Commercialization of New Type of Vacuum Featured Gas Insulated Switchgear (VFS)

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Abstract

The 72/84 kV Vacuum Featured gas insulated Switchgear (VFS) is composed of a Vacuum Circuit-Breaker (VCB), disconnecting switch, earthing switch, surge arresters, instrument transformer, and current transformers practically located in a single enclosed vessel. This type of equipment has contributed greatly to economic efficiency, installation space saving, and reduction of maintenance labor hours.

Responding to current demands from customers for further economic efficiency and prevention of global warming, we recently commercialized a new type of VFS for power grids. It adopts compact power circuit components and contained sulfur hexafluoride gas (SF_6 gas) used as a sealed insulation medium. The amount of SF_6 gas used is reduced by lowering its pressure.

1 Preface

While a conventional open substation is composed of several types of single equipment, the Vacuum Featured gas insulated Switchgear (VFS) collects each equipment in one sealed container. Accordingly, the VFS is adopted not only in newly installed substations but also in the replacement (renewal) of substation facilities. The use of the VFS has greatly contributed to economic efficiency, installation space saving, and the reduction of maintenance labor hours.

Nowadays, our customers tend to call for increased economic efficiency and heightened consideration of global warming. In this connection, we focused on VFS for electric power companies, realized weight reduction of equipment by a compact design and standardization of on-board equipment, and weight reduction of a sealed container by lowering the pressure of the enclosed insulating medium (SF_6 gas).

This paper introduces specifications and features of a new type of the VFS for power grids.

2 Ratings and Major Units

Table 1 shows the ratings of a new type of VFS for power grids. Fig. 1 shows the internal construction of the new VFS for power grids. By reducing the pressure of sulfur hexafluoride gas (SF_6 gas), a greenhouse gas, the amount of SF_6 gas used can be reduced and the components can be shared with the equipment used in VFS for general end-users. The dimensions have been reduced and the mass has been reduced compared to the conventional type. Table 2 shows a comparison of the conventional VFS and the new type of VFS for power grids.

Table 1 Ratings of New Type of VFS for Power Grids

Ratings of the new type of VFS for power grids are shown.

Items	Ratings and specifications
Model name	VFS-60/VFS-70
Rated voltage	72/84 kV
Power-frequency withstand voltage	140/160 kV
Lightning impulse withstand voltage	350/400 kV
Rated continuous current	800/1200 A
Rated frequency	50/60 Hz
Rated short-time withstand current	200/25/31.5 kA 2 s
Rated gas pressure	0.07 MPa·G at 20℃
Minimum guaranteed gas pressure	0.05 MPa·G at 20℃
Standard No.	JEM-1499 (2012) JEC-2350 (2016)

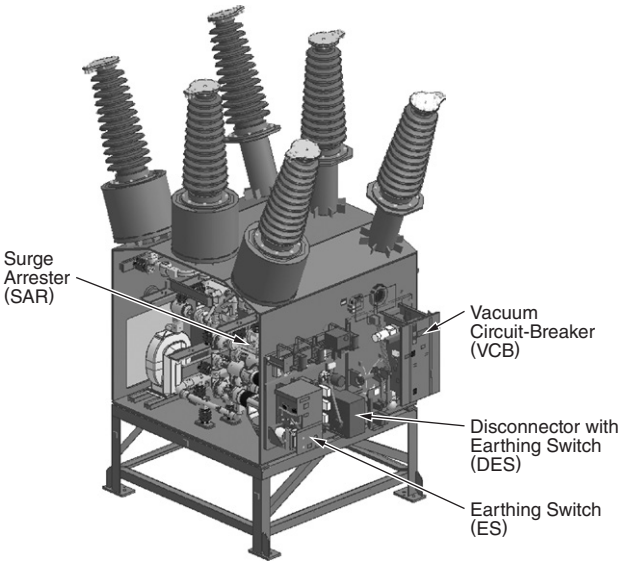

Fig. 1 Internal Construction of New Type of VFS for Power Grids

The internal construction of the new type of VFS for power grids is shown.

Table 2 Comparison of Conventional VFS and New Type of VFS for Power Grids

Comparison of dimensions, mass, and installation space is shown between the conventional VFS and the new VFS.

Item	Conventional VFS	New VFS for power systems
Rated gas pressure	0.10 MPa·G at 20℃	0.07 MPa·G at 20℃
External dimensions	W2645 × H3405 × D2780 mm	W2500 × H3360 × D2780 mm
Mass	6.4 t	5.5 t

2.1 VCB Unit

Table 3 shows a list of ratings and specifications for the VCB unit and Fig. 2 shows its construction. The Vacuum Interrupter (VI) is installed in a hermetically sealed vessel filled with SF_6 gas and a spring-operating mechanism is assigned on the air side. The pole unit has a construction where it is connected through the main circuit and contacts (contact structure). Materials of the VI insulation cylinders are modified from a conventional compound insulation system (glass and mold) to ceramics so that the VI exterior can be reduced. In addition, the latest vertical magnetic field type electrodes are adopted to establish a VI electrode structure to improve current interruption performance and current carrying characteristics.

Table 3 List of Ratings and Specifications for VCB Unit

Ratings and specifications of the VCB to be installed in the new type of the VFS for power grids are shown.

Items	Ratings and specifications
Type	VBU-70532JBB
Rated voltage	72/84 kV
Power-frequency withstand voltage	140/160 kV
Lightning impulse withstand voltage	350/400 kV
Rated continuous current	800/1200 A
Rated frequency	50/60 Hz
Rated short-time withstand current	31.5 kA 2 s
Rated contact parting time	0.05 s (5 cycles)
Contact closing time	0.1 s
Rated operating time	DC 100 V
Rated control voltage	DC 100 V
Rated gas pressure	0.07 MPa·G at 20℃
Operation system	Spring-charged closing, Spring-charged tripping
Standard operation duty	A/B/R
Standard No.	JEC-2300 (2010)

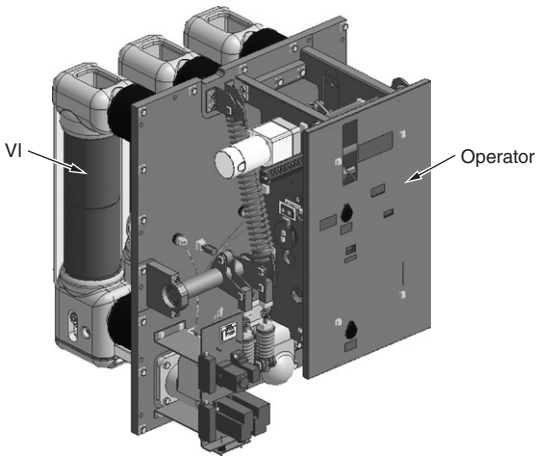

Fig. 2 Construction of VCB Unit

Construction of the VCB unit to be installed in the new type of the VFS for power grids is shown.

2.2 EDS Unit

Table 4 shows a list of ratings and specifications for the EDS unit and Fig. 3 shows the construction of the EDS unit. Withstand voltage performance is improved and operating mechanisms are simplified by adopting the operation method of the ON, OFF, and EARTH as a linear motion method. Since the structure design is based on an idea of making a mechanical interlock between the EDS and the ES, a sufficient safety is assured during operation.

Table 4 List of Ratings and Specifications for EDS Unit

Ratings and specifications of the EDS to be installed in the new type of the VFS for power systems are shown.

Items	Ratings and specifications
Type	DBU-70532JMH
Rated voltage	72/84 kV
Power-frequency withstand voltage	Line to earth: 140/160 kV
Lightning impulse withstand voltage	Line to earth: 350/400 kV
Rated continuous current	800/1200 A
Rated frequency	50/60 Hz
Rated short-time withstand current	31.5 kA 2 s
Value of capacitive current switching capability	1.0 A
Rated operating voltage	DC 100 V
Rated control voltage	DC 100 V
Rated gas pressure	0.07 MPa·G at 20℃
Operating system	Disconnector: Motor powered operation Earthing switch: Manual operation
Standard No.	JEC-2310 (2014)

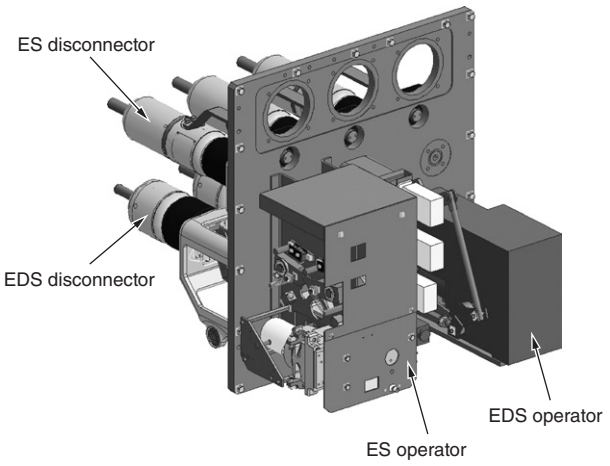

Fig. 3 Construction of EDS and ES Units

Construction of the EDS and ES units to be installed in the new type of VFS for power grids is shown.

2.3 ES Unit

Table 5 shows list of ratings and specifications for the ES Unit, and Fig. 3 shows the construction of the ES unit. This type of earth switch has a switching capability of an induced current. To secure efficient arc extinction performance during contact parting against induced current, a suction buffer system is adopted.

2.4 SAR Unit

This is a serial gapless surge arrester using zinc oxide elements. In the event of a surge arrester failure, a simplified separator unit is installed.

Table 5 List of Ratings and Specifications for ES Unit

Ratings and specifications of the ES to be installed in the new type of the VFS for power grids are shown.

Items		Ratings and specifications
Type		EPU-7032B
Rated voltage		72/84 kV
Power-frequency withstand voltage		140/160 kV
Lightning impulse withstand voltage		350/400 kV
Rated frequency		50/60 Hz
Rated short-time withstand current		31.5 kA 2 s
Switching ability	Static induction	0.3 A, 3 kV
	Electromagnetic induction	400 A, 3 kV
Rated gas pressure		0.07 MPa·G at 20℃
Operating system		Motor-charged spring operation
Standard No.		JEC-2310 (2014)

3 Features

3.1 Modular Design of Installed Equipment

The main equipment components of the VCB, EDS, ES, and SAR, adopted and realized a unit and compact design.

The operability of each device has also been improved by adopting a cassette method in which each device unit is assembled from the front side of the sealed container. In addition, we adopted a structure that can manage not only overhead line lead-in and lead-out work, but both cable laying-in-and-out work as well. In doing so, it is possible to meet any power delivery requirement of the end-user (by offering both overhead line lead-in and lead-out work and cable laying-in-and-out work.). Fig. 4 shows an example of cabling for a new type of VFS for power grids.

3.2 Reduction of Installation Labor Hours and On-Site Schedule

When carrying the VFS into the project site, there is little disassembly work required, and especially, in the case of overhead line lead-in and lead-out work, it is possible to carry out shipment in an integrated state by simply removing the support structure for the sealed container. There is, therefore, no need to collect and fill SF_6 gas at the time of shipment nor on-site installation. We could, thus,

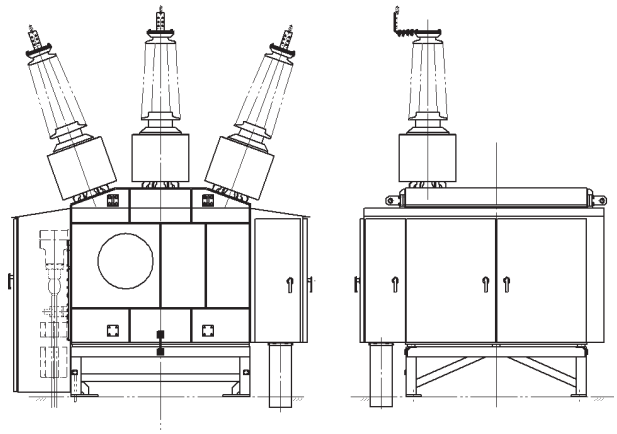

Fig. 4 Example of Cabling for New Type of VFS for Power Grids

An example of application of cabling to the new type of the VFS for power grids is shown.

Fig. 5 Application Example of Mobile Switchgear

This shows an application example of a mobile switchgear using the new type of the VFS for power grids.

achieve a shortened installation and on-site construction period.

3.3 Management, Maintenance, and Removal

In terms of operation and maintenance, each on-board equipment adopts a modular design, so even if the unit needs to be replaced, the replacement work can be easily performed. In addition, because the amount of SF_6 gas used has been reduced, the gas collection time and gas disposal cost at the time of removal have been reduced.

3.4 Operation as a Mobile Switchgear

We took advantage of the fact that VFS has a structure that allows the transportation of integrated state by simply removing the support structure. By eliminating the support structure and by putting the VFS on the trainer, it has been realized as a mobile switchgear. Fig. 5 shows an application example of a mobile switchgear.

4 Postscript

We have commercialized a new type of VFS for power grids. We took into account the economic efficiency and measures to prevent global warming.

We will continue to develop products that are eco-friendly and earn the trust and satisfaction of our customers.