

# Development of the New 24kV Cubicle Type Gas-Insulated Switchgear (C-GIS) Series for Overseas Markets

**Keywords** Switchgear, Downsizing, Low power loss, Insulated busbars, No Gas Handling work, Standardization

## Abstract

A switchgear is a major apparatus that establishes a substation facility. The market calls for a compact and light-weight design, high reliability and safety, and labor-saving maintenance and inspection work. In general markets, there are many customers who value labor-saving installation work at the site in addition to the aforementioned requirements. Some customers may demand a switchgear that does not require sulfur hexafluoride (SF<sub>6</sub>) gas handling work (vacuum purging work and gas filling work) during panel installation on-site. In order to meet such requirements, we developed a new type of 24kV Cubicle type Gas Insulated Switchgear (C-GIS). The new 24kV C-GIS employs plug-in type insulated busbars and does not require any gas handling work during on-site panel installation. In addition, the Vacuum Circuit-Breaker (VCB) and disconnecting switch with an earthing switch (EDS) are assembled into an integrated unit configuration. As a result, the newly developed switchgear has a feature realizing 50% reduction in size compared with conventional model.

## 1 Preface

A switchgear is a major apparatus that establishes a substation facility. The market calls for compact and light-weight design, high reliability and safety, and labor saving maintenance and inspection work. Meiden commercialized the Cubicle type Gas Insulated Switchgear (C-GIS) featuring a compact design, improved reliability, and labor-saving maintenance and inspection work compared with the medium-voltage class (12/24/36kV) Air Insulated Switchgear (AIS). Our C-GIS has been delivered to many customers, and in particular, to power utility firms and private customers domestically and abroad.

Among our supply records, the 24kV C-GIS for overseas users “HICLAD-20GB (‘20GB’ hereafter)” is our main product and more than 10,000 units have been delivered mostly to a Singapore power utility firm. In general end-user markets, there are many customers who value the feature of labor saving installation work on-site. These customers may demand a product that does not require any sulfur hexafluoride (SF<sub>6</sub>) gas handling work (air purging work and gas filling work) during on-site panel installation.

Such a feature is very common in the C-GIS produced by European suppliers (SIEMENS, ABB) with a large world share. This paper introduces a new type of 24kV C-GIS “HICLAD-20GC (‘20GC’ hereafter)” designed and developed to meet such requirements.

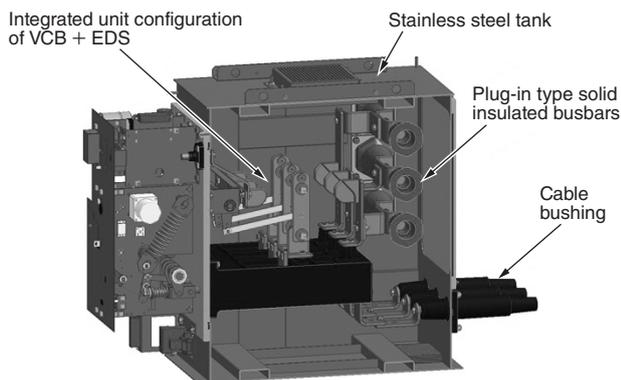
## 2 Ratings and Construction

**Fig. 1** shows an internal structure of the 20GC where the Vacuum Circuit-Breaker (VCB) and disconnecting switch with an earthing switch (EDS) are assembled into an integrated unit. **Table 1** shows specifications and the comparison result with the 20GB model.

## 3 Features

### 3.1 Going Compact by Integration of VCB and EDS into a Unit

**Fig. 2** shows a comparison result of the 20GC (Standard model) with the 20GB (Conventional model). The 20GB has a partitioned internal structure where the divided compartments for the VCB and the EDS are allocated. For the 20GC, the VCB



**Fig. 1 Internal Structure of the 20GC**

In the same SF<sub>6</sub> gas-filled area, it accommodates a VCB and an EDS as an integral unit.

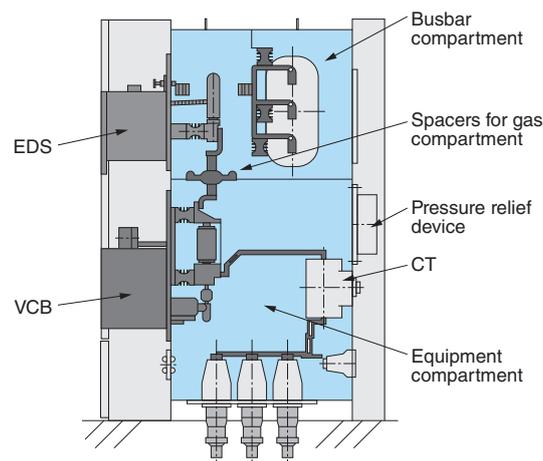
**Table 1 Specifications and the Comparison Result with the 20GB Model**

Compared with the conventional model, the 20GB, we realized a compact design (50% reduction in volume ratio). In addition, it does not require SF<sub>6</sub> handling work (air purging work and SF<sub>6</sub> gas filling work) at the on-site work.

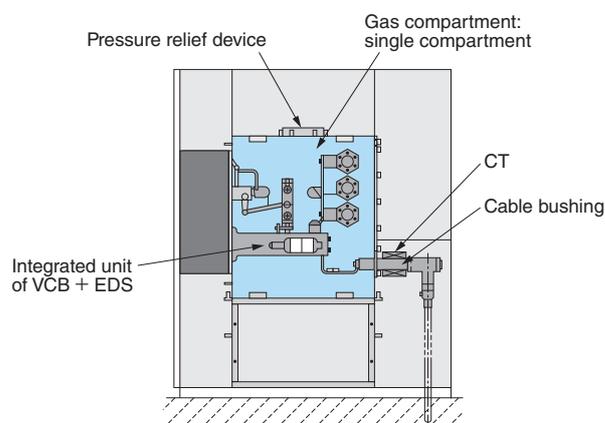
Items	Specifications	
Model name	20GB (Conventional model)	20GC (Standard model)
Rated voltage	24kV	
Rated current	1250A	
Rated breaking current	25kA	
Rated short-time withstand current	25kA-3s	
IEC class	E1, M1, C1, S1	
Rated gas pressure	0.05MPaG at 20°C	
Internal arc protection grade	25kA, AFLR	
Applicable standard	IEC 62271-200	
Loss of service continuity category <sup>(※1)</sup>	LSC2A	LSC2
On-site gas handling work	Required	Not required
Panel width	650mm	500mm
High voltage compartment volume ratio	100%	50%

Note: ※1. This category defines the possibility to keep other high-voltage compartments and/or functional units energized without stopping when there is a fault in a high voltage compartment or when opening an accessible high-voltage compartment. (IEC 62271-200).

and the EDS are put into an integrated unit. In doing so, these two components are changed to a single gas compartment. As a result, spacers for the partitioning of gas compartments became unnecessary. In addition, an optimal design for the main-circuit conductor was carried out by numerical electric field analysis. This approach is quite effective for the reduction of phase-to-phase and phase-to-earth insulation clearances. Formerly, the Current Transformers (CT) was accommodated inside the stainless tank



(a) 20GB (Conventional model)



(b) 20GC (Standard model)

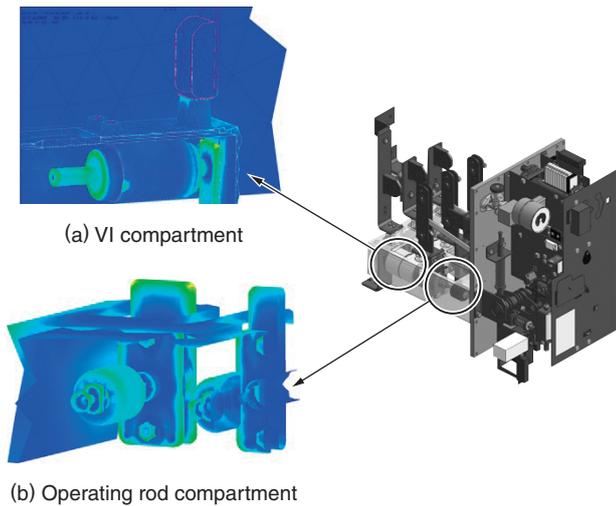
**Fig. 2 Comparison Result of 20GC with 20GB**

In the case of 20GC, the VCB and the EDS became integral units. Compared with the conventional model 20GB, the volume of the high voltage compartment is reduced by 50%.

of the C-GIS. Since these CTs are put outside the tank and around cable bushings (air borne side) in new model, the compact design on the high voltage compartment was realized. As a result, the panel width became 500mm and the volume of high voltage compartment is 0.34m<sup>3</sup> (50% reduction compared with volume ratio of conventional 20GB). This represents a world's smallest class C-GIS. Fig. 3 shows a result of electric field analysis for the VCB unit.

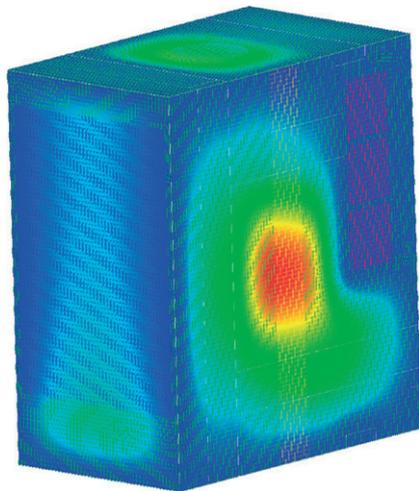
### 3.2 Low Power Loss and Painting-Free Construction by Adopting Stainless Steel Enclosure

The high voltage compartment is contained in a stainless steel enclosure that has non-magnetic and corrosion-resistant characteristics. This is the first case when this material is adopted for our C-GIS. Since the non-magnetic material is used, ohmic losses of the enclosure, caused by eddy currents are reduced. In addition, we realized a shorter



**Fig. 3** Result of Electric Field Analysis for the VCB Unit

Based on the result of electric field analysis, we created an optimal design on the shapes of the main-circuit conductors.



**Fig. 4** Enclosure Stress Analysis

By making enclosure stress analysis, we made an optimal design on the enclosure reinforcement.

manufacturing process because it does not require a painting process. The effect of enclosure compact design influencing the internal arc fault performance was examined. (This performance means that the enclosure is not destroyed during the internal arc fault event and the inner gas is safely discharged from the pressure relief device without affecting nearby workers.) For this safety examination, stress analysis was carried out to optimize the enclosure reinforcement. The result of actual testing indicates that the performance was satisfactory in accordance with the relevant IEC Standard. Fig. 4 shows a view of enclosure stress analysis and Fig. 5 shows a situation of the internal arc fault test.

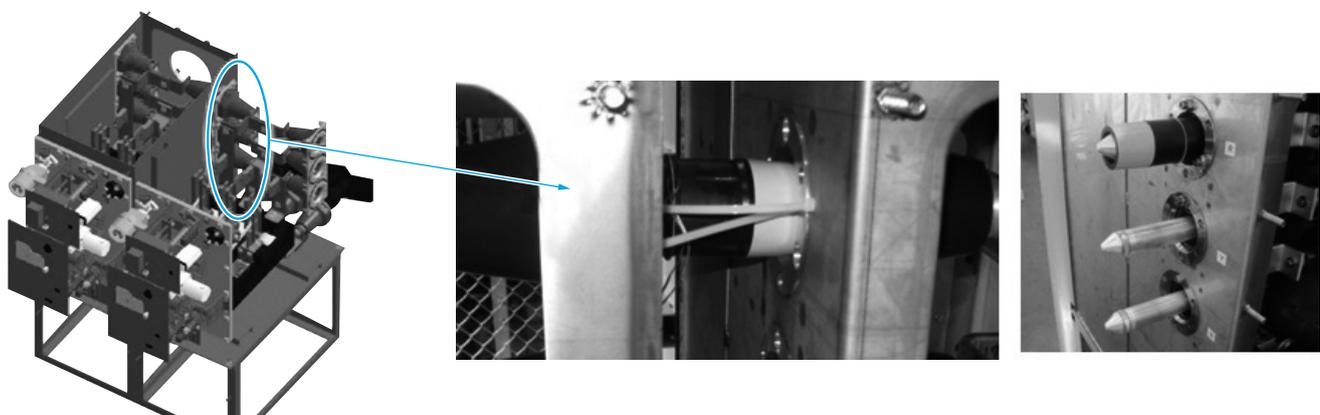
### 3.3 No SF<sub>6</sub> Gas Handling Work during On-Side Panel Installation by Adopting Plug-in Type Solid Insulated Busbars

Fig. 6 shows a busbar compartment construc-



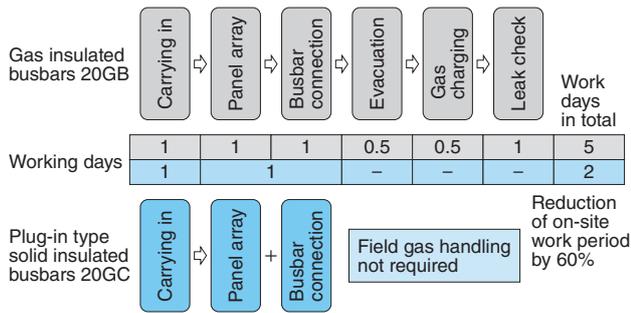
**Fig. 5** Situation of the Internal Arc Fault Test

By actual testing, we verified that the equipment meets with the IEC Standard requirements.



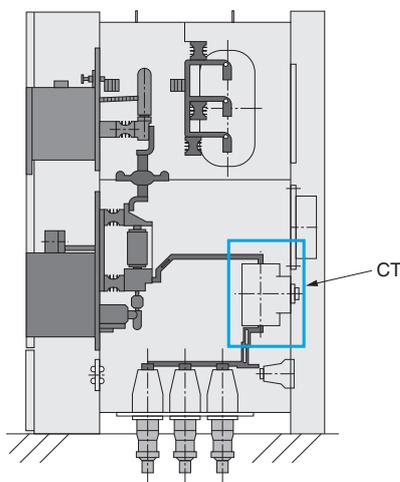
**Fig. 6** Busbar Compartment Construction

Since the plug-in type solid insulated busbars are adopted, it does not require gas handling work on-site.



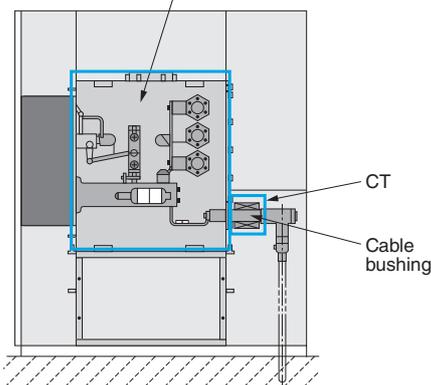
**Fig. 7** Number of Days of On-Site Work Schedule (This is for Standard 5-Panel Configuration.)

Since on-site gas handling work is not required, it realized a 60% reduction of scheduled construction work.



(a) 20GB (Conventional model)

Standardization of high voltage compartment



(b) 20GC (Standard model)

**Fig. 8** Standardization of High-Voltage Compartment

We put the CTs outside the tank and around the cable bushing (external airborne side) and then worked on standardization for the high voltage compartment.

tion. Since plug-in type solid insulated busbars are adopted, busbar connection work is possible by connecting the cable bushing outside the tank of C-GIS. This does not involve the SF<sub>6</sub> gas handling

**Table 2** Arrangement Variety Designs

The 20GC can flexibly meet the required change of arrangement to meet the customer's demands.

	Basic type	Arrangement ①	Arrangement ②
Construction diagram			
Customer specification	—	<ul style="list-style-type: none"> <li>• Busbar VT and line side VT incorporated</li> <li>• Cable top entry</li> </ul>	<ul style="list-style-type: none"> <li>• Front access to cables</li> <li>• Cable box with interlock function</li> </ul>

work (vacuum purging gas filling work). In doing so, we worked on reducing the installation period (from 5 days to 2 days). Fig. 7 shows the number of days of on-site work schedule (This is for standard 5-panel configuration.).

### 3.4 Standardization of High-Voltage Compartment by External Mounting of CTs

Fig. 8 shows standardization of the high-voltage compartment. The CTs were put around the cable bushing outside the tank though formerly they were installed inside the SF<sub>6</sub>-filled tank. In this arrangement, a factor of high voltage part (inside tank) specification change (this case CT design) was eliminated. In doing so, we standardized the high voltage part and improve productivity.

### 3.5 Improvement of Arrangement Variety Design

Thanks to the compact design of the high-voltage compartment of the C-GIS, we now can meet a variety of customer demands such as putting various external mounting CTs or making cable box front-accessible. Table 2 shows an example of an arrangement variety designs.

## 4 Test Result

This C-GIS went through type-certification and reliability tests shown in Table 3 at a third-party type-testing and certification institution in Korea,

**Table 3** List of Type Test Items

A list of Type Test items is shown.

IEC standad	Type test items
<b>62271-200 C-GIS</b>	Dielectric tests
	Temperature-rise tests
	Short-time and peak withstand current test
	Arcing due to internal fault tests
<b>62271-100 VCB</b>	Short-circuit current making and breaking tests
	Capacitive current switching tests
	Out of phase making and breaking tests
	Single-phase and double earth fault tests

Korea Electrotechnology Research Institute (KERI) which is a member of the Short-Circuit Testing Liaison (STL). We confirmed that the C-GIS has a positive performance and we received the third party type certification.

## 5 Postscript

We have developed a new type of 24kV C-GIS “HICLAD-20GC” that has the world’s smallest class size. Since we realized the compact design on the high voltage compartment, the 20GC now can offer a design variety to meet the various specifications and requirements of overseas markets. In addition, it has a feature of not needing SF<sub>6</sub> handling work (air purging work and SF<sub>6</sub> gas filling work) at on-site switchgear installation. For such reasons, we could supply more than 300 units of our C-GISs to the ASEAN markets.

Going forward, we will work on the improvement of our product offerings and we will reinforce local production in our overseas production hubs.

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