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ZF28-420 SF6 Gas-insulated Metal-enclosed Switchgear

O&M Manual for GIS ZF28-420

Sieyuan Electric Co., Ltd.
September 2018

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Preface

To push the overall lifecycle management of customer service, realize the lean management for GIS product service and guide the customers on the maintenance and repair of such model of GIS, the *Maintenance Manual for GIS ZF28-420 of Sieyuan Electric Co., Ltd.* is compiled according to relevant national and industrial standards, codes and specifications as well as our unit's requirements for equipment maintenance and repair, in which the technical requirements and implementation methods for all aspects such as daily patrol inspection, preventive testing, maintenance, etc, are specified.

The present specifications are put forward, managed, and explained by the Customer Service Department of Sieyuan Electric Co., Ltd.

O&M Manual for GIS ZF28-420 of Sieyuan Electric Co., Ltd

1. Application scope and reference

1.1 Application scope

This Manual specifies the technical requirements and implementation methods for all links of the equipment: daily patrol inspection, preventive testing, and maintenance, etc., and applies to the maintenance and overhaul of the ZF28-420 GIS produced by Sieyuan Electric Co., Ltd.

1.2 References

The following documents are indispensable to the application of this document. Only the dated version applies to this document, for any dated reference, and the newest version applies to this document, for any undated reference.

IEC 60060-1	High-voltage test techniques- Part 1: General definitions and test requirements
IEC 60071-1	Insulation co-ordination- Part 1: Definitions, principles and rules
IEC 60376	Specification of technical grade sulfur hexafluoride (SF ₆) for use in electrical equipment
IEC 60480	Guide to the checking of sulphur hexafluoride (SF ₆) taken from electrical equipment
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 62271-1	High-voltage switchgear and controlgear – Part 1: Common specifications for alternation current switchgear and controlgear
IEC 62271-203	High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV

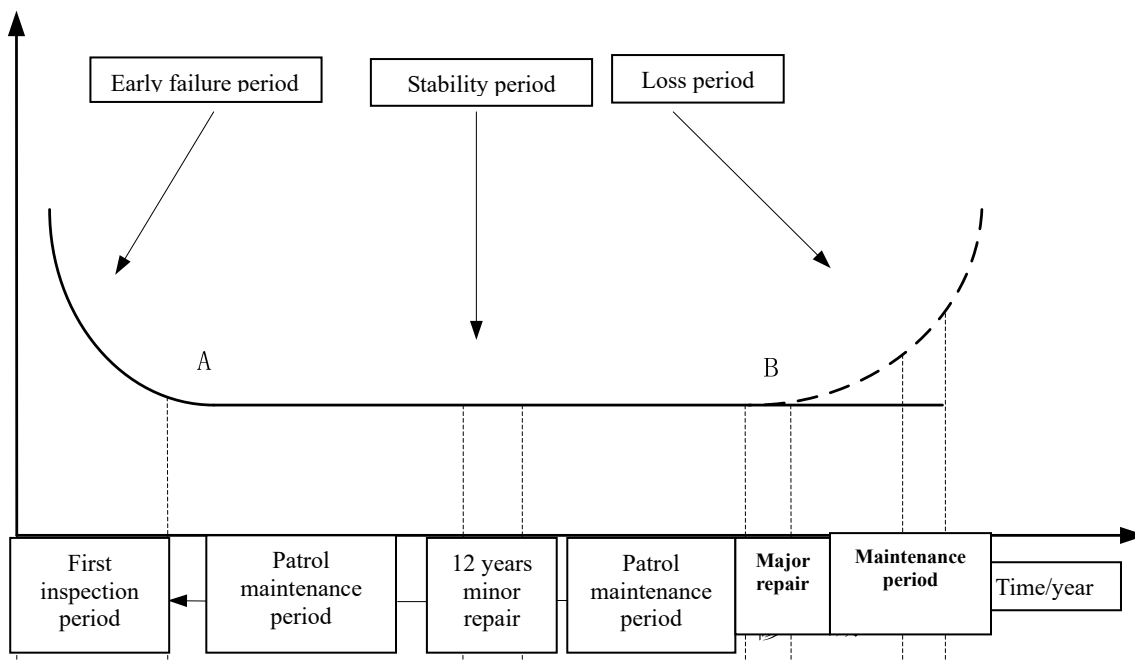
2. Technical parameter

2.1 Technical parameter list

S/N	Name of technical parameter		Factory standard parameter					Note
I.	General parameter: ZF28-420 gas-insulated enclosed switchgear							
1	GIS model: ZF28-420		Indoor					
2	Altitude		≤1000m					
3	Ambient temperature		-30 °C~+55 °C					
4	Relative humidity		Daily mean is not greater than 95%; monthly mean is not greater than 90% (indoor); 100% is required outdoors.					
5	Earthquake resistance		Horizontal acceleration is 0.50g, and vertical acceleration is 0.25g.					
6	Protection level		Indoor:: IP55、IK10					
7	Maximum day temperature difference		32K					
8	Insolation strength		Not exceeding 1000W/m²					
9	Maximum wind speed		73m/s					
10	Air dirty grade		Class III					
11	Icing thickness		20mm					
II.	Rated and guaranteed performance parameters: ZF28-420 gas-insulated enclosed switchgear							
1	Rated voltage kV		420					
2	Rated frequency Hz		50					
3	Rated current A		4000					
4	Rated power-frequency withstand voltage(1min)kV	Phase to phase, to earth	650					r.m.s value
		Between open contacts	815					r.m.s value
5	Rated lightning impulse withstand voltage kV	Phase to phase, to earth	1425					Peak value
		Between open contacts	1425+240					Peak value
6	Rated Switching impulse withstand voltage kV(peak withstand current)	Phase to phase, to earth	1050					Peak value
		Between open contacts	900+345					Peak value
7	Rated short-time withstand current kA		63					
8	Rated peak withstand current kA		157.5					(Peak value)
9	Rated short-time duration s		1					
10	SF6 annual gas leakage rate		≤0.1%					
11	Rated pressure of SF6 gas at 20 °C		Compartment	Rated	Re-filling	Low	Lockout	
			Circuit breaker	0.68	0.65	0.63	0.61	MPa
			DS	0.58	0.55	0.53	0.51	MPa
			Others	0.58	0.55	0.53		MPa
12	SF6 moisture in gas compartment (under 20℃)		Gas compartment of circuit breaker≤150μL/L, Others≤250μL/L					Accepted value
			Gas compartment of circuit breaker≤300μL/L,					In operation

S/N	Name of technical parameter	Factory standard parameter	Note
		Others≤500μL/L	

2.2 Bathtub curve diagram



Note: the GIS first inspection project is developed as per the power failure maintenance project, and it is required to evaluate the life after the GIS has operated for 30 years, to ascertain the actual life of GIS.

3. Maintenance period and items

The equipment patrol inspection and maintenance are divided into two categories: daily tour maintenance and special tour maintenance.

3.1 Daily tour maintenance items and period

(Daily tour maintenance consists of daily patrol inspection and simple maintenance, and is conducted by the operator. Please ascertain the daily tour maintenance items, requirements and period, in combination with your company's product features)

S/N	Item	Requirement	Period	Note
1	Wiring inspection	Lead wire should be connected reliably, drooping naturally, three-phase relaxation, no broken and oddlot phenomenon.	Developed in combination with daily tour inspection	

S/N	Item	Requirement	Period	Note
2	Bushing inspection	<ol style="list-style-type: none"> 1. There should be no serious fouling or damaged scar on the surface of the porcelain sleeve 2. flanges should have no cracks and flashover. 	Developed in combination with daily tour inspection	
3	GIS Framework inspection (framework, foundation, earthing)	<ol style="list-style-type: none"> 1. The GIS framework should be well grounded and fastened without looseness and rust. 2. The GIS foundation is free from cracks and settlement. 3. The GIS framework should be bolted firmly. 	Developed in combination with daily tour inspection	
4	Check whether the appearance of GIS is good	<ol style="list-style-type: none"> 1. Whether the paint on the surface is peeled and drops. 2. Whether the external metal surface is rusty and oxidized. 3. Whether the fastener is rusty and oxidized. 4. Whether the external surface has traces of bump by external force. 5. Whether the smeared waterproof glue is cracked. 6. the expansion joints have no rust, corrosion, deformation, loosening and other anomalies. 	Developed in combination with daily tour inspection	
5	Inspection of abnormal sound of equipment	Conduct patrol inspection for the circuit breaker, three-position disconnecting and earthing switch, busbar, branch bar, PT, CT and lightning arrester to see whether they give out abnormal sound.	Developed in combination with daily tour inspection	In case of any abnormal sound, timely contact the Customer Service Department of Sieyuan Electric Co., Ltd.
6	Pressure value of GIS and inspection of SF6 gas density meter	<ol style="list-style-type: none"> 1. The inspection window of SF6 density meter is clean, and the air pressure indication is clear. No dirt and damage exist on the surface. 2. The SF6 density meter is reliably firmly connected to the equipment body. 3. The pressure value should be within the scope of rated gas $\pm 0.02\text{MPa}$, and be compared with the pressure value of GIS body recorded last time, for ascertaining whether SF6 is leaked in advance. 	Developed in combination with daily tour inspection	Conduct this at the time of a day when the air temperature change is small, with the ambient temperature recorded. Develop air supply electrically, when the SF6 gas pressure is found to be lower than the operating pressure. Moreover, timely contact the Customer Service Department of Sieyuan Electric Co., Ltd.
7	Infrared test	Test and check whether the temperatures on	Developed in	

S/N	Item	Requirement	Period	Note
		the GIS arc extinguish chamber, and disconnecter, busbar and ceramic bushing are abnormal, with the infrared imager.	combination with daily tour inspection	
8	Live display	Visually check whether the live display and voltage relay work normally	Developed in combination with daily tour inspection	
9	Current transformer and voltage transformer	1. no serious corrosion and coating loss on the surface of secondary terminal. 2. the secondary junction box shall be sealed well and no water mark. 3. the external current transformer shall be well sealed and without water mark.	Developed in combination with daily tour inspection	
10	lightning arrester	Number of actions and leakage current of lightning arrester counter (at all intervals)	Developed in combination with daily tour inspection	
11	Opening and closing indication check	1. the switch indication card of each switch device should be in place and consistent with the actual position of the body and the indication light of the switch. 2. check and confirm that the Disconnector / Earth switch is clearly visible.	Developed in combination with daily tour inspection	
12	Check with tropical and heater	Manual control: 1. with tropical (heater) temperature control: when the region environment day minimum temperature is -25 DEG C, manually with tropical (heater) all input; when the temperature reaches the lowest environmental area that day more than -10 degrees, with tropical (heater) manual switch off (not open), with tropical (the heater stops working). 2. the heater of the size and LCP cabinet is divided into two groups, one group is often cast. A group of low input: when the region environment day minimum temperature is less than or equal to -20 DEG C, manual input; when the minimum temperature is greater than or equal to -10 the environment area C, manually shut down. Auto-Control: 1. automatic control program according to	Developed in combination with daily tour inspection	

S/N	Item	Requirement	Period	Note
		<p>the following settings: when the ambient temperature is less than or equal to -25 DEG C, temperature control action, heater (with tropical) power is turned on, the heater (with tropical) start heating of SF6 gas in the shell; when the ambient temperature rises to more than -20 DEG C, temperature control action, exit heater (band). The automatic input or exit of the heating device can be realized by the thermostat.</p> <p>2. the heater of the size and LCP cabinet is divided into two groups, one group is often cast. A group is controlled by a thermostat: when the ambient temperature is less than or equal to -20 DEG C, temperature control action, heater (with tropical) power is turned on, the heater (with tropical) start heating of SF6 gas in the shell; when the ambient temperature rises to more than -10 DEG C, temperature control action, exit heater (with the tropics). The automatic input or exit of the heating device is realized by the thermostat.</p>		
13	Check and control cabinet box mechanism	<p>Check the switch gear box and the exchange control cabinet:</p> <p>1) Electrical components and their secondary should be no corrosion, damage, loose, no burning paste or smell inside the body box.</p> <p>2) Turn off the indicator light, energy storage indicator light and lighting should be intact; sub-closing lights can correctly indicate the status of the position of the switchgear.</p> <p>3) Secondary cable perforation plugging should be intact.</p> <p>4) Respiratory pores no obvious pollution phenomenon.</p> <p>5) The action counter should work normally.</p> <p>6) "local / remote" switch should be hit in the "distance."</p> <p>7) The energy storage air switch should be</p>	Developed in combination with daily tour inspection	Due to equipment structure can not touch the case of the case can not check the inside of the case.

S/N	Item	Requirement	Period	Note
		<p>in the closing position.</p> <p>8) Seal should be good, to moisture, dust requirements. Seal no shedding, damage, deformation, loss of elasticity and other anomalies.</p> <p>9) No deformation of the cabinet door, can be closed normally.</p> <p>10) The box should be no water stains or condensation.</p> <p>11) The bottom of the box should be clean and free of debris; the secondary cable is sealed well.</p> <p>12) heater (drive tide device), the thermostat should be able to work properly: the heater should be long-term input requirements, in the daily inspections should use infrared or other means to detect whether the working state; for the environment-controlled heater , Should check the temperature and humidity controller settings meet the manufacturer's requirements, manufacturers no specific requirements, the temperature controller action value should not be less than 10 ℃, the humidity controller action value should not exceed 80%.</p>		
14	Drive rod check	<p>1. The appearance of the external transmission connecting rod of the switchgear is normal, no deformation, cracks and rust phenomenon.</p> <p>2. Connection bolts without loose, rust phenomenon. The appearance of each pin is normal.</p>	Developed in combination with daily tour inspection	

Note: 1) the daily tour maintenance items are conducted by the power transformation operator.

3.2 Special tour maintenance items and period

(The special tour maintenance consists of professional tour maintenance, power failure maintenance and dynamic tour maintenance.)

3.2.1 Professional tour maintenance items and period

Professional inspection tournaments by the manufacturers, who are familiar with equipment professionals responsible for regular inspections of equipment, live testing and defect handling.

S/N	Item	Requirements	Period				Note
			I	II	III	IV	
1	Rainproof and damp proof inspection inside the LCP cabinet, CT, PT box (outdoor engineering)	<p>Check whether water comes into the LCP cabinet, CT box and PT box, and whether all elements are affected with damp</p> <p>Check the sealing performance of LCP cabinet</p>	Once for half a year	Once a year	Not implemented	Not implemented	Please contact Sieyuan Electric Co., Ltd. for treatment and replacement, in case any water ingress and wetting is found.
2	Visual inspection for operating mechanism	<p>1. The appearance of driving part of operating mechanism is normal, and the enclosure has no cracks. The appearances of all shafts, pins and locking gaskets of the mechanism are checked to be normal.</p> <p>2. Check whether the buffer has oil leakage traces, and whether the fixing shaft and retainer ring are normal.</p>	Once for half a year	Once a year	No need	No need	<p>1. Investigate the reason in case the appearance of driving part is found to be abnormal. Start the mechanism case to check treatment in a sealed way, in power failure maintenance, if case rust is found.</p> <p>2. In case the buffer is found to be subject to oil leakage, ascertain the reason, and contact Sieyuan Electric Co., Ltd. in power failure maintenance, to start the buffer replacement.</p>
3	GIS mechanism case	<p>1. Check whether water comes into the mechanism case, and whether the element gets wet</p> <p>2. Check whether there are fragments and foreign matters at the bottom of GIS mechanism case.</p> <p>3. Check to ensure that the opening and closing buffers of CB mechanism are not subject to oil leakage.</p>	Once for half a year	No need	No need	No need	Ascertain the reason if any fragments and foreign matters are found at the bottom of the mechanism case.

4	Circuit breaker data analysis	SF6 gas pressure analysis: Horizontally and vertically compare the SF6 gas pressure values of circuit breaker based on the operating record. Early judge on whether SF6 leakage has occurred.	Once a quarter	Once every half a year	No need	No need	
5	SF6 qualitative leakage detection	Conduct leakage detection of density meter interface, butt joint surface of flange and shaft seal of mechanism case of DS and ES contact with the qualitative leakage detection instrument, at a speed no more than 2.5cm/second.	Once every two months after commissioning	Once every half a year	No need	No need	

Note: 1) The professional patrol maintenance items are executed by the power transformation maintenance or testing personnel under the guidance by the manufacturer.

2) Only for the professionalized patrol maintenance of Grades I and II controlled equipment (i.e., important and unhealthy equipment), the power transformation maintenance personnel should conduct a daily patrol maintenance as per the daily patrol maintenance requirement and completion standard and under the guidance by the manufacturer.

3.2.2 Dynamic tour maintenance items

(The dynamic tour maintenance means the aperiodic patrol inspection, operation, testing and maintenance for equipment triggered under the specific condition, and due to the influence of power grid, equipment, weather, etc.)

S/N	Item	Requirement	Triggering condition	Note
1	Dynamic tour maintenance upon operation of circuit breaker	<ol style="list-style-type: none"> The indicative opening and closing positions are correct; The operational counter calculates correctly; The energy storage position of mechanism is correct; No foreign smell is in the control cabinet and mechanism case. 	Upon each operation and upon fault trip.	
2	Dynamic tour maintenance when the operational risk changes	<ol style="list-style-type: none"> Conduct professionalized tour maintenance before the operational mode changes, if the dispatch department issues an early warning notice on power grid risk of Grade III and above, after the importance of circuit breaker changes based on operational mode of power grid and load change. <p>Conduct a full daily tour inspection before the operational mode changes, and carry out</p>	When the operational risk of circuit breaker changes	

S/N	Item	Requirement	Triggering condition	Note
		the relevant data recording, if an early warning notice on power grid risk of Grade III and below has been issued. 2. Carry out at least professionalized tour maintenance once for the key controlled equipment of Grades I and II involved in the important security supply period, before the peak hours and summer. 3. In case of extreme climate, earthquake and other serious natural disasters, conduct professionalized tour maintenance for the key controlled equipment of Grades I and II, and cut off power for inspection if necessary.		
3	Dynamic tour maintenance for circuit breaker leaking SF6	1. Conduct analysis as per the recorded data on SF6 gas pressure, and arrange air supplementation before the SF6 pressure drops to 0.02MPa before the alarm value. 2. Find leaking points with such live leakage detectors as infrared leakage detectors.	After the leakage of SF6 circuit breaker is found	
4	Dynamic tour maintenance for newly operated circuit breaker	Add daily tour maintenance items: “visual inspection for appearance of circuit breaker”, “leakproofness inspection for control box (mechanism case) of circuit breaker”, “inspection for bottom of mechanism case of circuit breaker”, “inspection for readings of SF6 barometer”, frequency of patrol inspections for “infrared testing” item.	Within half a year after the circuit breaker is put into operation	
5	Dynamic tour maintenance for circuit breaker upon a thunderstorm	Add daily tour maintenance items: “LCP cabinet leakproofness inspection”, “visual inspection for appearance of circuit breaker”, “leakproofness inspection for control box of circuit breaker (mechanism case)” “one leakproofness inspection for site CT and PT boxes”.	Upon a thunderstorm	
6	Dynamic tour maintenance of circuit breaker upon a gale	Add daily tour maintenance items: “visual inspection for appearance of visual inspection for appearance of circuit breaker” and one “infrared testing”	Upon a gale	
7	Dynamic tour maintenance of	Add daily tour maintenance items: “visual inspection for appearance of circuit	Upon sudden change of	

S/N	Item	Requirement	Triggering condition	Note
	circuit breaker upon sudden change of temperature	breaker”, “leakproofness inspection for control box of circuit breaker (mechanism case)” and one “infrared testing”.	temperature	
8	Dynamic tour maintenance of circuit breaker upon a heavy fog	Add daily tour maintenance items: one “visual inspection for appearance of circuit breaker”.	Upon a heavy fog	
9	Dynamic tour maintenance of circuit breaker upon a hail	Add daily tour maintenance items: inspect the “visual inspection for appearance of circuit breaker” once.	Upon a hail	
10	Dynamic tour maintenance of circuit breaker under the N-1 mode and in heavy load operation	Add daily tour maintenance items: patrol inspection frequency of “infrared testing”.	Under the N-1 mode and in heavy load operation	
11	Dynamic tour maintenance of circuit breaker upon an earthquake	Conduct professional tour maintenance for the key controlled equipment of Grades I and II, and conduct daily tour maintenance for the key controlled equipment of Grades III and IV.	Upon an earthquake	
12	Replacement of density relay	Replace the relevant seal ring	In fault	

3.2.3 Power failure maintenance and test items and period

The power failure maintenance means the equipment repair, testing, regular checking, defect elimination, minor repair, major repair, etc. in combination with the preventive test and regular checking in outage

a) Preventive test and maintenance items and period

The preventive test and maintenance should include all daily tour maintenance items as well as the following contents:

S/N	Item	Requirement	Period	Note
1	Inspection for action contact of density meter	The pressure alarm and locking circuit should function normally; Alarm pressure MPa: CB gas compartment 0.63, Breaker’s locking pressure MPa:0.60; others 0.53.	Developed in combination with preventive test in outage	Measure the corresponding node with millimeters
2	Incoming and	1. Clean the incoming and outgoing line	Developed in	

	outgoing line porcelain bushing	porcelain bushing and the appearance of porcelain bushing should be complete. 2. The waterproof glue shouldn't be cracked or drops.	combination with preventive test in outage	
3	The trace water content testing for all gas compartments of GIS	≤ 150 (upon major repair of newly operated CB) ≤ 300 (CB In operation) ≤ 250 (others; upon major repair of newly operated CB) ≤ 500 (other; in operation)	Developed in combination with preventive test in outage	(volume fraction of 20°C) μL/L
4	Inspection for the circuit breaker, three-position disconnecting and earthing switch and fault earth switch	1. The mechanical and electrical position display of circuit breaker is correct. 2. The mechanical and electrical position display of three-position disconnecting and earthing switch is correct. 3. The mechanical and electrical display of fault earth switch position is correct.	Developed in combination with preventive test in outage	Operation
5	Interlocking checking	The corresponding clauses of technical conditions of the product and the engineering project are complied, and check whether all interlocking functions are normal, effective and reliable.	Developed in combination with preventive test in outage	Operation

b) Minor repair items and period

The minor repair items should include all power failure maintenance items, as well as the contents in the table below. The minor repair should be guided by the technicians arranged by Sieyuan Electric Co., Ltd., and the GIS expansion maintenance report should be completed as per the inspection, with the special case indicated in the remarks column.

S/N	Item	Requirement	Period	Note
1	Verification of and contact inspection by density meter	The pressure alarm and locking circuit should function normally; Alarm pressure MPa: CB gas compartment 0.68, Breaker's locking pressure MPa: 0.61; others 0.58.	1) GIS has operated for 12 years; 2) The accumulated number of mechanical opening-closing operations of GIS under rated current reaches 5,000.	1. Sieyuan Electric Co., Ltd. arranges technicians to come to the site for guidance. All adjusted parts must be marked and the relevant written record made. 2. The tightening torques of bolts of different specifications are shown in Appendix-“Common Tightening Torque of Bolt” 3. See Appendix II “Common Grease List” for the grease required for all
2	Lubrication of circuit breaker, three-position disconnecting and earthing switch and earthing mechanism	1. Clean heavy-duty lubricating grease of circuit breaker mechanism. 2. Clean heavy-duty lubricating grease of three-position disconnecting and earthing switch mechanism. 3. Clean heavy-duty lubricating grease of fault earth switch mechanism.		

S/N	Item	Requirement	Period	Note
3	Testing of resistance of main circuit of GIS	The error between calculated resistance and measured value is -20%-0, the error between the measured value of field resistance and measured value in the factory and the socket resistance is $\pm 10\%$.		positions
4	Measurement of mechanical characteristic of GIS	Whether the mechanical characteristics of switchgear meets the technical conditions of product as well as the corresponding technical clauses in the project contract.		
5	Inspection of auxiliary switch and position switch	1. Action reliability, switchover flexibility, position correctness and effective contacting reliability of contact. 1. Inspection for all connecting rods and bolt torque.		
6	Heater replacement	Heater replacement, replacement test the following items: 1, the thermostat function test is normal 2, heater test function is normal		

c) Major repair items and period

Carry out the status evaluation, reliability evaluation and economic benefit analysis for the equipment, when the equipment meets the conditions listed in the table below, so that it can be ascertained whether the equipment requires or deserves a major repair. According to the evaluation results, the maintenance, minor repair, major repair for lifetime extension or replacement, etc. can be selected to promote the healthy level of the equipment, for ensuring its safe and stable operation.

The major repair items and period are ascertained after the evaluation is conducted based on the contents shown below. All items of minor repair should be included, in addition to those listed in the table below, if it is determined to conduct major repair for the equipment in the implementation.

S/N	Item	Requirement	Period	Note
1	Dismantle the GIS body, three-position disconnecting and earthing switch, fault earth switch, busbar, branch busbar, CT, PT and incoming and outgoing line bushings	The quality standard should meet the technical file and operational guidance of Sieyuan Electric Co., Ltd.	1. The GIS has operated for 25 years 2. Number of short-circuit current breaking of circuit breaker reaches 20 3. The arc extinguish chamber, three-position disconnecting and earthing switch have ever undergone voltage	In principle, the GIS major repair should be completed by Sieyuan Electric Co., Ltd. in the manufacturer with the rotation major repair.
2	Body disassembly repair: replace the whole set of seal rings, contacts, nozzles, insulated pieces, conductive/lubricating grease and spring			

3	Replace all rotating shafts, pins, moving parts, lubricating grease, bolts, fastening nuts and spring of body and mechanisms respectively		breakthrough	
4	Replace the absorbent in all disassembled chambers		4. Judge the faults of the arc extinguish chamber or spring mechanism of circuit breaker, through relevant detection means	
5	Replace all secondary control, signal and communication cables		6. Operate the fault earth switch electrically twice	
6	Check all SF6 density meters			
7	Carry out the vacuum, air inflation, leakage detection and trace water detection for the GIS body and all relevant parts, as per the product requirement			
8	Testing and adjustment of mechanical characteristics of GIS body, three-position disconnecting and earthing switch and fault earth switch			
9	Carry out the resistance testing of main circuit upon major repair, as per the product requirement			
10	Carry out the insulation testing of secondary circuit upon major repair, as per the product requirement			
11	Carry out the insulation testing of main circuit upon major repair as per the product requirement			

4. Maintenance and repair specifications

4.1 Requirements for daily tour maintenance items

4.1.1 Requirements for tools and appliances

4.1.2 Personnel demand

Personnel qualification requirement	Personnel demand		Man-hour demand	
	Personnel of the user	Personnel of the manufacturer	Personnel of the user	Personnel of the manufacturer

Personnel of the user: those who have passed the vocational skill authentication for watchers of power transformation operation	2	0	8	0
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4.2 Requirement for professional tour maintenance items

4.2.1 Requirements for tools and appliances

S/N	Name	Model and specification (accuracy)	Unit	Qty	Note
1	Open-jawed torque wrench	2~25 N.m	Set	1	Manual tools
2	Open-jawed torque wrench	20~200N.m	Set	1	
3	Open-jawed wrench	10mm, 13mm, 16mm 18mm, 24mm, 30mm, 32mm, 50mm	Set	1	
4	Socket	10mm, 13mm, 16mm 18mm, 24mm, 30mm	Set	1	
5	Slotted screwdriver	2, 4, 6, 8"	Set	1	
6	Cross screwdriver	2, 4, 6, 8"	Set	1	
7	Long nosed pliers	8"	Ea.	1	
8	Diagonal pliers	8"	Ea.	1	
9	Extension bar	used together with the box torque wrench, with one long and one short	Ea.	1 for each	
10	Box torque wrench	10~150N·m	Set	1	
11	Box torque wrench	10~300N·m	Set	1	
12	Flexible rule	3m	Ea.	1	
13	leveling rod	1m	Ea.	1	
14	Speed ratchet wrench	24	Ea.	1	
15	Speed ratchet wrench	18	Ea.	1	
16	Speed ratchet wrench	16	Ea.	1	
17	Speed ratchet wrench	13	Ea.	1	
18	Monkey wrench	450	Ea.	1	
19	Pipe wrench	24	Ea.	1	
21	Portable wire carrier	220V	Ea.	1	Safe tool
22	Safety belt	Whole body	Ea.	3	
23	Herringbone insulated ladder	2.5m	Ea.	1	
24	Insulated ladder	3m	Ea.	1	
25	SF6 leak detector	Conduct selection as per the condition of the user's equipment among common, laser or infrared leak detector	Set	1	

4.2.2 Personnel demand

Personnel qualification requirement	Personnel demand		Man-hour demand	
	Personnel of the user	Personnel of the manufacturer	Personnel of the user	Personnel of the manufacturer
Personnel of the user: Those with the qualification recognized by the power transformation maintenance discipline	4	1	16	16

4.3 Requirements for preventive test and maintenance items

4.3.1 Requirements for tools and appliances (Prepared by the customer)

S/N	Name	Model and specification (accuracy)	Unit	Qty	Note
1	Open-jawed torque wrench	2~25 N.m	Set	1	Manual tools
2	Open-jawed torque wrench	20~200N.m	Set	1	
3	Open-jawed wrench	10mm, 13mm, 16mm 18mm, 24mm, 30mm, 32mm, 50mm	Set	1	
4	Socket	10mm, 13mm, 16mm 18mm, 24mm, 30mm	Set	1	
5	Rotary socket	5 mm, 6 mm, 8 mm, 10 mm, 14mm	Set	1	
6	Iron hammer	1.5 pounds	Ea.	1	
7	Rubber hammer	1 pounds	Ea.	1	
8	Slotted screwdriver	2, 4, 6, 8"	Set	1	
9	Cross screwdriver	2, 4, 6, 8"	Set	1	
10	Long nosed pliers	8"	Ea.	1	
11	Diagonal pliers	8"	Ea.	1	
12	Terminal crimping pliers	91102 91105	Ea.	1 for each	
13	Square crimping pliers	LXC8 6-4 6-6	Ea.	1 for each	
14	Extension bar	Used together with the box torque wrench, with one long and one short	Ea.	1 for each	
15	Box torque wrench	10~150N·m	Set	1	
16	Box torque wrench	10~300N·m	Set	1	
17	Vernier calipers	0~125mm	Set	1	
18	Feeler	0.02-1.0mm	Set	1	
19	Flexible rule	3m	Ea.	1	
20	Leveling rod	1m	Ea.	1	
21	Plumb bob	/	Ea.	1	
22	Speed ratchet wrench	24	Ea.	1	
23	Speed ratchet wrench	18	Ea.	1	

S/N	Name	Model and specification (accuracy)	Unit	Qty	Note
24	Speed ratchet wrench	16	Ea.	1	
25	Speed ratchet wrench	13	Ea.	1	
26	Monkey wrench	450	Ea.	1	
27	Pipe wrench	24	Ea.	1	
28	dust collector	1200W	Ea.	1	
29	Socket head wrench package	1.5; 2.2 ; 2.5; 3; 4; 5; 6; 8; 10mm (9-piece)	Set	1	
30	Art knife	/	Ea.	2	
31	portable wire carrier	220V	Ea.	1	Safe tool
32	safety belt	Whole body	Ea.	3	
33	Temporarily earthed security line	>25mm ²	Ea.	3	
34	herringbone insulated ladder	2.5m	Ea.	1	
35	insulated ladder	3m	Ea.	1	
36	Climbing machine and tool	Overhead working truck of more than 10m or overhead lifting platform	Set	1	Large machine and tool
37	Circuit resistance tester	≥100A	Set	1	Testing instrument
38	Tramegger	1000V, 2500V	Ea.	Respectively 1	
39	millimeter	Electronic type/pointer type	Ea.	1 for each	
40	Mechanical characteristic instrument	Able to develop the testing for high and low voltage action characteristics and time characteristics of GIS	Set	1	
41	SF6 leak detector	Conduct selection as per the condition of the user's equipment among common, laser or infrared leak detector	Set	1	
42	Mutual inductor tester	Able to conduct the turns ratio of transformer	Set	1	
43	Micro-water instrument	ATSD902	Set	1	
44	Heat gun	/	Ea.	1	

4.3.2 Requirements for consumables (Prepared by the customer)

S/N	Name	Model and specification	Unit	Qty	Note
1	White cloth	/	m	2	
2	Scouring pad	3M brand	Ea.	5	
3	Fine grit sandpaper	#0	Ea.	3	

S/N	Name	Model and specification	Unit	Qty	Note
4	Towel	/	Ea.	3	
5	Industrial absolute ethyl alcohol	≥99.97%	kg	1	
6	Conductive grease	OKS VP980	kg	0.5	
7	Paint	As per the contract mark	kg	0.5	
8	Antirust paint	As per the contract mark	kg	0.5	
9	Wire brush	/	Ea.	1	
10	Paint brush	1.5in.	Ea.	4	
11	Paint brush	2in.	Ea.	4	
12	Plastic film	1m wide	Roll	1	(In case leakage detection is required with the bandaging method)
13	Bolt	M24, M20, M16, M12, M10	Set	Several	
14	Insulated tape	3M	Roll	3	
15	Hairless paper	Dupont D-2	Pack	3	
16	Waterproof sealant	KE-45-T	Ea.	5	Inlet
17	Thread-locking agent	LOCTITE243	Bottle	2	
18	Thread-locking agent	LOCTITE271	Bottle	2	
19	Transparent tape	/	Roll	3	
20	White gloves	/	Pair	10	

4.3.3 Personnel demand

Personnel qualification requirement	personnel demand		Man-hour demand	
	Maintenance personnel	Personnel of the manufacturer	Maintenance personnel	Personnel of the manufacturer
Requirements for the maintenance personnel: 1) At least one person with the senior worker qualification of power transformation maintenance discipline 2) The maintenance personnel has been trained by Sieyuan Electric Co., Ltd. and turned out to be qualified. At least one person with the qualification certified by Sieyuan Electric Co., Ltd.; 3) The remaining personnel should have the qualification recognized by the power transformation maintenance discipline.	4	1 (based on the actual situation of the project, may change when the project is executed)	16	16 (based on the actual situation of the project, may change when the project is executed)

4.4 Requirements for minor repair maintenance items

4.4.1 Requirements for tools and appliances

The following tools and appliances should be added, in addition to those required for the preventive test and maintenance items:

S/N	Name	Model and specification (accuracy)	Unit	Qty	Note
1	Mechanical characteristic instrument	GKC433F (provided by Sieyuan Electric Co., Ltd.)	Set	1	
2	GIS speed characteristic testing sensor	IP-6501-A502 (provided by Sieyuan Electric Co., Ltd.)	Set	1	

4.4.2 Requirements for consumables (Prepared by the customer)

The following consumables should also be added, in addition to the consumables included in the preventive test and maintenance items:

S/N	Name	Model and specification	Unit	Qty	Note
1	Mechanical lubricating grease	NB52	kg	0.25	
2	Conductive grease	OKS VP980	kg	0.25	
3	Dynamic lubricating grease	Molykote3451	kg	0.25	
4	Static lubricating grease	Molykote111	kg	0.25	
5	Dust cover	19.42.0005	Ea.	30	
6	Marking pen	Red	Ea.	4	

4.4.3 Personnel demand

Personnel qualification requirement	Personnel demand		Man-hour demand	
	Maintenance personnel	Personnel of the manufacturer	Maintenance personnel	Personnel of the manufacturer
Requirements for maintenance personnel: 1) At least one person with the senior worker qualification of the power transformation maintenance discipline 2) The maintenance personnel has been trained by Sieyuan Electric Co., Ltd. and turned out to be qualified. At least one person with the qualification certified by Sieyuan Electric Co., Ltd.; 3) The remaining personnel must have the qualification recognized by the power transformation maintenance discipline. Requirements for the personnel of the manufacturer: technical maintenance personnel arranged by Sieyuan Electric Co., Ltd.	7	1 (based on the actual situation of the project, may change when the project is executed)	5 hours/person	24 (based on the actual situation of the project, may change when the project is executed)

4.4.4 Cost estimation

Based on the quotation of Sieyuan Electric Co., Ltd., the onsite service labor fee is RMB 900 yuan/person/day. The material fee is calculated otherwise, in case of any material fee. The cost is included in the LCC evaluation. See Attachment 5 for the evaluation method.

Note: the fee standard is only for reference, and the specific fee is determined as the case may be.

4.5 Requirements for major repair maintenance items

4.5.1 Requirements for tools and appliances (Prepared by the customer)

The following tools and appliances should also be added, in addition to the tools and appliances including the preventive test and maintenance items and required for minor repair maintenance:

S/N	Name	Model and specification (accuracy)	Unit	Qty	Note
1	SF6 filling device	36 to 20mm (the interface meets the interface requirement of Sieyuan Electric Co., Ltd.)	Set	1	
2	SF6 gas recovery device	36 to 20mm (the interface meets the interface requirement of Sieyuan Electric Co., Ltd.)	Set	1	
3	Hoisting tool and machine	Crane of 10t and above	Set	1	
4	Lifting rope	10t	Ea.	2	
5	lifting rope	3t	Ea.	2	
6	Hand-drive block	5t	Ea.	2	
7	Hydraulic jack	1t, 2t	Ea.	4	
8	Movable scaffold	/	Pair	4	
9	AC welder	/	Set	1	
10	Cutting machine	/	Set	1	
11	Pistol drill	/	Set	1	Determined as the case may be when in use

4.5.2 Requirements for consumables of major repair maintenance

The following auxiliary materials should also be added, in addition to the tools and appliances including the preventive test and maintenance items and required for minor repair maintenance

S/N	Name	Model and specification (accuracy)	Unit	Qty	Note
1	Seal ring	Whole set of seal rings for circuit breaker	Set	1	To be bought from the high-voltage switch manufacturer of Sieyuan Electric Co., Ltd.

4.5.3 Personnel demand

Personnel qualification requirement	Personnel demand		Man-hour demand	
	Maintenance personnel	Personnel of the manufacturer	Maintenance personnel	Personnel of the manufacturer

Prevention type	Dangerous point	Precontrol measures			
Requirements for maintenance personnel: 1) One special maintenance person from the Power Supply Board, who is responsible for site operational control. 2) At least one person with the qualification of senior worker of power transformation maintenance discipline; 3) The maintenance personnel has been trained by Sieyuan Electric Co., Ltd. and turned out to be qualified. At least one person with the qualification certified by Sieyuan Electric Co., Ltd.; 4) The remaining personnel must have the qualification recognized by the power transformation maintenance discipline.		5	3 (based on the actual situation of the project, may change when the project is executed)	9	49 (based on the actual situation of the project, may change when the project is executed)

4.6 Preparation

4.6.1 Technical preparation

- Familiarized with the technical data on ZF28-420 GIS of Sieyuan Electric Co., Ltd., and ascertain relevant technical requirements and quality standards;
- Prepare the data on the ZF28-420 GIS requiring maintaining: product manual, electrical diagram, ex-factory test report;
- Learn the equipment operation on the site and the safety measures on the worksite;
- Find and collect the data on equipment defects as per the operation, maintenance and test records;
- Verify the numbers of GIS operations and short-circuit current openings, and determine the maintenance and improvement items.
- Formulate the maintenance plan and scheme as per the maintenance items.

4.6.2 Preparation of tools and appliances

- Check to ensure that the tools and appliances required in maintenance are complete and normal as per the requirements of the maintenance items, and transport them to the maintenance project site;
- Adopt proper protective, dustproof, damp roof and rainproof (outdoor items) measures for the GIS parts, insulated parts, etc;
- Adopt necessary dustproof and rainproof measures for construction of outdoor items;
- Properly conduct the construction safety and fireproof measures on the site.

4.6.3 Personnel preparation

- Organize all workers to conduct technical disclosure, and learn and execute safety measures;
- Ascertain the labor division for personnel of all items, and analyze risks clearly;
- The workers must adopt necessary protective measures, wear long-sleeve working clothes, work shoes and work caps, as well as protective gloves and goggles (if necessary).

4.7 Dangerous points and precontrol measures for power failure maintenance

Personal electric shock	Low voltage power supply connection and dismantling	<ol style="list-style-type: none"> 1. The maintenance power supply should be equipped with leakage protector, and the enclosure of electric tool should be reliably grounded; 2. The maintenance personnel should connect the maintenance power supply at the position in the transformer substation that is designated by the operator, and unauthorized connection of power supply and dragging of live power supply panel are prohibited; 3. Conduct measurement with multimeters to ensure there is no voltage before disconnecting and connecting the test power supply; 4. Disconnect the GIS operational power supply, energy-storing motor and heater power supply before maintenance; 5. Don't disconnect and connect the connector of operating circuit power supply electrically; 6. Conduct measurement with multimeters to ensure there is no voltage before disconnecting and connecting the connector of operating circuit power supply;
	Prevention of mistaken power failure and high-voltage electric shock	<p>Strictly implement the work ticket;</p> <p>Set the danger control board at neighboring intervals;</p> <p>Clearly tell the neighboring electrified equipment to the operation personnel and enhance monitoring before executing the operation;</p> <p>Don't span the barricade, or climb the framework of running equipment.</p>
	Accidental contact of live equipment	<ol style="list-style-type: none"> 1. A professional with the special operation qualification must conduct monitoring and commanding, before the crane enters the high-voltage equipment zone, so that the crane can travel and hoist as per the designated route; 2. Determine the scopes of activity and turning directions of suspension arm and heavy object before work; 3. Ensure the safety distance from the electrified body: no less than 4m for 420kV; 4. Add the protective earthing line when the power failure maintenance and repair of GIS is conducted in the 420kV transformer substation.
Gas processing	Ensure there is a reliable valve of good airtightness between the vacuum device and aim chamber	Conduct a test before use, for avoiding that backward pump oil flowing pump occurs due to the vacuum pump inversion, when power supply is suddenly disconnected during vacuum pumping vacuum, or the vacuum pumping operation is interrupted due to other reasons.
	Prevention of mistaken discharge of SF6 gas of electrified gas compartment	Strictly execute the operation order system, and closely monitor the sf6 gas pressure in the relevant gas compartment
Falling object from a high altitude, object impact	Wounding by falling object from a high altitude	<p>Anybody below the person working aloft should stay away, and cross-operation is prohibited;</p> <p>Any objects requiring passing up and down shouldn't be thrown, and safety caps must be worn before the operation site is entered.</p>

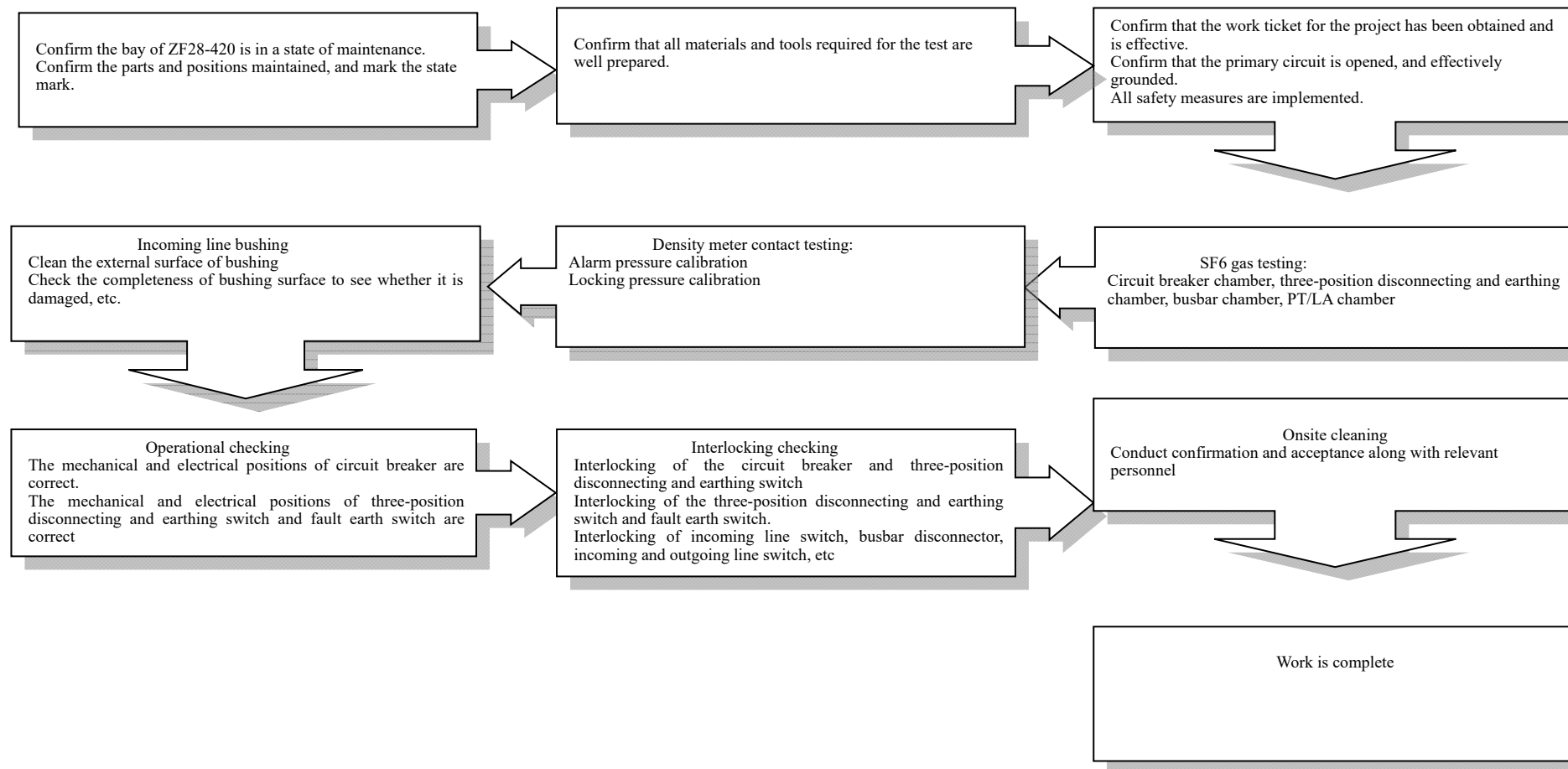
	Wounding by operating mechanism	<ol style="list-style-type: none"> 1. Operate the GIS to the opening position, disconnect the power supply and conduct grounding on the high voltage side; 2. Carry out one opening-closing operation after the energy-storing motor of GIS is powered off, so that it can ensured that the energy of spring mechanism is totally released; 3. For safety, the closing spring of GIS cannot store energy, before the maintenance is completed; 4. The workers must conduct operation as specified, and are well coordinated, in case of cross-operation, when the power failure maintenance and repair of GIS is conducted; 5. Confirm that the remote/site selector switch of central control box and mechanism case is moved to the “site” position, for preventing mistaken movement of mechanism; 6. Don’t develop maintenance before the energy of opening and closing springs of mechanism is released. 7. It is prohibited to conduct dummy instructions for the operating mechanism.
Equipment damage	Operational condition not provided	<ol style="list-style-type: none"> 1. Don’t operate the GIS before the operating mechanism is well connected to GIS; 2. Don’t operate the GIS, before the SF6 gas of rated pressure is filed in GIS; 3. Don’t press the contactor with hands for energy storage.
	Improper operation by the personnel	<ol style="list-style-type: none"> 1. Don’t release the opening and closing trippers manually. 2. Conduct the inching test for the lowest action voltage of coil. 3. It is prohibited to add operating voltage to the opening and closing circuits to operate the GIS without delay, when the GIS is in the closing position. 4. Firstly check whether the anti-trip relay and secondary circuit are complete for avoiding closing-opening operations without delay, when the driving GIS mechanism trips against circuit; 5. Don’t directly add operating voltage to the opening and closing coil, when the GIS switch is opened or closed, or when the action voltage of coil is measured.

Note:

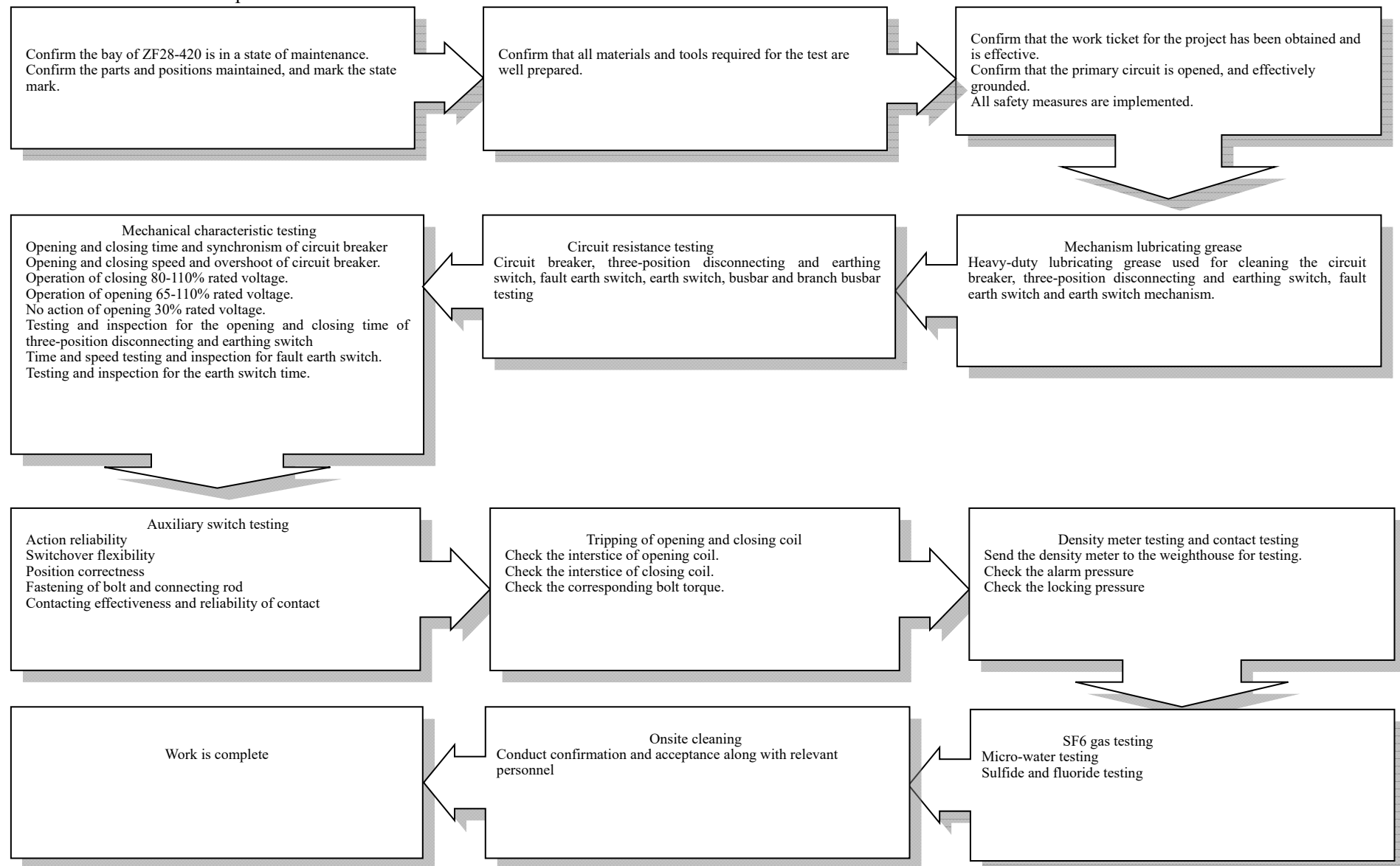
The personnel manually slowly opening and closing the GIS must be trained by Sieyuan Electric Co., Ltd. Such operation cannot be conducted for the GIS and operating mechanism by any personnel who haven’t been trained and any arbitrary operation may result in personal injury and equipment damage.

4.8 Workflow of power failure maintenance

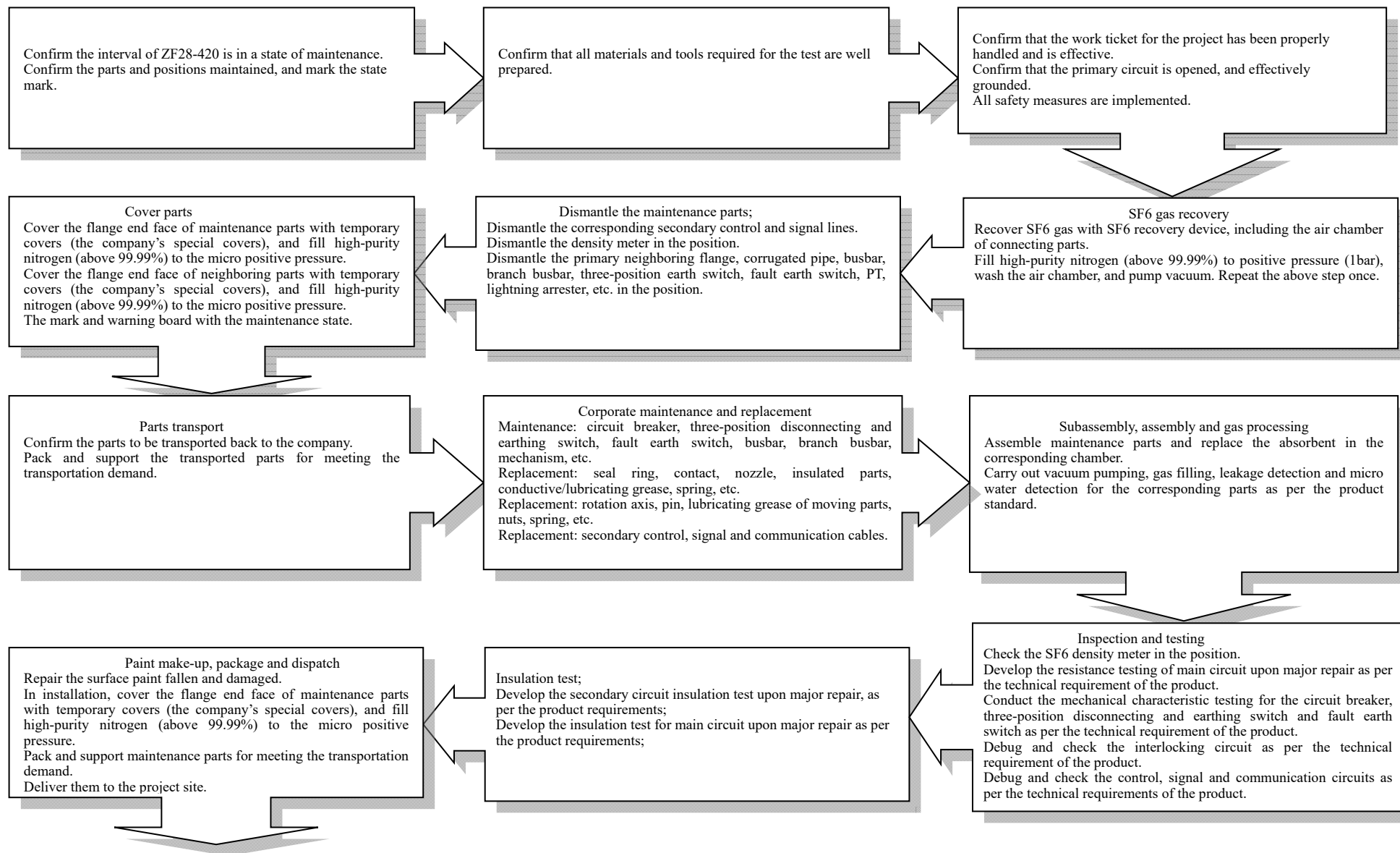
4.8.1 Preventive test and maintenance flows

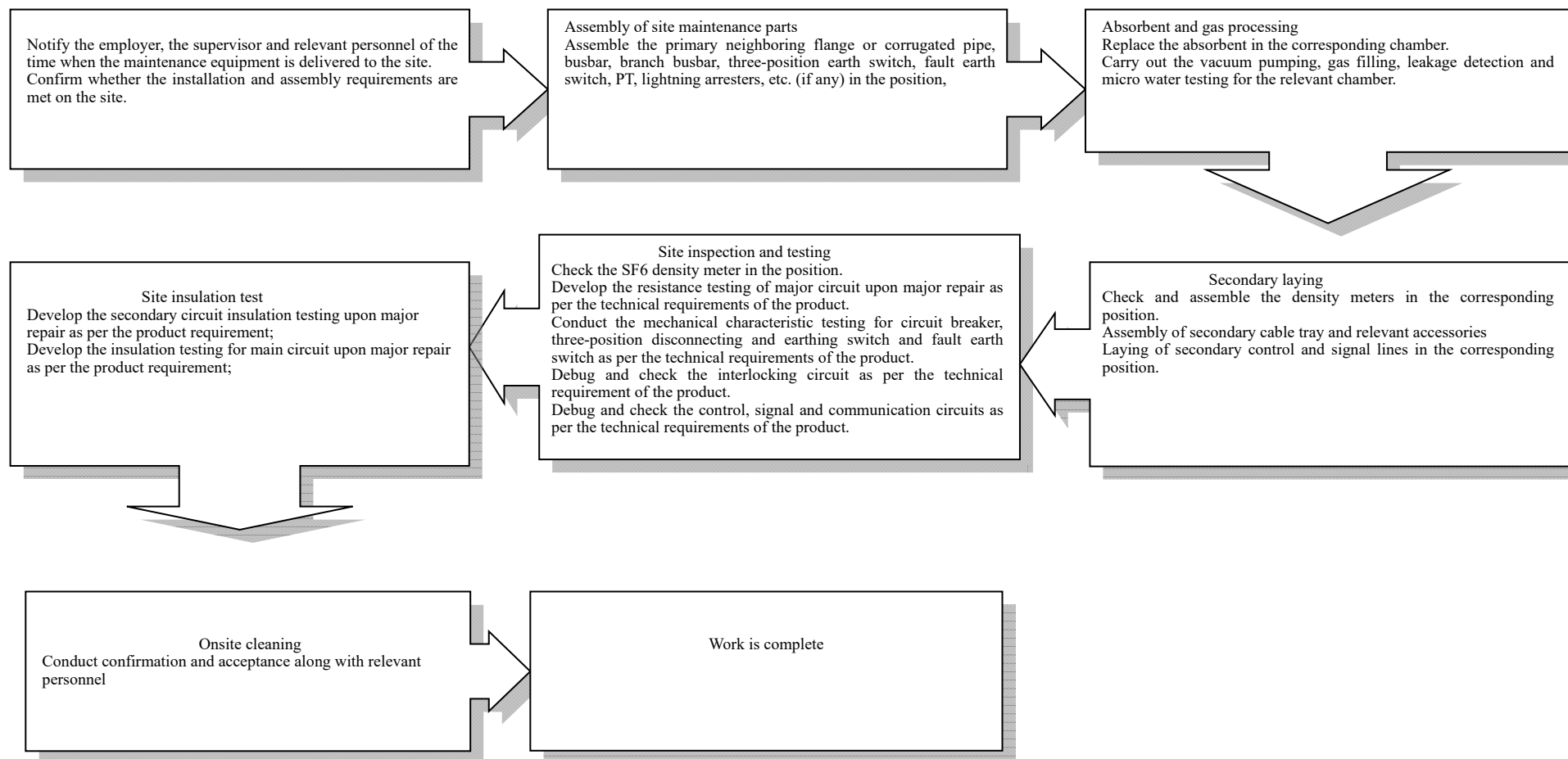


4.8.2 Workflow of minor repair



4.8.3 Workflow of major repair







Note:



The processes in dashed box are the relevant reworking, assembly, testing and testing items completed in Sieyuan Electric Co., Ltd.



2. The major repair involves all contents of minor repair and due to the limitation by onsite conditions, some contents of the major repair don't apply to the site. In principle, the major repair shall be completed in the factory in the integral rotation mode, and only replacement of relevant parts of GIS is required on the site.



5. Quality standard for maintenance and repair



5.1 Quality standard for daily tour maintenance

Requirements for daily maintenance	Quality standard	Inspection location	Type
Inspection of GIS framework (framework, foundation, earthing)	The earthing of GIS framework shall be favorable, fastened, firm, and rustless.	 <p>Earthing of framework</p>	Visual inspection
	The GIS foundation shall be without cracks, inclines, displacements or sedimentations.	 <p>Infrastructure construction</p>	
Check whether the GIS appearance is favorable.	The bolts of GIS framework shall be fastened (See Appendix		Visual


Requirements for daily maintenance	Quality standard	Inspection location	Type
	V "Common Tightening Torque of Bolt" for the tightening torque standard of bolts with different specifications.)	 <p>GIS underframe</p>	inspection
	<ol style="list-style-type: none"> 1. The oil paint of external surface shall be without scales or falling-off. 2. The metal external surface shall be without corrosions or oxidation. 3. The fastening element shall be without corrosions or oxidation. 4. No bump traces of external force shall occur at the external surface. 	 <p>External surface</p>	Visual inspection


Requirements for daily maintenance	Quality standard	Inspection location	Type
Check whether the GIS appearance is favorable.	The coated waterproof glue shall not craze or fall off.	 <p>Waterproof glue</p>	
Check the abnormal noise of equipment.	1. Tour inspection of the abnormal noise of circuit breaker, three-position disconnecting and earthing switch, bus, branch bus, PT, CT as well as lightning arrester.	 <p>The whole equipment</p>	


Requirements for daily maintenance	Quality standard	Inspection location	Type
Check the pressure value of GIS proper and SF6 density meter.	<ol style="list-style-type: none"> 1. For the SF6 density meter, the surface shall be clean; the indication of air pressure shall be clear and visible; no dirt or damages shall occur on the appearance. 2. The connection between the SF6 density meter and the proper shall be reliable and firm. 3. The amphenol connector between the SF6 density meter and the proper shall be reliable and firm. 4. The rated pressure of the circuit breaker shall be $0.68 \pm 0.2 \text{ MPa}$; other gas compartment rated pressure value of $0.58 \pm 0.02 \text{ MPa}$. 	 <p>Density meter</p>	Visual inspection
Infrared radiation test	Detect the GIS proper, three-position disconnecting and earthing switch, bus as well as the porcelain bushings at the inlet and outlet with infrared imager; the surface temperature shall have no obvious changes (under the same operation environment and load).	 <p>Porcelain bushing</p>	Visual inspection

Requirements for daily maintenance	Quality standard	Inspection location	Type
The leakage current of lightning arrester shall be normal.	The leakage current shall be around 0.5mA and the pointer shall not vibrate.		Visual inspection
Live display	For the live display, the live display shall be normal; the shutting indication shall be normal.		Visual inspection

5.2 Quality standard for professional tour maintenance

Requirements for professional maintenance	Quality standard	Inspection location	Type
Check of the base of GIS mechanism case	1. For the check of the base of GIS mechanism case, no fragments, bolts or foreign bodies, etc. shall exist.	 <p>Mechanism case</p>	Visual inspection

<p>Check of the base of GIS mechanism case</p>	<ol style="list-style-type: none"> 1. The transmission part of operating mechanism shall be normal in appearance and have no cracks in the enclosure. The appearance the axis, pin and lock washer of the mechanism shall be normal. 2. Check the oil leak trace of bumper and the fixed axis and rand are normal. 	 <p>Bumper</p>	<p>Visual inspection</p>
<p>Analysis of SF6 leakage data</p>	<ol style="list-style-type: none"> 1. For the SF6 gas pressure analysis, the horizontal comparison and vertical comparison of the SF6 gas pressure for the circuit breaker shall be conducted through the operation record, so as to make an earlier judgment for the existence of SF6 leakage. 	<p>Data analysis</p>	

<p>SF6 qualitative leakage detection</p>	<p>For the connector of density meter, the junction surface of flange face as well as the axis sealing point of the mechanism case of isolated earthing disconnecting link, four qualitative leakage detections shall be conducted with the qualitative leakage detector with a speed no more than 2.5cm per second, so as to determine the existence of leakage.</p>		
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5.3 Quality standard for dynamic tour maintenance

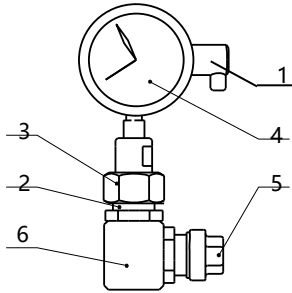
Item	Quality standard	Note
Dynamic tour maintenance after operation of circuit breaker	<ol style="list-style-type: none"> 1. The indicative positions of opening and closing shall be correct; 2. The operative rolling counters forward shall be correct; 3. The energy accumulation position of the mechanism shall be correct; 4. No smells shall occur in the control case or mechanism case. 	
Dynamic tour maintenance when operational risks change	<ol style="list-style-type: none"> 1. Conduct professionalized tour maintenance before the operational mode changes, if the dispatch department issues an early warning notice on power grid risk of Grade III and above, after the importance of circuit breaker changes based on operational mode of power grid and load change. Conduct a full daily tour inspection before the operational mode changes, and carry out the relevant data recording, if an early warning notice on power grid risk of Grade III and below has been issued. 2. Carry out at least professionalized tour maintenance once for the key controlled equipment of Grades I and II involved in the important security supply period, before the peak hours and summer. 3. In case of extreme climate, earthquake and other serious natural disasters, conduct professionalized tour maintenance once for the key controlled equipment of Grades I and II, and cut off power for inspection if necessary. 	
Dynamic tour maintenance for circuit breaker leaking SF6	<ol style="list-style-type: none"> 1. Conduct analysis as per the recorded data on SF6 gas pressure, and arrange air supplementation before the SF6 pressure drops to 0.02MPa before the alarm value. 2. Find leaking points with such live leakage detectors as infrared leakage detectors. 	
Dynamic tour maintenance for newly operated circuit breaker	Add daily tour maintenance items: "visual inspection for appearance of circuit breaker", "leakproofness inspection for control box (mechanism case) of circuit breaker", "inspection for bottom of mechanism case of circuit breaker", "inspection for readings of SF6 barometer", frequency of patrol inspections for "infrared testing" item.	
Dynamic tour maintenance for circuit breaker upon a thunderstorm	Add daily tour maintenance items: "visual inspection for appearance of circuit breaker", "one leakproofness inspection for control box of circuit breaker (mechanism case)"	
Dynamic tour maintenance of circuit breaker upon a gale	Add daily tour maintenance items: "visual inspection for appearance of circuit breaker" and one "infrared testing"	
Dynamic tour maintenance of circuit breaker upon sudden change of temperature	Add daily tour maintenance items: "visual inspection for appearance of circuit breaker", "leakproofness inspection for control box of circuit breaker (mechanism case)" and one "infrared testing".	

Item	Quality standard	Note
Dynamic tour maintenance of circuit breaker upon a heavy fog	Add daily tour maintenance items: one “visual inspection for appearance of circuit breaker”.	
Dynamic tour maintenance of circuit breaker upon a hail	Add daily tour maintenance items: inspect the “visual inspection for appearance of circuit breaker” once.	
Dynamic tour maintenance of circuit breaker under the N-1 mode and in heavy load operation	Add daily tour maintenance items: patrol inspection frequency of “infrared testing”.	
Dynamic tour maintenance of circuit breaker upon an earthquake	Conduct professional tour maintenance for the key controlled equipment of Grades I and II, and conduct daily tour maintenance for the key controlled equipment of Grades III and IV.	
Replacement of density relay	Replace the relevant seal ring	

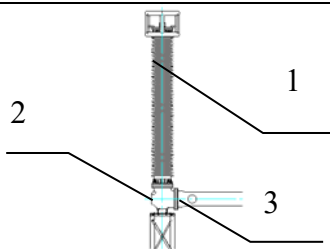
5.4 Power failure maintenance quality standard

5.4.1 Preventive test and maintenance quality standard

a) Checking of density meter and corresponding circuit


Maintenance process	Quality standard	Maintenance type
 <p>1. Terminal 2. Self-closed joint 3. Connector 4. SF6 density meter 5. Protective cover 6. Valve seat</p> <p>Fig.: Density Relay</p> <ol style="list-style-type: none"> LCP is powered off; Dismantle and install the density meter as per the step of “arrangement of density meter” in Appendix IV; Dismantle the terminal of cable connector of density relay; Manually short circuit the 1-2 terminal, power on the LCP, and view whether the low pressure alarm signal of the corresponding gas compartment is shown; the LCP is powered off, and the 1-2 short-circuited line is dismantled; Short-circuit the 3-4 terminal artificially, power on LCP, and view whether the low pressure locking signal of the corresponding gas compartment is shown; the LCP is powered off, and the 3-4 short-circuited line is dismantled; Reinstall the terminal of cable connector of density relay. <p>Note:</p> <p>It is required to power off the LCP during short circuiting, otherwise, electric shock may occur.</p>	<ol style="list-style-type: none"> Send the density meter to the organization with the corresponding qualification for inspection based on the product standard; The pressure alarm and locking circuits should function normally: CB gas compartment alarm pressure; 0.63 MPa, other gas compartment 0.53 MPa; CB gas compartment blocking pressure; 0.60 MPa, other gas compartment 0.50 MPa . The appearance of density meter should be clean, and can give indication clearly. For the standard for tightening torques of bolts of different specifications, see Appendix II “Common Tightening Torque of Bolt” ”All grease should accord with Appendix III “Common Grease List” Timely contact the Customer Service Department of Sieyuan Electric Co., Ltd., in case of any abnormal sound. 	Inspection of minor repair

b) Inspection for incoming and outgoing ceramic bushing

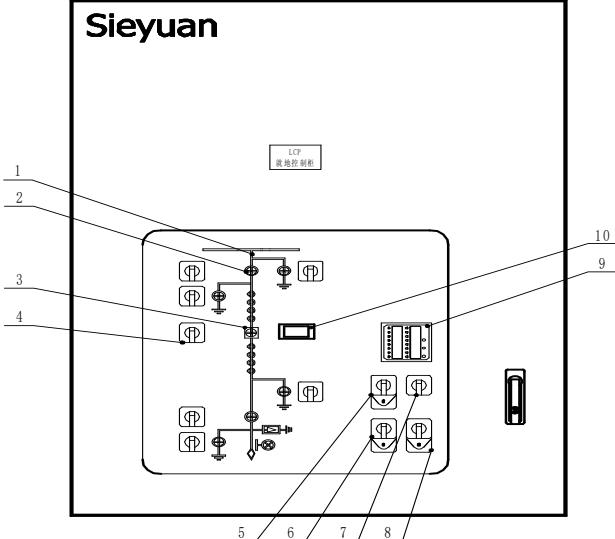


Maintenance process	Quality standard	Maintenance type
 <p>1. Bushing 2. Distribution module 3. Connecting bolt</p> <p>Fig.: Outgoing Line Bushing</p> <ol style="list-style-type: none"> Wipe the umbrella skirts of ceramic bushings one by one with towel or cloth and carefully check them, by a climbing tool or trestle ladder. Check the connecting bolt and protective silicon of flange, with a climbing tool or trestle ladder. <p>Note:</p> <p>a. There is high-pressure gas or damage or explosion from tool</p>	<ol style="list-style-type: none"> There is no dirt accumulates on the ceramic surface, the flange surface is free from cracks and both of them are combined well. The connecting bolt of flange is firm, and it should be fastened with the corresponding torque in case of any looseness. See Appendix II “Common Tightening Torque of Bolt”, for the standard for tightening torques of bolts of different specifications The protective silicon should be free from cracks and peeling. 	Inspection of minor repair

Maintenance process	Quality standard	Maintenance type
<p>impact in the ceramic bushing;</p> <p>b. There is high pressure gas in the ceramic bushing, and use climbing tool or trestle ladder in inspection, and no one is allowed to climb;</p> <p>c. Anti-falling measures should be taken for any overhead operations;</p>		

c) Micro-water detection for each gas compartment

Repair technology	Quality standard	Repair type
 <p>ATSD902 SF6 Precision dew-point hygrometer</p> <ol style="list-style-type: none"> 1. Measure the water content of SF6 with dew-point tester (with the volume fraction of 20°C; refer to specific equipment specification for usage method, but not limit to the instrument in this model); 2. Connect the thread end on the measurement channel with the switch connector; insert one end of the quick connector on the measurement channel into the sampling port on the dew-point instrument; connect the exhaust pipe to the air outlet; 3. Connect the switch connector with the measurement port of tested sample and lock them; <p>Open the power switch of instrument; the self calibration process initialization is required to be entered; the process will last about 10mins;</p> <ol style="list-style-type: none"> 4. Adjust the protection button of dew-point instrument to the "measurement" position; entirely open the flow valve of dew-point instrument; then adjust the flow to 0.5L/min by adjusting the needle of measuring channel; so the measurement begins. <p>Attention;</p> <p>Before test, the port, connector thread and surface shall be cleaned.</p>	<ol style="list-style-type: none"> 1. It shall conform to the technical requirements for product and relevant technical terms for engineering project; 2. When the acceptance check is conducted; Gas compartment of circuit breaker≤150μL/L; Others≤250μL/L; 3. When the equipment is operated; Gas compartment of circuit breaker≤300μL/L; Others≤500μL/L; 4. If the water content of SF6 is abnormal in a certain gas compartment, please contact the customer service department of Sieyuan Electric Co., Ltd. 	<p>Minor repair inspection</p>

d) Operation inspection for circuit breaker, three-position disconnecting and earthing switch and fault earthing switch

Repair technology	Quality standard	Repair type
<p>Sieyuan</p>  <p>1. Main Wiring Simulation Diagram 2. Position indicator 3. CB position indicator 4. Operating switch of local opening and closing 5. Transition switch of interlocking/deblocking 6. Transition switch for CB far-near control 7. Reset switch 8. Transition switch for DS/ES/FES far-near control 9. Fault alerter 10. Operative counter for circuit breaker</p> <p>Figure: Element of Local Control Cabinet</p> <ol style="list-style-type: none"> 1. Close the AC/DC power supply control switches for all the controls, motors and signals; 2. Select the CB//DS/ES/FES far-near control switch; 3. Select the operation switch of local opening and closing; 4. Select the transition switch of interlocking/deblocking; 5. Operate the opening and closing positions of CB//DS/ES/FES respectively and confirm the correctness and effectiveness of their relative positions. <p>Attention;</p> <p>The operation shall be conducted by the relevant personnel who are familiar with the operation flow of the equipment.</p>	<ol style="list-style-type: none"> 1. The energy-storing time (rated voltage) for the spring mechanism of circuit breaker shall be less than 15 seconds; 2. During the respective opening and closing process of three-position disconnecting and earthing switch and earth switch, clamping stagnation shall not occur; 1. The mechanical and electrical position displays of circuit breaker shall be correct; 2. The mechanical and electrical position displays of three-position disconnecting and earthing switch shall be correct; 3. The position displays of each earth switch shall be correct. 4. The electrical position of CB//DS/ES/FES switch shall display status;  <p>closing opening fault / failure</p> <ol style="list-style-type: none"> 5. The mechanical position of CB//DS/ES/FES switch shall display status;  <p>opening closing</p>	<p>Power failure maintenance</p>

e) Operation of interlocking and shutting circuit

Repair technology	Quality standard	Repair type
<p>1. When the isolated earth switch is in the closing state of disconnector, it cannot be directly transited to the closing state of earth switch by operation; the disconnector must be opened at first and opened in place, then the earth switch can be closed;</p> <p>2. When the isolated earth switch is in the closing state of earth switch, it cannot be directly transited to the closing state of disconnector; the earth switch must be opened at first and opened in place, then the disconnector can be closed;</p> <p>3. Refer to the technical conditions of product and the technical terms of engineering project for the interlocking functions and requirements for the circuit breaker, disconnector, earth switch and other devices;</p> <p>a. Prevent wrong opening and wrong closing of circuit breaker.</p> <p>b. Prevent on-load opening and closing of disconnector.</p> <p>c. Prevent electrified closing of earth switch.</p> <p>d. Prevent closing of disconnector with earth switch.</p> <p>e. Prevent misguidance into the electrified bay.</p> <p>Attention;</p> <p>The operation shall be conducted by the relevant personnel who are familiar with the operation flow of the equipment.</p>	<p>Each interlocking function shall be correct, effective and reliable;</p> <p>1. Local operation: the operation which is conducted when the remote/local selection keys are placed at the “local ” position;</p> <p>2. Circuit breaker : after all the electrical interlocking conditions are satisfied, the opening and closing operations of circuit breaker can be conducted through the rotation switch;</p> <p>3. Disconnector: after all the electrical and mechanical interlocking conditions are satisfied, the opening and closing operations of disconnector can be conducted through the rotation switch;</p> <p>4. Earth switch: after all the mechanical conditions of electrical interlocking are satisfied, the opening and closing operations of earth switch shall be conducted with corresponding key tripping and through the rotation switch;</p> <p>5. The operation which is conducted in the backstage when the remote/local selection key is placed at the “remote control” position;</p> <p>6. Each interlocking function shall satisfy the technical conditions of product and the corresponding technical terms of engineering project.</p>	Power failure maintenance

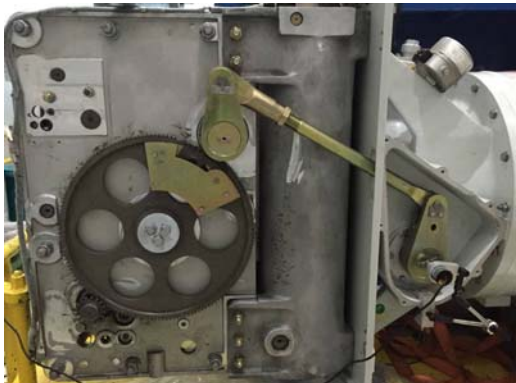
5.4.2 Quality standard for minor repair and maintenance

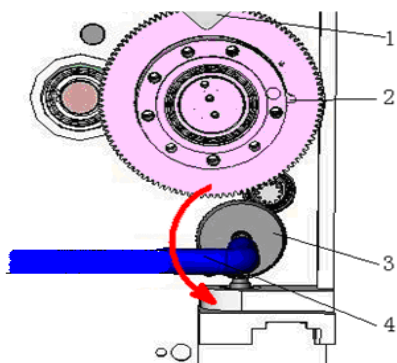
a) Calibration of density meter and inspection of corresponding circuit

See 5.4.1

b) The lubrication, auxiliary and position switches of each operating mechanism.

Spring mechanism, auxiliary and position switches of circuit breaker.

Repair technology	Quality standard	Repair type
<p>1. Cut off the power supply of energy accumulation and control circuit; check and ensure that the pressure in the gas compartment of circuit breaker surpasses the shutting pressure. If the pressure is too low, the opening and closing operations of circuit breaker cannot be conducted;</p> <p>2 Manually conduct the reclosing operation to totally release the spring energy of energy accumulation;</p> <p>3 Open the enclosure side cover of the mechanism; use ZZ000157 frock to conduct manual slow opening and slow closing operations for the circuit breaker and clean the original grease of the reduction gears, bearings, springs and sliding blocks with hairless paper or industrial alcohol at the respective opening and closing positions. Then recoat the clean grease.</p> <p>3. If the ideal effect cannot be satisfied by one-time of cleaning, the secondary cleaning can be conducted to ensure the recoated grease is clean and without obvious discoloration.</p> <p>4. Check the connecting rod connection and position switch of auxiliary switch and fasten relevant connectors and bolts;</p> <p>5. Check the contactor of switch transition with the multimeter and whether rust and poor contact occurs.</p> <p>6. Check the contact of position switch with the multimeter and whether rust and poor contact occurs.</p> 	<p>1. The recoated grease shall be even and clean. After the operation, no residual flow, falling-off and obvious discoloration shall occur.</p> <p>2. During the manual slow opening and slow closing with ZZ000157 frock for the circuit breaker, no clamping stagnation shall occur.</p> <p>3. The connection of each transition connector and connecting rod for the auxiliary switch shall be fastened and rustless. The switchover shall be reliable.</p> <p>4. The contactor of auxiliary switch shall be rustless. The contact shall be reliable.</p> <p>5. The contactor of position switch shall be rustless. The contact shall be reliable.</p> <p>6. The inner part of mechanism case shall be clean and without sundries.</p> <p>7. The tightening torque of standard component for bolts with different specifications shall conform to the Appendix II "Common Tightening Torque of Bolt ".</p> <p>8. The grease used shall conform to the "Common Grease List ".</p>	Minor repair inspection



1-Set square 2-Pawl 3-Bevel gear 4-Manual energy accumulation hand shank

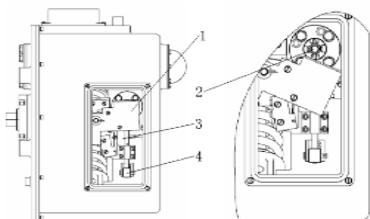
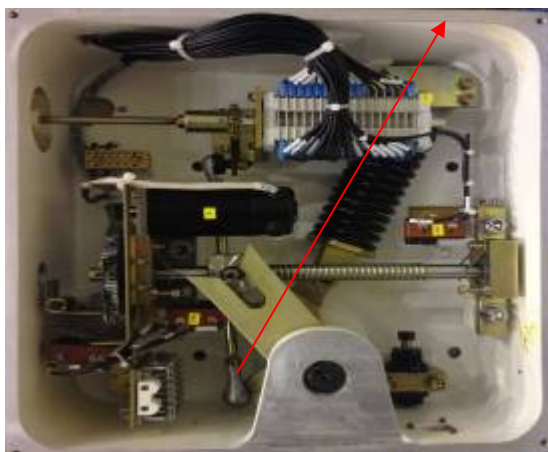
Figure1 Manual Energy Accumulation

Attention:

1. Only the trained personnel can conduct manual operation; before the manual operation, please cut off the power supply of energy accumulation and control circuit; check and ensure the pressure in the gas compartment of circuit breaker surpasses the shutting pressure. If the pressure is too low, the opening and closing operations of circuit breaker cannot be conducted.
2. Arbitrary operation may cause human injury and equipment damage.

Disconnecter electric operating mechanism, auxiliary switch and position switch

Repair technology	Quality standard	Repair type
<p>1. Please cut off the power supply of energy accumulation and control circuit;</p> <p>2. For manual operation, clean the original grease of the screw rods, bearings, bevel gears and sliding blocks with hairless paper or industrial alcohol at the respective opening and closing positions of the disconnector and earth switch. Then recoat the clean grease.</p> <p>3. If the ideal effect cannot be satisfied by one-time of cleaning, the secondary cleaning can be conducted to ensure the recoated grease is clean and without obvious discoloration.</p> <p>4. Check the connecting rod connection and position switch of auxiliary switch and fasten relevant connectors and bolts;</p> <p>5. Check the contactor of switch transition with the multimeter and whether rust and poor contact occurs.</p> <p>6. Check the contact of position switch with the multimeter and whether rust and poor contact occurs.</p>	<p>1. The recoated grease shall be even and clean. After the operation, no residual flow, falling-off and obvious discoloration shall occur.</p> <p>2. During the manual opening and closing of the disconnector and earth switch, no clamping stagnation shall occur.</p> <p>3. The connection of each transition connector for the auxiliary switch shall be fastened and rustless. The switchover shall be reliable.</p> <p>4. The contactor of auxiliary switch shall be rustless. The contact shall be reliable.</p> <p>5. The contactor of position switch shall be rustless. The contact shall be reliable.</p> <p>6. The inner part of mechanism case shall be clean and without sundries.</p> <p>7. The tightening torque of standard component for bolts with different specifications shall conform to the Appendix II "Common Tightening Torque of Bolt".</p> <p>8. The grease used shall conform to the "Common Grease List".</p>	Minor repair inspection



1. Panel 2. Jack of operating hand shank 3. Shutting rod 4.

Padlock pin

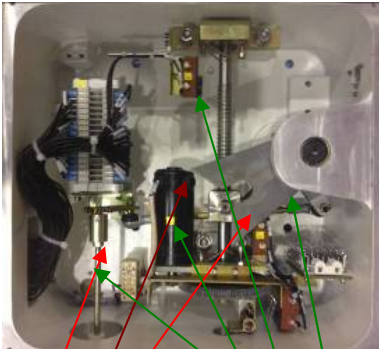
Figure Manual operation and shutting

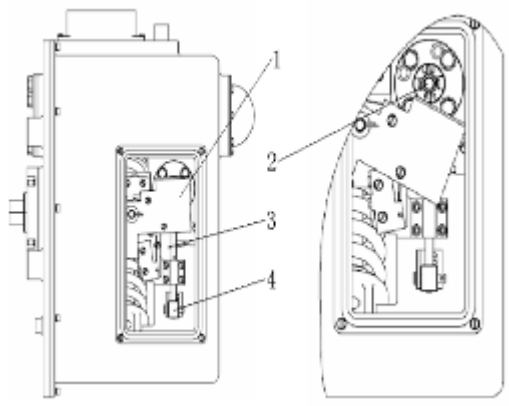
Attention:

1. The step of manual operation of isolated (earth) switch;
 - a) The earth switch must be in the opening position. Otherwise the opening operation of earth switch shall be conducted at first;
 - b) Take down the fixed bolt (or padlock);

<p>c) Rotate the baffle at the isolated side and take out the plug;</p> <p>d) Insert the operating hand shank and confirm its open slot is butt jointed to the upper and inner spring pins;</p> <p>e) Rotate the operating hand shank as per the indicative direction of manual operation nameplate;</p> <p>f) Continue rotating the operating hand shank; stop the rotation when the periodic "clicking" sound occurs in the mechanism and conduct the rotation for a cycle in the reverse direction;</p> <p>g) Stop the operation and confirm the correctness of 'I' and 'O' positions of the indicator in the isolated side;</p> <p>h) Take out the operating hand shank;</p> <p>2. A mechanical limiter (electromagnet) is installed on the manual device,do not forcibly rotate the panel, no will cause mechanical damage to the operating mechanism!</p>		
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Fault earthing spring mechanism, auxiliary switch and position switch

Repair technology	Quality standard	Repair type
<p>1. Cut off the power supply of energy accumulation and control circuit;</p> <p>2. For manual operation, clean the original grease of the screw rods, bearings, variable gears and sliding blocks with hairless paper or industrial alcohol at the respective opening and closing positions of the earth switch. Then recoat the clean grease.</p> <p>3. If the ideal effect cannot be satisfied by one-time of cleaning, the secondary cleaning can be conducted to ensure the recoated grease is clean and without obvious discoloration.</p> <p>4. Check the connecting rod connection and position switch of auxiliary switch and fasten relevant connectors and bolts;</p> <p>5. Check the contact of position switch with the multimeter and whether rust and poor contact occurs.</p>  <p>This point shall be cleaned and</p> <p>Inspection of bolt, connecting rod</p>	<p>1. The recoated grease shall be even and clean. After the operation, no residual flow, falling-off and obvious discoloration shall occur.</p> <p>2. During the manual opening and closing of earth switch, no clamping stagnation shall occur.</p> <p>3. The connection of each transition connector for the auxiliary switch shall be fastened and rustless. The switchover shall be reliable.</p> <p>4. The contactor of auxiliary switch shall be rustless. The contact shall be reliable.</p> <p>5. The contactor of position switch shall be rustless. The contact shall be reliable.</p> <p>6. The inner part of mechanism case shall be clean and without sundries.</p> <p>7. The tightening torque of standard component for bolts with different specifications shall conform to the Appendix II "Common Tightening Torque of Bolt ".</p> <p>8. The grease used shall conform to the Appendix III "Common Grease List".</p>	Minor repair inspection

 <p>1. Panel 2. Jack of operating hand shank 3. Shutting rod 4. Padlock pin</p> <p>Figure Manual operation and shutting</p> <p>Attention:</p> <ol style="list-style-type: none"> The step of manual operation of fault earthing switch: <ol style="list-style-type: none"> Dismantle the screws of protecting cover and take down the protecting cover; Insert the operating hand shank into the jack; Rotate the hand shank to conduct “opening” or “closing” operation of the quick earth switch (the operation in the clockwise direction is closing operation; the operation in the anticlockwise direction is opening operation); Continue rotating the hand shank to the ending position; Extract the operating hand shank; Install the protecting cover and tighten the screw. The manual device is equipped with a mechanical limiting stopper (electromagnet). Do not forcibly rotate the panel; otherwise the operating mechanism will suffer mechanical damage! 		
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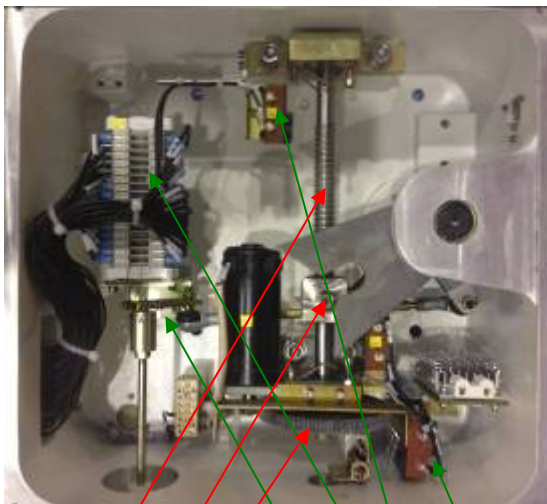
Earthing operation mechanism

Repair Process	Quality Standard	Type of Repair
<ol style="list-style-type: none"> Power off the energy storage and control circuits; Manually operate the earth switch and at the opening and closing positions, use lint free paper and industrial alcohol to remove the greases on the screw rod, bearing, cone gear and sliding block. Then, reapply the clean greases. Check the auxiliary switch for connecting rod connection and the position switch; fasten the relevant 	<ol style="list-style-type: none"> The greases reapplied shall be even and clean, and shall be free of residual stream, detachment and obvious discoloration after operation. Seizure shall not occur during the opening and closing of the earth switch when manually operated. Each adapter substitute of auxiliary switch shall be tightly connected, free of rust, and can be switched reliably. 	Minor repair and inspection

connectors and bolts;

4. Use multimeter to check the condition of change-over contact of the switch to see whether it is rusted and has a poor contact.

5. Use multimeter to check the contact condition of position switch to see whether it is rusted and has a poor contact.



Need to be cleaned
and re-greased

Check of bolt, connecting
rod and contact

Caution

1.Steps to manually operate the earth switch:

Dismantle the screw of manual cover plate and remove the manual cover plate (note: The padlock, if any, shall be removed first);

Insert the operating handle into jack socket;

Turn the handle in the manual operation direction and the direction as indicated in nameplate, to conduct "opening" or "closing" operations for earth switch;

Keep turning operating handle until an periodic "Click" sound is heard from the inside of the mechanism, then stop turning and turn back one round;

Take out operating handle to confirm whether positions of "I" and "O" on sign are correct;

Install manual cover plate and its screw;

4. Contacts of auxiliary switch shall be free of rust and have reliable contacting performance.


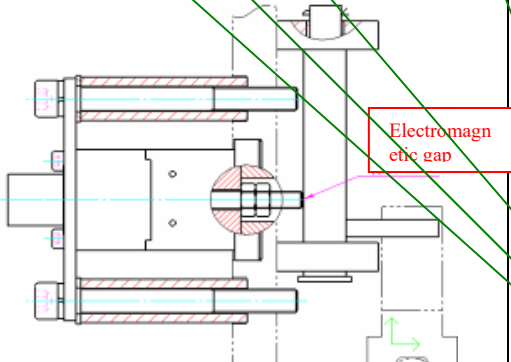
5. Contacts of position switch shall be free of rust and have reliable contacting performance.

6. Mechanism case shall be clean and contain no debris.

7. See Appendix II "Common Tightening Torque of Bolt" for fastening torque standard of bolt of different specifications;

8. Grease to be used shall comply with Appendix III "Common Grease List".

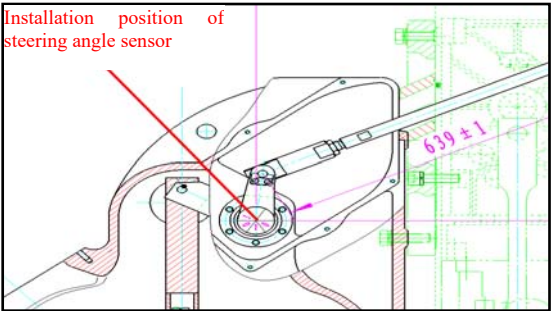
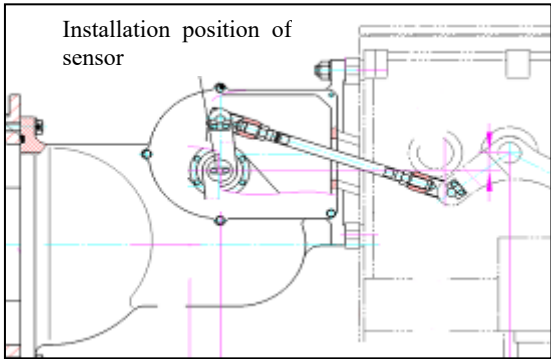
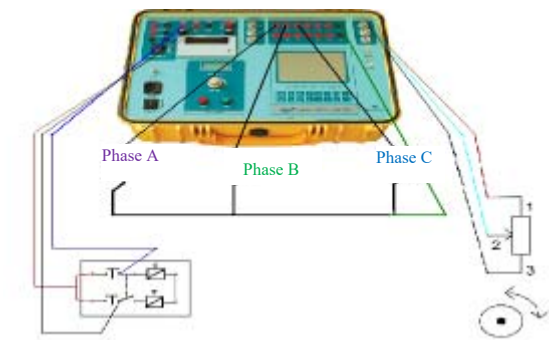
c) Checking the opening and closing coils for trip and resistance

Repair Process	Quality Standard	Type of Repair
<p>1. Power off the energy storage and control circuits of circuit breaker;</p> <p>Check and ensure that the pressure in gas compartment of circuit breaker is higher than locking pressure, otherwise opening and closing of circuit breaker cannot be conducted;</p> <p>2. Manually conduct reclosing operation to release all of stored spring energy;</p> <p>3. Open the side enclosure of circuit breaker spring mechanism;</p> <p>4. Check whether there is any overflow at monitor hole of the first opening and closing coils;</p> <p>5. Use torque spanner to recheck different marked bolt torques;</p> <p>6. Use tools or feeler gauge to measure at the positions as indicated in the figure;</p> <p>a. Use feeler gauge to directly measure the gap;</p> <p>b. Alternatively, use hands to push slightly the armature of the opening/closing coil to reach the top plate, and measure the starting value and ending value respectively.</p>  <p>Closing electromagnet and opening electromagnet</p>  <p>Position of gap of the opening and closing electromagnets</p>	<p>1. Such components as electromagnet, casing, plate, and cover shall be free of burr, dust, oil, residual water, and corrosion.</p> <p>2. No overflow should be present at monitor hole of first opening and closing coils;</p> <p>3. Fastening torque of bolt of different specifications shall comply with torque standards; see Appendix II “Common Tightening Torque of Bolt”.</p> <p>4. Grease to be used shall comply with Appendix III “Common Grease List”.</p> <p>5. Clearance between top rod and lever of split coil magnet is as follows: see technical specification for details; Switching coil resistance: see technical specification for details.</p>	Minor repair and inspection

6. Use multimeter, at proximal terminal block, to measure the resistance values of opening and closing coils respectively;		
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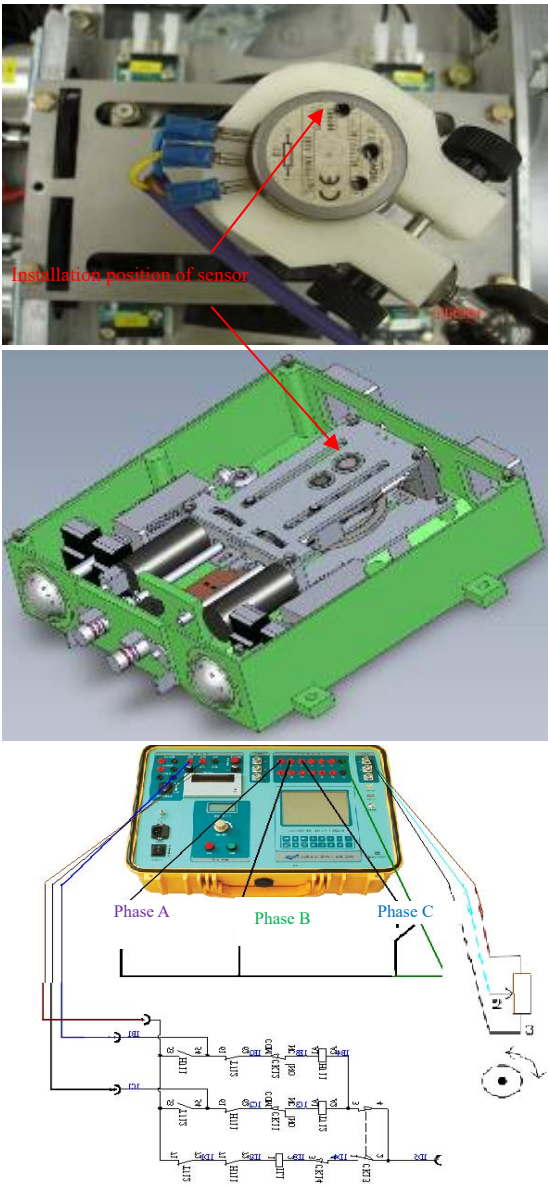
d) Mechanical property test of GIS

Mechanical property test of circuit breaker

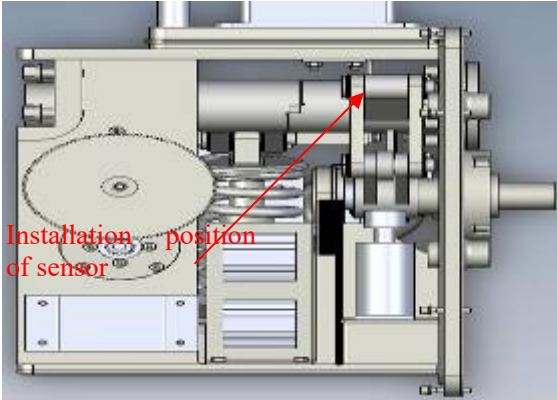
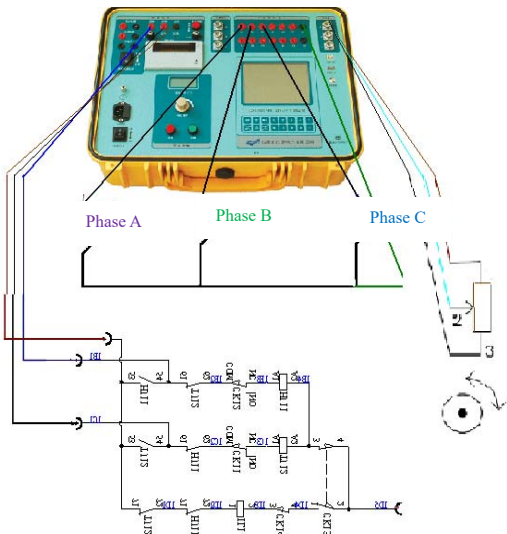
Repair Process	Quality Standard	Type of Repair
<p>1. Instruments: 420B mechanical property tester for circuit breaker and steering angle displacement sensor (being not limited to this tester).</p> <p>2. Wiring for test: Installation position of sensor and wiring for mechanical property test are shown in the following figure.</p>    <p>3. Install the sensor as per the drawing, and connect the measuring and control leadwire of 420B mechanical property measuring system to the corresponding terminals of the three-position disconnecting and earthing switch. Start the</p>	<p>Test result determination</p> <p>Mechanical characteristics and operation of circuit breaker test results should meet the requirements of product specifications and user technical agreement, otherwise it is judged to be unqualified.</p>	Minor repair and inspection

mechanical property measuring system to conduct the mechanical property test and mechanical operation test of the disconnecting switch;		
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Test of mechanical properties of three-position disconnecting and earthing switch and of earth switch

Repair Process	Quality Standard	Type of Repair
<p>1. Instruments: 420B mechanical property tester for circuit breaker and steering angle displacement sensor (being not limited to this tester).</p> <p>2. Wiring for test: Installation position of sensor and wiring for mechanical property test are shown in the following figure.</p>  <p>3. Install the sensor as per the drawing, and connect the measuring and control leadwire of 420B mechanical property measuring system to the corresponding terminals of the three-position disconnecting and earthing switch. Start the mechanical property measuring system to conduct the mechanical property test and mechanical operation test of the disconnecting switch;</p>	<p>I. Three-position disconnecting and earthing switch;</p> <p>1.Closing characteristics: (100%Ur) Closing time on earth side: $\leq 2s$ Closing time at disconnection side: $\leq 2s$ Non-synchronous closing time on earth side: $\leq 40ms$ Non-synchronous closing time on at disconnection side: $\leq 40ms$</p> <p>2.Opening characteristics: (100%Ur) Closing time on earth side: $\leq 2s$ Closing time on disconnection side: $\leq 2s$ Non-synchronous closing time on earth side: $\leq 40ms$ Non-synchronous closing time on disconnection side: $\leq 40ms$</p> <p>3.Operation with rated HV and LV Opening and closing are reliable within 85%-110% of rated voltage.</p> <p>4.Contact overtravel and travel; Contact travel on disconnection side: 110mm-114mm Contact overtravel at disconnection side: 31mm-39mm Contact travel on earth side: 110mm-114mm Contact overtravel on earth side: 31mm-39mm</p> <p>5.Judgment of test results; The result of the mechanical property and operation test of the three-position disconnecting and earthing switch shall meet the requirements of technical specifications of the products and the technical agreement of users, otherwise the test results shall be deemed as a failure.</p> <p>I. Earth switch;</p> <p>1.Closing characteristics: (100%Ur) Closing time: $\leq 3s$ Non-synchronous closing time : $\leq 80ms$</p> <p>2.Opening characteristics: (100%Ur) Opening time: $\leq 3s$ Non-synchronous opening time: $\leq 80ms$</p> <p>3.Contact overtravel and travel; Contact travel: 88mm-96mm Contact overtravel: 17mm-27mm</p>	<p>Minor repair and inspection</p>

Mechanical property test of fault earthing switch

Repair Process	Quality Standard	Type of Repair
<p>1. Instruments: 420B mechanical property tester for circuit breaker and steering angle displacement sensor (being not limited to this tester).</p> <p>2. Wiring for test: Installation position of sensor and wiring for mechanical property test are shown in the following figure.</p>   <p>3. Install sensor as per drawing, and connect measuring wire and control leadwire of 420B mechanical property measuring system</p> <p>4. Install sensor as per drawing, and connect measuring wire and control leadwire of 420B mechanical property measuring system to corresponding terminals of fault disconnecting and earthing. Start mechanical property measuring system to test the mechanical property of fault disconnecting switch and to conduct mechanical operation test;</p>	<p>1. Closing characteristics: (100%Ur) Closing time: $\leq 3s$ Average closing speed: $2.5m/s \pm 0.3m/s$ Non-synchronous three-phase closing time : $\leq 2ms$</p> <p>2. Opening characteristics: (100%Ur) Opening time: $\leq 3s$ Non-synchronous three-phase opening time : $\leq 60ms$</p> <p>3. Operation with rated HV and LV Opening and closing are reliable within 85%-110% of rated voltage.</p> <p>4. Contact overtravel and travel; Contact travel: 92.5mm-105.5mm Contact overtravel: 17mm-27mm</p> <p>5. Judgment of test results; The result of the mechanical property and operation test of the three-position disconnecting and earthing switch shall meet the requirements of technical specifications of the products and the technical agreement of users, otherwise the test results shall be deemed as a failure.</p>	Minor repair and inspection

e) Test of main circuit resistance of GIS

Repair Process	Quality Standard	Type of Repair
<p>1. Use DC circuit resistance tester by pressure drop method, with test current being not less than 100A;</p> <p>2. Use scouring pad or industrial alcohol to clean the parts to be tested, especially the surface oxide layer at earthing end;</p> <p>3. Close all disconnecting switches (open earth switches); connect test wiring of circuit resistance tester to primary terminal of main circuit, with voltage line connected at inner side and current line at outer side; Note: whether phase sequences of tested circuit are consistent shall also be confirmed;</p>  <p>Figure 7 FES floor bolt position</p> <p>Caution</p> <p>It is not allowed to dismount the bolts on insulated parts at site; if required at the time of measuring resistance, only the triangular plate in the middle can be dismounted. The dismounting method as indicated in the following figure is wrong. See figure for details.</p>	<p>1. Resistance value measured at site shall be less than or equal to 1.2 times of that calculated in factory, and phase sequence shall be correct.</p> <p>2. In case of any abnormality of circuit resistance, please contact in a timely manner the Customer Service Department of Sieyuan Electric Co., Ltd.</p>	<p>Minor repair and inspection</p>

5.4.3 Quality standard for major repair and maintenance

In principle, major repair of GIS need to be done by turns in factory and implemented by Sieyuan Electric Co., Ltd.

Quality system of major repair consists of the following operation instructions prepared by Sieyuan Electric Co., Ltd.

Items repaired	Document No.	Name of document
Technological documents required for assembly of on-site primary equipment	S020000347	General operating instructions for thread locking agent coating, bolt fastening and inspection marking
	0SS.972.012	General assembly work instruction for waterproof sealant coating
	0SS.972.030	Assembly cleaning operation instructions
	0SS.972.035	General operating instructions for vacuum treatment / inflation
	W40000737	Guide cover installation work instruction
	S020000346	General assembly instructions for grease coating
	W40000254	General operating instructions for air tight packing
	W40000021	Density relay assembly work instruction
	M020000668	420kV field installation work instruction
	S020002729	420 kV field cable terminal installation work instruction
	S020002764	420 kV GIS - manual for production and operation of removable units
	0SS.974.243	General assembly operation instructions for site installation of molecular sieve
	S020002713	General operating instructions for 420kv hoisting
Technical documents required for on-site secondary wiring	0SS.972.011	General operation instructions for secondary wiring
	0SS.974.231	Operation instructions for on-site cable distribution
	0SS.972.104	General operation instruction for cable assembly

6. Appendix

6.1. Common problems and related descriptions

1. Alarm device

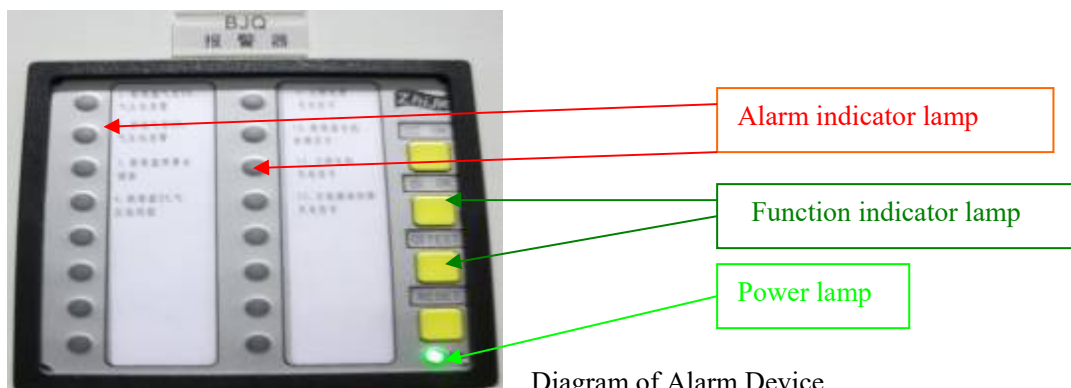


Diagram of Alarm Device

1. Interlocking of circuit breaker SF6: Pressure in gas compartment of circuit breaker is reduced to below the minimum value of 0.5MPa. Precautions in tour inspection: in case such signal is given, check whether the pointer of density relay in the breaker gas compartment of this bay is in red zone; notify repair crew to calibrate pressure value and perform leakage detection and air supplement.
2. Motor fault signal of circuit breaker: When protective air switch of energy-storage motor trips, alarm signal is given. This air switch is located in local control cabinet. If this switch does not trip, but energy-storage motor of circuit breaker operates for more than 25 sec, alarm signal will also be sent. Once such signal arises, abnormal energy-storage power supply of circuit breaker shall be recovered; reset button of time relay of circuit breaker on control cabinet shall be pressed to recover energy-storing of circuit breaker. Besides, attention shall be paid to, during energy storage, whether abnormal sound is made during operation of motor; if any, it shall be confirmed by measuring current.
3. SF6 low pressure alarm in gas compartment of circuit breaker: When abnormal pressure with leakage in gas compartment of circuit breaker is less than 0.53MPa, alarm signal is given. Precautions in tour inspection: in case such signal is given, check whether the pointer of density relay in the breaker gas compartment of this bay is in yellow zone; notify repair crew to calibrate pressure value and perform leakage detection and air supplement.
4. Spring of circuit breaker has no storage energy: no energy stored by the spring or abnormality of control power supply for the circuit breaker.
5. SF6 low pressure alarm in others: When abnormal pressure with leakage in others (beyond the gas compartment of circuit breaker) is less than 0.53MPa, alarm signal is given. For example, secondary line fault is generally detected during the inspection of density monitor, which is normal. It is noted that alarm is given as long as there is leakage from any one of gas compartment. Precautions in tour inspection: in case such signal is given, check whether the pointer of density relay in all gas compartments (beyond that of circuit breaker) of this bay is in yellow zone; notify repair crew to calibrate pressure value and perform leakage detection and air supplement.
6. Power loss signal of knife-switch: When protective air switch of knife-switch control power supply trips, alarm signal is given. This air switch is located in local control cabinet. Once such signal arises, abnormal knife-switch control power supply shall be recovered.
7. Power loss signal of knife-switch motor: When protective air switch of power supply of knife-switch motor trips, alarm signal is given. This air switch is located in local control cabinet. Once such signal arises, abnormal knife-switch motor power supply shall be recovered.
8. Power loss signal of auxiliary AC circuit: When protective air switch for heating and lighting trips, alarm signal is given. This air switch is located in local control cabinet. Once such signal arises, abnormal AC circuit power supply shall be recovered.
9. Fault at AC side of rectifying device: When any one of the miniature circuit breakers for power supply of rectifying device trips, alarm signal is given; if no trip, it is secondary line fault.(This signal is only limited for conditions involving rectifying device)
10. Fault at DC side of rectifying device: When air switch for direct-current output of rectifying device trips, alarm signal is given (this signal is only limited to the conditions involving rectifying device).
11. Air switch of DK8 rectification power supply is in "off" position: When air switch of rectification

power supply trips, alarm signal is given (this signal is only limited to the conditions involving rectifying device).

Remarks:

Pressure values mentioned above are standard values at 20°C. For different temperatures, please refer to comparison table of SF₆ pressure and temperature.

2. Replacement of adsorbent

1. Use lint free paper and dust catcher to clean the surfaces requiring replacement of adsorbent.
2. Remove adsorbent to install cover plate

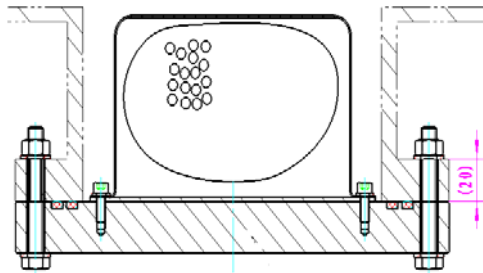


Figure 9 Adsorber

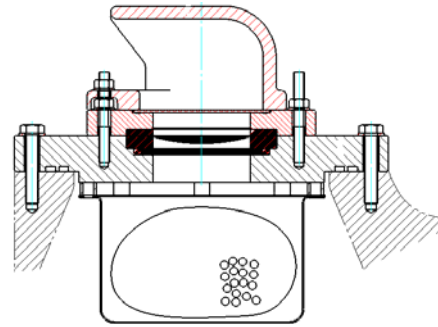


Figure 10 Adsorber

3. Tools: 16mm ratchet wrench, 16mm metric hexagon socket, torque spanner (10-100), 5mm spanner, 5mm internal hex wrench, torque spanner (2-25) and dust catcher.

4. Auxiliary materials: lint free paper, absolute ethyl alcohol, red marking pen and sealing grease.

5. Operation process

5.1 Loosen bolts connected diagonally, and remove them one by one after being loosened; It is prohibited to remove each bolt before they are loosened.

5.2 Take off adsorber: When taking off, the adsorber shall be kept perpendicular to the surface of shell flange, to prevent relative sliding from scratching the joint face of the flange.

5.3 After that, put timely the used seal ring into its dedicated recycle bag, avoiding mixing use during assembly;

5.4 Check the sealing surface of flange and basin is free of bumping and scratch;

5.5 Remove adsorbent cover and take out the used adsorbent;

5.6 Check whether the specification and type of new adsorbent are correct; Check whether the packaging bag of the new adsorbent is intact, if not, and there is no vacuum degree in, the adsorbent cannot be used.

5.7 Put qualified adsorbent into the dedicated dry cloth bag, with the amount meeting requirements of the drawing.

5.8 Pack the adsorbent into the cover; install the cover on cover plate with pre-tightening operation, and fasten attachment bolt;

5.9 Clean flange face and seal ring; and install the seal ring into sealing groove; It shall be noted that all removed seal rings are required to be put into dedicated recycle bag, and that new seal ring shall be used at the time of assembling products.

5.10 Install the attachment bolt of flange face after the adsorber is installed on flange face; Specifications of bolt shall be elected according to the drawing.

Caution:

1. Appendix V “Common Tightening Torque of Bolt” shall be followed for torque of all bolts.

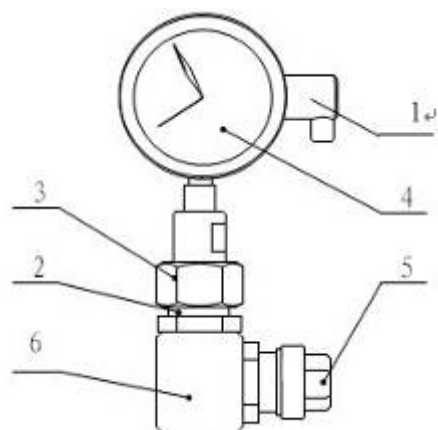
2. Grease to be used shall comply with Appendix VI “Common Grease List”.

3. At the time of installing, flow guiding covers shall be adjusted uniformly. Exhausting directions shall not be oriented to the personnel responsible for tour inspection and operation, and they shall be kept in one direction.

4. Assembly shall be done at the ambient humidity of less than 80%RH.

5. The time from unpacking vacuum bag to being closed in gas compartment shall not be more than 30min, and the time from installing to vacuum pumping shall not be more than 2h.

3. Installation of density relay



1. Connector socket
2. Self-closed joint
3. Connector
4. SF6 density gauge
5. Protecting cover
6. Valve seat

Figure: Density Relay

1. Tools: torque spanner (30N.m), torque spanner (60N.m), 32mm open spanner, 18mm open spanner and dust catcher.
2. Auxiliary materials: lint free paper, absolute ethyl alcohol, red marking pen, sealing grease and waterproof glue.
3. Check the surfaces of flange and self-closing valve are free of bumping and scratch; check various components and parts are free of bumping, scratch, burr, dust, oil, residual water, etc.; and check quantity and specification of various components and parts (including surfaces and sealing gasket) meet requirements of the drawing and are correct.
4. Select appropriate specification and type of density relay as per requirements of the drawing;
5. Use lint free paper, absolute ethyl alcohol, and dust catcher to clean the sealing gasket (18×Φ6×3) integrated with the density gauge, relevant screw thread and seal groove.
6. At the time of installing, density gauge and connector shall be connected by 18mm and 32mm open spanners with a tightening torque of 30N.m, and the connector and self-closed joint shall be connected by 32mm and 50mm open spanners with a tightening torque of 50N.m. At the time of installing the connector of density gauge and self-closed joint, spanner is needed to lock the density gauge so as to prevent it from rotating during application of torque. After air inflation, reconfirmation shall be done for whether the values of torque applied between the density gauge and connector and between the connector and self-closed joint are 30N.m and 50N.m respectively.
7. Apply waterproof glue on appropriate parts as per technical requirements; (Outdoor)
8. Use lint free paper, absolute ethyl alcohol, and dust catcher to clean the surface of density relay and keep the surface free of various residual foreign matters;

Caution:

1. Appendix V “Common Tightening Torque of Bolt” shall be followed for torque of all bolts.
2. Grease to be used shall comply with Appendix VI “Common Grease List”.
3. The density gauge shall be calibrated before being installed.
4. The dial plate of density relay shall be oriented to the passage of tour inspection, and pressure gauges at the same position shall be consistent in direction.
5. The pressure relief bolt of oil density relay shall be closed before assembly and opened after assembly.

4. Site treatment of gas

During fabrication and site installation of GIS, manufactured by Sieyuan Electric Co., Ltd., micro-water content in SF6 is strictly stipulated. Specifically, at the time of leaving factory, the micro-water in SF6 must be proved qualified, and 0.02-0.03Mpa N2 shall be prefilled. At the time of site installation, check shall be conducted first for whether there is any air pressure in transport compartment and inside components; if

positive air pressure is found, vacuum pumping shall be done for GIS and air shall be inflated to rated pressure.

1. Vacuum pumping treatment

1.1 Equipment, tools and auxiliary materials;

- a. Vacuum pumping device (the pumping speed of no less than 72L/s is recommended, and the function of preventing oil return shall be equipped with);
- b. Metal pressure hose (one end connected to vacuum device and the other end connected to DILO VK/F-02/20 joint) and wrench of 12 inch;
- c. Lint free paper and absolute ethyl alcohol;

1.2 Management of vacuum pumping

1.2.1 Operation process: connect vacuum pumping device with GIS products, start vacuum pump, turn on the valve between equipment and the products to start vacuum pumping. When vacuum degree in gas compartment is 133Pa, continue vacuum pumping for 30min, and then shut off the valve and stop the pump. Read the vacuum degree A of the gas compartment after 30min. After the gas compartment is maintained at that vacuum degree for 5h, measure and read vacuum degree B. Calculate the difference value of vacuum degree B and A is not more than 133Pa. If it is lower than 133Pa, the required vacuum degree is reached; but if it is higher than 133Pa, leakage point shall be checked.

1.3 Precautions:

1.3.1 It is not allowed to apply voltage on the equipment undergoing vacuum pumping and under vacuum state. Such circumstances are listed as follows:

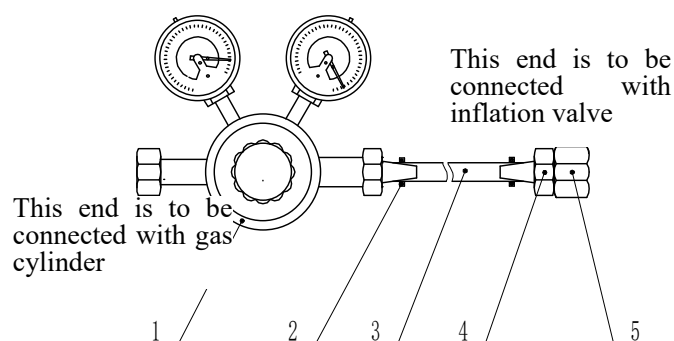
- a) Measure the resistance of main circuit;
- b) Use insulation resistance meter to measure insulation resistance (DC 500V or DC 1000V);
- c) Conduct withstand voltage test when vacuum pumping is performed in adjacent gas compartment;

1.3.2 During the operation of vacuum pumping and the persistence of vacuum pressure, the products must have obvious state marks on surfaces, to prevent misoperation.

1.3.3 Oil vapor may generate during operation of vacuum pump, and to prevent such vapor from entering into gas compartment, it must be ensured that the vacuum pump is under running status at the time of being moved from the top of the gas compartment.

1.3.4 It is not allowed to conduct vacuum pumping for the gas compartments of voltage transformer and lightning arrester without the consent of the manufacturer.

2. Inflation of SF6 gas



2.1 Equipment, tools and auxiliary materials;

a. Metal pressure hose (one end connected to vacuum device and the other end connected to DILO VK/F-02/20 joint) and wrench of 12 inch;

b. Lint free paper and absolute ethyl alcohol;

2.2 Requirements on inflation;

a) Quality of the gas shall meet GB/T 12022 requirements.

b) Pressure increasing speed in gas compartment shall not be more than 400kPa/min.

c) The final inflation pressure of CB is 0.68mpa, and other inflation pressures are 0.58mpa (20 °C).

d) The pressure gauge on middle gas compartment must be used to monitor the whole process of inflation operation.

e) During the operation of inflation and the persistence of pressure, the products must have obvious state marks on surfaces, to prevent misoperation.

f) The difference of pressure in two adjacent gas compartments shall not be more than 0.4MPa.

2.3. Inflation of SF6 from gas cylinder

2.3.1. Operation process;

2.3.1.1. Keep pressure relief valve cut off, connect GIS products with gas cylinder reliably, and ensure no leakage.

2.3.1.2. Turn on the valve of SF6 gas, adjust the adjusting ring of pressure relief valve, pre-select outlet air pressure (being slightly larger than required inflation pressure), and inflate the products to the pressure as required.

2.3.1.3 Replace gas cylinder; when pressure in the gas cylinder is equal to or less than current pressure in the gas compartment, the gas cylinder must be replaced.

2.4 Inflation of SF6 gas from pressure gas tank

2.4.1 Equipment, tools and auxiliary materials

a) Recycle device specialized for SF6 inflation

b) Metal vacuum and pressure hose (one end connected to vacuum device and the other end connected to DILO VK/F-02/20 joint);

2.4.2 The recycle device shall be operated according to its operation manual.

Caution;

Each screwed joint and attachment joint shall be cleaned before inflation.

3. Air tight test

3.1 Instruments: quantitative leak detector and qualitative leak detector of SF6 gas;

3.2 Measurement method and steps of quantitative leak detector of SF6 gas;

3.2.1. Prepare test object, instrument, equipment, and wrapping material;

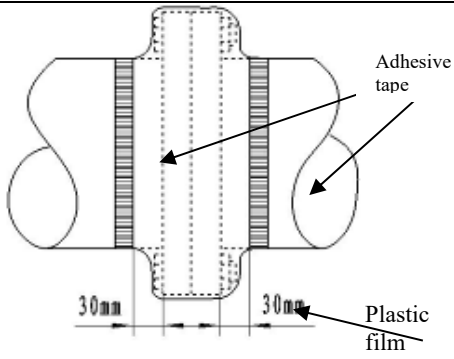
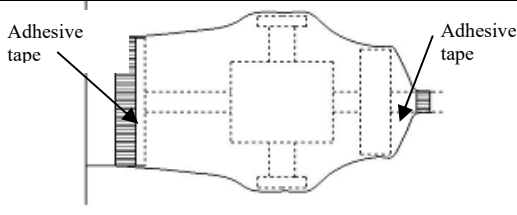
3.2.2. It shall be noted that the surface of test object needs to be cleaned. The leak detector of SF6 gas shall be set in advance to “quantitative” display mode.

3.2.2 Wrapping materials: Plastic film (with the thickness being about 0.1mm, the translucency at which sealed parts of test object can be seen, the width being about 350mm, and without damaged hole); several volumes of adhesive tapes with width being about 60mm; or a plurality of cylinder-shaped elastic bands with length of about 3m and diameter of about 6mm as well as strong elasticity as replacement of the adhesive tape.

3.2.3 Wrapping of test object: Table 1 is a living example for wrapping parts of test object. Other parts shall be wrapped by referring to such wrapping method.

3.3.4 Precautions in wrapping: The required parts must be reliably wrapped, and it must be ensured that the leak detector cannot be affected by wrapping tape and surrounding air environment. The wrapping volume shall be minimized. Plastic cover (bag) shall be free of holes. Confirmation and measurement shall be performed by qualified personnel after wrapping.

Table 1 Wrapping Parts and Method of Test Object

S.N.	Living example for wrapping parts	Diagram	Specific operation
1	Shell flange		<p>Use plastic film to twine one round and a half on coupling flange with opening upward (also wrap the opening), and then use adhesive tape being about 50mm in width to paste the both ends of the plastic film to shape wrapping cavity, with pasting position being 30mm from flange. Reference is made to the partial wrapping method in Section 4.2.3 of GB/T 11023.</p> <p>Elastic bands can be used as a replacement of adhesive tape to fasten plastic film.</p>
2	SF6 density relay and piping		<p>As shown, the two ends of plastic film shall be twined and pasted to shape wrapping cavity, with a wrapping distance as specified above.</p>

3.3 Detection before being held still

3.3.1 Open a hole at lower position of the plastic film wrapping test object with size equal that of one-yuan coin, as shown in Figure 4. Start SF6 gas leak detector, stretch detection gun, and probe into wrapping cavity to detect the concentration of SF6 gas with probing depth being not less than 50mm. It shall be noted that the probe cannot contact the surface of test object, and the hole shall be sealed with adhesive tape after detection. The concentration of SF6 detected in wrapping cavity is recorded as K1.

3.3.2 Open more one hole at the position being symmetric with the above detection hole (e.g. bilateral symmetry position), use the same method to detect the concentration of SF6 in wrapping cavity, record the concentration value as K2, and seal the hole with adhesive tape after detection.

3.3.3 Take $K = (K1 + K2) / 2$ as the concentration value of SF6 gas before being held still.

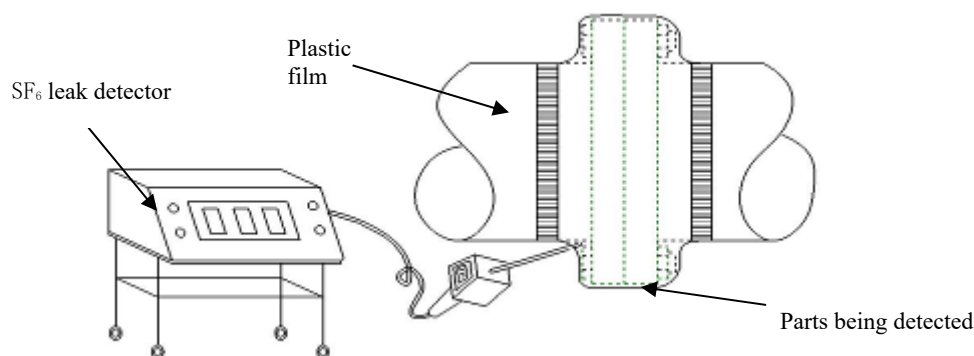


Figure 4 Schematic Diagram for Leak Detection of Air Tightness

3.3.4 Test object being held still: the stilling time is 24h.

3.4 Detection after being held still

3.4.1 Start SF6 leak detector, set it to “quantitative” display mode, detect the concentration of SF6 gas through the above two holes, and record the concentration values as K'1 and K'2 respectively. When one of holes is detected, the other one can only be detected after the former is sealed.

3.4.2 Take $K' = (K'1 + K'2)/2$ as the concentration value of SF6 gas after being held still.

3.4.3 Calculate $K' - K$ and take a record;

4. Measurement method of qualitative leak detector of SF6 gas

4.1. Prepare test object, instrument, equipment, and wrapping material;

4.1.1 It shall be noted that the surface of test object needs to be cleaned.

4.1.2 Wrapping materials: Plastic film (with the thickness being about 0.1mm, the translucency at which sealed parts of test object can be seen, the width being about 350mm, and without damaged hole); several volumes of adhesive tapes with width being about 60mm; or a plurality of cylinder-shaped elastic bands with length of about 3m and diameter of about 6mm as well as strong elasticity as replacement of the adhesive tape.

4.1.3 Wrapping of test object

Table 10 is a living example for wrapping parts of test object (wrapping method is same as that for quantitative test). Other parts shall be wrapped by referring to such wrapping method.

Precautions in wrapping: The required parts must be reliably wrapped, and it must be ensured that the leak detector cannot be affected by wrapping tape and surrounding air environment. The wrapping volume shall be minimized. Confirmation and measurement shall be performed by qualified personnel after wrapping. Before wrapping the product, qualitative leak detector shall be used to detect the flange joint surface of the product at speed four, to confirm there is no air leakage on flange face.

4.2 Test object being held still: the stilling time is 24h.

4.2.1 Air tightness detection after being held still

After the 24h, a small hole shall be opened at lower position of the plastic film wrapping test object with size equal to that of one-yuan coin, as shown in the figure Start qualitative leak detector of SF6 gas, adjust it to speed four, and stretch detection gun and probe into wrapping cavity to detect the concentration of SF6 gas with probing depth being not less than 50mm. It shall be noted that the probe cannot contact the surface of test object. The hole shall be sealed with adhesive tape after detection.

5. Qualification evaluation

Quantitative leak detection: if $(K' - K) \leq 20 \mu\text{L/L}$, the air tightness detection for the test object is qualified, otherwise unqualified. Unqualified gas compartment shall be marked in red chalk for repair, and after repair, the air tightness shall be detected again with the same method. Qualitative leak detection: The leak detector shall be set to speed four. During the detection, if the detector sends out alarm, the air tightness detection

for the product is unqualified. The unqualified gas compartment shall be marked in red chalk for repair, and after repair, the air tightness shall be detected again with the same method.

Note: as per the type of leak detector on site, make corresponding selection.

Table 11 Relationship between the Data of Quantitative Leak Detector and of Qualitative Leak Detector

S.N.	Quantitative leak detector	Qualitative leak detector
1	2-3PPM	Speed 7
2	4-5 PPM	Speed 6
3	8-10 PPM	Speed 5
4	16-20 PPM	Speed 4

6. Measuring of micro-water

6.1 Instrument: dew point moisture meter

6.2 See table 2 for measuring method and requirements;

6.3 Criterion for qualification: The measured value of moisture content in each gas compartment shall meet the requirements in article 3 of table 3, otherwise the result shall be deemed as a failure. If the result of this measurement fails to comply with relevant standards, recheck shall be conducted. If still unqualified, the gas in SF6 electrical equipment shall be treated.

Table 2 Test Method for Measuring Moisture Content in SF6 gas

S.N.	Operation flow	Contents	Precautions
1	Pre-test preparation	<ol style="list-style-type: none"> 1. Clear identification of product; 2. Former procedure being qualified in inspection and recorded completely; 3. Charge new SF6 gas, check that the indicating value of gas density shall meet the requirements of technical specification, and conduct moisture content test after 24h; 	Every operator and test personnel shall be responsible for checking the cleanness of equipment within respective duty scope.
2	Measuring	<ol style="list-style-type: none"> 1. Connect the threaded end and switch connector on test pipe, tighten them with wrench, and shut off the needle valve at the other end of the pipe; 2. Insert one end of quick coupling on the test pipe into the sampling port on dew point meter; 3. Connect exhaust pipe to air outlet; 4. Connect and tightly lock the switch connector and the measuring port of the object to be tested; 5. Turn on the power switch of instruments, and request to enter initialization self-calibration process (this process will take 10min or so); 6. Adjust the protection button of the dew point meter to “measure”, turn on the flow valve of the dew point meter completely, use the needle valve on the test pipe to adjust the flow to 0.5L/min, and then start to measure the dew point of SF6; 7. Keep the data measured in the instrument after that; 8. Shut off the needle valve on test pipe and the adjusting valve on dew point meter; 9. Take off the adapter from the object to be tested; repeat the above steps for continuously measuring other products; or cut off the power in case of no more measurement; 	

3	Requirements on micro-water content	<ol style="list-style-type: none"> 1. At the time of handing over for acceptance: Its content shall be equal to or less than 150μL/L in the gas compartment of circuit breaker, and 250μL/L in others. 2. During operation of equipment: Its content shall be equal to or less than 300μL/L in the gas compartment of circuit breaker, and 500μL/L in others. 	
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6.2 Common spare parts of Sieyuan Electric Co., Ltd.

S/N	Accessory Name	Recommended Quantity
1	Loading line	1
2	Electromagnet	4
3	Electromagnet	4
4	Position signal lamp	3
5	Position signal lamp	3
6	SF6 density monitor oil-free	1
7	SF6 density monitor oil-filled	1
8	Self-closing valve	2
9	Pilot switch	3
10	Reset switch	3
11	Opening/closing change-over switch	3
12	Handle	1
13	Handle	1
14	SF6 gas	50kg
15	SF6 gas cylinder	1
16	Overvoltage protector of current transformer (CTB)	1
17	High-voltage live display	1
18	DC air switch 10A	2
19	DC air switch 6A	2
20	Three-phase AC air switch	2
21	Motor	1
22	Motor	1
23	Contactor	5
24	Auxiliary contact	5
25	Intermediate relay	5
26	Relay socket	5
27	Contactor	5
28	Time relay	5

29	Relay socket	5
30	Temperature and humidity controller	2
31	Controller socket	2

Remarks:

Please purchase based on the actual demand of different projects.

6.3 List of common bolt torque of Sieyuan Electric Co., Ltd.

Nomin al Diamet er	Bolt Tightening Torque N·m (kgf·cm)						
	Connection of epoxy resin and aluminum parts			Connection between metal parts			
	Class 6.8	Class 8.8	A2-70	Class 6.8	Class 8.8	A2-70	/
M4	/	/	/	/	2	2	/
M5	/	/	/	/	4	4	/
M6	/	/	/	/	7	6	/
M8	/	/	/	/	18	16	/
M10	/	/	/	/	36	31	/
M12	/	/	/	/	62	54	/
M16	/	/	/	/	154	135	/
M20	/	/	/	/	301	263	/
M24	/	/	/	/	521	455	/
M30	/	/	/	/	1034	905	/
M36	/	/	/	/	1807	1581	/
M42	/	/	/	/	2890	2529	/
M48	/	/	/	/	4335	3793	/

List of commonly used greases:

Number	Name	Model specification	Unit	Quantity	Remarks
1	Mechanical grease	NB52	kg	0.25	
2	Conductive grease	OKS VP980	kg	0.25	
3	Dynamic grease	Molykote3451	kg	0.25	
4	Static grease	Molykote111	kg	0.25	

Note: the torque values listed on this table shall be applied, unless otherwise specified in the guide book, drawing, and quality tracking card.

6.4 Basic operation instructions of mechanisms of Sieyuan Electric Co., Ltd.

The operating method of the mechanism is detailed in the installation and operation manual of model M020000588ZF28 - 420 SF6 gas insulated switchgear.

6.5 Calculation of Life Cycle Costs (LCC)

The list of expenses shall be provided by Sieyuan Electric Co., Ltd. based on variations in markets.

LCC is composed of:

$$LCC = CI + CO + CM + CF + CD$$

Where:

LCC—Total costs of GIS equipment in the entire life cycle;

CI—initial cost;

CO—cost of operation;

CM—cost of maintenance;

CF—cost of failure;

CD—cost of disposal.

1. Cost of investment (CI)

CI refers to the cost in equipment purchasing year, i.e. the starting year (base year) of the counting period.

$CI = \text{equipment acquisition expenses} + \text{installation and commissioning expenses} + \text{other expenses}$.

1) Acquisition expenses

$\text{Acquisition expenses} = \text{equipment costs} + \text{special tool and initial spare parts costs} + \text{field service charge} + \text{supplier's transport charge}$

Acquisition expenses refer to the equipment expenses after technical and supply scope adjustment.

2) Installation and commissioning expenses

$\text{Installation and commissioning expenses} = \text{Employer's transport charge} + \text{construction and installation expenses} + \text{commissioning expenses}$

The Employer's installation and commissioning expenses are determined based on the engineering budget.

3) Other expenses

Other expenses include the special commissioning project expenses and costs of state detector may be purchased, etc.

The special commissioning project expenses are determined based on the engineering budget. The costs of state detector are determined based on the offer.

Data sheet is as follows:

S/N	GIS Model	Quantity	Unit Price	Special Tool Expenses	Spare Parts Expenses	On-line Detector Expenses	Field Service Charge	Supplier's Transport Charge	Total
1									

Note: the supplier shall provide an exhaustive list of the special tool, spare parts and on-line detector.

The installation and commissioning expenses and special experimental expenses are determined by the Employer based on the engineering budget.

2. Cost of operation (CO)

$Co \text{ of Year } n = \text{annual daily tour inspection expenses}$

Annual labor charges for tour inspection are based on the statistics of each power supply bureau.

The present value of base year can be obtained by the CO of year n after multiplying by $(1+i)^{-n}$, and the CO value within the life cycle can be obtained by adding up the COs of all years.

Note: i refers to the loan interest rate which is the average value of several years (such as 5%); n refers to the number of years with respect to the base year, i.e. the equipment purchasing year, same as follows.

Data sheet is as follows:

Commissioning Year	GIS Model	Quantity	Annual Routing Inspection Expenses	Discounting to the Base Year

Note: costs discounting to the base year = total of current year $\times (1+i)^{-n}$

3. Cost of maintenance (CM)

CM= periodic overhaul (major repair) expenses + various periodic maintenance (minor repair, power failure maintenance and trial test) expenses

1) Periodic overhaul (major repair) expenses

Periodic overhaul expenses = supplier's equipment and material expenses + supplier's service charge + Employer's equipment, material and tool expenses + Employer's labor costs + Employer's other expenses

The periodic overhaul expenses are based on the statistics of each power supply bureau.

2) Periodic maintenance (minor repair, power failure maintenance and trial test) expenses

Periodic maintenance expenses = supplier's equipment and material expenses + supplier's service charge + Employer's equipment, material and tool expenses + Employer's labor costs + Employer's other expenses

Periodic maintenance expenses are based on the statistics of each power supply bureau.

The annual CM can be obtained by adding up the above mentioned expenses, and it is converted into the present value of the base year by multiplying it by $(1+i)^{-n}$. The CM value in life cycle is obtained by adding up the CMs of all years.

Data sheet is as follows:

Periodic overhaul (major repair) expenses:

Commissioning Year	GIS Model	Quantity	Supplier's Equipment and Material Expense	Supplier's Service Charge	Employer's Material and Tool Expenses	Employer's Labor Costs	Employer's Other Expenses	Total of Current Year	Discounting to the Base Year

Note: Employer's cost can be proposed based on the statistics of the power supply bureau; other expenses are provided by the supplier.

Periodic maintenance (minor repair, power failure maintenance and trial test) expenses:

Commissioning Year	GIS Model	Quantity	Supplier's Equipment and Material Expense	Supplier's Service Charge	Employer's Material and Tool Expenses	Employer's Labor Costs	Employer's Other Expenses	Total of Current Year	Discounting to the Base Year

Note: Employer's cost can be proposed based on the statistics of the power supply bureau; other expenses are provided by the supplier.

The above expenses shall be filled in according to the overhaul frequency in the GIS life cycle.

4. Cost of failure (CF)

CF= cost of failure overhaul + cost of failure loss

1) Cost of failure overhaul

Annual cost of failure overhaul = annual fault probability * field failure repair cost = annual fault probability * [supplier's equipment and material expenses + supplier's service charge + Employer's equipment and material expenses + Employer's labor cost (including the labor cost of the third party)]

Annual fault probability = annual fault frequency/number of set(s) in the statistic year [time(s)/set year]

The annual fault probability is determined according to manufacturer's data after confidence coefficient analysis, and industrial statistical data shall also be used when necessary. The field repair cost is determined based on the actual empirical data provided by the administration of power supply.

2) Cost of failure loss

Cost of failure loss = annual fault probability * outage cost = annual fault probability * (outage cost load * outage duration) * power price

The CF of current year is discounted to the present value of base year with $(1+i)^{-n}$. The CF value in the life cycle is obtained by accumulating the CF of each year.

The outage cost load and outage duration are determined based on the operating experience of power grid, and the power price is the actual annual power price evaluated by the power supply bureau.

Data sheet is as follows:

Cost of failure loss:

S/N	GIS Model	Quantity	Annual Fault Probability	Supplier's Equipment and Material Expenses	Supplier's Service Charge	Employer's Equipment and Material Expenses	Employer's Labor Cost	Total	Discounting to the Base Year

Note: Employer's cost can be proposed based on the statistics of the power supply bureau; other expenses are provided by the supplier.

Cost of failure loss:

S/N	GIS Model	Quantity	Annual Fault Probability	Outage Cost Load	Outage Duration	Power Price	Total	Discounting to the Base Year

5. Cost of disposal (CD)

Cost of disposal = disposal expenses - residual value when the equipment is disposed

1) Equipment disposal expenses

Equipment disposal expenses = disposal charge rate * direct engineering cost on installation

The disposal expenses are determined based on relevant standards, the disposal charge rate is

determined according to the 2007 *Instruction on Budget Compilation and Calculation Standard in Electric Power Grid Construction Projects* prepared by the electric power engineering costs and quota management main station, and the current charge rate of electromechanical device is 32%.

2) Residual value when the equipment is disposed

It is 5% of the equipment acquisition expenses determined based on budget estimate.

The disposal cost of the equipment at the last year of its life cycle is calculated with above method, and the present value of base year is discounted by multiplying it by $(1+i)^{-n}$.

S/N	GIS Model	Quantity	Disposal Expenses	Residual Value	Total	Discounting to the Base Year

Total LCC can be got by accumulating CI, CO, CM, CF and CD together.

6.6 Maintenance record

6.6.1 Maintenance record chart – daily tour maintenance

S/N	Item	Maintenance Parts	Date	Personnel
1	Wiring inspection			
2	Bushing inspection			
3	Inspection of GIS framework (framework, foundation, earthing)			
4	GIS appearance inspection			
5	Equipment abnormal noise inspection			
6	GIS proper pressure value and SF6 gas density meter inspection			
7	Infrared test			
8	Live display			
9	Current transformer and Voltage transformer			
10	Arrester			
11	Opening and closing indication check			
12	Tropical and heater check			
13	Inspection of mechanism box and exchange control cabinet			

S/N	Item	Maintenance Parts	Date	Personnel
14	Transmission link check			
15	Other daily tour maintenance			

6.6.2 Maintenance record chart – professional tour maintenance

S/N	Item	Maintenance Parts	Date	Personnel
1	Visual inspection of operating mechanism			
2	GIS mechanism case			
3	Breaker data analysis			
4	SF6 qualitative leakage detection			
5	Other professional tour maintenance			

6.6.3 Maintenance record chart – dynamic tour maintenance

S/N	Item	Maintenance Parts	Date	Personnel
1	Dynamic tour maintenance after breaker operation			
2	Dynamic tour maintenance in case of operating risk variations			
3	Dynamic tour maintenance on the breaker with SF6 leakage			
4	Dynamic tour maintenance on the breaker newly put into operation			
5	Dynamic tour maintenance on the breaker after thunderstorm			
6	Dynamic tour maintenance on the breaker after high wind			
7	Dynamic tour maintenance on the breaker after sudden temperature change			
8	Dynamic tour maintenance on the breaker after heavy fog			
9	Dynamic tour maintenance on the breaker after hail			

S/N	Item	Maintenance Parts	Date	Personnel
10	Dynamic tour maintenance on the breaker after under N-1 mode and in heavy load operation status			
11	Dynamic tour maintenance on the breaker after earthquake			
12	Replacement of density relay			
13	Other dynamic tour maintenance			

6.6.4 Maintenance record chart – preventive test and maintenance

S/N	Item	Maintenance Parts	Date	Personnel
1	Inspection of the action contact of density meter			
2	Come-in and go-out line insulator			
3	Micro-water content test in various GIS chambers			
4	Inspection of breaker, three-position disconnecting and earthing switch, and fault earthing switch			
5	Interlocking inspection			
6	Other preventative tests and maintenance			

6.6.5 Maintenance record chart – minor repair

S/N	Item	Maintenance Parts	Date	Personnel
1	Density meter calibration and contact inspection			
2	Lubrication of breaker, three-position disconnecting and earthing switch, and earthing mechanism			
3	Test of GIS main circuit resistance value			
4	GIS mechanical properties test			
5	Inspection of auxiliary switch and position switch			
6	Inspection of opening and closing coil releasing			

S/N	Item	Maintenance Parts	Date	Personnel
7	Measurement of opening and closing coil resistance (Ω)			
8	Other minor repair			

6.6.6 Maintenance record chart – overhaul

S/N	Item	Maintenance Parts	Date	Personnel
1	Removal of GIS proper, three-position disconnecting and earthing switch, fault earthing switch, bus, branch bus, CT, PT as well as come-in and go-out line sleeve			
2	Disassembly and overhaul of the proper; replacement of a complete seal ring, contact, nozzle, insulating part, conductive/lubricating grease and spring			
3	Replacement of the propers and their live shaft, pin, moving parts, lubricating grease, bolt, tight nut and spring			
4	Replacement of the adsorbent of all disassembled chambers			
5	Replacement of all secondary controlling, signal and communication cables			
6	Inspection of all SF6 density meters			
7	Vacuum, air inflation, leakage and micro-water inspection of GIS proper and relevant parts based on product requirements			
8	Test and adjustment of mechanical properties of GIS proper, three-position disconnecting and earthing switch and fault earthing switch			
9	Test the resistance of major circuit after overhaul based on product requirements			
10	Conduct insulation test on the secondary circuit after overhaul based on product requirements			

S/N	Item	Maintenance Parts	Date	Personnel
11	Conduct insulation test on the major circuit after overhaul based on product requirements			
12	Other overhaul items			

6.7 GIS Maintenance List of Sieyuan Electric Co., Ltd.

GIS Maintenance List of Sieyuan Electric Co., Ltd.

S/N	Stage	Period			Tour Maintenance Item	Inspection and Applying of Lubricating Grease					Inspection and Replacement of Damaged Components and Parts													Maintenance and Replacement of Unserviceable Component										
						Waterproof sealant	Lubricating grease111	Lubricating greaseN352	Lubricating grease3451	Lubricating grease VP980	Auxiliary contact	Travel switch	Secondary controlling cable	Motor	Electromagnet	Position indicator	Temperature and humidity controller	Live display	Time relay	Heater	Contactor	Density relay	Breaker	Insulating switch	Bus	Operating mechanism	Arrester and voltage transformer	SF6 gas	Molecular sieve	Seal ring	Sleeve			
1	Daily tour maintenance	Coordinate with daily tour inspection			Lead inspection																										★			
2					Casing inspection																												★	
3					GIS framework, foundation and grounding inspection							★														★	★							★
4					GIS appearance inspection	★																												
5					Equipment abnormal noise inspection	★	★			★		★														★	★	★		★				★
6					SF6 density meter inspection																				★									
7					Infrared temperature inspection																					★	★	★		★		★	★	
8					Live display																★													
9					Current leakage of arrester																									★				
10					Opening / closing indication check																					★	★		★					
11					Tropical and heater check																		★			★	★							
12					Transmission link check							★															★							
13	Professional tour maintenance	Once half a year			Rain-proof and damp-proof inspection inside LCP cabinet and CT, PT	★						★	★	★	★	★	★	★	★	★	★				★	★								

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Note: ★ refers to the maintenance, replacement and inspection item

