


COMMENT RESOLUTION SHEET

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	1		ZF28-420 SF ₆ Gas-insulated Metal-enclosed Switchgear – Product Description *Note: DES(disconnector & earthing switch) is not applicable for 420kV GIS.										91				
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ZF28-420 SF₆ Gas-insulated Metal-enclosed Switchgear

Product Description

Sieyuan Electric Co., Ltd.

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1. Overview

The instructions belong to the top secret document, which is restricted to be used by the users of Shanghai Sieyuan Electric Co., Ltd.. (hereafter referred to as Sieyuan), and is dedicated for installation and maintenance of 420kV GIS. Please do not disclose any content in the instructions to the third party without permission from Sieyuan.

1.1 Instruction

Contents in the instructions are only applicable for the appointed model and specifications of the gas-insulated metal-enclosed substation; it will help the operator to be familiarized with structure and function of the switchgear, and guide the operation, installation and maintenance matters.

1.2 Cautions

- 1) The operation instructions include the operation and maintenance information of the related switchgear, and the purpose is propose the possible risks during switchgear operation, and prevent misoperation.
- 2) If you want to get further information or something witch is not involved in the operation instructions, please contact Sieyuan.

1.3 Framework

The manual is conformed of the following 7 parts:

- 1) Part 1 Overview: GIS product features, performance parameters and so on.
- 2) Part 2 Overall introductions: structure, functions ect. of each component of GIS, such as the circuit breaker, disconnecter, current transformer and other components.
- 3) Part 3 Package, transportation and storage: product package, transportation~~and~~, storage method and precautions
- 4) Part 4 Field installation: Work instructions during product field installation process
- 5) Part 5 Test before trial operation: introduction of test items to be performed before operation.
- 6) Part 6 SF₆ gas operation: SF₆ gas characteristic parameters and so on as well as precautions for handling SF₆ gas.
- 7) Part 7 Maintenance: maintenance instructions during operation of the product and precautions.

1.4 Specified Application

- 1) The data parameters in the instructions shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project, and the equipment and special tools shall be provided for intended use.
- 2) In case of any failure in observing above conditions or safety instructions, the following equipment or situation may cause death, serious personal injuries, material damage or environmental pollution. The following is the main precautions:
 - a) Gas system with electricity and pressure, charging spring, SF₆ gas and decomposers thereof.
 - b) Part falling and tilting.
- 3) it shall not be used for other purposes unless agreed by Sieyuan.

1.5 Responsibility of Operator

- 1) In order to avoid adverse impact of accident, failure, damage or environment destroy, transportation, installation, operation, maintenance and disposal of the switchgear or parts must be performed by the appointed personnel with qualified training.
- 2) Before operation, after normal operation and in case of any accident, the workers shall clearly know the possible hazards and safety measures for accident prevention.
- 3) The related personnel can obtain the safety operation regulations and guide. If necessary, these operation regulations and guide shall be displayed at the workplace.
- 4) The related personnel can use the equipment and facilities required for work safety, and can only adopt the spare parts, lubricating grease and so on provided by the manufacturer.

2 General Introduction

2.1 Bay

2.1.1 Brief introduction

420kV GIS (Gas Insulated metal-enclosed Switchgear), horizontal layout of the circuit breaker, flexible layout of the main bus, compact structure, small standard bay width; It is equipped with the local control cabinet, can perform local operation of the switch, and meanwhile can prevent any manual, local or remote wrong operation.

2.1.2 Product features

- GIS has small volume and less floor area
- Internal insulation of GIS bay is not subject to environmental impact during operation
- Safe and reliable operation
- GIS does not cause interference on the communication device
- Short construction period

2.1.3 Technical parameters

For technical parameters, see Table 2-1.

Table 2-1 420kV GIS technical parameters

S/N	Name of parameter		Unit	Value
1	Rated voltage		kV	420
2	Rated frequency		Hz	50
3	Rated current		A	4000
4	Rated short-circuit breaking current		kA	63
5	Rated short-time withstand current (r.m.s. value)		kA	63
6	Rated duration of short-circuit		s	1
7	Rated peak withstand current (peak value)		kA	157.5
8	First-pole-to-clear factor	50Hz	/	1.3
9	Ambient temperature	High temperature	°C	55
		Low temperature	°C	-25
10	Rated power frequency withstand voltage (1 min)	Phase to earth	kV	650
		Across the isolating distance	kV	815
11	Rated switching impulse withstand voltage (peak value)	Phase to earth	kV	1050
		Across the isolating distance	kV	900+345
12	Rated lightning impulse withstand voltage (peak value)	Phase to earth	kV	1425
		Across the	kV	1425+240

S/N	Name of parameter			Unit	Value
			isolating distance		
13	SF6 gas pressure (at 20℃)	Circuit breaker	Norminal pressure	MPa	0.68
			Gas Re-fill pressure	MPa	0.65
			Gas low pressure	MPa	0.63
			Lockout pressure	MPa	0.61
		DS	Norminal pressure	MPa	0.58
			Gas Re-fill pressure	MPa	0.55
			Gas low pressure	MPa	0.53
			Lockout pressure	MPa	0.51
		Others	Norminal pressure	MPa	0.58
			Gas Re-fill pressure	MPa	0.55
			Gas low pressure	MPa	0.53
14	Partial discharge (1.2 times of phase voltage)	Whole bay		pC	≤5
		Insulating part		pC	≤3
15	Rated short-circuit making current (fault making earthing switch)			Times	2
16	Mechanical duration	Circuit breaker		Times	10000
		Disconnector/ earthing switch / fault earthing switch		Times	10000
17	Moisture content of SF6 gas in the gascompartment	Circuit breaker	Acceptance value	μL/L	≤150
				μL/L	≤300
		Other gas compartment s	During operation	μL/L	≤250
				μL/L	≤500
18	Annual leakage rate of SF6 gas			%	≤0.1



Note: the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.1.4 Structure description

420kV whole bay has compact structure, so as to reduce field operation time and difficulty. The spring mechanism is adopted, the structure is more reliable, which conforms to the trend of no oil and no gas; environmental-friendly, free of hidden danger of oil leakage. The separate gas compartment can be arranged at the cable terminal, and it is convenient to disassemble the internal conductor, which is easily for voltage condition check to cable on site test.

2.2 Circuit Breaker

2.2.1 Overview

Circuit breaker can make, withstand and break normal current in circuit, but also make, withstand and break specified short-circuit current in a given period.

2.2.2 Main technical parameters of the circuit breaker

For main design parameters of the circuit breaker, see Table 2.2:

Table 2-2 420kV CB technical parameters

S/N	Function description	Conditions	Unit	Value
1	Rated voltage		kV	420
2	Rated frequency		Hz	50
3	Rated current		A	4000
4	Rated power frequency withstand voltage (1 min)	Phase to earth	kV	815
		Across the isolating distance		650
	Rated switching impulse withstand voltage (peak value)	Phase to earth	kV	900+345
		Across the isolating distance		1050
5	Rated lightning impulse withstand voltage (peak value)	Phase to earth	kV	1425+240
		Across the isolating distance		1425
6	Rated short-circuit breaking current		kA	63
7	Rated short-circuit making current (peak value)		kA	157.5
8	Rated short-time withstand current and duration		kA/s	63/1
9	Rated peak withstand current		kA	157.5

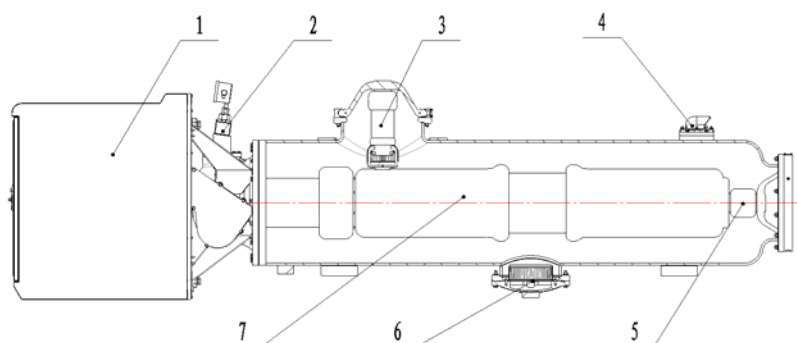
S/N	Function description	Conditions	Unit	Value
10	Rated / Re-filling/Low / locking out gas pressure		MPa	0.68/0.65/0.63/0.61
11	First-pole-to-clear factor	50Hz	/	1.3
12	Opening and closing coil voltage		V	DC220
13	Motor voltage		V	DC 220
14	Motor power		W	1000



Note: the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.2.3 Structure of Circuit Breaker

420kV circuit breaker has a single-pole box layout, and three-phase mechanism is operated through electrical linkage. Each phase of circuit breaker includes the arc extinguishing compartment, mechanism, underframe and other parts. The external structure of circuit breaker is shown in Fig. 2-2.



- 1- Operating mechanism 2- Gas density gauge 3- Upper conductor
4- Protector 5- Side conductor 6- adsorbent 7- Arc extinguishing compartment

Fig. 2-2 External Structure of Circuit Breaker

2.2.4 Internal Structure of arc-extinguishing compartment

The internal structure of circuit breaker is shown in Fig. 2-3.

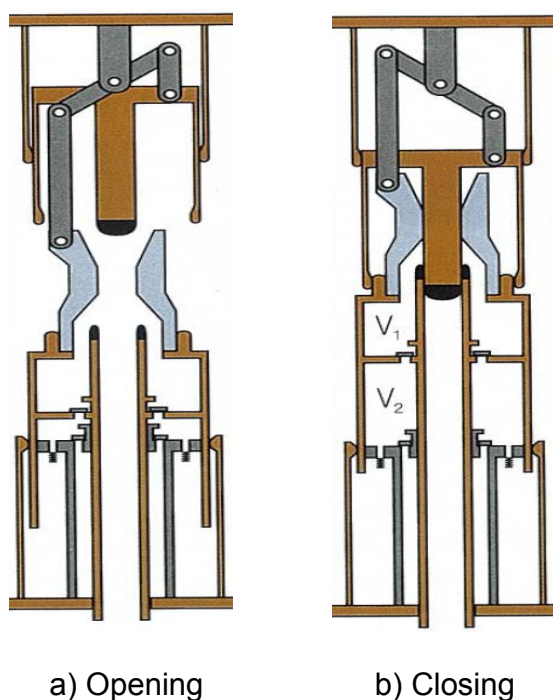


Figure 2-3 Structure of the arc extinguishing compartment

Internal conductive circuit of circuit breaker is composed of conductors and arc-extinguishing compartment components. The internal structure of arc-extinguishing compartment components is shown in Fig. 2-3. The principle of self-blast is adopted for the arc extinguishing compartment. When the circuit breaker receives the opening command, the rigid moving components consisting of the cylinder, moving arcing contact, rod and so on move downward, driven by the force of the opening spring. In the movement process, fixed main contact will be apart from moving main contact and current will be transferred to two arc contacts which are still closed. Arc will be formed after arc contact separated from each other.

When break short-circuit current, due to large short-circuit current, arc energy among arc contact is large and heat gas in arc zone will flow into thermal expansion compartment and will exchange heat in thermal expansion compartment to form gas with low temperature and high pressure. At this time, due to the pressure in thermal expansion compartment is greater than that in the pressure compartment, free valve stays closed. When the current passes through zero, high pressure gas in thermal expansion compartment will flow to arc and take away arc energy to extinguish the arc. Meanwhile, in the process of opening, pressure in pressed gas-compartment will start to be compressed. But once a certain pressure value is reached, elastic pressure-relief valve at bottom will be opened; the gas in pressed gas-compartment will be compressed and exhausted at the same time. In this way, mechanism needn't to overcome more antforce from

compressed gas to greatly lower down the operation power.

When breaking small current (normally below a few thousand amperes), due to small arc energy, pressure generated inside thermal expansion compartment is low. At this time, pressure in pressed gas-compartment is higher than that in expansion compartment and free valve will be opened. When the current passes through zero, gas with certain pressure will be blew to fracture to extinguish arc.

2.2.5 Operating mechanism

Operating mechanism equipped by the product is a spring operating mechanism. Each phase is equipped with single-pole mechanism as Fig. 2-4. Spring operating mechanism is fixed onto the crankarm box of circuit breaker with the following functions:

- a) Charging
- b) Closing
- c) Opening
- d) Reclosing (O—0.3s—CO)

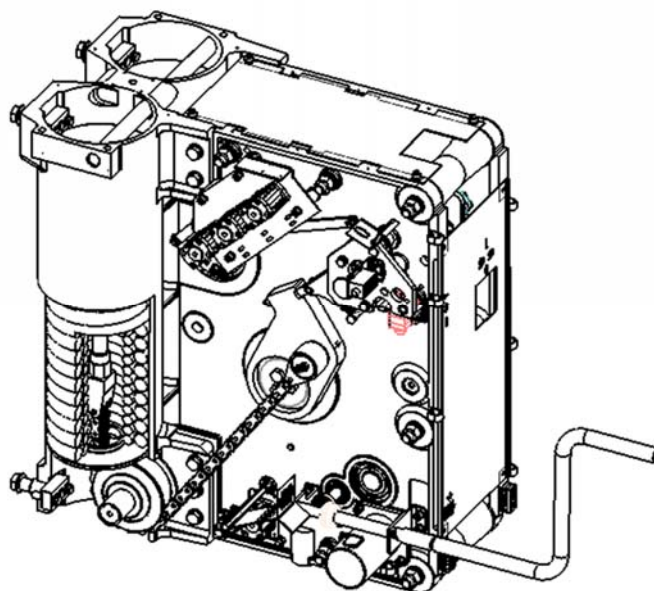


Fig. 2-4 Spring Operating Mechanism

Spring operating mechanism acquires the following four major working states (each state is represented with number). Closing and opening position are represented by the state of opening

spring while charging state is represented by the state of closing spring:

- ① Opening position, no charging state
- ② Opening position, charging state
- ③ Closing position, no charging state
- ④ Closing position, charging state

Under normal operating conditions, after closing, energy will be stored automatically. "Charging state" is the static working state of mechanism and "non charging state" is the non-static working state of mechanism. Switch among four states of mechanism is shown in Fig 2-5. The switch between each stage shall be carried out in accordance with the direction specified with arrow.

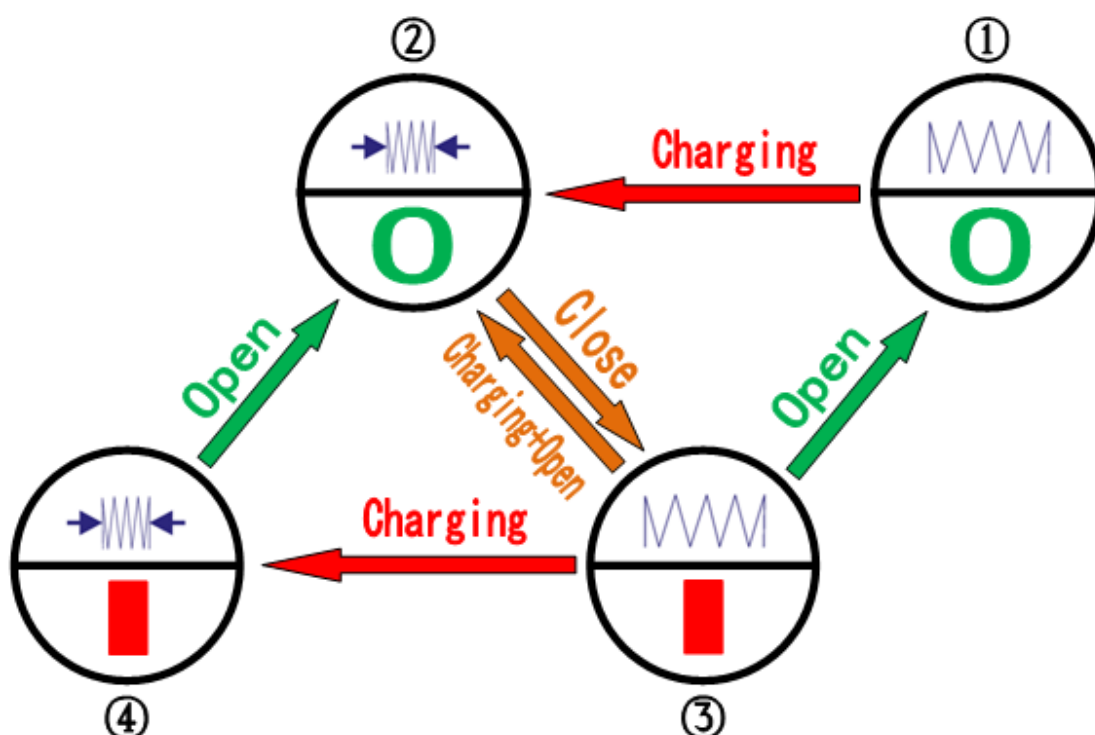
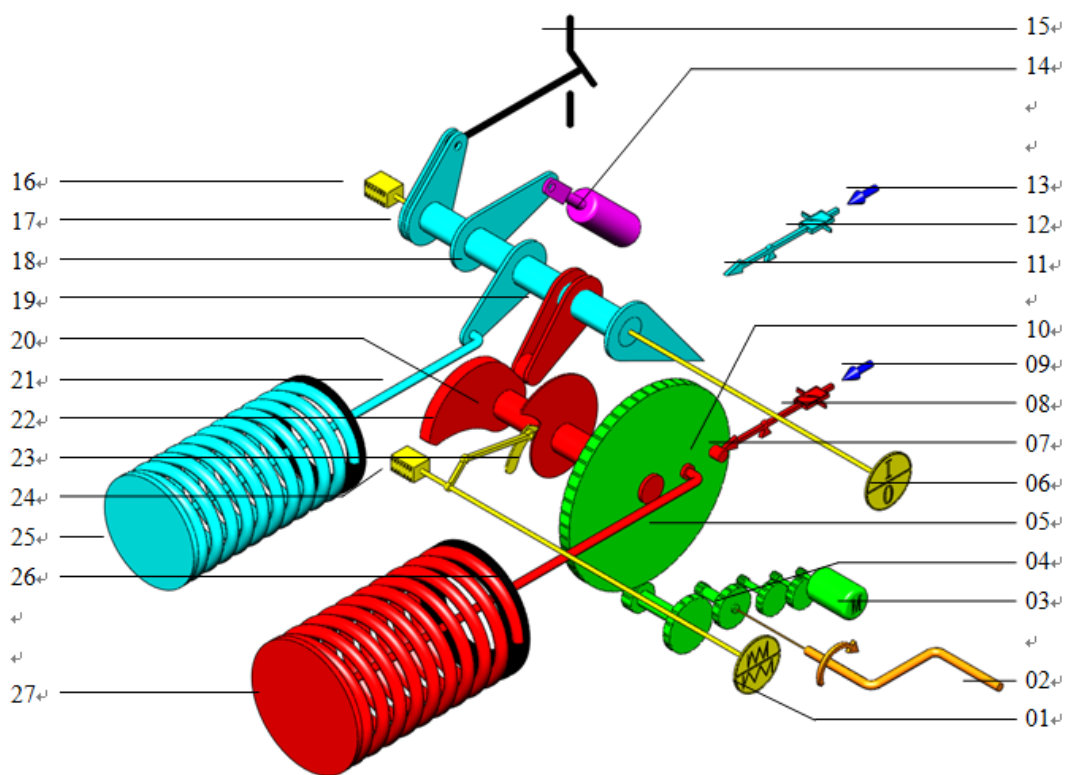


Figure 2-5 Schematic diagram of the mechanism state

The energy required for operation is stored in the closing spring and opening spring; When the spring operating mechanism is at the working state ①, the circuit breaker is at the opened state, and the closing spring and opening spring at the released state without charging. At the moment, any opening and closing operation is impossible.

Function principle of spring operating mechanism is shown in Fig. 2-6.



1	Indicator	10	Roller	19	Output crankarm
2	Charging handle	11	Opening releasing component	20	Charging shaft
3	Motor	12	Opening coil	21	Opening chain
4	Gear set	13	Manual opening device	22	Cam
5	Big gear	14	Buffer	23	Cam
6	Indicator	15	Circuit breaker	24	Motor switch
7	Closing releasing component	16	Auxiliary switch	25	Opening spring
8	Closing coil	17	External crankarm	26	Closing chain
9	Manual closing device	18	Output shaft	27	Closing spring

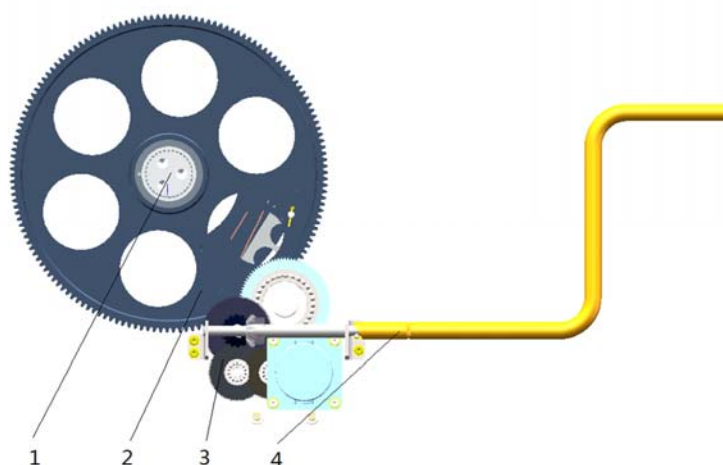
Fig 2-6 Opening Position and Charging State of Spring Operating Mechanism (Working State ②)

2.2.5.1 The charging motor of the closing spring (03) is started after power on, and charging of the closing spring (27) is realized through the gear set (04), wheel gear (05) and closing chain (26). When the closing chain (26) crosses the center of the charging axle (20), the roller (10) on wheel gear (05) contacts the closing trip component (07), and charging of the closing spring is

available. At the moment charging is over, gear set (04) will stop at the position where the big gear (05) is out of tooth (no diagram) to break the motion transmission of gear sex and big gear. At this time, motor switch (24) will be switched by cam (23) and motor (03) will be stopped. After motor switch (24) is switched, closing circuit will be started and indicator (01) will switch to "energy stored" position of closing spring. Charging for closing spring is over and mechanism is at working condition ② as shown in Fig. 2-5.

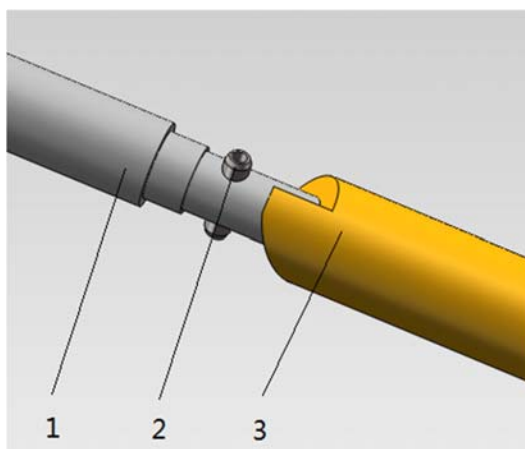
In the event that power supply or charging motor fails to store energy for closing spring, special charging handle can be applied to store energy as shown in 2-7. Rotate charging handle (4) clockwise to store energy for closing spring through gear set (3), big gear (2) and charging shaft (1). After charging shaft surpasses the highest point, transmission relation between big gear and charging handle will be separated. Crankarm will hit the charging keeping pawl with a "bang" sound to show charging is over.

Contact relation between the charging handle and the transmission shaft is shown in Figure 2-8. The front end of the handle is inserted into the spring pin position on the transmission shaft for guide during manual charging. Rotate the handle clockwise, and the transmission system drives rotation of the charging axle for charging of the closing spring. When the charging axle rotates over the highest point, or the motor is suddenly live during manual charging, causing that the rotating speed of the transmission shaft exceeds the rotating speed of the handle, the inclined plane on the transmission shaft generates thrust on the charging handle, so that transmission relation between the charging handle and the transmission shaft is released, so as to protect the operating personnel safety.



1- Charging axle 2- Wheel gear 3- Transmission gear 4- Charging handle

Figure 2-7 manual charging



1- Transmission shaft 2- spring pin 3- Charging handle

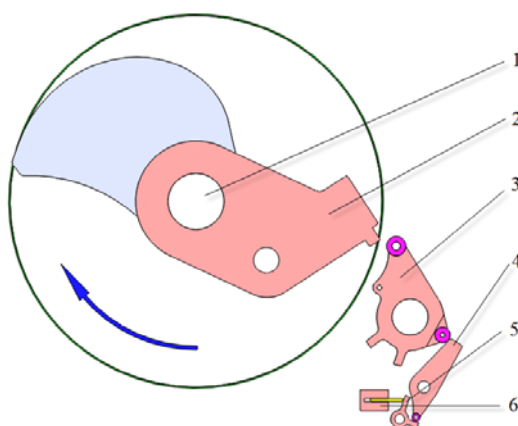
Figure 2-8 Structure diagram of the charging handle and transmission shaft



Note: only the trained personnel can conduct manual operation; before manual charging operation, please cut off power supply for charging and control loop.

2.2.5.2 Closing operation

As shown in Fig. 2-9, after closing coil (6) is supplied with power, closing releasing components (2), (3), (4), (5) will be released. With the closing coil, charging shaft (1) accelerate to rotate clockwise.



1-Charging shaft
4-Class II closing lever

2-Charging keeping crankarm
5-Class III closing lever

3-Class I closing lever
6-Electromagnet

Fig. 2-9 Closing Releasing Process

As shown in Fig. 2-10, after being released, cam (1) rotates driven by charging shaft. The outline of cam is pressed on roller (2) to push output crankarm (9) to move to closing direction. The output crankarm drives output shaft (8) to rotate and transfer the movement to circuit breaker to achieve closing operation. When closing is over, after the overshoot of output crankarm, the output crankarm will swing back slightly, and cam will be separated from output crankarm. Braking lever (10) on output crankarm will buckle onto opening releasing component (11) and circuit breaker will be hold at "closing" position. At this time, opening operation can be carried out.

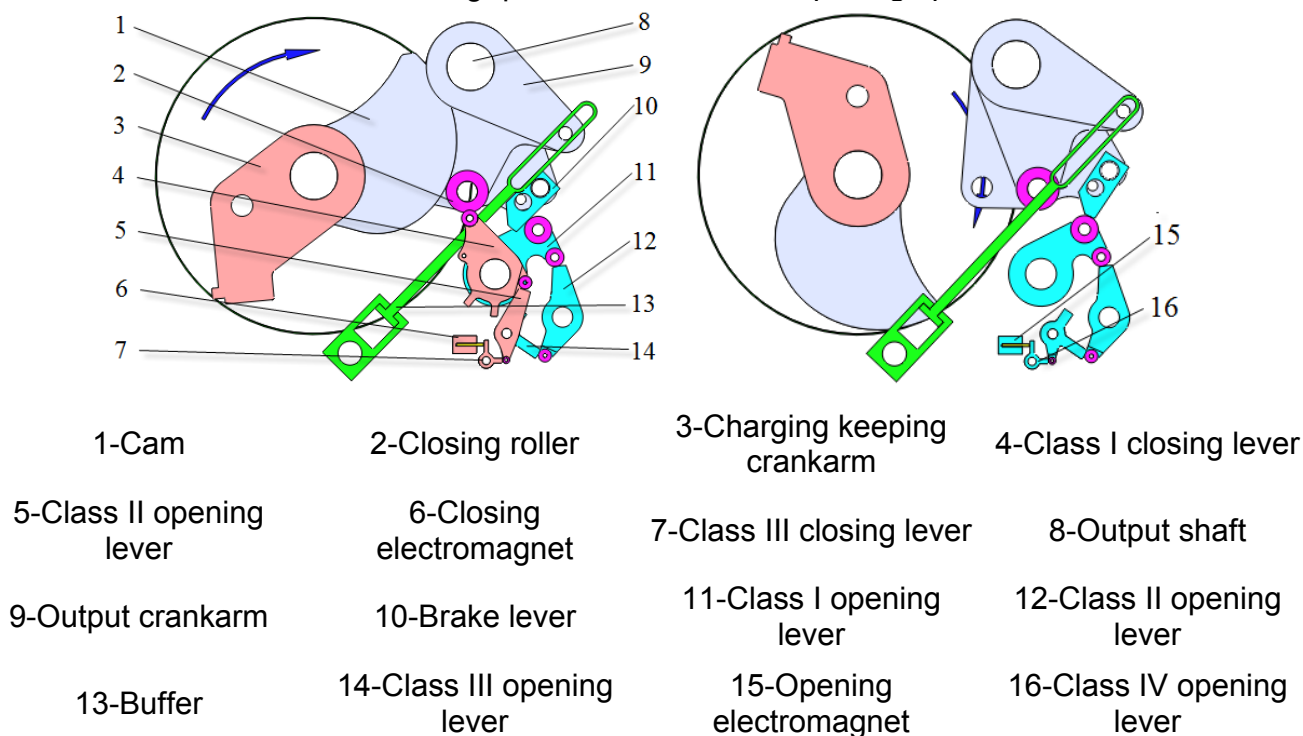


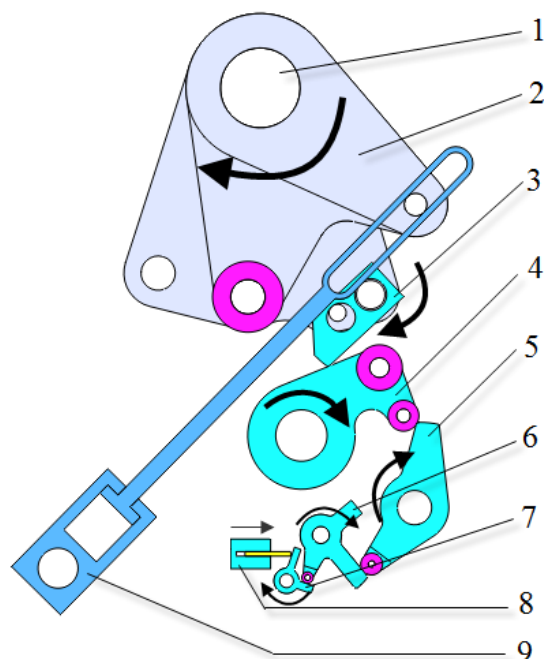
Fig. 2-10 Closing Keeping Process

2.2.5.3 Charging of the closing spring again

When closing process is over, motor circuit will be closed by motor switch and closing spring will automatically store energy.

2.2.5.4 Opening operation is shown in Figure 2-11. After the opening coil (8) is power on, the opening trip components (3), (4), (5), (6) and (7) are loosen. Driven by opening spring, output crankarm (2) rotates clockwise. Output crankarm drives output shaft (1) to rotate and transfer the movement to circuit breaker to achieve closing operation.

At the end of opening, residual energy of opening spring will be absorbed by buffer (9) to ensure circuit breaker achieve opening operation in a steady way. Opening buffer also plays its function to stop opening movement. The circuit breaker mechanism is provided with two identical opening coils.



- | | | |
|--------------------------|--------------------------|---------------------------|
| 1-Output axis | 2-Output crankarm | 3-Brake lever |
| 4-Class I opening lever | 5-Class II opening lever | 6-Class III opening lever |
| 7-Class IV opening lever | 8-Opening electromagnet | 9-Buffer |

Figure 2-11 Opening trip

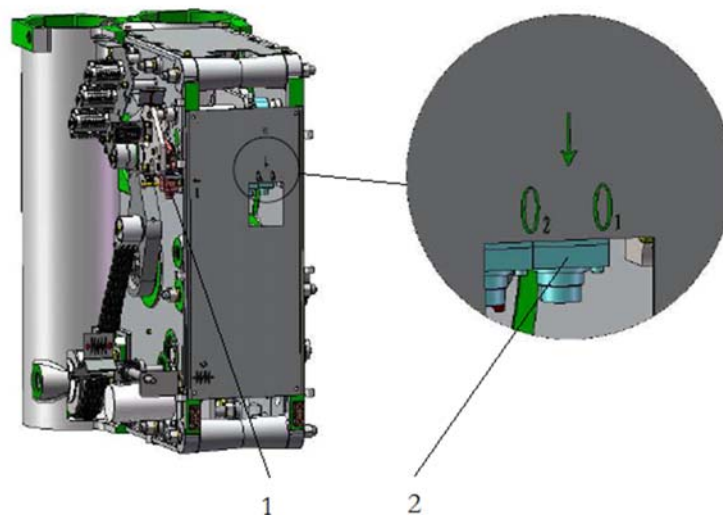
2.2.5.5 Re-closing operation

When the circuit breaker is at the closed position, charging of the opening and closing spring has been conducted. Therefore, the circuit breaker can execute O—0.3s—CO re-closing operation.

2.2.5.6 Manual closing and opening operation

As in Figure 2-12, during commissioning or maintenance, or in case of emergency such as control power supply fault or spring mechanism fault, the closing/opening of circuit breaker can be operated manually. The closing and opening electromagnets of the product are at the position convenient for safety operation. Therefore, the manual closing and opening operation can be completed by operating the electromagnet.

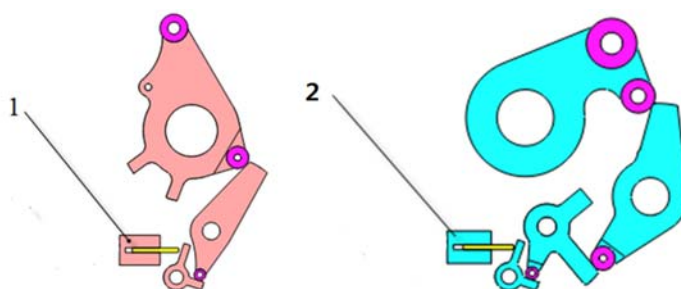
When the closing spring of the circuit breaker has been subject to charging, and the circuit breaker is at the opening position, push the closing electromagnet (1) with force to close the circuit breaker. When the opening spring of the circuit breaker has been subject to charging, and the circuit breaker is at the closing position, push the opening electromagnet (2) with force to open the circuit breaker. The manual closing and opening operation force shall be about 30N.



1 - Closing electromagnet 2 - Opening electromagnet

Figure 2-12 Manual closing/opening operation

The principle of manual closing and opening operation is shown in Figure 2-13. Push the rear cover of the electromagnet with handle, so that the stroke lever of electromagnet moves outward. Push the final stage lever of the closing and opening trip system for rotation, and finally realize closing and opening operations.



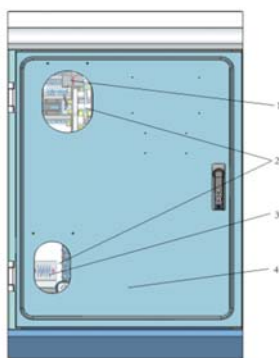
1 - Closing electromagnet 2 - Opening electromagnet

Figure 2-13 Schematic diagram of manual closing/opening operation

Note: only the trained personnel can conduct manual operation; before manual close-open operation, please cut off power supply for charging and control loop; check and guarantee that the pressure of the circuit breaker gas compartment exceeds the locking out gas pressure. If the pressure is too low, opening operation of the circuit breaker cannot be performed.

2.2.5.7 Indication of mechanism state

As mentioned above, during the mechanism operation, the state is divided as: 1. opening position, non charging state; 2. opening position, charging state; 3. closing position, non charging state; 4. closing position, charging state, wherein the opening/closing position is presented by the state of opening spring, and the charging state is presented by the state of closing spring. In addition to electrical indication, the mechanism is provided with the mechanical state indicating device, as shown in Figure 2-14. The lower side is indication of charging and no charging, and the upper side is closing and opening state indication.



1- Closing and opening state signage 2- Observation window

3- Charging and no charging state signage 4- Mechanism case

Figure 2-14 Indicating device of mechanism state

As shown in Figure 2-15, seen from the transparent part of the observation window, when the schematic diagram with arrow at both red ends is indicated, the mechanism is at the charging state; when the schematic diagram of green spring is indicated, the mechanism is at the no charging state.

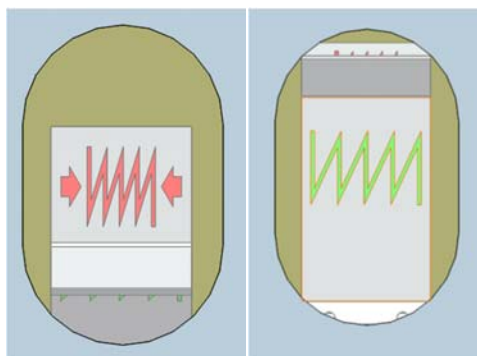


Figure 2-15 Indication of charging/non charging

As shown in Figure 2-16, seen from the transparent part of the observation window, when the red letter I is indicated, the mechanism is at the closing state; when the green letter O is indicated,

the mechanism is at the opening state.

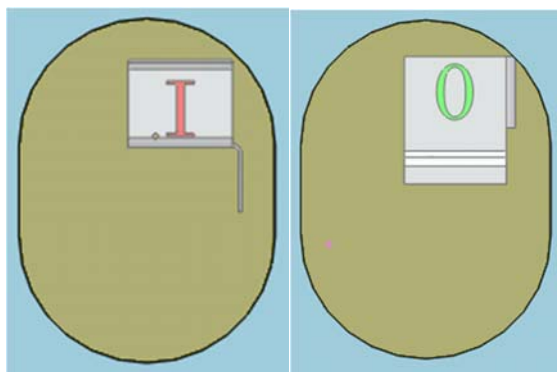


Figure 2-16 Indication of closing/opening

2.3 Disconnecter (Including operated mechanism)

2.3.1 Overview


The opening and closing operations can be conducted electrically and manually with the disconnector. At the opening position, there is insulation distance and obvious break sign conforming to requirements in the provisions between conducts; At the closing position, it can withstand the current at the normal circuit conditions and current at the abnormal condition within the specified time (such as short circuit).

2.3.2 Main parameters

Table 2-3 420kV DS main technical parameters

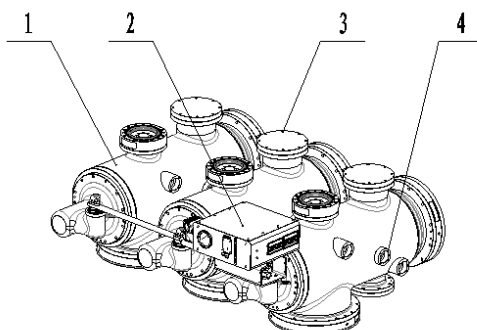
S/N	Name of parameter		Unit	Value
1	Rated voltage		kV	420
2	Rated frequency		Hz	50
3	Rated current		A	4000
4	Rated short-time withstand current and duration (effective value)		kA	63/1
5	Rated peak withstand current (peak value)		kA	157.5
6	Rated short-term power frequency withstand voltage Ud (Effective value, 1min)	Earthing	kV	650
		Breaking	kV	815
7	Rated power-frequency	Earthing	kV	1050

	withstand voltage U_s (peak value)	Breaking	kV	900+345
8	Rated lightning impulse withstand voltage U_p (peak value)	Earthing	kV	1425
		Breaking	kV	1425+240
9	Opening and closing capability of bus transfer current of the disconnector	Bus transfer current	A	1600
		Bus transfer voltage	V	20
		Breaking times	Times	100
10	Rated value of charging current of opening and closing bus of the disconnector	Current	A	0.5
11	Rated /Re-filling/low/ minimum function air pressure		MPa	0.58/0.55/0.53/0.51
12	Mechanical stability		Times	≥ 10000
13	Enclosure protection degree		—	IP65、IK10

 **Note:** the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.3.3 External structure

DS three phases shares a mechanism, and mechanical linkage is conducted through the connecting rod. For schematic diagram of the external structure of the disconnector, shown in Figure 2-17.



1- Primary equipment 2- Electrical operating mechanism

3- Adsorbent cover plate 4- Observation window

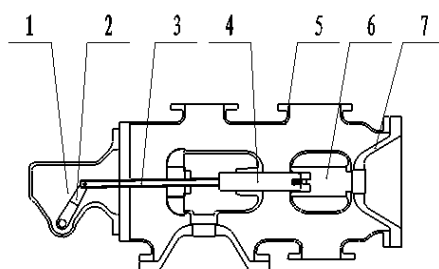
Figure 2-17 External structure of the disconnecter

2.3.4 Internal structure

2.3.4.1 Internal structure of the disconnecter

For schematic diagram of the internal structure of the disconnecter, is shown in Figure 2-18.

Transmission principle: mechanism input shaft rotation → crank arm rotation (spline coordination) → insulation pulling lever translation → moving contact motion. Rotation and reverse rotation of the motor realize opening and closing.



- 1- Crank arm box 2- Crank arm 3- Insulation pulling lever 4- Moving contact base
5- Enclosure 6- Disconnecting base 7- Disconnecting insulator

Figure 2-18 Internal structure of the disconnecter

2.3.4.2 Working state of the disconnecter

There are two working states of the disconnecter, closing position and opening position of the disconnecter respectively, as shown in Figure 2-19 and Figure 2-20.

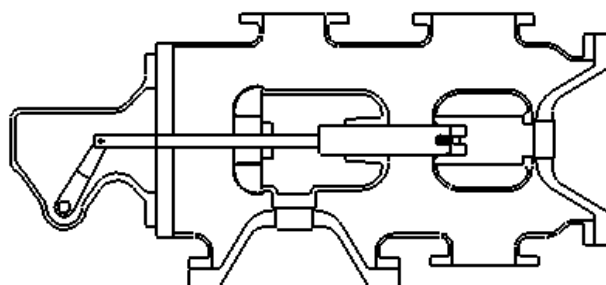


Figure 2-19 Closing position of the disconnecter

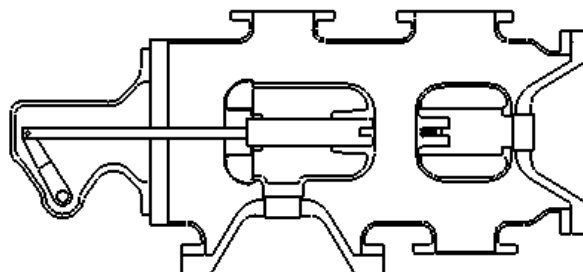


Figure 2-20 Opening position of the disconnecter

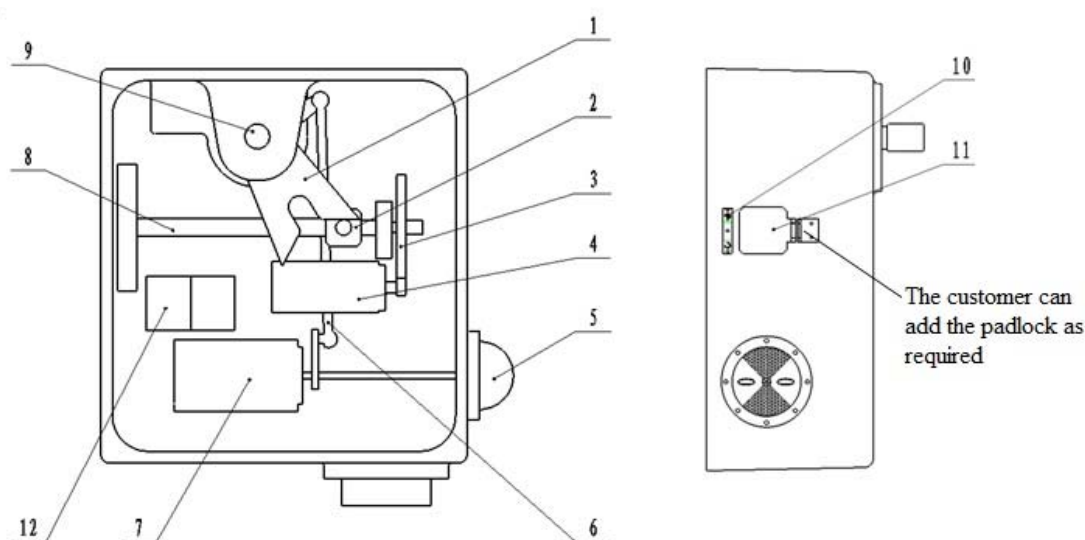
2.3.5 Operating mechanism

2.3.5.1 Overview

SSDS05 disconnecter for ZF28-420 adopts SSCJ31 motor-driven operating mechanism. The operating mechanism can be operated in an electric or manual way. It has the features of small volume, compact structure, reliable action and so on.

2.3.5.2 Structural feature and working principle

SSDS05 disconnecter driven by SSCJ31 motor-driven operating mechanism adopts three-phase linkage operating mode. See Figure 2-21 for the structure. It mainly consists of the crank arm (1), screw rod (8), screw rod nut (2), gear (3), motor (5), auxiliary switch (7) and so on.



1- crank arm 2- Screw-nut 3- Gear 4- Monitor 5- Position indicator 6- Connecting rod 7- Auxiliary switch

8- Lead screw 9- Shaft 10- Indicator for manual operating 11- Board for manual operating 12- contactor

Figure 2-21 SSCJ31 main transmission link of the mechanism

The operating mechanism is driven by the motor (4) and gear (3) or the operating handle is adopted to drive rotation of the screw rod (8) manually, so as to realize leftward motion of the screw rod nut (2). Drive clockwise rotation of the crank arm (1) and output shaft (2), so as to drive clockwise rotation of the output shaft of the body connected with the output shaft (9), so that the moving contact of the body moves to the closing position. On the contrary, conduct reverse rotation of the motor or swing the operation arm in the reverse rotation, and conduct opening operation of the driving mechanism and body.

2.3.5.3 Closing and opening position state conversion

The mechanism is at the opening position as shown Figure 2-21. During closing operation, the crank arm (1) rotates clockwise, so as to drive motion of the connecting rod (6). The connecting rod (6) moves and drives rocker arm rotation, so as to drive rotation of the moving contact of the auxiliary switch (7) by about 90°, and realize switching of the closing signal. Meanwhile, the closing position indication in the switch state indication 'I' is visible. On the contrary, the opening signal switching and opening position indication 'O' is visible.

2.3.5.4 Manual operation

- a) Remove the screw of the manual cover plate, and remove the manual cover plate (note: remove the padlock firstly before operation if any);
- b) Insert the operating handle into the jack;
- c) Rotate the handle according to the manual operation direction nameplate and nameplate indicating direction for "opening" or "closing" operation of the earthing switch;
- d) Continuously rotate the operating handle. When one hears the periodic "click" sound in the mechanism, stop rotation and conduct reverse rotation by 1 turn;
- e) Remove the operating handle, and confirm whether the positions of 'I' and 'O' of the signage are correct;
- f) Install the manual cover plate and manual cover plate screw.

2.4 Earthing switch (including operated mechanism)

2.4.1 Overview

The earthing switch has the capability to withstand short-circuit current within a period, and is driven by the electrodynamic mechanism.

2.4.2 Table of technical parameters

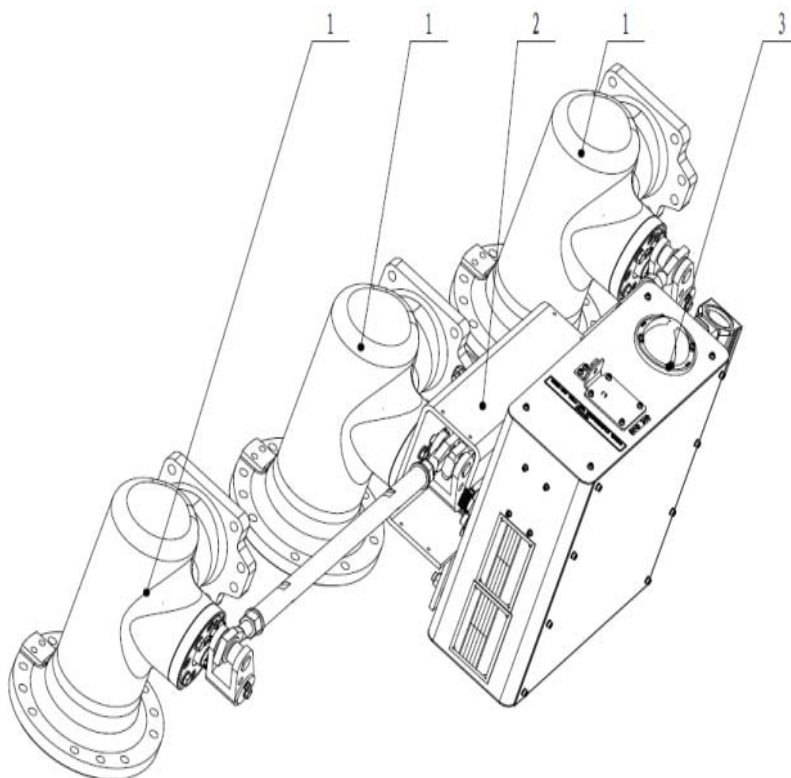
Table 2-4 420kV ES main technical parameters

S/N	Name of parameter	Unit	Value
1	Rated voltage	kV	420
2	Rated frequency	Hz	50
3	Rated short-time withstand current and duration (r.m.s. value)	kA/s	63/1
4	Rated peak withstands current (peak value)	kA	157.5
5	Rated short-term power frequency withstand voltage Ud (Effective value, 1min)	kV	650
6	Rated operation impulse withstand voltage Us (peak value)	kV	1050
7	Rated lightning impulse withstand voltage Up (peak value)	kV	1425
8	Rated / Re-filling / low pressure	MPa	0.58/0.55/0.53
9	Mechanical stability	Times	≥10000
10	Enclosure protection degree	——	IP65、IK10

Note: the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.4.3 External structure

Three-phase mechanical linkage structure is adopted for the earthing switch, and three-phase opening and closing action is driven through an electrodynamic mechanism. See Figure 2-22.

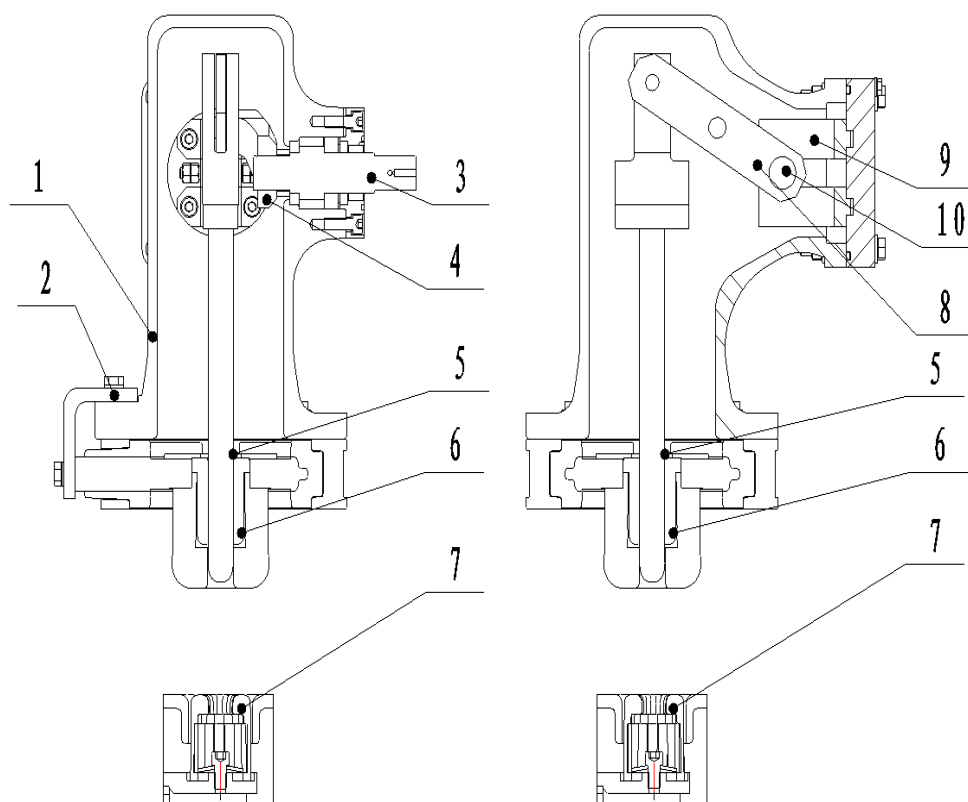


1- body 2- connecting mechanism 3- mechanism body

Figure 2-22 External structure of the earthing switch

2.4.4 Internal structure

For schematic diagram of the internal structure of the earthing switch, see Figure 2-23. The cross elliptical transmission mechanism is adopted for the structure, and the crank arm (4), connecting plate (8), sliding bar (10) and guide frame (9) constitute the crank sliding block mechanism. The crank arm (4) rotates clockwise (closing) and counterclockwise (opening) under driving by the mechanism. The moving contact (5) hinged with the connecting plate makes vertical motion under restriction of geometric dimensions of the elliptical mechanism, completing opening and closing operations.



1- enclosure 2- grounding plate 3- shaft 4- crank 5- moving contact 6- contact
7- fixed contact 8- connecting plate 9- guide track 10- sliding bar

Figure 2-23 Internal structure of the earthing switch

2.4.5 Operating mechanism

SSCJ31 motor-driven operating mechanism is adopted for SSES05 earthing switch. For detailed part, please see the operating mechanism in Section 2.3.4 of the instructions.

2.5 High-speed earthing switch (including operated mechanism)

2.5.1 Overview

The high-speed earthing switch has the capabilities of making short-circuit current, making and breaking inductive current. The electrical spring mechanism is adopted by each phase. In case of power failure or maintenance, manual operation can be performed.

2.5.2 Technical parameters

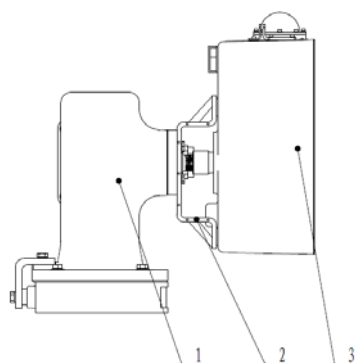
Table 2-5 technical parameters for FES

S/N	Parameter		Unit	Value
1	Rated voltage		kV	420
2	Rated frequency		Hz	50
3	Rated short-time withstand current and duration (r.m.s value)		kA/s	63/1
4	Rated peak withstand current (peak value) / short-circuit making times		kA	157.5
5	Rated power frequency withstand voltage Ud (r.m.s value, 1 min)		kV	650
6	Rated switching impulse withstand voltage Us (peak value)		kV	1050
7	Rated lightning impulse withstand voltage Up (peak value)		kV	1425
8	Making and breaking induced currents	Rated electromagnetic induced current	A	200
		Rated electromagnetic induced voltage	kV	25
		Rated electrostatic induced current	A	20
		Rated electrostatic induced voltage	kV	22
9	Rated /Re-filling / low pressure		MPa	0.58/0.55/0.53
10	Mechanical endurance		Times	≥10000
11	Enclosure protection degree		——	IP65、IK10

Note: the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.5.3 External structure

Single phase transmission is adopted for the high-speed earthing switch, and each phase drives through an electrical spring mechanism, as shown in Figure 2-24.

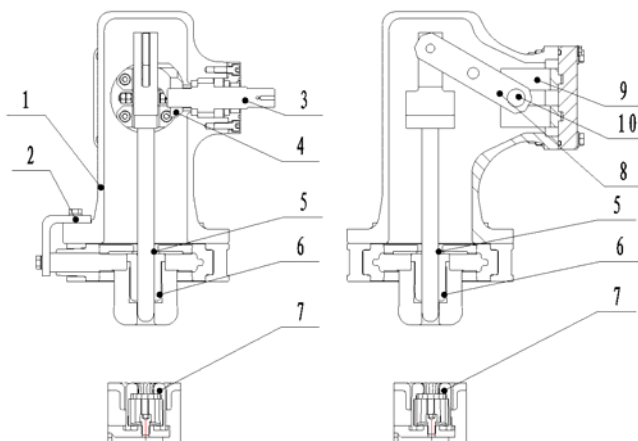


1- high-speed earthing switch 2- connecting mechanism 3- electrical spring mechanism

Figure 2-24 External structure of the high-speed earthing switch

2.5.4 Internal structure

The internal structure of the earthing switch, see Figure 2-25. The cross elliptical trammel mechanism is adopted for the structure, and the crank (4), connecting plate (8), slider (10) and guide track (9) constitute the slider crank mechanism. The crank (4) rotates clockwise (closing) and counterclockwise (opening) under driving by the operate mechanism. The moving contact (5) hinged with the connecting plate makes vertical motion under the constraint of geometric dimensions of the elliptical trammel mechanism, completing opening and closing operations.



1- enclosure 2- grounding plate 3- shaft 4- crank 5- moving contact 6- contact 7- fixed contact 8- connecting plate 9- guide track 10- slider

Figure 2-25 Internal structure of the high-speed earthing switch

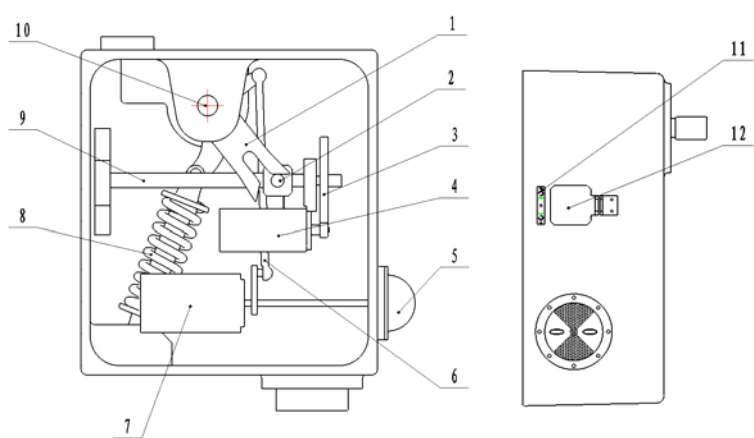
2.5.5 Operating mechanism

2.5.5.1 Overview

SSFES05 high-speed earthing switch for ZF28-420 adopts SSCT31 electrical spring mechanism. The operating mechanism can be operated in an electric or manual way.

2.5.5.2 Structural feature and working principle

The structure of SSCT31 electrical spring mechanism. See Figure 2-26. It mainly consists of the crank arm (1), lead screw (9), screw-nut (2), gear (3), motor (5), auxiliary switch (7) and so on.

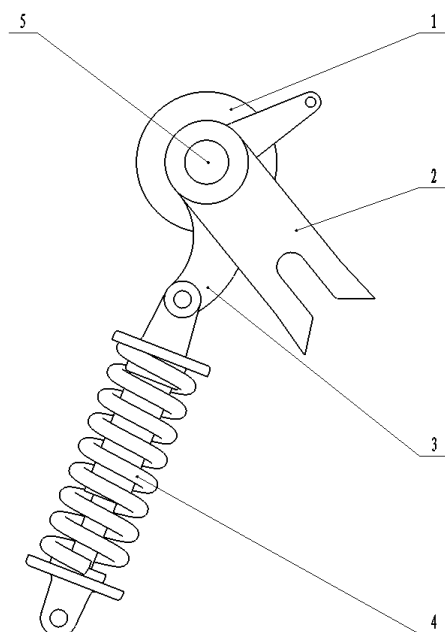


1. Crank arm 2.Screw-nut 3.Gear 4.Monitor 5. Position indicator 6.Conecting rod 7. Auxiliary switch 8.Spring 9. Lead screw 10. Output Shaft 11.Indicator for manual operating 12.Board for manual operating

Figure 2-26 SSCT31 electrical spring mechanism

1) The operating mechanism is generally driven by motor (4), and the operating handle can only be used for manual operation in case of any emergency. The mechanism is connected with the High-speed earthing switch through the axle (10) connected with the crank arm (1) .

2) The details work principle are shown in figure 2-39, 2-40, 2-41. In open position, after the mechanism gets a close command, the motor is decelerated through the gear and drives the rod for rotation. The Screw-nut moves along the lead screw, drives the slow crank arm (2) and compresses the spring (4). After passing the dead point, the spring releases its energy and drives the fast crank arm (3) to rotate. The fast crank arm drives the output shaft (5) by their spline tooth, and therefore drives FES to close fast. When the nut meets the travel switch, the motor stops working, and the close operation is over. To the contrary, the motor conducts reverse rotation, and mechanism makes the opening operation.



1- flange 2- slow crank arm 3- fast crank arm 4- spring 5- Output Shaft

Figure 2-27 Schematic diagram of the opening position

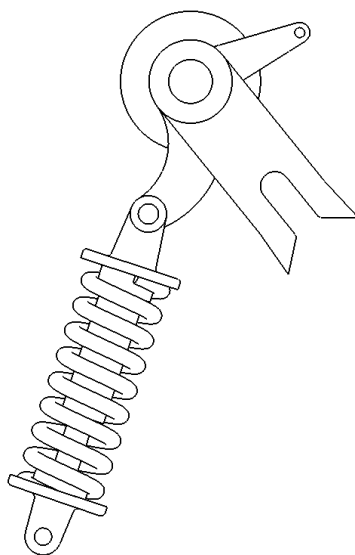


Figure 2-28 Schematic diagram of the dead point position

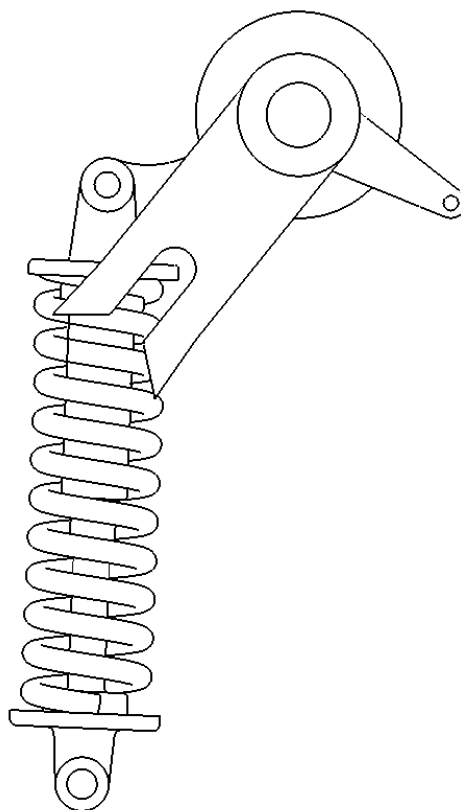
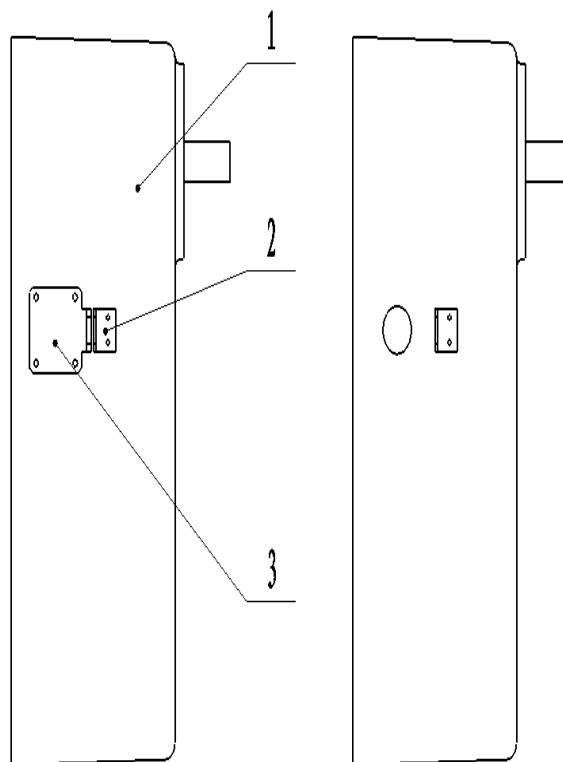


Figure 2-29 Schematic diagram of the closing position

2.5.5.3 Manual operation

- 1) The manual operation is allowed only in condition that all the locking relationship is satisfied and the equipment is unlocked ahead.
- 2) In an emergency, you can use a handcrank to operate FES. In manual operation, the power of the motor will be cut off automatically.
- 3) Steps for manual operation of the failure making earthing switch:
 - a) Remove the manual cover plate (3) (note: remove the padlock firstly before operation if any);
 - b) Insert the operating handle into the jack;
 - c) Follow the operate direction on the indicating sign to turn the handle
 - d) Keep on turning the operating handle, until large impact sound is heard.
 - e) Take out the operating handle, and confirm whether the positions of 'I' and 'O' of the signage are correct;

f) Install the manual cover plate.



1- base 2- locking plate 3- manual cover plate

Figure 2-30 Manual

2.6 Current Transformer

2.6.1 Overview

The current transformer is the electromagnetic current transformer, of which the primary current is actually in proportion to the secondary current at the normal use conditions, and the phase difference is close to zero when the connecting method is correct. The current transformer is one of the components of 420kV GIS, which is used for the electrical measuring instrument and electrical protection device in the power system with rated voltage of 420kV.

2.6.2 Main parameters

Table 2-6 Parameters of the current transformer

S/N	Parameters	Requirements
1	Rated voltage of system	420kV
2	Rated frequency	50Hz
3	Rated primary current	4000A
4	Rated secondary current	1A
5	Rated output capacity	As per SLD
6	Rated short-time withstand current	63kA
7	Rated short-circuit duration	1s
8	Rated peak withstand current (peak value)	157.5kA
9	Rated power frequency withstand voltage Ud (r.m.s value, 1min)	650kV
10	Rated switching impulse withstand voltage Us (peak value)	1050kV
11	Rated lightning impulse withstand voltage Up (peak value)	1425kV
12	Rated pressure of SF6 gas	0.58MPa



Note: the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.6.3 Technical requirements

- 1) Single phase type; the secondary winding of each phase consists of one or more coils.
- 2) The conductor of GIS is primary winding of transformer.
- 3) Secondary winding of the current transformer is fixed on the grounded metal cylinder.
- 4) Secondary winding can have multiple taps.
- 5) The output terminal board of secondary wiring is the wiring terminal block.
- 6) Specifications of the current transformer are engraved on the nameplate, and there also instructions for related part of the supply document.

2.6.4 External structure

The appearance structure of the current transformer is shown in Figure 2-31.

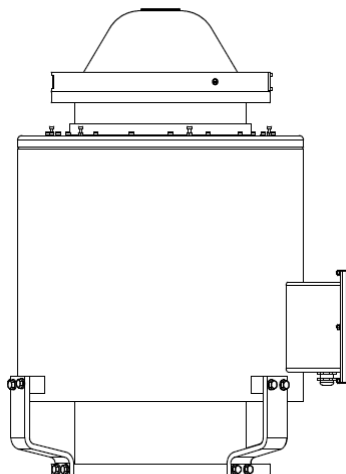


Figure 2-31 External structure of current transformer

2.7 Voltage transformer

The voltage transformer is the electromagnetic voltage transformer, which converts the primary voltage to the secondary voltage through electromagnetic induction principle.

2.7.1 Overview

The operating voltage value is lowered, so as to be applicable for the measuring instrument and protection device connected as well as detection of grounding failure.

2.7.2 Main parameters

Table 2-7 Parameters of the voltage transformer

S/N	Parameters	Requirements
1	Rated voltage of system	420kV
2	Rated frequency	50Hz
3	Rated power frequency withstand voltage U_d (r.m.s value, 1min)	650kV
4	Rated switching impulse withstand voltage U_s (peak value)	1050kV
5	Rated lightning impulse withstand voltage U_p (peak value)	1425kV
6	Rated power frequency withstands voltage of secondary winding	3kV, 1min

S/N	Parameters	Requirements
7	Annual leakage rate of SF ₆ gas	≤0.1%
8	Rated pressure of SF ₆ gas at 20°C (gauge pressure)	0.58MPa
9	Moisture content	≤250μL/L



Note: the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.7.3 Technical requirements

- 1) The voltage transformer is single phase structure.
- 2) The voltage transformer is the independent compartment, its enclosure is separated from GIS other compartment through the basin-type insulator, and it is charged with SF₆ gas.

2.7.4 External structure

The appearance structure is shown in Figure 2-32.

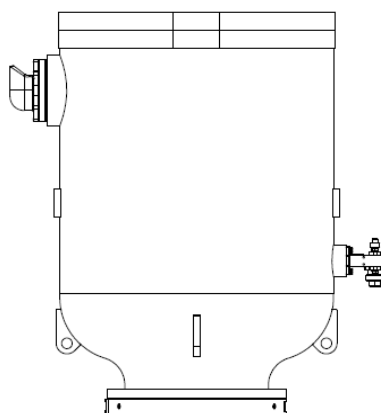


Figure 2-32 External structure of the voltage transformer

2.8 Surge Arrester

The Surge Arrester is SF₆ tank gapless metal oxide arrester, and the online monitoring instrument is installed generally, so as to measure the leakage current value and action times.

2.8.1 Main parameters

Table 2-8 Table of main parameters of the Surge Arrester

S/N	Parameters	Unit	Requirements
1	Rated voltage	kV	As per SLD
2	Continuous operating voltage	kV	As per SLD
3	Nominal discharging current (8/20 μ s)	kA	As per SLD
4	Steep impluse current residual voltage (1/10 μ s)	kV	As per SLD
5	Lightning impluse current residual voltage (8/20 μ s)	kV	As per SLD
6	Operating impluse current residual voltage (30/60 μ s)	kV	As per SLD
7	DC 1mA reference voltage	kV	As per SLD

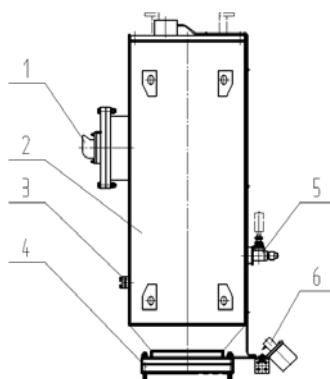
Note: the parameters in the table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.8.2 Technical requirements

- 1) The Surge Arrester is single phase structure.
- 2) The Surge Arrester is the independent compartment, its enclosure is separated from GIS other compartments through the basin-type insulator, and it is charged with SF₆ gas.

2.8.3 Appearance structure

The appearance structure is shown in Figure 2-33.



1. Explosion-proof device
2. Surge Arrester enclosure
3. ground block

4. basin-type insulator 5. gas joint 6. online monitoring instrument

Figure 2-33 External structure of the Surge Arrester

2.9 SF6 gas to Air Bushing

2.9.1 Overview

- 1) The bushing is used to lead the wire from the gas compartment and connects with the bare conductor.
- 2) The bushing consists of the internal conduct and the hollow bushing.

2.9.2 Main parameters

Table 2-9 Main parameters of the bushing

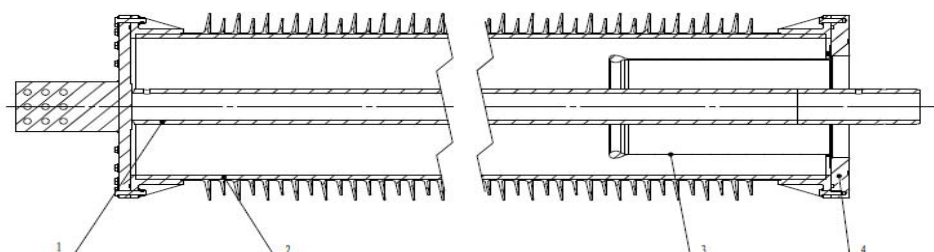
S/N	Parameters	Requirements
1	Rated voltage of system	420kV
2	Rated frequency	50Hz
3	Rated power frequency withstand voltage Ud (r.m.s value, 1 min)	650kV
4	Rated switching impulse withstand voltage Us (peak value)	1050kV
5	Rated lightning impulse withstand voltage Up (peak value)	1425kV
6	Pollution class	Level III
7	Elevation (indoor / outdoor)	≤3000m
8	Creepage distance	11550mm (Level III, ≤1000m)
9	Minimum cantilever strength	10 kN
10	Annual leakage rate of SF6 gas	≤0.1%
11	Rated gas pressure of SF6 gas at 20°C (gauge pressure)	0.58MPa
12	Moisture content	≤250μL/L



Note: the parameters in the above table shall be the universal data, and the technical agreement and supply conditions required shall prevail for each project.

2.9.3 Appearance structure

The appearance structure is shown in Figure 2-34.



1- Conductor, 2- Hollow bushing, 3- Shield, 4- flange

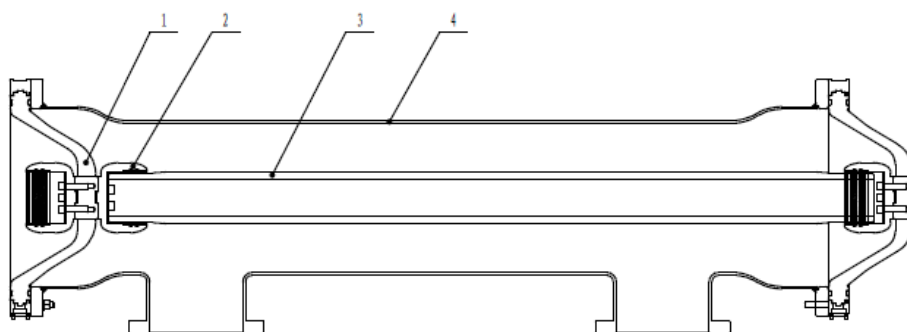
Figure 2-34 Structure of composite bushing

2.10 Gas Insulated Bus (Gas Insulated bus & Bellows)

- 1) The bus has the single-phase structure, and is used to connect various parts of the switchgear
- 2) Each bus module consists of the Enclosure, conductor, basin-type insulator, spring contact, contact holder. The conductor and contact holder are supported by the basin-type insulator, and the bus module and the adjacent element are connected through the spring contact.

2.10.1 Straight bus

The spring touch finger is adopted for the straight bus conductor with reliable electric conduction ability and convenient installation. For general structure, see Figure 2-35.

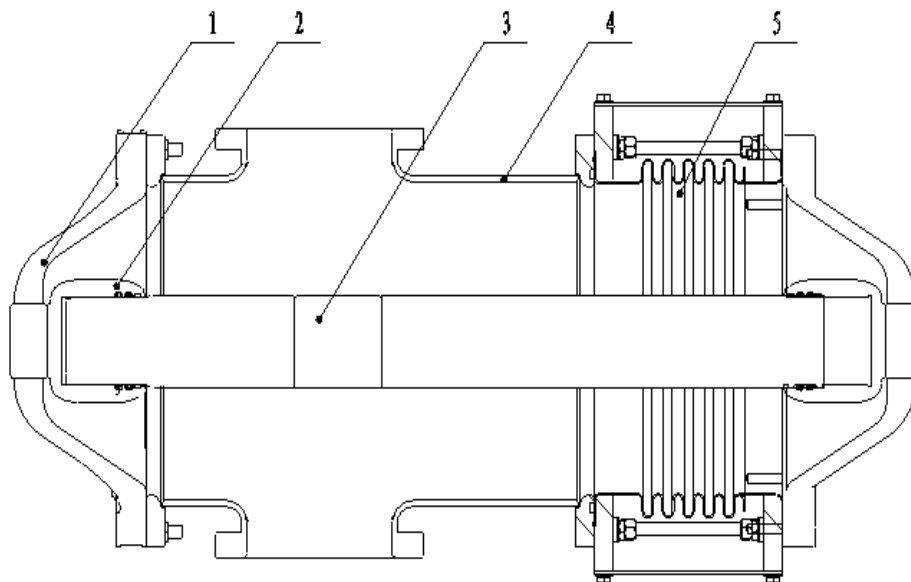


1- Basin-type insulator, 2- Contact, 3- Conductor, 4- Enclosure

Figure 2-35 Structure diagram of the straight bus

2.10.2 Removable bus

The removable bus is mainly used for connection between the Bay and bus, so as to facilitate overall removal of the bay or GIS module for maintenance.



1- basin-type insulator 2- contact 3-removable conductor 4- enclosure 5- bellows

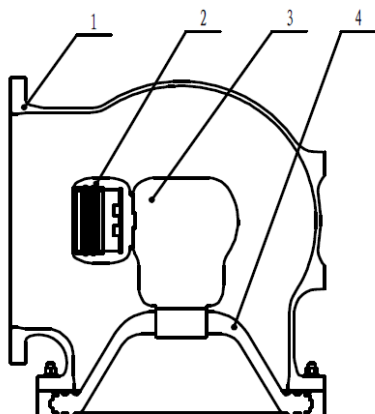
Figure 2-36 Removable bus

The working process of the removable bus is as follows:

- 1) Dismantle and remove out the removable conductor through the hand hole;
- 2) Dismantle the conductors at both sides of the removable conductor, and put the left conductor in the bus;
- 3) Remove the bolt between the insulator and the enclosure;
- 4) Move the bellows out after leftward compression by a certain distance.

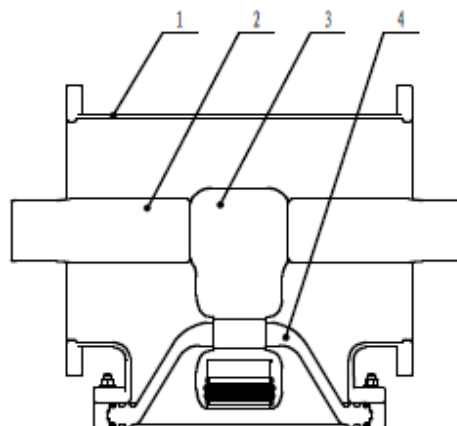
2.10.3 Connecting module

It is used for interconnection in the GIS. According to space requirements for main circuit and layout, there are several the connecting modules for option.



1- enclosure 2- contact 3- conductor 4- insulator

Figure 2-37 L bus

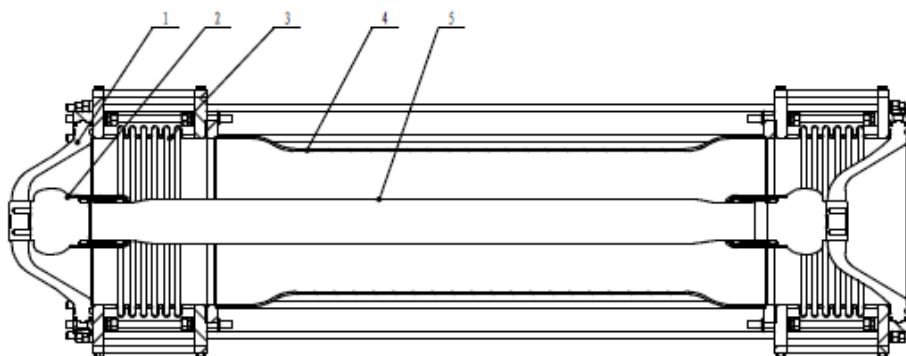


1- enclosure 2- conductor 3- conductor 4- insulator

Figure 2-38 T bus

2.10.4 Radial compensation bus

It can also make compensation for changes in the radial length of the bus caused by thermal expansion and contraction, and can also make compensation for error caused by foundation settlement.

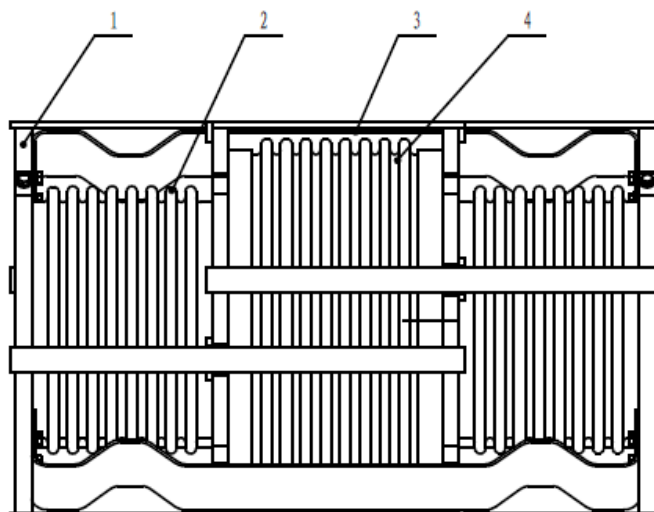


1- insulator 2- contact 3- bellows 4- enclosure 5- conductor

Figure 2-39 Radial compensation bus

2.10.5 Self-balancing bellows

It can make compensation for changes in the axial orientation of the bus caused by thermal expansion and contraction, and the axial compensation amount can be up to $\pm 30\text{mm}$.

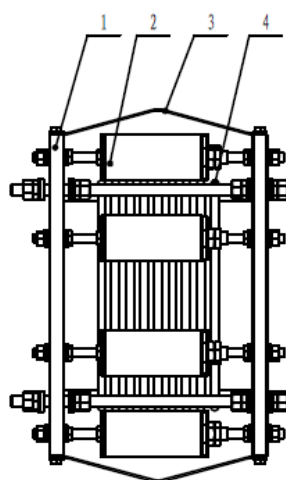


1- flange 2- working bellows 3- grounding plate 4- balancing bellows

Figure 2-40 Structure of the self-balancing bellows

2.10.6 Disc spring bellows

It can make compensation for changes in the axial orientation of the bus and mounting error caused by thermal expansion and contraction, and the axial compensation amount is $\pm 10\text{mm}$.



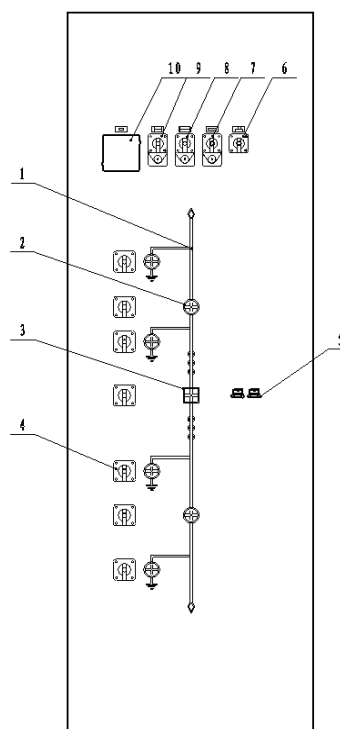
1- flange 2- disc spring assembly 3- grounding plate 4- bellows

Figure 2-41 Structure of the disc spring bellows

2.11 Local control panel

2.11.1 Introduction of local control panel

- 1) The local control cabinet (LCP) is the centralized control panel for field monitoring and control of GIS, and the relay hub for electrical contact among various switching elements inside and outside GIS interval and between GIS and the master control room.
- 2) The local control cabinet has the functions of local operation, signal transmission, protection, relay and monitoring of SF₆ system.
- 3) A local control cabinet is equipped for each GIS circuit breaker interval generally.
- 4) Schematic diagram of the cabinet and the component is shown in Figure 2-43.



- 1-schematic diagram of main wiring simulation 2-switch position indicator
- 3- Circuit breaker position indicator 4- local opening and closing operations switch
- 5-asynchronous pressure plate 6-reset switch 7- interlock / unlock change-over switch
- 8-DS/ES/FES local / remote change-over switch
- 9-circuit breaker remote/ local change-over switch 10- failure alarm

Figure 2-43 Schematic diagram of the local control cabinet

2.11.2 Instructions of LCP control panel

2.11.2.1 Main connection simulation

The main connection simulation represents the main connection form of the interval, with the schematic diagram as shown in Figure 2-44.

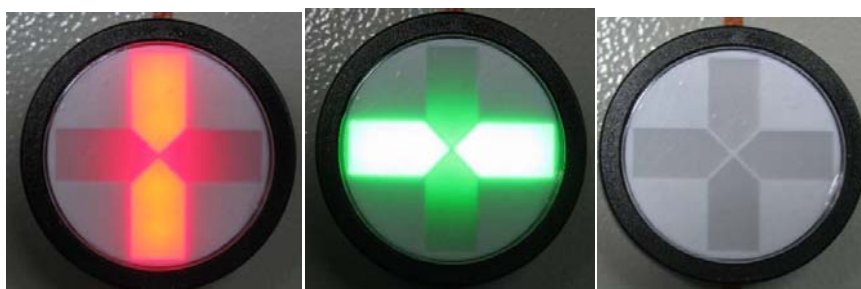


Figure 2-44 Schematic diagram of main connection simulation

2.11.2.2 Position indicator

The round position indicator is used to represent the opening and closing positions of the disconnector, earthing switch and failure making earthing switch and the square position indicator is used to represent the opening and closing positions of the circuit breaker mechanism.

Take the earthing switch as an example, the corresponding relation between the position indicator and the switch opening and closing state is shown in Figure 2-45.



(a) Closing

(b) opening

(c) error / failure

Figure 2-45 Schematic diagrams of closing, opening, error / failure

2.11.2.3 Opening / closing operation switch

Each set of mechanism is equipped with a self reset opening/closing operation switch, which can perform opening/closing operation in each local control mechanism, as in Figure 2-46.

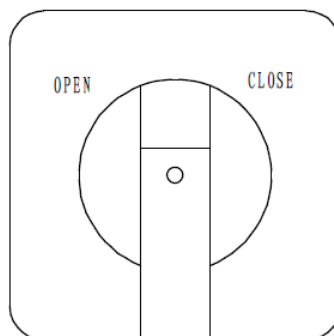


Figure 2-46 Opening/closing operation switch

2.11.2.4 Interlock / unlock change-over switch

For the "interlock / unlock" key change-over switch, the interlock restriction can be released for operation when license is obtained, as shown in Figure 2-47.

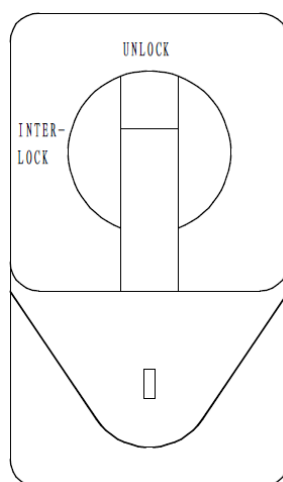


Figure 2-47 "Interlock / unlock" key change-over switch

2.11.2.5 Local / remote change-over switch

The "local/remote" key switch can select the remote control operation or local operation, as in Figure 2-48.

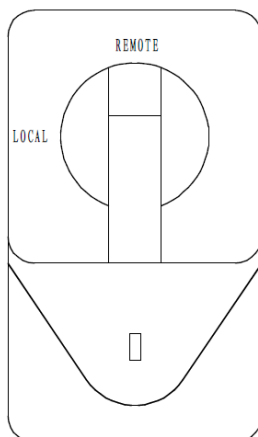


Figure 2-48 "Local / remote" key change-over switch

2.11.2.6 Reset switch

The reset switch is used to release the circuit breaker motor operation failure, as shown in Figure 2-49.

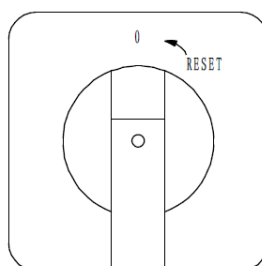


Figure 2-49 reset switch

2.11.2.7 Circuit breaker operation counter

The breaker operation counter applies to recording the action times of closing operation of the circuit breaker, as in Figure 2-50. The counter is installed in the mechanism case of the circuit breaker.



Figure 2-50 Operation counter of the mechanical circuit breaker

2.11.2.8 Failure annunciator

The failure annunciator sends alarms of various faults generated in GIS in a centralized way. In case of a certain fault, the corresponding alarm indicator LED is on, warning the operator to deal with the fault in time. The failure annunciator state display is shown in Figure 2-51.

1) DC power switch trip.

If any power switches in the control panel is not closed or in fault trip, the alarm indicator will be on.

2) No energy storage of the closing spring of the circuit breaker.

If the closing spring of breaker mechanism is not energy stored or is storing the energy, the alarm indicator will be on.

3) Overcurrent and overtime protection of the circuit breaker motor.

If the energy storage of breaker motor is not completed until the reset time is over, or the over current fault of energy storage occurs, the alarm indicator will be on.

4) Isolating switch, grounding switch and failure making grounding switch motor overcurrent protection.

In case of any overcurrent failure of the isolating switch, grounding switch and failure making grounding switch, the alarm indicator lamp will be on.

5) SF₆ pressure drop alarm.

SF₆ pressure in the air chamber is reduced below the alarm pressure, and the alarm indicator lamp will be on.

6) SF₆ pressure drop lock.

SF₆ pressure in the air chamber is reduced below the locking pressure, and the alarm indicator lamp will be on.

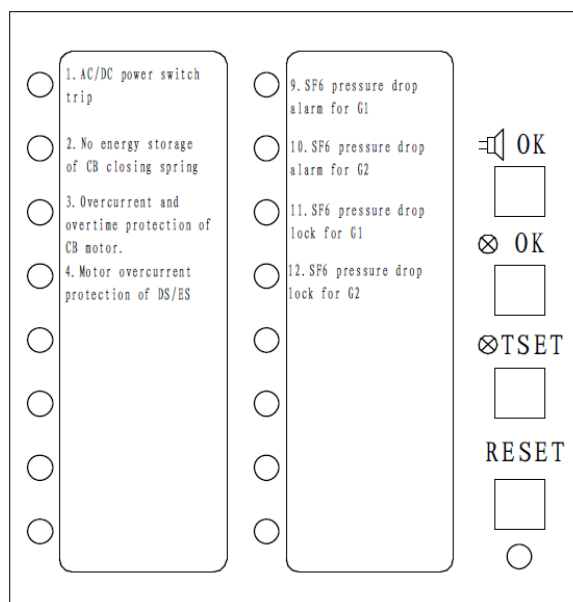


Figure 2-51 Failure annunciators

2.12 Enclosure

1) The primary conductive part of the product is closed in the charged metal casing, and is assembled through necessary adjustment and connection.

2) The enclosure is casted with aluminum alloy or welded with aluminum alloy, and all enclosures have passes water pressure and leakage test.

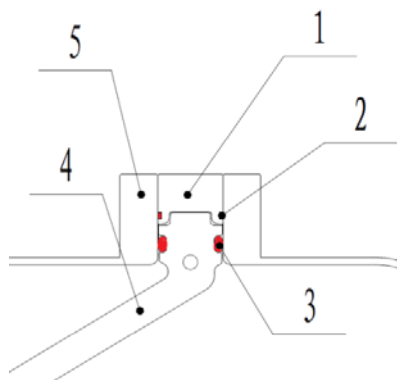
3) The enclosure categories are as follows roughly:

- Circuit breaker enclosure
- Current transformer enclosure
- Voltage transformer enclosure
- Grounding switch / failure making grounding switch enclosure
- Isolating switch enclosure
- Cable terminal enclosure
- Surge Arrester enclosure
- Straight bus enclosure

■ L-shaped and tee bus enclosure

2.13 Sealing Structure (Structure of Gas Tightness with O-Ring)

There are two seals between flanges, the inside sealing ring prevents gas leakage, and the outside sealing ring prevents water immersion, as shown in Figure 2-52.



1-outer ring of the basin-type insulator flange 2-outside sealing groove
3-inside sealing groove 4-epoxy resin 5-enclosure flange

Figure 2-52 Structure diagram of double sealing

2.14 Gas insulation insulator (Insulation Spacer)

2.14.1 Basin-type insulator

1) The metal outward flange structure is adopted for the basin-type insulator, realizing directly connection with the enclosure, and it is not required to add the bridging terminal. The basin-type insulator includes the gas insulation insulator and through-hole insulator, as shown in Figure 2-53 and Figure 2-54.

2) The rupture pressure of the basin-type insulator is calibrated according to the national standards, which can withstand normal pressure of GIS and partial unbalanced pressure during installation and operation.

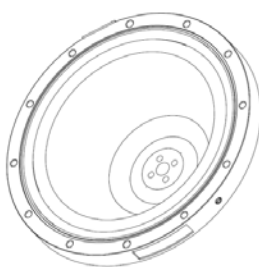


Figure 2-53 Schematic diagram of the gas insulation insulator

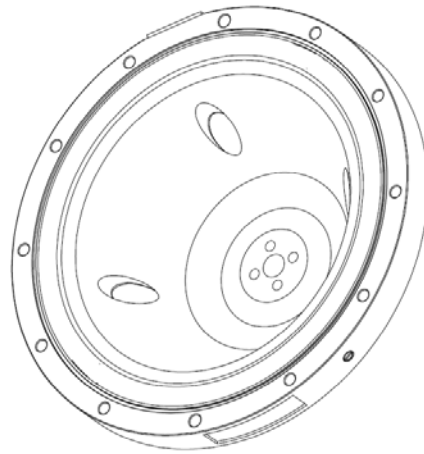
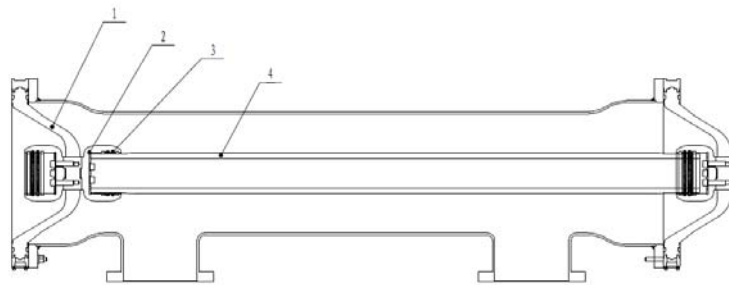


Figure 2-54 Schematic diagram of the through-hole insulator

2.15 Conductor

- 1) Sliding contact is adopted at both ends for conductor connection.
- 2) Aluminum alloy tube or cast aluminum alloy is adopted for conductor processing.
- 3) The spring contact is adopted for slip connection.



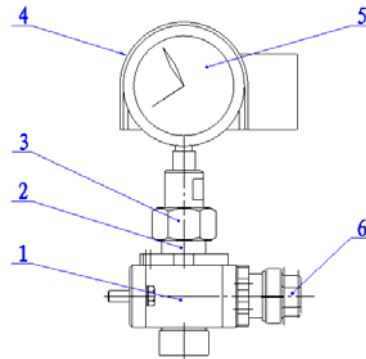
1- basin-type insulator, 2- contact holder, 3- spring contact, 4- conductor

Figure 2-55 Structure diagram of the straight bus

2.16 Gas density monitor (Gas monitoring Device)

2.16.1 Structure

The structure of density relay is shown in Fig. 2-56.



1-Valve Base, 2- Self-sealing Joint, 3-Joint, 4-Shield, 5-SF₆ densimeter, 6-protecting cover

Fig. 2-56 Density Relay

2.16.2 Function

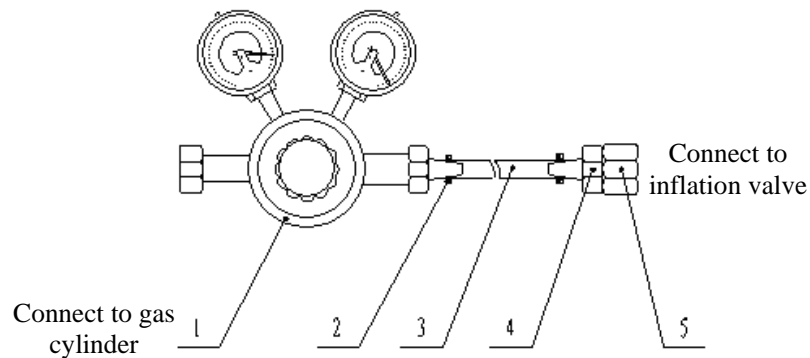
- 1) It can monitor SF₆ gas density within the ambient temperature range specified, and automatically make compensation to the corresponding pressure value at 20°C.
- 2) The alarm and locking signals are provided.

2.16.3 Change of density relay

- 1) When the density relay is replaced, SF₆ gas in the corresponding gas compartment will not be released.
- 2) When the density relay is screwed out, the self-sealing valve on the valve seat will isolate the gas compartment.
- 3) Online calibration of the density relay.

2.16.4 Charging line

Charging pipeline shown in Fig. 2-57 is applied when inflating gas compartment.

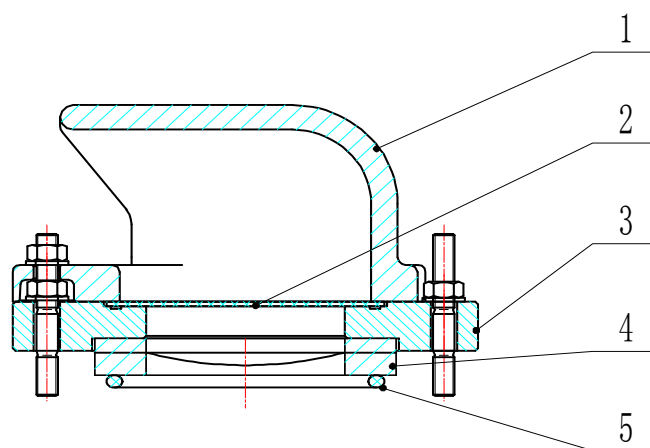


1-pressure reducing valve, 2- hose clamp, 3- air pipe, 4- joint, 5- self-sealing joint

Fig. 2-57 Charging Line

2.17 Safety protecting disks (Pressure Relief Device)

- 1) The protector is mainly used to restrict too high internal pressure in case of any failure.
- 2) When the pressure in the gas compartment is too high, the explosion-proof membrane will have fracture, so as to drain pressure, and guarantee product and personnel safety.
- 3) The wind deflector can control the direction of high-pressure air flow, so that it is discharged in the safe direction. Direction of exit can be directly changed without affecting gas compartment during installation or maintenance.
- 4) The structure of protector is shown in Figure 2-58.

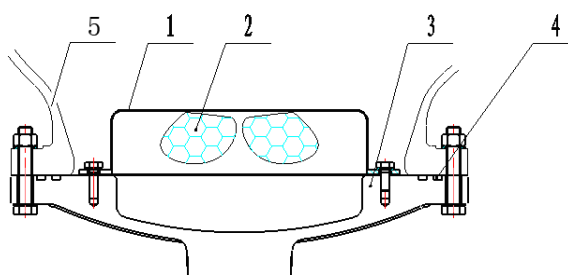


1-wind deflector, 2- baffle plate, 3- pressure plate, 4- baffle plate, 5- O ring

Fig. 2-58 Protector

2.18 Static moisture filter (Adsorbent)

- 1) Each function unit is configured with the adsorbent.
- 2) The adsorbent can absorb the residual moisture in the gas compartment.
- 3) In the circuit breaker and disconnector gas compartment, the adsorbent can absorb the decomposer generated due to arcing.
- 4) The structure of absorber is shown in Figure 2-59.



1- cover, 2- adsorbent, 3- flange, 4- O ring, 5- gas compartment enclosure

Fig. 2-59 Absorber

Loop power supply: check and guarantee that the pressure of the circuit breaker gas compartment exceeds the locking pressure. If the pressure is too low, opening operation of the circuit breaker cannot be conducted.

3. Packing, transport and storage

3.1 Packing

3.1.1 Transport unit

The product is usually packed in wooden case for transportation, and the product is filled with 0.03Mpa N₂ or SF₆.

3.2 Transport

The transportation road conditions are complicated and changeable. In order to guarantee product quality after arrival, each transportation unit is pasted with the Shockwatch label. The electronic impact recorder can also be installed as required.

The Shockwatch labels are 10G and 15G. When 10G label becomes red, our company shall conduct field inspection and review whether it can be normally used; when 15G label becomes red, the product shall be returned to our company for detailed inspection. The label is the disposable auxiliary material, and recovery is not required; the label is not a part of normal operation of the product. The acceleration recorder records the impact acceleration during transportation. The acceleration recorder belongs to the material recovered by Sieyuan Company.

3.3 Unloading

3.3.1 Receipt and appearance inspection of goods


The goods recipient must inspect the completeness and integrity of goods before formally receiving (signing for) them. Loss, damage and so on found shall be accurately recorded on the corresponding form, the evidence shall be reserved (the image record at best), and our company shall be informed immediately.

- 1) The packing and shipping order can be utilized to determine product delivery integrity during goods receiving.
- 2) The shipping order shall include the following information: customer order items, factory order items, quantity and number of the packing box, gross weight, net weight and dimensions.
- 3) The packing list shall include the following information: goods name, goods quantity, category and quantity of documents shipped with goods.
- 4) Appearance inspection.

Whether the product surface has any coating damage, part bruise or accumulated water;

Check whether the package surface is damaged;

Check whether the vibration label has any color change.

 **Note: the above inspection shall be deemed as passed after the product is signed and received.**

3.3.2 Lifting requirements

- a) The lifting personnel shall have the qualifications for operation of the crane and fork truck, have the work license, and be familiarized with various operation and requirements for lifting.
- b) One shall guarantee no collision or scratch during lifting;
- c) The lifting tool shall be lifting rope, which shall satisfy load bearing requirements. The bearing

capacity of the lifting rope shall be 1.5 times of the product weight, and the flexible sling shall be selected.

d) The product shall be lifted in a stable way, and handled with care during lifting. Move slowly and at uniform speed. Prevent substantial swing of the product in the air, and change line stably.

e) The lifting point shall be comply with requirements of the site customer service personnel of our company. Our company shall not assume any responsibility for the lifting problem caused without confirming the lifting form.

f) The transport vehicle shall be at the braking state during unloading.

g) The temporary area for unloading shall have flat ground, so as to prevent tilting during product storage. It shall be transported to the region satisfying requirements afterwards, and stored according to requirements. For storage, see Section 3.4.

h) The fork truck shall not be adopted for the package unit not packed in the wooden box.

3.4 Storage environment

3.4.1 Storage environment

The storage environment is divided into two classes of indoor and outdoor. The storage environment and inspection requirement of the packing modes of different types shall be different correspondingly. The user can select it according to the actual situation, and inspection items and frequencies are different for different environments. The user shall conduct inspection according to requirements, so as to prevent product damage.

3.4.2 Storage rules

1) Product stack cannot exceed requirements for stacking layer limit labeled on the packing box.

2) The product storage area shall satisfy the load carrying capacity, and the ground load bearing shall exceed $1t/m^2$; The storage area shall have flat terrain, and the ground shall be free of obvious accumulated water. In case of the area with grade, the product must be stored along the slope, and the slope of the storage area shall not be larger than 5° ; There shall be good ventilation conditions in the storage area, so as to avoid gathering of water vapor and so on in the product storage area.

3) The storage area shall be equipped with suitable lifting and handling equipment, the height of the operation space of the crane required for lifting of the packing box shall not be less than 8m, and the tonnage of the crane shall be over 16T; The tonnage of the fork truck shall be over 3t, and larger than the weight of the equipment handled.

- 4) The channel in the storage area shall be maintained unblocked, so as to facilitate access of the personnel for inspection and material transport.
- 5) During storage, the label on the packing box shall be faced at the channel side or in the direction for reading by the personnel.
- 6) Fire resistance requirements. The corresponding fire-fighting equipment shall be equipped in the storage area according to fire fighting design, and it is strictly prohibited to bring the spark into the storage area.
- 7) Mouse proofing requirements. The mouse proof trench shall be arranged in the storage area according to the field situation, the rat guard or rat clip shall be arranged in the storage area, and over two rat proofing measures shall be guaranteed.
- 8) The stored products shall be subject to tour inspection once every two weeks during storage, preparation for anti-theft shall be made, and the appropriate remedial measures shall be taken after windstorm and heavy rain or snow.

3.4.3 Requirements for storage and handling during logistics process

The requirements for temporary storage and transportation at the destination port, is shown in Table 3-2.

Table 3-2

	Temporary storage at the destination port
Environment for storage / transportation	It shall be loaded with package in the container for temporary storage; if it cannot be loaded in the container at the special circumstance, it shall be covered with the waterproof cloth for temporary storage.
Requirements for transfer	Container transfer
Requirements for storage / transportation	Maintain dryness in the container; cover the waterproof cloth for outdoor storage at the special circumstance, tie the rope at four edges of the waterproof cloth, clear the accumulated water and snow on the waterproof cloth, and lift the waterproof cloth.
Requirements for handling	The tonnage of the fork truck / crane shall be larger than the weight of the container, loading, unloading and handling cannot be conducted with brute force, so as to avoid damage to the packing box. The vibration indicator shall be pasted on the product, and shall not become red.

3.4.4 Requirements for customer site storage

During customer site storage, it is divided into short-term storage and long-term storage according to the storage time. For storage requirements, see Table 3.3 The storage mode adopted shall be determined according to the predicted site storage period. Storage with package inner: ≤12 months; Outdoor simple warehouse (tent): ≤6 months. If 6 months are exceeded, it

must be transferred for indoor storage; outdoor waterproof cloth storage ≤ 3 months. If 3 months are exceeded, it shall be transferred for indoor storage. If customer site storage of the product exceeds a year, complete detection shall be conducted before installation (inform our company to fabricate the special detection scheme).

Table 3-3 Requirements for export product site storage

S/N	Name	Packing mode	Short-term storage mode	Long-term storage mode	Storage protection Requirements	Number of stacking layers	Storage temperature	Storage humidity	Special requirements
1	Data case	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent)	Indoor storage with package	Damp-proof and waterproof	Stack for two layers with same specification	-20°C ~40°C	$\leq 70\%$	None
2	Interval / circuit breaker	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	Outdoor simple warehouse (tent)	Damp-proof and waterproof Wind-sand proof; one shall pay attention to anti-vibration during product lifting and storage, and avoid the vibration indicator on the product from becoming red;	Cannot be stacked	-20°C ~40°C	$\leq 90\%$	None
3	Current transformer / voltage transformer / Surge Arrester	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	Indoor storage with package / outdoor simple warehouse (tent)	Damp-proof and waterproof Wind-sand proof; one shall pay attention to anti-vibration during product lifting and storage, and avoid the vibration indicator on the product from becoming red	Cannot be stacked	-20°C ~40°C	$\leq 90\%$	The product cannot be placed horizontally, and can only be placed vertically.
4	Control cabinet	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent)	Indoor storage with package	Damp-proof and waterproof Wind-sand proof;	Cannot be stacked	-20°C	$\leq 90\%$	None

							~40°C		
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Table 3-3 Requirements for export product site storage (continued)

S/N	Name	Packing mode	Short-term storage mode	Long-term storage mode	Storage protection Requirements	Number of stacking layers	Storage temperature	Storage humidity	Special requirements
5	Bus	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	Indoor storage with package / outdoor simple warehouse (tent)	Damp-proof and waterproof Wind-sand proof; one shall pay attention to anti-vibration during product lifting and storage, and avoid the vibration indicator on the product from becoming red	Stack for two layers with same specification	-20°C ~40°C	≤90%	None
6	Ceramic bushing	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent)	Indoor storage with package	Damp-proof and waterproof Wind-sand proof; one shall pay attention to anti-vibration during product lifting and storage, and avoid the vibration indicator on the product from becoming red	Stack for two layers with same specification	-20°C ~40°C	≤90%	None
7	Shielded cylinder / grading ring	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent)	Indoor storage with package / outdoor simple warehouse (tent)	Damp-proof and waterproof Wind-sand proof;	Stack for two layers with same specification	-20°C ~40°C	≤90%	None

Table 3-3 Requirements for export product site storage (continued)

S/N	Name	Packing mode	Short-term storage mode	Long-term storage mode	Storage protection Requirements	Number of stacking layers	Storage temperature	Storage humidity	Special requirements
8	SF6 gas	Wooden box package	outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	Far from heat source, avoid direct sunlight, ventilation for drying, and regularly check product storage state	Stack for two layers with same specification	-20℃ ~40℃	≤90%	The hazardous article shall be stored separately, far from the work and living area of the personnel
9	Cable	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	Indoor storage with package / outdoor simple warehouse (tent)	Damp-proof and waterproof Wind-sand proof;	Stack for two layers with same specification	-20℃ ~40℃	≤90%	None
10	Bracket class	Wooden box package	Indoor storage with package / outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	Indoor storage with package / outdoor simple warehouse (tent) Outdoor storage with waterproof cloth	Anti-collision	Stack for two layers with same specification	-20℃ ~40℃	≤90%	None
11	Tooling / tools	Wooden box package	Indoor storage with package	Indoor storage with package	Damp-proof and waterproof Wind-sand proof;	Stack for two layers with same specification	-20℃	≤90%	None
12	Spare parts						~40℃	≤70%	

4 On-site Installation

4.1 On-site Installation Preparations

4.1.1 On-site installation responsibilities

- 1) According to the contract requirements, our company shall be responsible for field assembly or guidance installation.
- 2) Our engineer shall go to the site to guide field installation.
- 3) Installation guide given in the manual shall not substitute the training of the field installation personnel.

4.1.2 On-site installation staff qualifications

4.1.2.1 Field installation of GIS. An installation team with high level, coordination and cooperation shall be required, and demands for personnel are as follows:

- 1) A customer service engineer, comprehensively responsible for installation guide, including assembly of various units of the product, commissioning of the inflation and circuit breaker operating mechanism.
- 2) A craneman, responsible for handling of heavy goods.
- 3) A cable worker, responsible for installation of the busbar and the circuit, low-voltage line and grounding loop.
- 4) A test engineer.
- 5) Several installers, configured according to the project scale.

4.1.2.2 The installation personnel must be subject to safety education, and understand hazard of GIS installation work. The contents are as follows:

- a) Lift the heavy object.
- b) Use the ladder, crane and elevator.
- c) Get close to the container charged with SF₆ gas with a certain pressure.
- d) In the environment possibly including SF₆ gas.
- e) Contact the high-low voltage equipment, and use the electric tools.

4.1.3 On-site environment

- 1) The building, foundation and other civil engineering shall be completed.
- 2) GIS field installation environment can be sealed, and shall be clean and dust-free. If necessary, the protection layer shall be applied.
- 3) In the assembly area, the condensate water shall not be drop from the roof and the top.
- 4) The ground of the installation area must be firm, and the ground dust can be cleared with the vacuum cleaner.
- 5) Clear the site, and do not place the tools and Equipment unrelated with GIS field installation.

4.1.4 On-site safety

- 1) Control the personnel with access to the site: only the personnel related with is allowed to enter it.
- 2) The installation tool, special tools and spare parts shall be appropriately kept and watched by the special person.
- 3) The storage room which can be locked shall be provided on site.

4.1.5 Flow chart of field installation

For flow chart of 420kV field installation, see Figure 4-1.

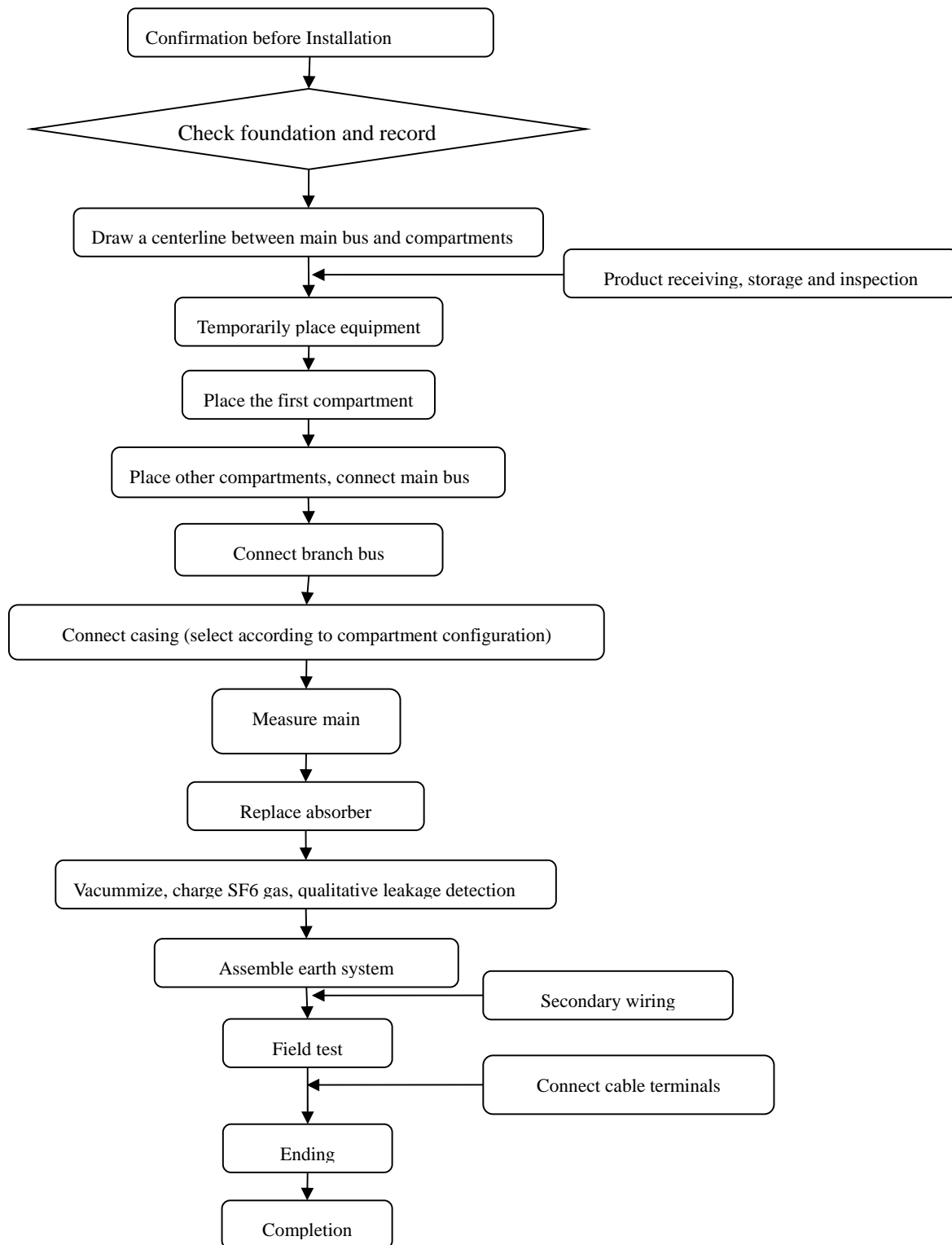


Figure 4-1 Flow chart of field installation

5 Site tests

5.1 General provisions

Fielol test is the effective monitoring method to check whether there is any abnormal phenomenon of GIS during packaging, transportation, storage and installation, which must be conducted before GIS is put into operation.

5.2 Site test program

The test items of SF₆ sealed composite apparatus shall include the following contents:

5.2.1 Check product structure and appearance

- 1) During product reassembly, supervision of the following matters shall be emphasized.
- 2) Site environment control shall guarantee that the site is clean and dust-free as far as possible.
- 3) The positions of the grounding terminal and ground strap at all positions shall be correct.
- 4) The positions of all locking device shall be correct.
- 5) The position indication of all valve switches shall be correct.

5.2.2 Measure the main loop resistance

The main loop resistance value shall be measured with the loop resistance tester, and DC voltage drop method with current not less than 100A shall be adopted. The measured value shall not exceed 1.2 times of the specified value in the product technical conditions.

5.2.3 Measure insulation resistance of the main loop, control loop and auxiliary loop

It is tested with the insulation megohm meter. The main loop insulation resistance shall not be less than 1000MΩ, and the insulation resistance of the auxiliary loop and the control loop shall not be less than 2 MΩ; the specific requirements for insulation resistance value shall be subject to the technical agreement.

5.2.4 AC withstand voltage test of the main loop, control loop and auxiliary loop

AC withstand voltage test program and method of the main circuit shall comply with the product technical conditions.

5.2.5 Sealing test

- 1) Instrument: SF₆ gas quantitative leak detector.
- 2) Measurement method:

- a) Preparation of the interval product, instrument, equipment and binder.
 - b) Vacuum pumping shall be conducted to each closed intervals according to related work instructions for SF₆ gas vacuum pumping.
 - c) Each closed bay shall be charged with SF₆ gas to the leak detection pressure.
- 3) Cautions of experiment binding:
- a) Do not let the bandage and ambient air environment influence the leak detector.
 - b) The binding volume shall be reduced as much as possible.
 - c) Confirmation and measurement after wrapping shall be conducted by the qualified personnel.

5.2.6 Measurement of SF₆ water content

SF₆ water content shall be measured with the dew point tester (volume fraction at 20°C). The use method refers to the operation instructions for equipment.

5.2.7 Inspection of the current transformer

Inspection of polarity of the current transformer: apply a DC current pulse on the primary side of the current transformer, and connect the measuring device at the secondary side (generally the analog ammeter). When polar connection is correct, the pointer shall swing clockwise at power on, and the pointer shall swing counterclockwise at power off; if the swing directions of the pointer are opposite, the polarities are opposite.

5.2.8 Operation test of the composite apparatus

It shall be conducted with the switch feature tester, and the operation test shall be conducted according to provisions in the product technical conditions. During operation test of the composite apparatus, the interlock and locking device action shall be accurate and reliable.

5.2.9 Inspection of the gas density gauge, pressure gauge and pressure action valve

The action value of the gas density gauge and the pressure action valve shall be checked during inflation, which shall conform to provisions in the product technical conditions. These equipment sent to the site separately shall be calibrated.

5.2.10 Cautions of ultrasonic flaw detection of the welding enclosure

If the customer requires ultrasonic flaw detection test of the welding enclosure on site, vaseline and other fat coupling agents shall be adopted, and the coupling agent with strong fluidity, such as engine oil, shall not be adopted, so as to prevent the coupling agent from flowing into the

enclosure flange sealing groove along the outer wall of enclosure, causing corrosion of the sealing ring, gas leakage and other quality risks.

6. Used by the user

6.1. Overview

All mechanisms shall be installed and adjusted before ex-factory, and the user do not need to perform installation and adjustment again.

The following conditions must be satisfied for repair in case of any fault of the mechanism:

When the circuit breaker and the disconnecter are at the opening position, the earthing switches at both sides are at the closed position, and CB mechanism has no energy storage, repair can be conducted.

6.2 Cautions

GIS provides measures with high security, but the operator shall still operate according to safety regulations. In addition to related national safety regulations, there are also following preventive measures and key points to be noticed:

6.2.1 The mechanism case shall be locked during operation.

6.2.2 Manual operation shall not be conducted during operation.

6.2.3 The accessories required for the switchgear operation and safety (manual operation device, warning label, fire extinguisher and so on) shall be stored at the determined place orderly, and perfection and correctness of functions shall be inspected regularly.

6.2.4 Each key and button can only be used by the operators.

6.2.5 One shall remember "five prevention" operation protection during manual operation of the switchgear.

6.2.6 Do not enter inside the switchgear.

6.2.7 Do not close or cover the vent of the explosion-proof membrane during operation, and do not change or hinder the exhaust direction in any way.

6.2.8 All inspection, failure maintenance and other operations shall be conducted under supervision by the qualified personnel from Siyuan High Voltage.

6.3 User operation

During commissioning, maintenance and in emergency situation of any fault in the control power

or motor operating mechanism, the Disconnector, earthing switch, fault earthing switch, circuit breaker, LCP operation, gas supply, gas inflation and other related operations can be subject to manual operation.

Interlocking relation shall be disabled before manual operation. Only the qualified personnel with sufficient qualifications can perform manual operation, and one shall check the opening and closing indications before manual operation, so as to satisfy interlocking conditions. 6.3.1 Instructions for use of LCP control panel, see 2.12.2.

6.3.2 Instructions for use of CB mechanism see 2.2.5.

6.3.3 Instructions for use of DS mechanism see 2.3.4.4.

6.3.4 Instructions for use of ES mechanism see 2.4.4.

6.3.5 Instructions for use of FES mechanism see 2.5.4.3.

6.3.6 Instructions for operation and use of gas supply and inflation see A.6 and A.7.

6.4 Anomaly inspection and corrective measures

It mainly introduces fault signal during operation, and the reason and corrective measures thereof.

6.4.1 Safety instructions

During manual operation at the normal conditions, action can be performed when interlock is released. Otherwise, the equipment or component will be damaged.

Cautions:

- 1) Any fault can only be checked and corrected by the qualified personnel subject to training and with specific operation qualification.
- 2) All safety instructions and operation requirements shall be observed during operation.
- 3) Be careful and prudent during operation.

6.4.2 Inspection

Parameters related with GIS device operation shall be always monitored by equipment generally. In case of any anomaly, the alarm signal will be generated, and the abnormal noise will be sent in some special circumstances. The switchgear protection equipment shall be disconnected in the serious situation. The display and digital signal module of the indicator lamp shall be inspected during operation.

6.4.2 Pressure alarm of the circuit breaker

6.4.2.1 Leakage of SF₆ gas in CB

The gas density in the gas compartment is reduced generally. When the pressure is reduced to 0.63Mpa, the alarm will be sent.

(1) Problem: poor sealing causes that the gas enters atmosphere or the adjacent gas compartment.

(2) Measures:

Use the Gas filling device for gas supply of the gas leakage module, and read the data on the density meter to check leakage of the gas compartment. The anomaly shall be informed to Shanghai Sieyuan Electric Co., Ltd.. Before it is repaired by the professionals from Sieyuan Electric Co., Ltd., the leaked gas shall be complement by the Gas filling device.

6.4.2.2 CB gas compartment reaches the locking pressure

When the gas pressure in CB reaches the locking pressure 0.6Mpa, CB cannot satisfy requirements for breaking. The circuit has been interrupted due to secondary interlocking relation at the moment, and the circuit breaker mechanism cannot be subject to electrical operation.



Notice: if manual operation is performed after unlocking at the gas compartment locking pressure, the circuit breaker cannot satisfy rated parameters for breaking, which will cause damage to the circuit breaker. Therefore, one shall check whether the gas compartment pressure of the circuit breaker reaches the locking pressure before manual operation. Manual operation of the circuit breaker can only be conducted in commissioning, maintenance and emergency, and the circuit breaker cannot be operated manually during normal operation.

(1) Problem: poor sealing causes that the gas enters atmosphere or the adjacent gas compartment.

(3) Measures: Use the Gas filling device for gas supply of the gas leakage module, so that the gas compartment pressure is higher than the locking pressure, and the circuit breaker trips. Meanwhile, the anomaly shall be informed to Shanghai Sieyuan Electric Co., Ltd..

6.4.3 Switchgear (DS/FES/ES) alarm signal

6.4.3.1 SF₆ gas leakage in the switchgear

The gas density in the gas compartment is reduced generally. When the pressure is reduced to 0.53Mpa, the alarm will be sent.

(1) Problem: poor sealing causes that the gas enters atmosphere or the adjacent gas

compartment.

(2) Measure: use the Gas filling device for gas supply of the gas leakage module, and read the data on the density meter to check leakage of the gas compartment. The anomaly shall be informed to Shanghai Sieyuan Electric Co., Ltd.. Before it is repaired by the professionals from Sieyuan Electric Co., Ltd., the leaked gas shall be complement by the Gas filling device.

6.4.3.2 Rise of SF₆ gas pressure in the switchgear

When the gas pressure in the gas compartment rises above the rated working standard, the alarm will be sent.

(1) Problem: when the temperature is low during Gas filling, or the gas enters the gas compartment from the adjacent gas compartment with higher gas pressure.

(2) Measures: discharge SF₆ gas into the container through the valve, and lower the gas pressure to the rated gas pressure; or inform Shanghai Sieyuan Electric Co., Ltd.. and request to send the professionals for settlement.

7 Maintenance

7.1. Overview

7.1.1 Concept of maintenance

Maintenance means that the normal state of equipment is kept or recovered by taking technical and management measures, and thus the equipment can execute necessary functions.

Maintenance work includes:

1) Preventive maintenance: it shall be conducted according to the determined timetable, and adjusted according to the number of cycles of operation conducted actually. The purpose is to prevent faults from occurring.

2) Corrective maintenance: it shall be conducted after failure, and determined according to failure. The purpose is to clear faults and recover the original functions of equipment.

7.1.2 Safety measures

1) Before all work started:

a) Open the circuit breaker.

b) Open the disconnecter.

c) Grounding of all earthing switches.

- d) Verify that all equipment have no power.
 - e) Separate the electrified body nearby.
- 2) The closing and opening spring shall be released for maintenance of the circuit breaker. For this reason:
- a) Disconnect the motor power supply.
 - b) If the switch is still at the closed position, it shall be disconnected.
 - c) Disconnect the control and heating source.
- 3) During maintenance of the quick earthing switch, the control voltage and motor power supply shall be disconnected.
- 4) If it is expected that SF₆ decomposition product will appear, the stated protection measures must be taken. See A.5: cautions for handling SF₆ gas.

7.1.3 Equipment and personnel requirements

- 1) It is required to open the gas compartment, replace the parts or subassembly for maintenance work. Inspection and maintenance personnel should have related qualifications and experience to be in charge of maintenance work, and Sieyuan staff shall be supported by clients or users
- 2) Siyuan High Voltage can perform work according to the latest information and experience, which are obtained from installation of the gas insulated switchgear of the metal enclosed switch.
- 3) Experience of Siyuan High Voltage can guarantee rapid completion of work, which means that when the switchgear work must be restricted or interrupted, time will be shortened as far as possible.
- 4) The document cannot substitute the experience accumulated during training and maintenance work. These are only summarized information and related problems according to experience. However, actual maintenance work is not limited thereto.

7.1.4 Response to fault

- 1) Any bad behavior in the correct function of whole switchgear or any cabin shall be deemed as problem.
- 2) The problem is caused by failure of one or more switchgear parts. For example, parts lose the wear expiration date too early. Or it caused by misoperation. For this reason, inspection shall be conducted. If necessary, the three-phase fault earthing switch caused by careless closing shall be repaired.

3) In case of any problem, one shall contact Siyuan High Voltage on designation of the qualified personnel, indicate the problem type and degree as accurate as possible, and indicate all parts with damage sign. In order to simplify recognition, the names of the parts given in the operating instructions shall be described.

7.1.5 Maintenance period

1) Manufacturing of the gas-insulated metal-enclosed substation guarantees optimum fitting between the structure and the material, and also gives consideration to coordination between the maintenance work and cycle, which reaching the optimum application effects.

2) Therefore, the switchgear provides high reliability, and the functions are also the same even if it has been close to the wear limit.

3) The switchgear can only obtain reliable functions after correct maintenance. So the purposes of inspection and maintenance are as follows:

- a) Determine wear degree of some parts and evaluate their state.
- b) Guarantee those parts still at good state, and maintain the state.
- c) Replace some parts at the appropriate time.

7.1.5.1 Factors affecting maintenance period

1) Inspection and maintenance are classified and named correspondingly according to related work.

2) The switchgear with frequent work apparently withstand more wear than the switchgear with less work, and the following difference must be indicated hereby:

- a) Mechanical wear caused by friction.
- b) Arc corrosion caused by switching of the load current or fault current.

7.1.5.2 Start date

1) The inspection and maintenance plan is started from vacuum pumping from the gas compartment and Gas filling.

2) However, not all gas compartments are charged with gas on the same day, and it must be determined that the switchgear is taken as the start date for the whole (or different building stages). Generally speaking, differences of two to three months are within the allowed range.

3) It is unrelated with use of the Gas filling switchgear after installation.

4) In order to understand whether the inspection and maintenance work are conducted as the time or wear function, the start date shall be recorded in writing, and the mechanical operation and fault current operation shall be monitored.

7.1.5.3 Maintenance cycle

1) At the normal operating conditions (such as in the power distribution network) and indoor transformer substation (not subject to climate conditions), electrical and mechanical durability of GIS can be up to 30 years according to experience, unless the heavy load operation is frequently conducted.

2) GIS life is also related with aging time of the sealing system.

3) There are very few demands for maintenance at the initial operation period of GIS, and it is not necessary to conduct major repair of the switch. Renovation of GIS may be required according to the specific service conditions 30 years after, which can extend the service life by 15 years at least.

7.2 Maintenance work

The external factors, such as dust, dampness and so on, will not influence operation reliability of the gas-insulated metal-enclosed substation. Therefore, GIS product of Siyuan High Voltage is actually maintenance-free.

7.2.1 Inspection

Function inspection and visual inspection shall be conducted once every 5 years, and it is not required to open the gas compartment during the process.

7.2.2 Maintenance

Each switching device needs to be monitored after a certain number of operations, and maintenance is performed according to the condition of the contact bearing current load. In the maintenance process, the corresponding gas compartments of the switching devices need to be opened, and parts of power stations have to be out of service. Suggestion, as for all work related to internal devices, please contact service department of Sieyuan.

7.2.3 Maintenance plan

For maintenance schedule, see Table 7-1.

Table 7-1 Maintenance schedule

Equipment	Item	Every 1 year	Every 5 years	After 20 years	After 1,000 operation cycles	After 2000 operation cycles	After 5,000 operatio n cycles	After 1 short-circuit current making	After indu curn mak
Overall equipment	Check SF ₆ gas state	✓							
	Inspecting an earthing system	✓							
	Inspecting the density relay and alarm setting		✓						
	Check LCP wiring and cable		✓						
	Check high voltage live display device		✓						
	Check the painting	✓							

	layer										
	Open the cover for major repair			✓			✓				
	Inspecting number of operations	✓									
	Check local and remote opening and closing operations	✓									
	Inspecting fasteners				✓						
	Check the auxiliary switch				✓						
	Measure mechanical properties					✓					
	Lubricating an operating					✓					

	mechanism										
Circuit breaker	Check the contact state										✓
Disconnector	Check the contact state									✓	
Quick earthing switch	Check the contact state							✓	✓		
Note: maintenance of the above components include the corresponding operating mechanism.											

7.3 Monitoring and maintenance of moisture content

7.3.1 Limited standard of moisture content

Gas moisture content needs to be measured when gas in the gas compartments is in a balanced state (it usually takes place 24 hours after the charge).

The limit standards of SF₆ water content in the gas compartment are:

- 1) Handover acceptance value: the circuit breaker gas compartment shall not be larger than 150μL/L, and other gas compartments shall not larger than 300μL/L.
- 2) During operation: the circuit breaker and current transformer gas compartment shall not be larger than 250μL/L, and other gas compartments shall not larger than 500μL/L.

7.3.2 Maintenance

- 1) When the water content reaches the critical value, monitor the gas compartment, and measure the water content value according to the specified time interval (6 months). If the moisture content rises continuously, gas in the gas compartments has to be purified.
- 2) When the water content reaches the limited value, please inform Siyuan High Voltage that gas in the gas compartment shall be subject to dry treatment, and the adsorbent shall be replaced or regenerated.

7.3.3 Adsorbent

7.3.3.1 Use a good asorbent

Adsorbent package is inspected carefully, no leakage, and whether a humidity indicator is abnormal or not is observed. Once adsorbent is exposed in the air for more than 30min, the adsorbent cannot be used directly and needs to be regenerated or replaced.

7.3.3.2 Measures for preventing moisture from entering

- 1) Before the gas compartment is opened, one shall make efforts to maintain it above the specified temperature.
- 2) A gas compartment with slight positive pressure can be opened to generated the cooling effects.
- 3) Place the adsorbent bag in the environment with temperature equal to or higher than the original temperature, and open the package.
- 4) For the gas compartment placed with adsorbent, vacuum pumping shall be conducted immediately, so as to prevent the adsorbent from absorbing moisture from the surrounding

object.

7.3.3.3 Regeneration of adsorbent through electric heating drying oven

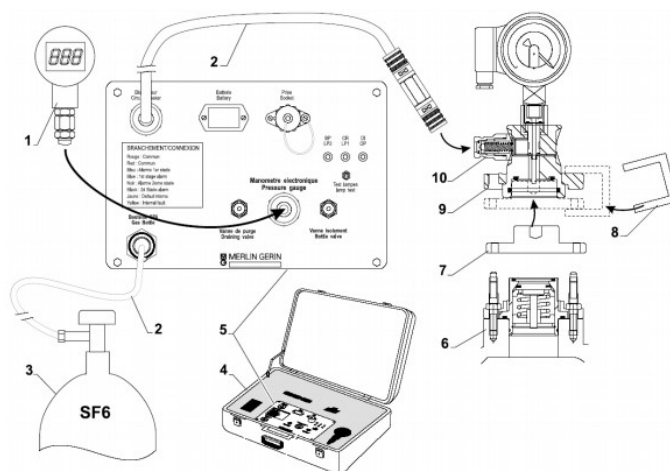
- 1) Baking time: at least 2h.
- 2) Temperature: 200°C to 300°C.
- 3) After baking and natural cooling to 40°C, the baking oven door can be opened.
- 4) Maintain the adsorbent after regenerative at the hot state (40°C), immediately place it in the gas compartment, or place the polyethylene isothermic bag.
- 5) Use the appropriate tools and protective gloves, so as to avoid polluteing the active adsorbent.
- 6) Save the active adsorbent in the sealed container.

7.4 Inspection and maintenance of density relay

- 1) The density relay has been set in the project.
- 2) Inspection conditions: on the equipment or gas compartment which has stopped operation.
- 3) The inspection contents include rise or fall of gas pressure and determining the accurate gas pressure at the moment of signal tripping.
- 4) When the precision pressure gauge is adopted to check the density relay, compensation must be made due to measurement of relative pressure (substitute the filling pressure in the relative pressure formula). If density measuring equipment is directly used for inspecting the density relay, no correction is needed.
- 5) Replace it in case of any damage.
- 6) Warning: one must guarantee test accuracy. In case of question, the calibration measuring system shall be adopted for repeated measurements in the standard test environment.

7.4.1 Inspection procedure

Inspection procedure of the density relay is shown as figure 7-1.



1- standard pressure gauge 2- pipeline 3-SF₆ gas cylinder 4- test device 5- control panel 6-GIS 7- division board

8-clamping plate 9-density relay charging base 10-charging connector

Figure 7-1 Inspection procedure of density relay

1) Prepare test

- a) Remove and disassemble the Gas filling seat of the density relay from GIS, and prepare the test device.
- b) Connect the standard pressure gauge with the control panel, and connect the control panel with SF₆ gas cylinder.
- c) Clear the gas and moisture in the pipeline and the standard pressure gauge.
- d) Set the test device pressure, and the value is close to the pressure value in the measuring gas compartment. Valve cannot be operated tap at the moment.

2) Isolated density relay assembly

- a) Connect the fender 7 with 9 through the plywood 8, and then connect the test equipment with the pneumatic nozzle 10.

3) Check the alarm contact

- a) Measure connection of the alarm contact at pressure drop.

b) Record the measured value and the atmospheric environment conditions, and make appropriate adjustment.

4) Install the density relay on GIS

a) Disconnect test equipment.

b) Detect sealing of GIS Gas filling device with the leak detector.

7.5 Installation method of the mechanical characteristic sensor of the circuit breaker

As shown in Figure 7-2, the sensor shall be installed at the side of the crank arm box. Remove the cover plate, and install the sensor at the reserved mounting position of the crank arm.

Meanwhile, fix the sensor, and conduct feature measurement.

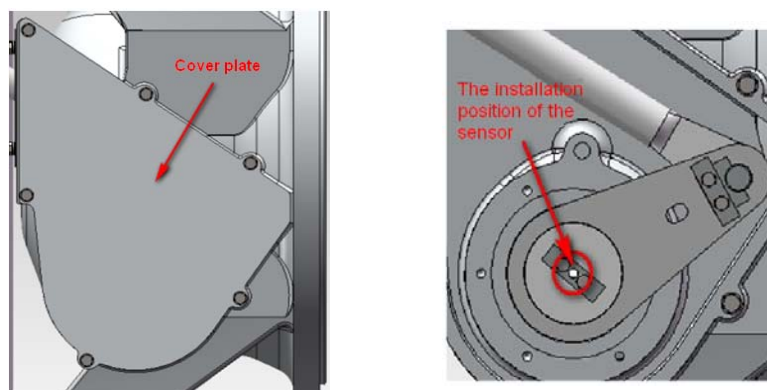


Figure 7-2 Installation method of the sensor

7.6 Method of part repair and replacement of the circuit breaker mechanism

7.6.1 Motor replacement

As shown in Figure 7-3, the motor is positioned at the lower left corner of the front mechanism. Remove the front cover of the mechanism box to replace the motor. Firstly cut off the motor connecting line, then disassemble the four mounting screws respectively to remove the motor. Install the new motor mounted with gear on the base (pay attention to the mesh between motor output shaft gear and the lower class gear as well as the alignment of motor assembly positioning boss and base motor mounting hole), tighten the mounting screws and connect the power line (irrespective of positive and negative electrode) to replace the motor.

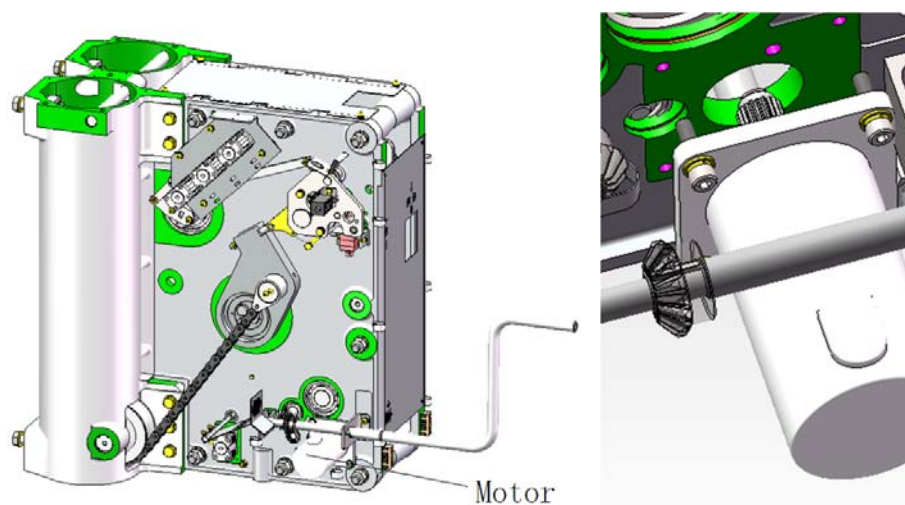


Figure 7-3 Schematic diagram of motor replacement

1) Replacement of the opening and closing electromagnet

As shown in Figure 7-4, the closing electromagnet is located at the upper right corner in front of the mechanism, and the opening electromagnet is at the base side.

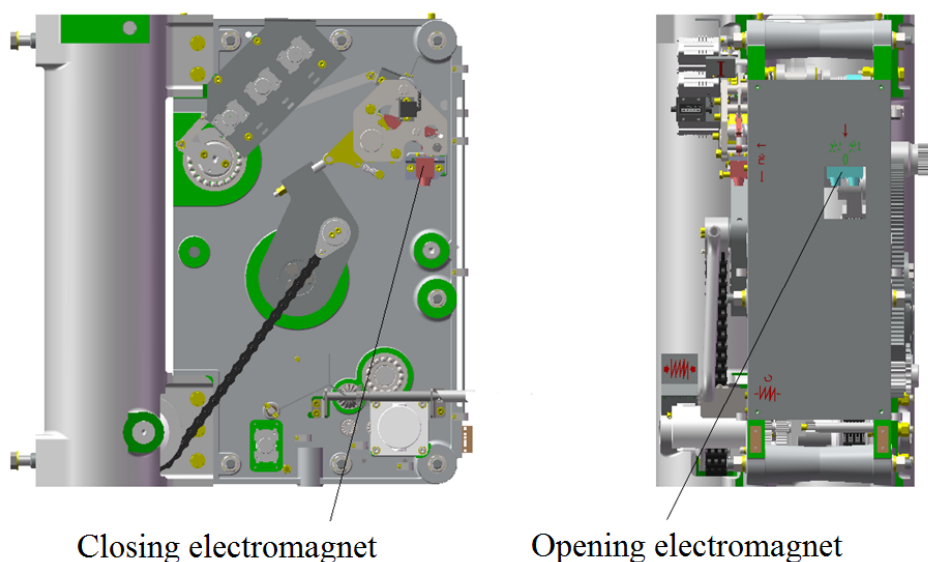


Figure 7-4 Schematic diagram of electromagnet position

Remove the front cover of the mechanism case to replace the closing electromagnet. Firstly, cut the power cord, and remove the angle plate for installing the electromagnet, as shown in Figure 7-5. Remove the angle plate from electromagnet, install the angle plate on the base after replacement of electromagnet, connect the power cord, and complete replacement of

electromagnet.

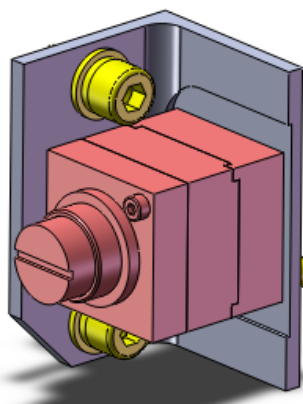


Figure 7-5 Schematic diagram of closing electromagnet installation

Because limited by the position of the opening electromagnet, before replacement of the opening electromagnet, remove the mounting cover plate shown in Figure 7-6, and the opening electromagnet in the middle of the base shall be exposed at the moment.

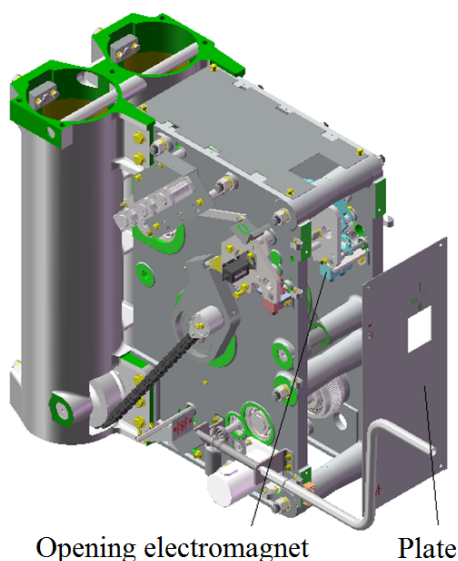
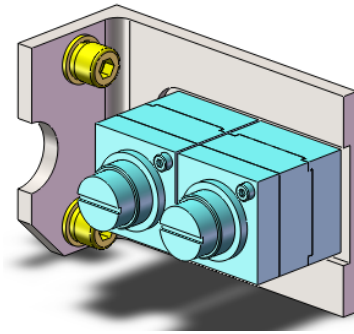


Figure 7-6 Opening electromagnet replacement

Replace the opening electromagnet. The replacement steps are consistent with the closing electromagnet, and assembly of the opening electromagnet and the angle plate is shown in Figure 7-7.



7-7 Schematic diagram of installation of the opening electromagnet



Note: cut off the power when replacing the electromagnet and confirm the closing/opening spring is not energy stored.

7.7 Treatment of product near end of life

When the life of product is ended, a use unit shall treat the product. Please pay attention to environmental protection, recycling and treatment of gas should be well handled, and the environment cannot be polluted. Meanwhile, you can contact Sieyuan. Our Sieyuan can use products near the end of life as far as possible, and therefore resource waste and pollution are reduced.

Appendix A: SF₆ gas operation (Introduction of SF₆ Gas)

A.1 SF₆ gas parameters

Table A.1 Table of SF₆ gas parameters

S/N	Index items	Index
1	SF ₆ mass content /%	≥99.9
2	Air mass content/%	≤0.04
3	Water mass content/%	≤0.0005
4	Moisture dew point/°C	≤-49.7
5	CF ₄ mass content/%	≤0.04
6	Acidity (take HF as the example) mass content/%	≤0.00002
7	Mineral oil mass content/%	≤0.0004
8	Toxicity	The biological examination proves free of toxicity

A.2 SF₆ gas package and storage

1) SF₆ gas shall be charged in the clean and dry gas cylinder. The filling coefficient of cylinder shall be less than 1.17kg/L for the designed pressure 8MPa, and when the pressure is 12.5MPa, the filling coefficient shall be less than 1.33kg/L; the gas cylinder shall be equipped with a safety cap and a shake-proof rubber ring.

2) SF₆ storage vessel shall be free of sun exposure, and shall far from the combustible place with oil stain. It shall be stored in the warehouse with shed, the warehouse shall be shady and ventilated, and the temperature shall not exceed 50°C.

3) SF₆ gas stored in the new cylinder for over half a year shall be subject to random inspection before use, and can be used after the standards are satisfied.

A.3 SF₆ gas density curve

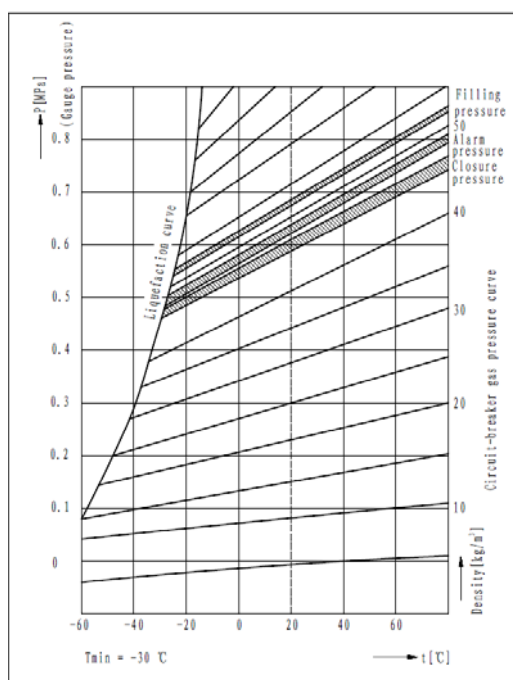


Figure A.1 SF₆ gas density curve

A.4 SF₆ pressure / elevation curve

SF₆ pressure / elevation curve, as shown in Figure A-2.

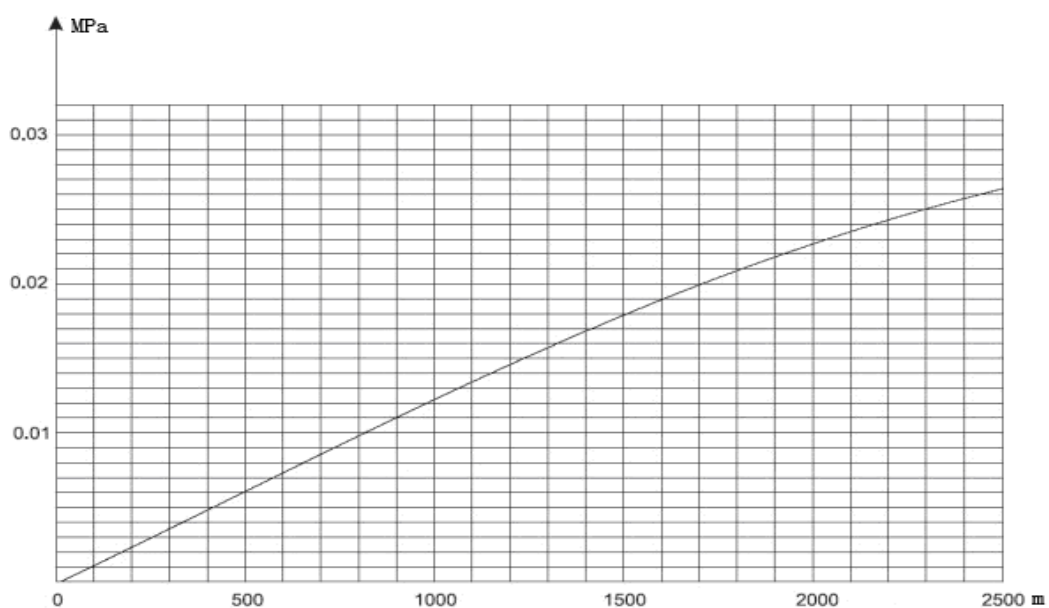


Figure A-2 SF₆ pressure / elevation curve

A.5: precautions for handling SF₆ gas.

A.5.1 SF₆ gas characteristics

- 1) SF₆ is colorless and odorless. The density is 6.07g/L at 20°C and 1bar, five times of the gas density. The SF₆ is liquid under high pressure, so that it shall be stored and conveyed by using the gas tank.
- 2) SF₆ has chemical and thermal stability, inactivity (inertness), almost insoluble in water and nonflammable at the conventional ambient temperature.
- 3) SF₆ has high dielectric strength and excellent arc extinction characteristics, and becomes a good insulation and arc-extinguishing medium.
- 4) If SF₆ gas leak from the equipment, and mix with indoor air. The SF₆ may land on the ground or leak into basement because of its high concentration. Once mixed with the ambient air, SF₆ gas will not be separated.
- 5) If SF₆ is exposed in the electric spark and arc, decomposition will be caused until cooling, and recombination in the large range will occur.

A.5.2 Characteristics of SF₆ decomposer

- 1) SF₆ decomposition product has various toxicities, and it can react with the water vapor in the air and building material. Therefore, strong corrosive compounds such as gaseous low hexafluoride, solid metal fluoride and hydrofluoric acid may be produced, the compounds may cause skin, eye and mucosa allergies, and people may suffer from nausea, dizziness and pulmonary edema due to excessive inhalation.
- 2) The molecular sieve and aluminum oxide can absorb most of the decomposition concomitancy. Pay attention to the danger even there is a small quantity of the gaseous decomposition products. Judge through the pungent smell before risk of poisoning takes place.

A.5.3 Environment and health requirements

SF₆ obtained in the commercial approach is the non-toxic substance, and SF₆ containing impurities used in the switchgear will not cause hazards to health.

However, when SF₆ concentration reaches the volume percentage above 19%, special vigilance shall be caused! Such concentration can occur in the open and non-ventilated SF₆ gas compartment, closed basement, system shrinkage unit and low-layer room.

1) Work health requirements

- a) Prevent the skin, eyes or clothes from contacting with the decomposition products, do not swallow or breath in the air containing with these materials.
- b) The used clothes, material, filter in SF₆ device, respiratory equipment, maintenance tools or vacuum cleaner, switch dust and cleaning liquid shall be disposed, so as to prevent them from releasing the dust and water-soluble fluoride.
- c) Make sure that the skin, clothes and working place are free from pollution. Use plenty of water to clean if the skin is in contact with any dust.
- d) After the working clearance or task is completed, wash the face, neck, arm and hand with plenty of water.
- e) Do not bring the food, beverage, cigarette or stored food into the open room with SF₆ device containing switch dust.
- f) Smoking and the use of ignition device are prohibited.

2) Requirements for working environment

- a) Good ventilation must be provided. A significant ventilation effect shall be guaranteed for the ground layer.
- b) Make sure that there is no open fire or hot surface near the workplace.
- c) SF₆ gas compartment can only be opened when the gas pressure reach the atmosphere standard during evacuation.
- d) The maintenance equipment used for closed system operation must be used to charge and discharge SF₆ device. After such equipment is docked with SF₆ device, the connection air tightness must be detected.

A.5.4 Disposal of SF₆ decomposition concomitancy

- 1) Do not inhale the irritating and suffocating gas, and use the gas mask.
- 2) Do not contact dust and decomposer, and wear the dust proof clothes, gloves and goggles.
- 3) Clear dust with the special vacuum cleaner filled with micron filter.
- 4) Ventilate the room.
- 5) Wash the decomposition concomitancy and polluted equipment and clothes with clean water: before the wastewater is discharged, it shall be neutralized with saleratus (NaHCO₃), so that pH value reaches 7.

A.5.5 Health care measures

Move the victim out of the polluted area immediately once the victim is suffocated. Treatment shall be carried out as soon as possible. Whatever the conditions are, make sure that the doctor is informed of the toxicity symptoms and the risk of the delaying medical treatment.

A.5.6 Equipment

SF₆ gas processing equipment shall enable the gas compartment to rapidly discharge and charge gas, effectively and safely handle the waste material, and provide protection to the personnel.

A.5.6.1 Conduct gas-related work outside the gas compartment

- 1) Inform the people of instructions about safety regulations, including the drawing indicating the switchgear layout and gas compartment separation.
- 2) SF₆ maintenance unit or SF₆ Gas filling device with cylinder
- 3) SF₆ content percentage measuring device
- 4) The device measuring SF₆ water content.
- 5) SF₆ leakage measuring device.
- 6) Accurate pressure gauge 0 to 10MPa.
- 7) First aid equipment

A.5.6.2 Work in the open gas compartment without SF₆ decomposer.

The following equipment are also recommended for work in the open gas compartment in addition to the equipment recommended in 6.6.6.1.

- 1) Electric suction blower with hose for forced ventilation.
- 2) Cloth gloves.
- 3) Sleeve.
- 4) Oxygen measuring instrument.

A.5.6.3 Work in the open gas compartment with SF₆ decomposer.

- 1) Full vision safety goggles
- 2) Half-mask respiratory equipment with the combined filter cartridge.

- 3) Cotton gloves with protective sheath (rubber)
- 4) Place the double-layer plastic waste bag and plastic container with clean material.
- 5) Clean cloth roll, dustpan and brush made of lint-free paper.
- 6) High-power vacuum cleaner with fine dust filters adsorbing 0.3um particles.
- 7) Pre-filtration unit with joint and used for maintenance unit.
- 8) Decomposer measuring device with the corresponding quantity of test tubes

A.6 Gas filling

Fill small amount of gas into the gas compartment directly during equipment operating. Use the precise pressure meter in the charging process for indicating accurate pressure. Other value readings can be read through the density relay.

A.6.1 Warning

- 1) Carefully dry the Gas filling equipment, so as to avoid water entering the gas compartment.
- 2) The gas over charged in the gas compartment easily causes overpressure alarm or explosion-proof membrane fracture. Therefore, all necessary preventive measures shall be taken to prevent the situation.
- 3) Gas shall be charged at slow speed, so as to avoid inhalation of dust or icing of the Gas filling valve.

A.6.2 Gas density gauge description

- 1) The effects of temperature compensation are accurate only at the minimum operating pressure. If the pressure is different from the minimum operating pressure, the pointer cannot be accurately pointed at the pressure value at 20°C.
- 2) If the relative pressure standard meter is used for Gas filling, the relative pressure shall be calculated. Record the current environment temperature and the atmospheric pressure.
- 3) Preparation of the test equipment:
 - a) Connect the equipment with the gas cylinder.
 - b) Clear the gas and moisture in the pipeline and the standard pressure gauge.
 - c) Set the test device pressure, and the value is close to the pressure value in the measuring gas compartment. Valve cannot be operated at the moment.

d) Connect the equipment with the inspection joint.

e) Fill gas to the system: control the gas flow rate at 0.01 MPa/min during gas filling, and wait until the temperature is stable, so as to set the temperature calibration value.

f) Recover the gas compartment.

A.7 Gas filling

A.7.1 Gas compartment assembled on site

A.7.1.1 before Gas filling

1) Place the adsorbent.

2) Vacuumizing

3) Fill SF₆ gas

A.7.1.2 After Gas filling

1) Check gas leakage of all gas compartments assembled on site.

2) Install the density relay, and check make sure it is in normal operation.

3) Measure and record water content in the gas compartment.

A.7.2 Gas compartment installed in the workshop and precharged with gas

1) Place the adsorbent in the gas compartment installed in the workshop, and precharge N₂ slightly higher than the atmospheric pressure. Replacement of the adsorbents is not conducted on the site any more. However, vacuum and charge of SF₆ gas must be conducted during assembly.

2) Measure and record water content after Gas filling.

A.7.3 Complete Gas filling operation

A.7.3.1 Place the dry adsorbent. Precautions

1) The dwell time of adsorbent exposed in the atmosphere cannot exceed 1h.

2) Cover the gas compartment, and evacuate as quickly as possible after installation. If the Gas filling operation is delayed, SF₆ gas higher than the atmospheric pressure shall be charged in the gas compartment before the vacuum pump is disconnected.

3) Make sure that there is no condensation before the gas compartment is opened or the gas

entered. If the temperature of the gas compartments is lower than or equal to the environment temperature, inside condensation is likely to happen.

Cautions: the gas compartment not disassembled shall be charged with N₂ at ex-factory, and the adsorbent will not be replaced on site. However, vacuum must be pumped to charge SF₆ gas during assembly.

A.7.3.2 Start vacuum pumping, detect leakage, and charge SF₆ gas to the rated pressure.

A.7.3.3 Measure and record the water content.

A.8 Measurement of leakage rate

Adopt the local wrapping method.

A.8.1 Local wrapping method

A.8.1.1 Several common position wrapping methods for leak detection:

- 1) Flanged connection position of the tank body: wrap the flanged connection position of the tank body with PVC, seal the middle opening with tape, and bundle both ends on the tank body with tape in a solid way.
- 2) Position of CB gearing mechanism,DS,ES: wrap the whole CB gearing mechanism box with the plastic bag with an end sealed, and bundle the open end on the tank body with tape in a solid way.
- 3) Position of the end cover plate: wrap the whole crank arm box with the plastic bag with an end sealed, and bundle the open end on the tank body with tape in a solid way.

A.8.1.2 Precautions for local wrapping for leak detection

- 1) No hole in the plastic cover (bag).
- 2) The volume of the plastic cover (bag) shall be appropriate, about 2L to 5L.
- 3) All leak detection points shall be covered, free of omission.
- 4) The inspector shall be careful and responsible, and the detection equipment and appliance shall be good and reliable.

A.8.1.3 Measurement procedure

- 1) Pump vacuum of the product, and then wrap all sealing position of the coupling flange surface and axle afterwards.

2) Detection before settling.

3) Settle the sample.

4) Detection after settling.

A.8.1.4 Calculation and qualification judgment

If the test value of package do not change more than 20 μ L/L, the product leakage is qualified, and otherwise it is unqualified.

A.8.2 Detection equipment

1) Use SF₆ leak detector to measure product leakage rate.

2) Equipment principle: ECD (electron capture detector) principle is adopted for the instrument, which is the gas chromatographic detector with the highest sensitivity and the selective detector appearing at the earliest. It only responds to those compounds capable of capturing electrons such as halogenated hydrocarbon and compounds containing heteroatoms of N, O, S, etc., and the applied range is wide.

3) Instrument calibration: the instrument can conduct calibration automatically. After the detector is started, preheating is conducted for 10min. After preheating is over, the system can be calibrated automatically and then enters in the testing state.