Phase Segregated Type

SF₆ Gas Insulated Switchgear

Type SDA514 for 72.5 to 145 kV

Example of GIS

Typical Layout

[Unit: mm]
Small Space Requirement & High Reliability

The number of application for SF₆ gas insulated switchgear has been tremendously growing all over the world, because it has many advantageous features as below:

- Small space requirement
- High reliability
- Safety
- Good harmony with environment
- Long maintenance intervals
- Short erection period at site

Fuji started the development of SF₆ gas insulated switchgear (GIS) in 1966. The first 72.5 kV GIS, which was of the phase segregated type, was put into operation in 1970. Since then Fuji also developed three phase encapsulated type GIS in addition to phase segregated one as our standard series of GIS. Based on these experiences with high technology, Fuji has successfully developed as a standard series which realizes a quite compact and very reliable construction of phase segregated type GIS. The 72.5 kV and above GIS is being manufactured in our substation equipment factory located in Chiba prefecture, Japan. The substation equipment factory has been recognized to be in accordance with the requirements of the quality standards ISO 9001.

SDA514 145 kV 2000 A 40 kA

Small overall dimensions make for minimum space requirements. Therefore, the costs of foundations and buildings can be minimized.

Long service life of the switchgear can be realized due to nonoxidizing of SF₆ gas in enclosure and oil in electro-hydraulic operating mechanism.

The modular design principle applied realizes the standardization of components and parts. This makes possible the large quantity production way which increases the reliability of components and parts with their easy stock control.

The fully earthed enclosure protects operators not to touch live parts directly, prevents from radio interference, and realizes no atmospheric pollution.

### Technical data

<table>
<thead>
<tr>
<th></th>
<th>IEC</th>
<th>ANSI</th>
<th>JEC</th>
</tr>
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<tbody>
<tr>
<td>Rated voltage [kV]</td>
<td>72.5</td>
<td>100</td>
<td>123</td>
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<tr>
<td></td>
<td>145</td>
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<tr>
<td>Rated power frequency withstand voltage [kV]</td>
<td>IEC</td>
<td>140</td>
<td>116</td>
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<tr>
<td></td>
<td>ANSI</td>
<td>160</td>
<td>280</td>
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<tr>
<td></td>
<td>JEC</td>
<td>140</td>
<td>230</td>
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<td>Rated lightning impulse withstand voltage [kV]</td>
<td>IEC</td>
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<td>450</td>
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<td></td>
<td>ANSI</td>
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<td>550</td>
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<tr>
<td></td>
<td>JEC</td>
<td>350</td>
<td>550</td>
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<tr>
<td>Rated normal current [A]</td>
<td>Busbar</td>
<td>2000, 3150</td>
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</tr>
<tr>
<td></td>
<td>Others</td>
<td>1200, 2000, 3000</td>
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</tr>
<tr>
<td>Rated short-circuit breaking current [kA]</td>
<td>31.5</td>
<td>40</td>
<td></td>
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<tr>
<td>Rated short-time withstand current (3 sec.) [kA]</td>
<td>31.5</td>
<td>40</td>
<td></td>
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<tr>
<td>Rated peak withstand current [kA]</td>
<td>IEC, JEC</td>
<td>80, 100</td>
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<tr>
<td></td>
<td>ANSI</td>
<td>85, 108</td>
<td></td>
</tr>
<tr>
<td>Rated SF₆ gas pressure, gauge (at 20 ℃) [MPa]</td>
<td>Switchgear</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Circuit breaker</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Rated break time of circuit breaker [cycles]</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated operating sequence of circuit breaker (standard)</td>
<td>IEC</td>
<td>0-3 min-CO-3 min-CO, CO-15 s-CO, O-0.3 s-CO-3 min-CO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ANSI</td>
<td>CO-15 s-CO, O-20 cycles-CO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>JEC</td>
<td>O-1 min-CO-3 min-CO, CO-15 s-CO, O-0.35 s-CO-1 min-CO</td>
<td></td>
</tr>
</tbody>
</table>
Section of a Cable Feeder Bay with Double Busbar

Fig. 1 Sectional view of a cable feeder bay with double busbar

Fig. 2 Single line diagram of double cable feeder bay with double busbar
Circuit breaker

Thousands of Fuji SF₆ circuit breakers with hydraulic operating mechanism were delivered into all over the world and have been in satisfactory operation since 1973. The SF₆ switchgear is equipped with the single pressure puffer type gas circuit breaker with hydraulic operating mechanism which is used uniformly also for outdoor circuit breakers. Fuji SF₆ circuit breakers have the advantages:

- Low noise level during operation
- Excellent interruption performance
- Long maintenance intervals
- Individual energy supply, no air-compressor necessary

The earthed metal housing accommodates single pole interrupter fixed on insulating mount and support insulator for each phase. At the front of the circuit breaker, the operating box is arranged, which accommodates hydraulic operating mechanism and monitoring unit for the circuit breakers. The interrupter has a double-flow system and the compressed SF₆ gas which is produced by the movement of the puffer cylinder at opening, flows into both directions in order to distinguish effectively the generated at arcing contacts. The moving section is composed of nozzle, moving contact and puffer cylinder connected to hydraulic operating mechanism through insulating rod and operating links mechanically.

The current path is composed of fixed contact support, fixed contact, moving contact and moving contact support. This inspection and replacement of nozzle and arcing contacts can be carried out by removing the access cover.

Fig.3 Section of SF₆ circuit breaker

Fig.4 Principle of arc quenching

- Closed position
- Opening (priming)
- Opening (arc quenching)
- Open position

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Components and Construction

Hydraulic operating mechanism

Oil-hydraulic operating mechanism is almost free from rust and corrosion unlike other operating mechanisms such as motor-spring or pneumatic systems.

- Oil pump, oil tank, main valve unit, pilot valve unit, pressure switches and gauges are incorporated as one block unit and connected directly to main cylinder.
- Therefore, the most compact, very reliable and pipeless hydraulic operating mechanism was realized.
- The valve seal of oil system is made of metal seat and metal ball, which eliminate damage of valve seal due to eccentricity and are good for permanent use without necessity of replacement.

Busbar

- The single-phase conductor made of aluminum or copper, depending on the current rating, is supported by the gas tight insulators.

Disconnectors and earthing switches

- Line disconnector is incorporated together with earthing switches in one housing as a combined disconnectors/earthing switch.
- Bus disconnector is assembled in each bus enclosure.
- Disconnectors are normally motor or manual-operated. Earthing switches are normally manual-operated.
- The disconnectors have a switching capability of bus-transfer current, small current as charging current and transformer magnetizing current, if required.
- The make-proof earthing switch is provided with the motor-charged spring mechanism.
- Maintenance earthing switches on the both sides of the circuit breaker are linked together by a operating rod and operated by the common operating mechanism.
- Earthed side of the earthing switch is brought out from the earthed metal housing and earthed to it through a removable bolted link for primary injection test.

Current transformer

- The current transformer is of foil-insulated bushing type with ring cores mounted in a CT housing.
- The cable through type current transformer is also used for cable feeder unit, if necessary.

Voltage transformer

- The voltage transformer is of the inductive type. SF6 gas provides the high-voltage insulation.
- The high-voltage winding discs are well insulated by plastic foils.

Surge arrester

- The surge arrester consists of zinc oxide (ZnO) element with excellent low residual voltage characteristics and long service life.
**SF₆ gas system**

Rated SF₆ gas pressure is unified at 0.6 MPa, gauge for all components. SF₆ gas pressure changes depending on the ambient temperature as shown in Fig.9 pressure-temperature characteristic curve. The monitoring of SF₆ gas is carried out by means of temperature compensated pressure switches in the manner as tabulated below.

<table>
<thead>
<tr>
<th>Components</th>
<th>Rated SF₆ gas pressure (MPa)</th>
<th>Low alarm pressure (MPa)</th>
<th>Operation lockout pressure (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit breakers</td>
<td>0.6</td>
<td>0.55</td>
<td>0.5</td>
</tr>
<tr>
<td>Disconnector and earthing switches</td>
<td>0.6</td>
<td>0.55</td>
<td>Note</td>
</tr>
<tr>
<td>Other components</td>
<td>0.6</td>
<td>0.55</td>
<td>Note</td>
</tr>
</tbody>
</table>

Note: Operation lockout at 0.5 MPa (at 20 °C) is upon request.

Fig.10 shows the typical gas zones and gas monitoring system. The SF₆ gas filled disconnectors/bus chamber is sealed off from the adjacent unit by gastight and arc-proof insulators.

A similar insulator seals off this chamber from the circuit breaker. All gas zones are monitored by gas density relays. Three phase circuit elements are monitored in common. The switchgear has a very low gas leakage rate. Guaranteed gas loss is less than 0.5% per annum.

**Fig.9 Pressure-temperature characteristic curve of SF₆ gas**

<table>
<thead>
<tr>
<th>Pressure (MPa)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>0.4</td>
<td>20</td>
</tr>
<tr>
<td>0.3</td>
<td>30</td>
</tr>
<tr>
<td>0.2</td>
<td>40</td>
</tr>
<tr>
<td>0.1</td>
<td>50</td>
</tr>
</tbody>
</table>

**Condensation curve**

- Rated pressure [0.6 MPa at 20°C]
- Alarm pressure [0.55 MPa at 20°C]
- Lockout pressure [0.5 MPa at 20°C]

Note 1: Fuji also has 1800 mm of width between bays as our standard.

Note 2: Fig.11 to 14 show minimum height of GIS on each pattern. Height will depend upon CT requirement.
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