1 Introduction

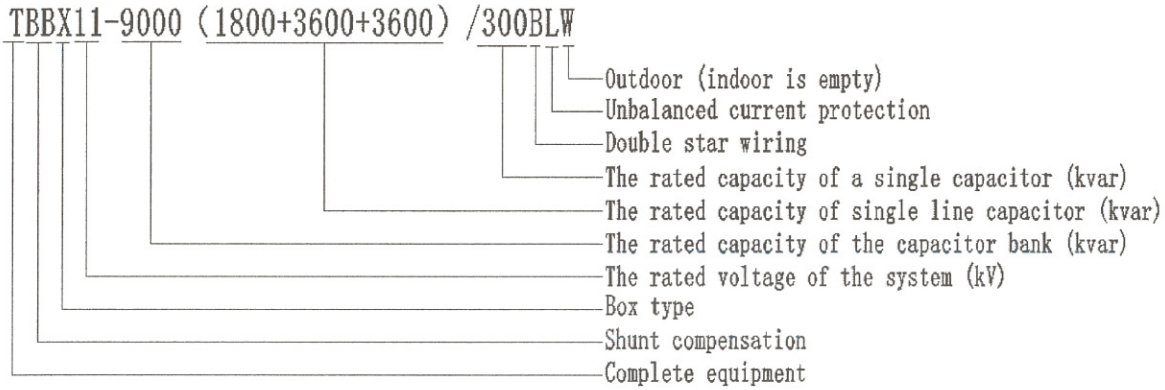
1.1 Main purposes and applicable range

The box type high voltage shunt capacitor device (hereinafter referred to as the device) is used in the AC power system with the rated voltage of 11kV and 22kV and the rated frequency of 50Hz in the Egyptian market. It is designed to increase the grid power factor, increasing the voltage quality of the power system, fully exploit the economic efficiency of the power transmission and transformation equipment, reducing power losses and improving power utilization.

1.2 Product model description

The device falls into two types according to the voltage level: 11kV and 22kV, and contains the models of TBBX11-9000 (1800+3600+3600)/300BLW, TBBX22-9000 (1800+3600+3600)/300BLW.

Taking 11kV device as example



The naming of the above models follows the conventional way of definition. In case of special requirements, customization is provided as required.

2 Service conditions

2.1 Environment conditions

1) Ambient air temperature

Temperature range: -5 ～ 55℃ or 0 ～ 60℃ (With different ambient temperatures, the cooling systems are different)

Maximum daily temperature difference: 25K

The average temperature in the hottest month: 45℃

Maximum annual average temperature: 35℃

2) Height above sea level: ≤1000m

3) Maximum wind speed: 35m/s

4) Maximum ice coating thickness: 10 mm

5) Solar radiation intensity: 0.1 W/cm^2 (wind speed 0.5m/s)

6) Environmental relative humidity (at 25℃)

Daily average: 95%

Monthly average: 90%

7) Earthquake level acceleration: 0.3g

8) Installation location: Indoor, outdoor (box)
Indoor (control cabinet)

9) Corrosion level of the operating environment: C3

3 Main technical parameters and technical performance indicators

3.1 Main technical parameters

Table 1.Main technical parameters

SN	Parameter name		Unit	Parameter value	
1	Device model			TBBX11-9000 (1800+3600+3600) /300BLW	TBBX22-9000 (1800+3600+3600) /300BLW
2	Rated voltage		kV	11	22
3	Maximum operating voltage		kV	12	24
4	Rated frequency		Hz	50	50
5	System grounding method			Small resistance ground	Small resistance ground
6	Minimum insulation distance between phases		mm	120	220
7	Phase to ground minimum insulation distance		mm	120	220
8	Protection level			IP54	IP54
9	Device control method			Switch manual/automatic	Switch manual/automatic
10	Protection method			Double star unbalanced current protection	Double star unbalanced current protection
11	Heat dissipation method			Forced air cooling	Forced air cooling
12	Capacitor unit	Model		BAM11/√3-300-1W	BAM22/√3-300-1W
		Protection mode		Internal fuse	Internal fuse
		Discharge method		Internal discharge resistor	Internal discharge resistor
13	Current limiting reactor Model			CKGKL-11-200A-0.1mH	CKGKL-22-100A-0.1mH
14	Breaker	Type		Vacuum type or SF6 type	Vacuum type or SF6 type
		Rated current	A	630~1250 (optional)	630~1250 (optional)
15	Isolated earthing switch	Model		GN24-12D/1250-31.5-3	GN24-24D/1250-31.5-3
16		Operating mode		Manual or electric	Manual or electric
17	Reactive power controller model			RVT-6	RVT-6
18	Secondary power supply		DC voltage	V	40~275 (optional)
19			AC voltage	V	220

3.2 Capacitance deviation

a) The allowable capacitance deviation of the capacitor bank is 0～+5% of the rated capacitance of the device;

b) The ratio of the maximum to the minimum between any two line terminals of a three-phase capacitor bank shall not exceed 1.02.

3.3 Inductance deviation

a) The device has a current limiting series reactor. Under the rated current, the allowable deviation of the reactance value is 0～+10%;

b) For a three-phase reactor bank consisting of a three-phase reactor or a single-phase reactor, the reactance value of each phase not exceed ±2% of the average value of the three phases;

3.4 Insulation level

The withstand voltage between phases as well as between the phase and the ground for the primary circuit of the device (excluding components) and between the secondary circuit and the ground shown in Table 2 (except for the special requirements of the customer). The time to apply the frequency withstand voltage is 1min.

Table 2 Insulation level

Nominal voltage (kV)	Maximum voltage of the device (kV)	Primary circuit		Power Frequency withstand voltage of the secondary circuit (kV, RMS value)
		Power Frequency withstand voltage (kV, RMS value)	Impulse withstand voltage (kV, [(1.2～5)/50μs, peak value]	
11	12	28	75	2
22	24	50	125	

3.5 Temperature rise

For box-type devices, the temperature rise of relative electrical equipment shall not exceed the respectively specified value. The rest shall comply with the relevant provisions of IEC 62271-1.

3.6 Withstand short-circuit current capability

The electrical equipment, connecting wires and mechanical structures in the main circuit shall be able to withstand the short-circuit current of the system for 3s without causing thermal and mechanical damage and significant deformation.

3.7 Overload capability

3.7.1 Steady-state over-current

The device shall be capable of continuous operation at a current with an RMS value not exceeding 1.3 I_N. This current is the result of a combination of 1.1 U_N, capacitance value deviation and high harmonic.

3.7.2 Steady-state over-voltage

The device has a continuous operating voltage of 1.05 U_N and can operate for a corresponding period of time under the steady-state over-voltage specified in Table 3.

Table 3 Steady-state over-voltage

Power Frequency over-voltage	Maximum duration	Notes
1.10 U_N	Long-term (not exceed 12h per 24h)	Meaning that the maximum value of long-term working voltage shall not exceed 1.1 times
1.15 U_N	30min per 24h	Adjustment and fluctuation of the system voltage
1.20 U_N	5min	Voltage rise under light load
1.30 U_N	1min	

3.7.3 Inrush current

The device is equipped with a current-limiting series reactor to effectively limit the switching inrush current of the capacitor bank to less than 65 times.

3.7.4 Transition over-voltage

The switching apparatus selected for the device has over-voltage between terminals less than $2\sqrt{2}U_N$ (peak) during operation.

4 The main components of the box type shunt capacitor complete device

The box-type capacitor device is composed of a case and a control cabinet. The box is pre-assembled with a shunt capacitor unit, a circuit breaker, a reactor, an isolated earthing switch, a current transformer, a lightning arrester, an online monitor, a post insulator, a bus bar and other components. It has an external control cabinet (placed in the main control room) used to control the switching of the capacitor bank and realize the function of voltage and current protection of the capacitor bank.

4.1 Shunt capacitor

The shunt capacitor is mainly used to increase power factor, improve voltage quality, and reduce line losses. The shunt capacitor, unlike most other appliances, always operates at maximum load when applied in a power system.

The introduction of centralized capacitance in the system will cause various unfavorable operating conditions as follows: after the capacitor is connected in the system, the system voltage will rise; the voltage on the capacitor terminal will increase abnormally at light load; if the system has harmonic source (eg. large rectifiers, saturated transformer cores, electric arc furnaces, and rolling mills), it will cause over current in the capacitor and produce a greater thermal effect than the fundamental wave.

If the voltage, current and temperature during operation exceed the specified limit, the life of the capacitor will be shortened. Therefore, it is necessary to make a reasonable choice for the operating conditions of the capacitor.

4.2 Current limiting series reactor

The current limiting series reactor is connected in series in the capacitor circuit to suppress the switching inrush current.

4.3 Circuit breaker

The circuit breaker selected by the device is a vacuum circuit breaker or the SF_6 circuit breaker, which is used for switching of each branch capacitor bank. The performance of the circuit breaker shall meet the following requirements:

a) When the vacuum circuit breaker is closed, the contact bounce time is less than 2ms;

b) Opening and closing current capability of circuit breakers shall reach C2 level;

c) Capability of withstanding the switching inrush current;

d) Capability of the circuit breaker to quickly break the short-circuit current;

e) Capability of capacitive current breaking;

f) The arc extinguishing chamber shall be handled in a sophisticated manner;

4.4 Metal oxide arrester

The main function of the arrester is to protect the shunt compensation capacitor bank from damage by lightning overvoltage and operating overvoltage.

4.5 Online monitor

The online monitor makes a real time record of the times of the arrester discharges and an online monitor of the leakage current change of the lightning arrester. According to the variation of leakage current, the working condition and abnormal condition of the arrester in operation shall be estimated in time to prevent accidents and improve the reliability of the operation of the power system.

4.6 Isolated earthing switch

The high-voltage isolated earthing switch, as a power inlet switch for manual and offload operation, provides an obvious electrical breakpoint and reliable grounding of the equipment end during the power outage maintenance to ensure the safety of the operator. The switch can be equipped with an electric operating mechanism or an operating handle. The electromagnetic lock can be installed according to the need and form electrically interlock with the higher-level circuit breaker to prevent on load switching the isolating switch to ensure the safety of operation and maintenance personnel.

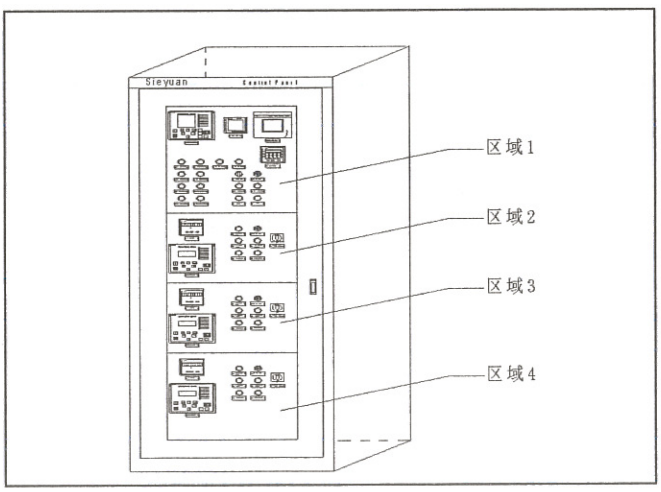
4.7 Current transformer

The current transformer is installed at the neutral to achieve double star unbalanced current protection.

Note: No open circuit on secondary side of current transformer.

4.8 Control cabinet

The control cabinet contains the control equipment, measuring instruments, protection equipment and auxiliary alarm equipment, which are assembled in the metal cabinet according to the requirements of electrical control and protection interlock. It should achieve manual or automatic opening and closing the capacitor branch during normal operation. In the case of a failure or abnormal operation, the circuit is switched off or the alarm is triggered with the aid of a protection device. The measuring instruments in the cabinet display various parameters during operation. The control cabinet needs to be placed indoors and connected to the box through the secondary cable. The front panel is divided into four areas, as shown in the following figure (it may be different when the user has special requirements).



区域 1	Area 1
区域 2	Area 2
区域 3	Area 3
区域 4	Area 4

1) Area 1: The main control part is mainly installed with power factor controller, power factor meter, voltage protection measuring and controlling device, three-phase ammeter, isolating switch and grounding switch with closing/opening button, isolating switch and grounding switch status indicator, fault alarm indicator, reset button, and secondary power (DC, AC) status indicator.

Functions to realize: automatically control capacitor bank switching, measuring system current, voltage, active power, reactive power and power factor, system voltage measurement and protection, controlling the opening and closing of isolating switch and grounding switch, displaying switch status, fault feedback and power indication.

2) Areas 2-4: The subdivided capacitor control is mainly installed with the group capacitor automatic/manual selection switch, unbalanced current protection device, single-phase ammeter, circuit breaker closing/opening button, circuit breaker and status indicator, circuit breaker energy storage indicator, current protection fault alarm, and reset button.

Functions to realize: switching control, closing and opening switch and energy storage status display of subdivided capacitor bank, unbalanced current measurement and protection, current fault alarm and reset.

The use of each component in the control cabinet panel is shown in the following figure.(it may be different when the user has special requirements).

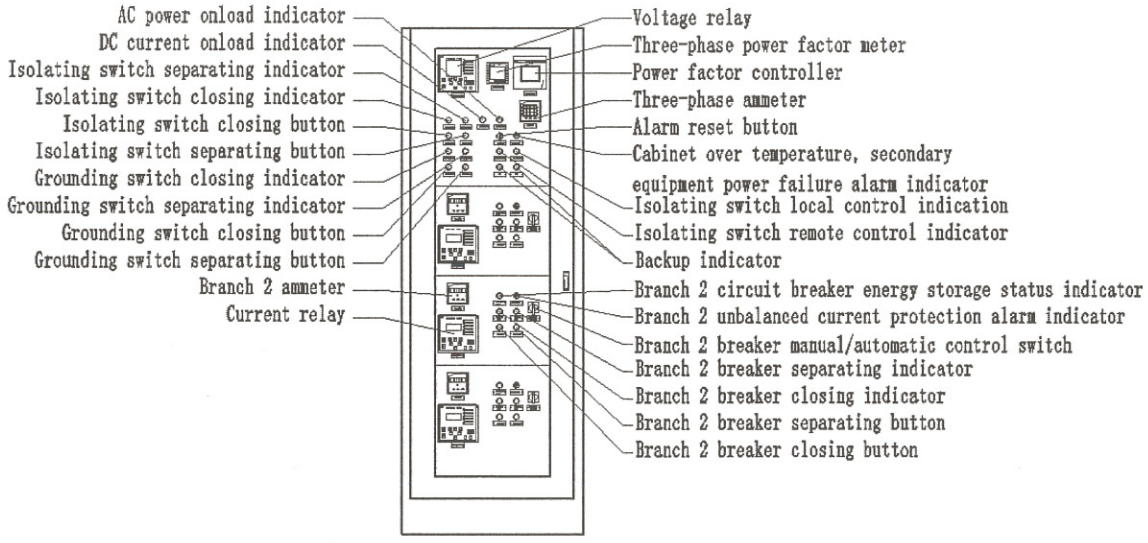


Figure.3

4.9 Local instrument box

The local instrument box is located inside the box with the main function of displaying the status of the isolating grounding switch and each branch circuit breaker and controlling the air cooling system. It is also the interface connecting the box and the control cabinet. The use of each component of the instrument box panel is shown in the figure below.(it may be different when the user has special requirements).

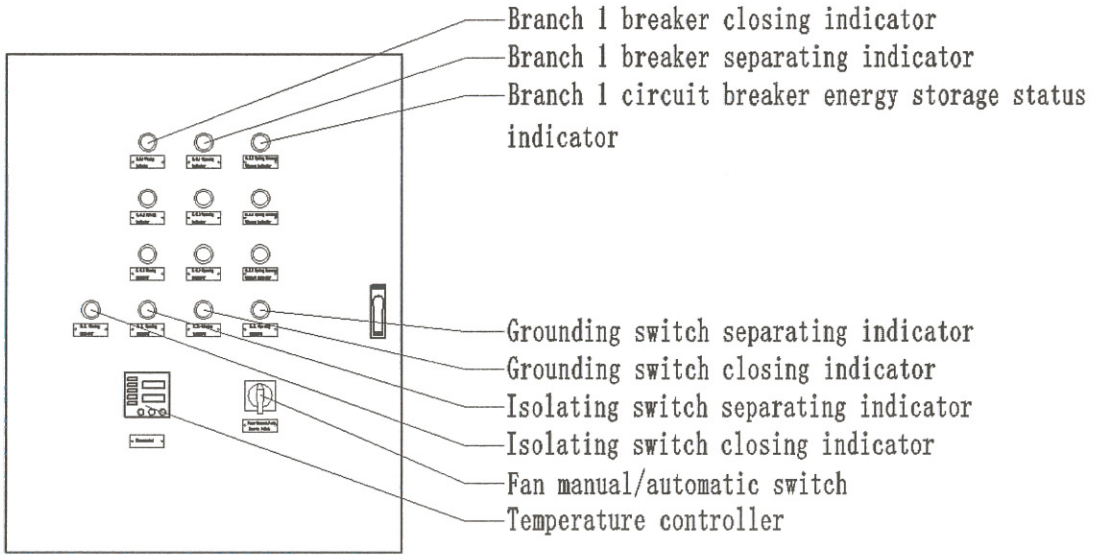


Figure.4

5 Protection methods

The protection of capacitor devices is divided into internal protection and external protection.

5.1 Internal protection

The internal protection consists of internal fuse protection and relay protection. Internal fuse protection is the first protection against internal faults in capacitors. The blowing of the fuse can isolate the damaged elements in time to ensure the safe operation of the rest capacitor device. Relay protection is the second protection for capacitor unit failure. The relay protection is double star unbalanced current protection.

5.2 External protection

The external protection of the device includes: over-voltage protection, voltage loss protection, over-current protection, and short circuit quick disconnect protection, etc. The voltage and current signal sources for protection are provided by the customer.

6 Packaging, transportation, acceptance and storage

6.1 Packaging and transportation

6.1.1 The devices are packaged separately by the packing list. During transportation, the box-type device shall be shipped as a whole, and the components of the device shall be pre-installed in the box.

6.1.2 The device and the main supporting components shall be clearly marked; the logo shall have the name, model and name of the manufacturer, the main technical parameters, the product serial number and the date of manufacture.

6.1.3 The box-type equipment shall be attached technical documents such as packing list and device drawings.

6.1.4 When a single capacitor is carried, the capacitor shall be in an upright position which means bushing upwards. It is strictly forbidden to grasp the bushing when moving.

6.1.5 When loading and lifting the box-type devices, following the lifting sign on the base of the box-type device. Note that do not damage the structure of the box or scratch the surface of the box and the equipment inside

the box.

6.1.6 The transportation mark shall be posted outside after the box-type device is packaged. The box-type device and spare parts shall be protected from rain, moisture and shock during long-distance transportation to ensure no damage occurs during transportation.

6.2 Acceptance

After receiving the product, the customer shall conduct check according to the acceptance items. The acceptance items are as follows:

a) Check the appearance of each box and the internal pre-assembled components to confirm there is no damage, and that all the contents listed on the packing list are not missing;

b) If any damage to the items or if any discrepancy with the packing list, notify Shanghai Sieyuan Electric Co., Ltd. immediately;

c) Acceptance shall be conducted according to the requirement of technical conditions of each component;

d) It is necessary to restore the original status of the package if the package still needs transfer or long term storage.

6.3 Storage

6.3.1 The device shall not be stored in a damp, dusty, hot, flammable, explosive, or corrosive place. If the box is placed outdoors, it must be protected from rain.

6.3.2 The spare parts and tools of the device shall be kept in a room where they can be protected from rain and snow. Do not keep the device near heat sources, and make sure no corrosive gas exists in the room. When storing a single capacitor, keep bushing upright and do not stack it.

7. Installation and commissioning

7.1 Installation

7.1.1 Customer shall check devices according to the packing list in time after receiving the devices, and check the appearance. The main parts and components shall be checked according to the requirements of the corresponding manual and technical documents.

7.1.2 Clean up the site and foundation and ensure that the foundation of each independent device is at the same level. The device shall be installed on the foundation conforming to the requirements, and the device and the foundation shall be fixed by welding.

7.1.3 Removing the wooden bricks and steel components used to fix the capacitors, current transformers, and reactors.

7.1.4 Wiring the primary and secondary cables by reference to the drawings and take measures to fix the cables.

7.1.5 Making reliable ground wiring.

7.1.6 Check whether bolts are loose. If there is looseness, resetting the torque and marking sign. The tightening torque of equipment and wiring inside of box refer to the general assembly drawing. The tightening torque of the remaining bolts is as shown in the following table.

Table 4 Bolt torque table

Specification mm	Torque value N·m
M6	5.6
M8	13.6
M10	20.9
M12	46.9
M16	117

7.1.7 Check whether the electrical distance between the live part and the ground part and the live part of the different phases meets following requirements: the net distance requirement for 11kV device is 120mm, and the net distance requirement for 22kV device is 220mm.

7.2 Setting

7.2.1 Control part

The voltage and current signals of the power factor controller are taken from the preceding stage voltage and current transformer. The customer needs to set the ratio of the transformer according to the actual situation. The target power factor of the controller is set to 0.95 at the factory, and the user could re-set it as needed.

7.2.2 Protection part

7.2.2.1 Voltage relay REU611

1） The signal of the voltage protection device is taken from the previous voltage transformer, and the customer shall set the transformer ratio as the actual situation.

2） The setting of the over-voltage protection setting is shown in Table 5:

Table 5 Table for the over-voltage protection setting

Category of the device	Stage-I protection		Stage-II protection		Trip reset	
	Action value	Delay time	Action value	Delay time	Action value	Delay time
11kV device	$1.1U_N$ (12.1 kV)	3s	$1.2U_N$ (13.2 kV)	0.1s	$100\%U_N$ (11 kV)	/
22kV device	$1.1U_N$ (24.2 kV)	3s	$1.2U_N$ (26.4 kV)	0.1s	$100\%U_N$ (22 kV)	/

The over-voltage protection setting is already made at the factory and the customer could reset it as needed.

3） The under voltage protection setting is shown in Table 6:

Table 6 Table for the under voltage protection setting

Category of the device	Under voltage protection		Trip reset	
	Action value	Delay time	Action value	Delay time
11kV device	$0.6\ U_N$ (6.6 kV)	1s	$75\%U_N$ (8.25 kV)	/
22kV device	$0.6\ U_N$ (13.2 kV)	1s	$75\%U_N$ (16.5 kV)	/

The under voltage protection setting is set at the factory and customer could reset it as needed.

7.2.2.2 Current relay REF615

1） Unbalanced current protection setting:

The signal of unbalanced current protection is taken from the current transformer in the box. The transformer ratio and protection setting are shown in Table 7:

Table 7 Table for unbalanced current protection setting

Voltage level (kV)	Branch capacity (kvar)	Current transformer ratio	Alarm secondary value (A)	Alarm delay	Trip secondary value (A)	Trip delay
11	1800	30/1	0.115	5s (1-10s) adjustable	0.172	0.5s (0.1-1s) adjustable
11	3600	30/1	0.114	5s (1-10s) adjustable	0.169	0.5s (0.1-1s) adjustable
22	1800	30/1	0.031	5s (1-10s) adjustable	0.047	0.5s (0.1-1s) adjustable
22	3600	30/1	0.030	5s (1-10s) adjustable	0.047	0.5s (0.1-1s) adjustable

Note: The alarm and trip protection settings and delays are set at the factory. It is forbidden to change the current value. The delay time can be adjusted by the consumer as needed.

2） Over-current protection setting:

The over-current protection needs to be set in the switch cabinet of the preceding stage. The over-current protection is divided into two sections, namely over-current and quick-break. Over-current protection is calculated as follows,

$$I_g = K_g I_N$$

I_N —Rated current of the device;

K_g —Reliability factor (the recommended over-current sets 1.5, and the quick-break sets 6)

The calculated protection setting is as follows:

11kV device: The primary value of over-current protection is 708.6A, and the delay is 0.3s; The primary value of quick-break protection is 2834.4A, and the delay is 0.1s.

22kV device: The primary value of over-current protection is 354.3A, and the delay is 0.3s; The primary value of quick-break protection is 1417.2A, and the delay is 0.1s.

The reliability factor is the recommended value and the consumer could adjust it as needed.

7.2.3 Temperature control

The maximum operating ambient temperature category of the device is divided into 55°C and 60°C. The corresponding temperature controller parameter settings are shown in Table 8.

Table 8 Temperature controller setting parameter table

Maximum use ambient temperature	55℃	60℃
Fan initiating temperature	45℃	45℃
Fan stopping temperature	40℃	40℃
Alarm temperature	55℃	60℃

Trip temperature	56℃	61℃

7.2.4 Delay setting

There are four time delay relays in the control cabinet, three of which provide delay for the adjacent closing gap of the branch breaker, and the other provides delay only for the power-off opening. The setting time is 600s. The consumer must not change the delay time.

8 Use and operation

8.1 Inspection before operation

8.1.1 Visual inspection

The following visual inspection must be performed during before operation:

1） Clean up the debris on the site and foundation, confirming that there are no installation tools and materials left over in the device box. The inside box shall be clean and tidy.

2） Confirm whether the mechanical parts of the equipment are in good condition.

3） Clean the surface of the insulator and bushing to prevent flashover by contamination.

4） Check whether the insulator and bushing are broken and whether the capacitor leaks oil.

8.1.2 Electrical connection inspection

The following electrical connection inspection must be performed before operation:

1） Confirm whether the primary wiring is correct and contact is good. Perform commissioning after confirmation.

2） Ensure the net power distance in different potentials.

3） Confirm whether the secondary control cable is correctly connected, the contact is good, and whether the secondary control and status display are normal.

8.2 Commissioning inspection

The following inspection must be performed during test operation:

1） Verify whether the voltage, current and output power within the rated value range after the device is switched on.

2） Re-check the three-phase current balance condition of the capacitor bank after operation within 8h~24h.

3） Monitor the temperature rise of electrical joint and equipment surface, and make records regularly.

8.3 Inspection after commissioning

The following inspection must be performed after commissioning

1） Observe whether the capacitor has leakage, the connector is discolored and the casing swells and rupture.

2） Observe whether the ground and the box bottom have oil stains.

3） Check whether the electrical connection is overheating.

4） Check for discharge traces.

5） Check whether the connection is loose and whether the wire is abraded. Re-tighten the capacitor outlet end (30N·m recommended).

8.5 Monitoring and recording during operation

The following parameters should be monitored and recorded during operation:

1） Voltage, Power factor;

2） The rated voltage, Current and output power of the device.;

3） Three-phase current balance condition;.

4） Temperature rise on the electrical contact and equipment surface.

5） Signal relay and indicator action condition.

8.6 Operation method of control protection

8.6.1 Automatic mode

Turn all the transfer switches to the automatic position, the controller is set to the automatic mode, and the alarm reset button is turned to the closing position. The capacitor bank will be automatically switched into the cut-off capacitor bank according to the load change without manual intervention.

8.6.2 Manual mode

Under special circumstances, when the capacitor bank needs to be manually controlled, the corresponding switch can be turned to the manual position, and the capacitor bank can be switched by the opening and closing buttons.

Since the device switching circuit is equipped with a time delay relay, the gap between two closings of the same circuit breaker must be 600s. During this period, even if the closing button is pressed, the circuit breaker will not be closed again.

8.6.3 Temperature control system

Manual control: put the fan control switch to the manual position, the fan starts; when it is placed in the "stop" position, the fan stops;

Automatic control: Place the fan control switch in the automatic position. When the set start temperature is reached, the fan starts running; when the temperature restores to the stop temperature, the fan stops.

8.6.4 Alarm signal

1） Unbalanced current protection alarm indicator

After the capacitor bank unbalanced current protection action, the alarm is activated, and the branch breaker is forced cut off and the branch capacitor bank is powered off. The current relay must be reset to restore to normal, and the alarm will not go out automatically before the current relay is reset. Note that the capacitor bank must be fully inspected after the alarm is activated, and the fault can be removed before it runs again..

2） Over temperature, secondary power loss alarm indicator action

The alarm indicator is alarmed after the internal over-temperature of the device or the slightly break action in the secondary circuit. After the alarm indicator is activated, the alarm reset button is turned to the separating position. At this time, the alarm indicator goes out. After the fault is removed, the alarm reset button is turned to the closing position and the device restores operation.

8.6.5 Fault reset

Press GRP+ENT in the main interface to reset. If the current page is not on the main screen, press ESC to return to the main interface.

8.7 Electrical interlock operation steps

The device is equipped with five anti-electrical interlock to ensure the safety of personnel and equipment. The steps are as follows:

1） When the device is put into operation: close all the cabinet doors → close the isolating switch (the grounding switch is disconnected at the same time) → close the preceding stage circuit breaker.

2） When the device is out of operation: the preceding stage circuit breaker is disconnected → the isolating switch is disconnected (the grounding switch is closed at the same time) → the door is opened.

Because the device interlock loop is equipped with a time delay relay, it takes 600s to open the cabinet door after the power off.

9 Maintenance and overhaul

1） After the capacitor bank is put into use, the capacitor bank shall be maintained and overhauled according to the following requirements:

Observe the operation of each component of the capacitor bank. Observation at least once a day is recommended. If it is found that the surface of each bushing and the case and structure of the electrical equipment are ash-filled, it shall be cleaned up in time to prevent accidents.

2） A routine inspection shall be started one week after the commissioning; observe whether there are oil

stains on the ground; and observe whether there is overheating in the electrical connection.

3） Conduct a routine inspection every three to six months and tighten all electrical joints.

4） Conduct a periodic measurement of the capacitance of a single capacitor of a capacitor bank and make a comparison with the original record. When the capacitance is reduced by more than 6%, check carefully and switch off in case of problem happening. If the capacitor is damaged and needs to be replaced with a new capacitor, noted that the rated voltage, capacity, and external dimensions shall meet the relevant requirements and meet the requirements for capacitor balance.

5） Check the fan and filter every month. Clean or replace blockage in time to ensure the normal function of the heat dissipation system. It is recommended that the filter shall be cleaned at least once every three months. If the filter protection function fails to meet the requirements, needs to be replaced directly. The filter model is lk3327.300 of LINKWELL.

6） After the protection of the capacitor bank is in action, it is necessary to carry out a comprehensive inspection and analyze the cause of the problem. It is strictly forbidden to re-close the switch before the problem found and handled correctly, so as to prevent the damaged capacitor from causing greater accident when it is in operation.

10 Fault analysis and troubleshooting

Once the capacitor has fault, keep recording (voltage, capacitance, load and capacitor capacitance and number) and do not put it into operation before the problem is found and solved properly. Table 9 shows common fault analysis and troubleshooting of the capacitors.

Table 9 Common fault analysis and troubleshooting

Fault phenomenon	Cause analysis	Troubleshooting method
Automatic control function of the controller failure	Signal line error	Check whether the terminals of the voltage and current signal wiring have false connection and whether the phase is correct.
Temperature alarm capacitor bank cannot be put into normal operation	1. The efficiency of the heat dissipation system is reduced. 2. The capacitor unit dielectric aging and losses increases.	1. Check whether the function of the fan is normal and whether the filter is clogged. Replace the capacitor unit with high losses in time. 2. Replace the capacitor unit with high loss
SF6 circuit breaker low air pressure alarm	Air chamber pressure is too low	Supplement SF6 gas
The preceding stage circuit breaker cannot be put into normal operation	The electrical interlock circuit broken	Check whether the isolating switch is closed in place and the cabinet doors are all closed.
Bushing rupture	Collision during transport and careless installation	Replace the capacitor
Casing topcoat damage	Scratch during transport and careless installation	Repair in case of minor damage,

Fault phenomenon	Cause analysis	Troubleshooting method
Breakdown during acceptance test	1. The product is damaged during transportation 2. Test voltage too high or lasts too long 3.Wrong voltage measuring method	Replace the capacitor
Remarkable capacitance change	Elements breakdown and (or) fuse blown	Replace the capacitor
The capacitor unit losses increases	Quality of capacitor deterioration	Replace the capacitor
Cases swelling abnormally	1. Internal partial discharge within the product 2. Elements breakdown or terminals to-case breakdown	Replace the capacitor
Oil leakage	1. The flange is not sealed tightly due to hold the bushing when carrying 2. The bushing is damaged due to excessive force in screwing nuts. 3. Defects caused in the manufacturing process 4. Severe temperature change	Replace the capacitor

11 Precautions for safety use

11.1 Safe operating method

1） As the capacitor is an energy storing device, when it is disconnected from the grid, the stored charge cannot be discharged within short time, and the charge in the capacitor is easy to transfer. Before personnel touch of the on load capacitor, the capacitor should be earthed, short circuited and discharged eve if the break time of the capacitor is long enough. Do not touch the two outlet terminals of the capacitor any time with both hands at the same time to avoid the impact of residual charge and causing personal injury. The capacitor off service should be short circuited and earthed for a long time to avoid impact of residual charge during removal and wiring.

2） When repairing, the power must be cut off first. Enter the inspection area until the signal indicator goes out and confirm it is correct. First turn on the isolating switch, then close the grounding switch, discharge the capacitor short-circuit and the special temporary grounding wire shall be hung before the maintenance can be carried out. Remove it after the maintenance is completed.

3） The cabinet door, the isolating switch, the grounding switch, the closing and opening switch and the preceding stage circuit breaker of the device shall be electrically interlocked. Before it is put into operation, the isolating switch must be closed and the grounding switch must be turned on. Lock the cabinet door and it is not allowed to open it during operation.

4） The grounding points for isolating switches, circuit breakers (vacuum, SF6), reactors, cable and cable terminal boxes, earthing-switches, zinc oxide surge arresters, current transformers, capacitor cases, and capacitor racks, etc. shall be reliably grounded.

5） The discharge time of the shunt capacitor unit is 50V/5min, and the minimum time gap after the complete device is opened and before it is closed is not less than 600 seconds to prevent the influence of the residual charge of the capacitor.

6） After the protection device is operated, it is not allowed to force commissioning. It shall be analyzed and

estimated according to the protection action. Checking whether the capacitor has blown fuse, swelling, overheating, rupture or casing discharge, and whether the capacitor has obvious failure. Its supporting equipment shall also be inspected. Only after the fault is found and eliminated can the device be put into use.

11.2 Possible incorrect operating method or mistaken operation

11.2.1 Wrong use

Reclosing the switch before protective action breaker trips and the problem has not been identified and solved properly.

11.2.2 Wrong operation

After the device disconnects, the device is re-put into the device within the specified discharge time

11.3 Possible injuries caused by incorrect use and operation

If the capacitor is operation with fault before the customer verifies there is no fault, it will cause greater accident. If the device is re-put into operation within the stipulated discharging time after it is switched off, the capacitor will not be fully discharged and overvoltage will be caused after it is put into operation again, which may damage the capacitor.

11.4 Emergency treatment measures under abnormal conditions

In case of the following conditions, switch off the capacitor immediately and inform the personnel of the manufacturer.

1) Capacitors exploded.

2) Severe heating at joints or the infrared thermometer detects that the temperature rises obviously.

3) The capacitor bushing is fractured and has flashover.

4) The capacitor sprays oil severely or is on fire.

5) The capacitor case swells severely.

6) Abnormal sound in the capacitor.

11.5 Precautions for capacitor replacement

1) When a capacitor unit in the device needs to be replaced, first check the capacitance value on the nameplate of the unit to be replaced according to the capacitance position table, and then consult the factory test report of the capacitor unit to find a unit with close capacity and replace it. It is enough to replace the unit needed to be replaced.

2) When removing a single capacitor, take care to prevent bumping and damage to the intact capacitor.

11.6 Other safety warnings

The insulating oil in the capacitor unit is irritating to the cornea and should be avoided. Once it contacts the eye, rinse with water immediately; it will not cause harm to the human body when in contact with other parts of the human body, but it cannot be eaten.

12 Environment protection and others

Biodegradable materials such as films, paper and oil (non-toxic, PCB-free) and other metal materials and electro-ceramic materials used in the product will not pollute the environment during manufacturing, use and waste disposal. The capacitors must be recycled by the qualified company after being scrapped.