning

Terminal fastening

Power circuit check

Pipe cleaning

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NO.	NAME of equipment	Maintenance project	Maintenance standard
1	Control loop	Relay check and inspection	The relay operates normally, the nodes are not glued, and there is no abnormality such as flashover.
2		Important trip signal loop check	Short-circuit terminal or analog protection action, signal transmission is normal
3		Terminal fastening	All terminals are tightened and the wiring is not loose

Control loop check

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NO.	NAME of equipment	Maintenance project	Maintenance standard
1	Filter	Main filter cleaning	No impurities at the bottom of the filter, no impurities attached to the filter
2		Refill pup filter	No impurities at the bottom of the filter, no impurities attached to the filter
3		Precision filter replacement	No impurities at the bottom of the filter

V. Valve cooling system maintenance

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Filter pipe drain

Main filter flange removal

Main filter, precision filter removal

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Main filter, precision filter

High pressure water gun flush

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NO.	NAME of equipment	Maintenance project	Maintenance standard
1	Air circuit seal inspection	nitrogen circuit sealing inspection	no air leakage
2		Nitrogen bottle pressure check	>1.0MPa
3		Expansion tank related valve sealing inspection	Good valve switching performance, good exhaust function, no air leaks at the interface
4		Solenoid valve check	Open and close normal

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Air circuit seal inspection

5. 阀冷系统维护及保养

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NO.	NAME of equipment	Maintenance project	Maintenance standard
1	Cooling tower	Fan motor start	Should be free from overheating, overload, and steering correctly
2		Motor protection	Do not malfunction, the power cord should be insulated with wires
3		pond	Clean

V. Valve cooling system maintenance

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Cooling tower clean

Pond clean

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Thank You!