12 kV HS-X Type C-GIS for Overseas RMU Renewal Market

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1. Introduction

In the overseas markets for 12 kV loop-powered receiving systems, a ring main unit (RMU) comprising one vacuum circuit breaker (VCB) unit and two load break switch (LBS) units has been the typical configuration.

Recently, however, there has been an increasing demand to renew the existing RMU to a cubicle-type gas insulated switchgear (C-GIS) comprising three VCB units, for the purpose of shortening the power outage time. In response to this demand, Mitsubishi Electric Corporation has developed a 12 kV HS-X type C-GIS (hereafter, "HS-X type C-GIS").

This paper describes the arrangement, configuration, specifications, and technologies of the HS-X type C-GIS.

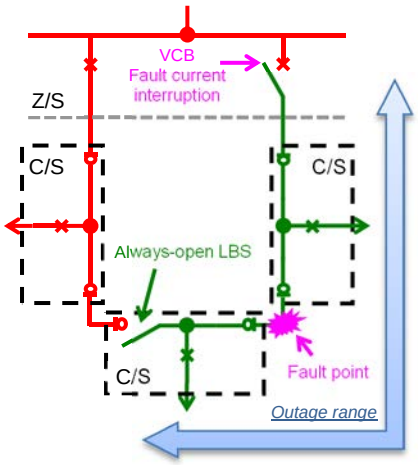
2. HS-X type C-GIS

2.1 Loop-powered receiving system and C-GIS arrangement

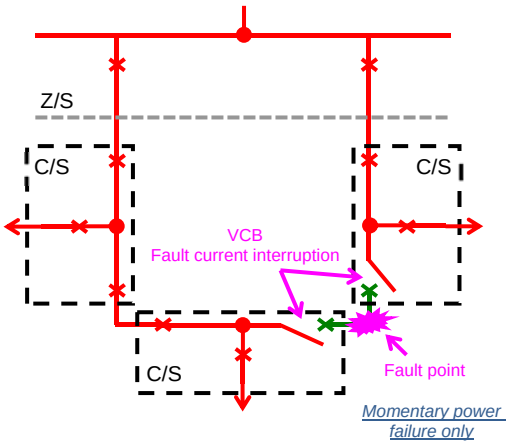
Figure 1 (a) shows an open-ring type loop-powered receiving system that uses the existing RMU. From the RMU of each consumer substation (C/S), a VCB is connected to the load side. Two LBSs are connected to a nearby C/S. A loop system is formed via the VCB of the zone substation (Z/S). This is called an open-ring system. Since one location of the LBSs in the system is always open, when a fault occurs, power will be lost from the always-open LBS to the VCB of the Z/S, with the fault point between them. Later, the LBSs on both sides of the fault point are opened, and the other systems are restored, while the power outage continues for several minutes.

On the other hand, if all LBSs were replaced with a VCB capable of fault current interruption, it would be possible to keep the loop system always closed, as shown in Fig. 1 (b). When a fault occurs, the VCBs on both sides of the fault point are instantly opened, limiting the power outage time to nearly zero (momentary power failure only). This is called a closed-ring system.

Figure 2 shows the C-GIS arrangement for a closed-ring type C/S. The minimum configuration is two incoming panel faces to be connected to the loop system and one feeder panel face to be connected to the load side. More feeder panels can be added depending on the configuration on the load side.



(a) Open-ring system



(b) Closed-ring system

Fig. 1 Loop-powered receiving system

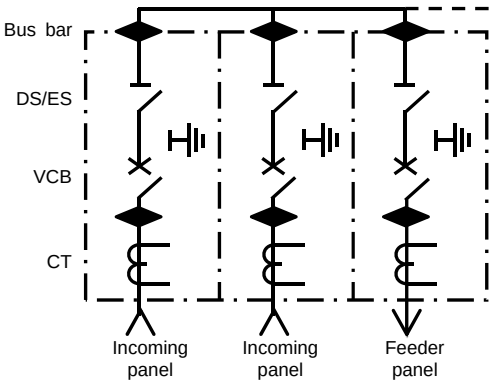


Fig. 2 C-GIS arrangement for C/S in closed-ring system

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2.2 Configuration and specifications of HS-X type C-GIS

Figure 3 shows the configuration of the HS-X type C-GIS. Table 1 shows its specifications. Placed inside the tank, which is filled with SF_6 (sulfur hexafluoride) gas as the insulation medium, are a VCB and a disconnect switch/earthing switch (DS/ES) on its bus bar side. Each device has its operating mechanism on the front, all of which are mounted on a flange as a single unit.

Bushings are mounted at the bottom of the tank in the vertically downward direction, where cables are to be connected. Current transformers (CTs) are placed on the cable compartment side (in the air) at the bottom of the tank, in such a way that the bushings penetrate them. On the tank ceiling, a plug-in type bus bar is connected via another bushing, using a solid insulated adapter.

A pressure relief plate is placed at the rear of both the tank and the cable compartment. If an internal arc fault occurs, the pressure relief plate is opened as the internal pressure rises. The internal arc classification pursuant to the IEC standard is AFL (F for front and L for lateral side), since high-temperature gas is discharged to the upper section through the space on the rear side of the C-GIS.

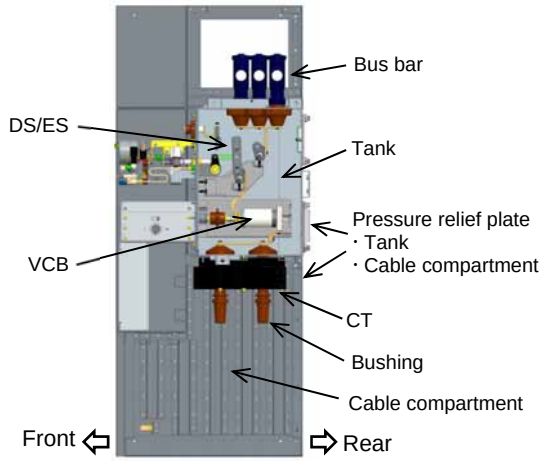

Fig. 3 Configuration of HS-X type C-GIS

Table 1 Specifications of HS-X type C-GIS

Device	Item	Specification
C-GIS	Applicable standard	IEC 62271-200
	Rated voltage	12 kV
	Rated current	630 A
	Rated frequency	50 Hz
	Short-time withstand current	21 kA, 3 s
	Internal arc classification	AFL 21 kA, 1 s
	Filling gas	SF_6 gas
	Gas pressure	Rated: 0.03 MPa-G Alarm: 0.02 MPa-G
Circuit breaker (CB)	Applicable standard	IEC 62271-100
	Type	Vacuum circuit breaker (VCB)
	Rated breaking current	21 kA
	Operating mechanism	Motor spring charged operation
	Classification	S1, M2, E2, C2
Disconnect switch/earthing switch (DS/ES)	Applicable standard	IEC 62271-102
	Operating mechanism	Manual operation
	Classification	M1, E0

3. Technologies used in HS-X type C-GIS

In the newly developed 12 kV HS-X type C-GIS, we employed five major technologies: (1) Unit downsizing and unit layout optimization; (2) high-temperature gas relief during an internal arc fault; (3) cable bushing compatible with both a compression terminal (existing cables) and a plug-in connector (new cables); (4) a plug-in bus bar using solid insulated adapters; and (5) robot welding for a gas tight tank.

3.1 Downsized unit and optimized unit layout

Figure 4 shows the configuration of the VCB-DS/ES unit of the HS-X type C-GIS. The main circuit section was renewed by changing the unit configuration of the existing 24 kV HS-X type C-GIS as a base to a 12 kV rating. The width dimension was cut by about 25% through the three-phase integration of insulators that support the pole assemblies of VCB-DS/ES. The depth dimension was also reduced by about 13% by placing the VCB operating mechanism at the lower front, which was previously dead space. By further optimizing the layout of the bushings, CT, etc., the panel exterior was downsized to width 450 × depth 820 × height 2,000 mm.

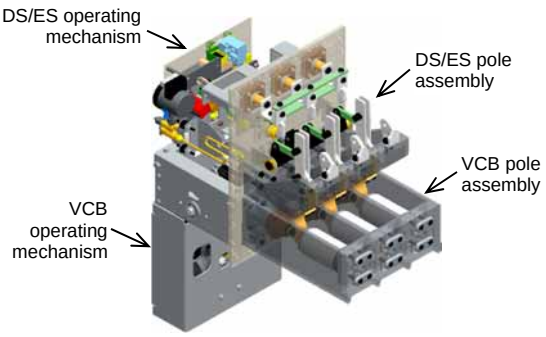

Fig. 4 Configuration of VCB-DS/ES unit

3.2 Internal arc pressure relief structure

The main target of the HS-X type C-GIS is renewal demand for the existing RMU. As such, it requires installation in a narrow electric room in a city basement, for example, which poses major restrictions on the depth dimension. Considering that such installation is against the wall, and on the assumption that personnel will not enter the rear side “R” of the C-GIS, we set the internal arc classification to “AFL,” where safety against high-temperature gas relieved during an internal arc fault will be secured only on the front side “F” and lateral side “L.” “A” indicates that only authorized personnel can approach the C-GIS.

Figure 5 shows comparison diagrams of the pressure relief path and the electric room outline of the 12 kV and an existing 24 kV HS-X type C-GIS. In the case of the 24 kV HS-X type, which has a pressure relief plate on the tank ceiling, a panel depth of 1,150 mm, and an “AFLR” designation that requires rear-side safety, the depth dimension including the rear-side space is 1,950 mm. On the other hand, in the case of the 12 kV HS-X type, a limited “AFL” designation allows for a pressure relief plate on the rear side; the panel depth is 820 mm thanks in part to the downsized unit as mentioned in the previous section; and high-temperature gas relieved on the rear side moves upward through the 100 mm space between the panel and the rear wall. Thus, the depth dimension including the rear-side space is 920 mm. In addition, the height of the electric room was also reduced from 3,400 mm to 2,600 mm by setting up a barrier at the front of the panel ceiling to restrict the discharge direction of high-temperature gas.

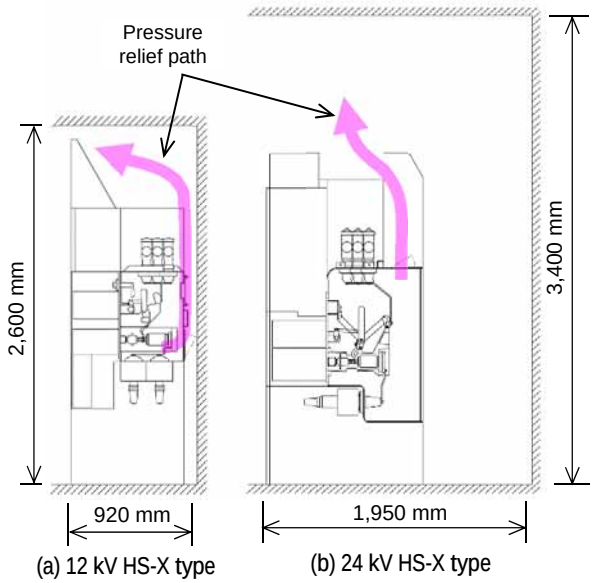

Fig. 5 Internal arc pressure relief path and electric room outline

3.3 Cable bushing

For the 12 kV HS-X type C-GIS, we developed a special cable bushing that faces the vertically downward direction so that the existing cable can be connected through the compression terminal in the air without installing a new cable equipped with a connector in compliance with common DIN (Deutsches Institut für Normung) standards (Fig. 6 (a)). This could shorten the power outage time when renewing the existing RMU.

The shape of the end resin of this bushing is the DIN standard type C. By removing the terminal, a new cable can be connected using a straight plug-in connector, as shown in Fig. 6 (b).

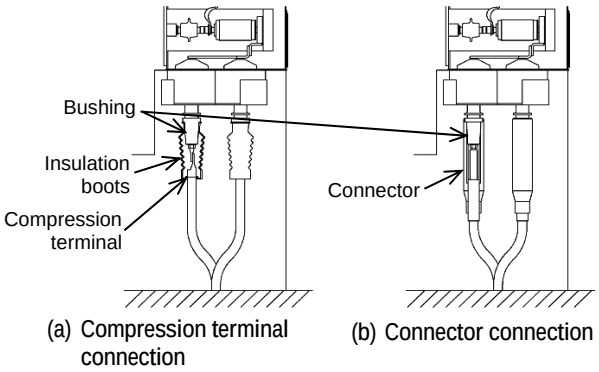

Fig. 6 Cable connection

3.4 Solid insulated plug-in bus bar

The 12 kV HS-X type C-GIS adopts a plug-in bus bar using solid insulated adapters, which have already been used in the existing 24 kV HS-X type C-GIS, successfully eliminating the need for on-site gas treatment during installation/panel arrangement. This could shorten the on-site installation time and reduce SF_6 gas consumption.

3.5 Robot welding

A robot welder (Fig. 7) has been introduced for gas tight welding of the tank. Although there are concerns to be addressed in the design or prototype stage, such as limited motion when welding inside the tank and the need for robot instruction each time a design is renewed or changed, the welding time during mass production (excluding welding preparation) can be shortened to one-half to one-third of that for manual operation. The welding state is also good.

Fig. 7 Robot welder

This C-GIS has a more reliable gas sealing structure for the mechanism using metal bellows and has eliminated the need for on-site gas treatment by using the solid insulated plug-in bus bar mentioned in the previous section, achieving an annual gas leak rate of

0.1 weight% or less. This meets the conditions required for exemption from periodical gas leak inspection during equipment operation under the revised F-gas regulation (No. 517/2014) of the EU.

4. Conclusion

We described the specifications, configuration, and technologies of the recently developed 12 kV HS-X type C-GIS. With our focus on renewal demand for the existing RMU, we have completed development conforming to internal arc classification "AFL" to accommodate narrow space installation. We plan to start offering the product to our customers in the latter half of FY2017. Figure 8 shows a three-panel arrangement of this C-GIS.

Fig. 8 Three-panel arrangement of HS-X type C-GIS

In the future, taking into consideration the demand for new installation, internal arc classification "AFLR," and rated current and other upgrades, we will seek to increase market share, as well as expand overseas procurement and production.