Development of Product Series for 24 kV Cubicle Type Gas Insulated Switchgears (C-GIS)

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Abstract

The markets currently call for switchgears to be a more compact design, with mass saving, and a higher reliability and safety. We developed and delivered 24/36 kV switchgears to a variety of customers. The following two types of models were additionally developed:

(1) The 24 kV Cubicle Type Gas Insulated Switchgears (C-GIS) for overseas customers called "20 GB"

Further reduction of size and mass was attained by making the specification limited to the rated current up to 800 A. This model passed a series of type tests at Korea Electrotechnology Research Institute (KERI), a third-party organization.

(2) The 24 kV Double Busbar Type C-GIS for Japan Market was developed based on upper model 36 kV C-GIS "30 GB" for overseas markets.

The high reliability double busbar system is adopted. Bus-transfer current switching test stipulated by JEC2310 was carried out and the specified requirements were satisfied. Since inside panel bellows are adopted, the structure is convenient for the replacement of an intermediate panel.

1 Preface

Switchgears are major equipment to compose substation facilities. The markets call for a compact design, mass saving, higher safety, and easy maintenance for labor-saving. We commercialized medium-voltage class (12/24/36 kV) cubicle type gas insulated switchgear (C-GIS) featuring further a compact design, more improved reliability, and easy maintenance for labor-saving in comparison with air-insulated cubicles. Our C-GISs have been supplied to many customers represented by power utility companies and private end-users at domestic and abroad.

To aim for further market share expansion, we realized a compact design and mass saving for the 24 kV C-GIS called the "20 GB", a major product for overseas markets. It has supply records of more than 10,000 panels, power utility in Singapore. Based on upper model 36 kV double-busbar type C-GIS called the "30 GB" for overseas markets, we also developed the 24 kV double-busbar type C-GIS for Japan Market. This paper introduces the major features of these products.

2 Compact and Mass Saving Design for 20 GB

To meet the requirements from our customers for a further compact design, the equipment rating, which was previously designed common with 1250 A and 800 A, has now been reduced to limited 800 A specifications. In doing so, we realized a compact and mass saving design.

2.1 Ratings and Construction

The panel width was reduced from the conventional 650 mm to 550 mm, and the C-GIS volume has been reduced to 85% compared to the conventional one. In addition, the busbar connection dimensions are compatible with conventional model, making it feasible to add this newly developed model to existing substations. Fig. 1 shows the construction of the newly developed model. Fig. 2 shows the comparison between the conventional model and the newly developed model. Table 1 shows the ratings.

2.2 Analytical Approach

Due to the reduction of the conductor cross

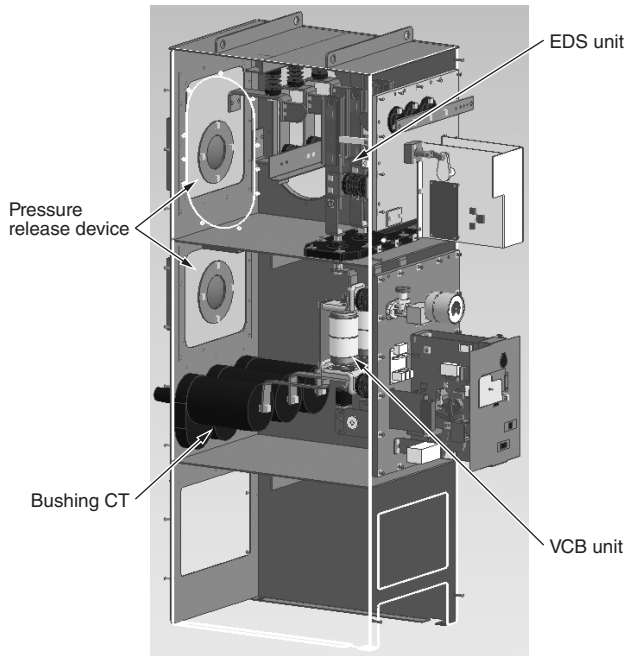


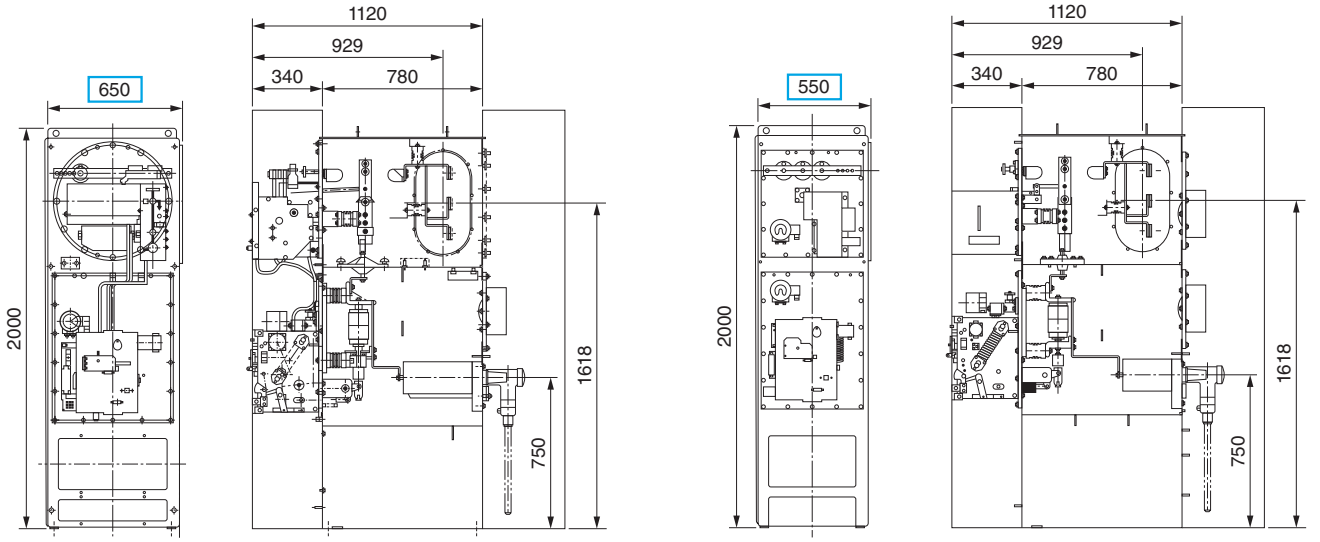
Fig. 1 Construction of Newly Developed Model

Construction of the newly developed model is shown.

Table 1 20 GB Ratings

Ratings of conventional and newly developed model are shown.

Items	Conventional model	Newly developed model
Model name	NBG-24	BGB-24
Rated voltage	24 kV	
Rated current	1250/800 A	Busbar: 1250 A
		Branch circuit: 800 A
Rated frequency	50/60 Hz	
Rated breaking withstand current	25 kA	
Rated short-time current	25 kA-3 s	
Power frequency withstand voltage	50 kVrms	
Impulse withstand voltage	125 kV	
Rated gas pressure	0.05 MPa·G	
C-GIS main-body dimensions	W650 × H2000 × D1450 mm	W550 × H2000 × D1450 mm
C-GIS main-body mass	570 kg	460 kg



(a) Conventional model

(b) Newly developed model

Unit: mm

Fig. 2 Comparison between Conventional Model and Newly Developed Model

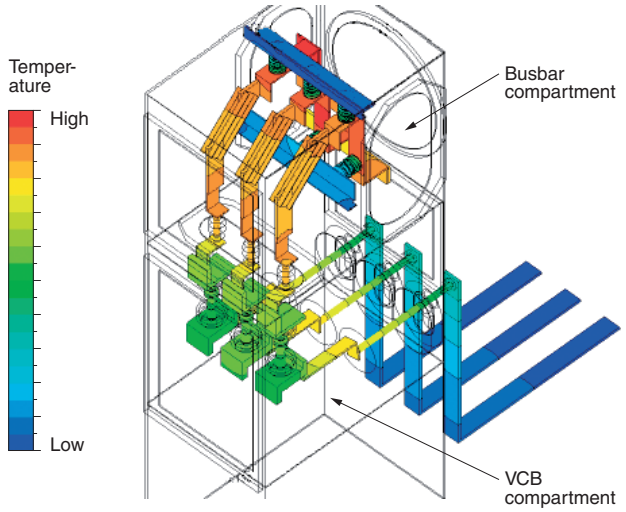
Comparison of construction is shown between conventional model and newly developed model. Since the equipment width is reduced to 550 mm, the volume of high-tension section is reduced to 85% that of conventional versions.

section and the tank width, the temperature rise value may be larger than that of the conventional model. As a preliminary study of the temperature rise test, a thermo-fluid analysis was performed using by Computational Fluid Dynamics (CFD).

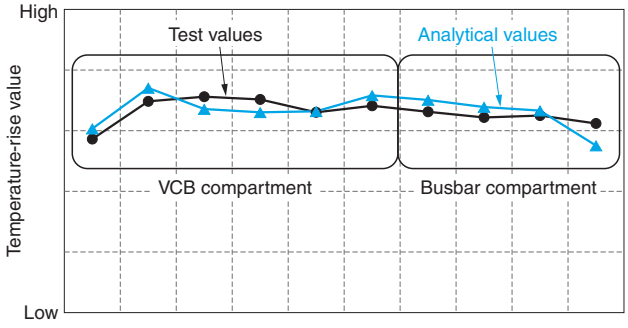
The analysis results were within the range of ±5 K against the actual temperature rise test, and a highly accurate study was feasible. Fig. 3 shows the results of the thermal fluid analysis.

2.3 Test Result

This type of C-GIS carried out a series of type tests and reliability tests stipulated by the IEC Standard, such as the short-circuit test and internal



(a) Analytical result contour



(b) Comparison of temperature rise between test result and analytical result

Fig. 3 Results of Thermal Fluid Analysis

For the thermal design, thermal fluid analysis was carried out with the aid of ANSYS.

arc test, at Korea Electrotechnology Research Institute (KERI), which is a third-party organization. It was verified that the C-GIS has satisfactory performance characteristics.

3 Development by Converting 36 kV Double Busbar Type C-GIS for Overseas Markets to Japan Market

In Japan, there is a need for a C-GIS-based equipment configuration that can make a smaller installation footprint and is more space-saving than the conduit type GIS. Since developing the 36 kV C-GIS called the “30 GB” for overseas markets in 2013, we have delivered more than 400 panels. This time, we adopted the units used in the 30 GB and developed a 24 kV double busbar type C-GIS for Japan Market.

Table 2 Ratings of 24 kV Double Busbar Type C-GIS for Japan Market

Ratings of the 24 kV double busbar type C-GIS for Japan Market are shown.

Items	Specifications
Model name	BGB-36
Rated voltage	24 kV
Rated current	1200/2500 A
Rated frequency	50/60 Hz
Rated breaking current	31.5 kA
Rated short-time withstand current	31.5 kA-1 s
Power frequency withstand voltage	50 kVrms
Impulse withstand voltage	125 kV
Rated gas pressure	0.08 MPa·G
Applicable standard	JEM-1425 (2011)

3.1 Ratings

Table 2 shows the ratings of 24 kV double busbar type C-GIS for Japan Market.

3.2 Features

3.2.1 Classification of Gas Compartments

The equipment is classified into five gas compartments: busbar compartments (Bus-A and Bus-B), EDS compartments (Bus-A and Bus-B), and a VCB compartment. As a result, the range of a service interruption can be minimized at the time of a busbar accident or facility expansion. Table 3 shows the difference in Loss of Service Continuity (LSC) by gas compartment classification.

3.2.2 Mid-Panel Bellows

Mid-panel bellows are adopted in consideration of easy replacement of mid-panels in the event of a panel failure. Fig. 4 shows images of an intermediate panel replacement. Since mid-panel bellows can be removed to create a panel-to-panel clearance, it is easy to replace a faulty intermediate panel.

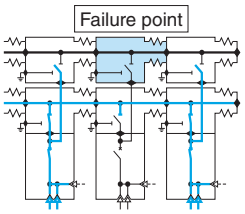
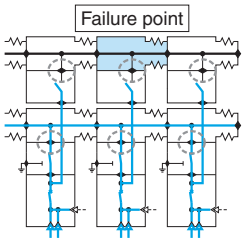
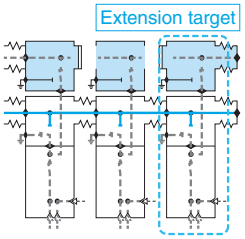
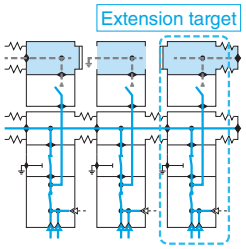
3.2.3 Closed Circuit (Loop) Current Switching

Fig. 5 shows a loop circuit. In the mode of double busbar management, a busbar circuit switchover by means of a disconnector is required under the electrified condition and without tripping the circuit breaker (circuit shutdown). In this case, a bus-transfer current flowing in the loop circuit relating to the busbar is, therefore, subject to being switched on and off. Since arcs are generated at the time of switching on and off, the conductor is provided with an arcing section to suppress the con-

Table 3 Difference in LSC by Gas Compartment Classification

The gas compartment classification is defined to minimize the LSC in consideration of a system failure and facility extension.

Shutdown circuit — Electrified circuit ---- Earthed circuit Gas recovery spot

Gas classification configuration	【Standard specification】 Busbar/Gas classification identical with EDS compartment	【Developed specification】 Busbar/Gas classification added between EDS compartments
Recovery pattern after the occurrence of busbar failure	 Circuit shutdown in failure target panel: Necessary	 Circuit shutdown in failure target panel: Unnecessary
Status of circuit at the time of facility extension	 Tentative circuit shutdown in neighboring panel: Necessary	 Tentative circuit shutdown in neighboring panel: Unnecessary

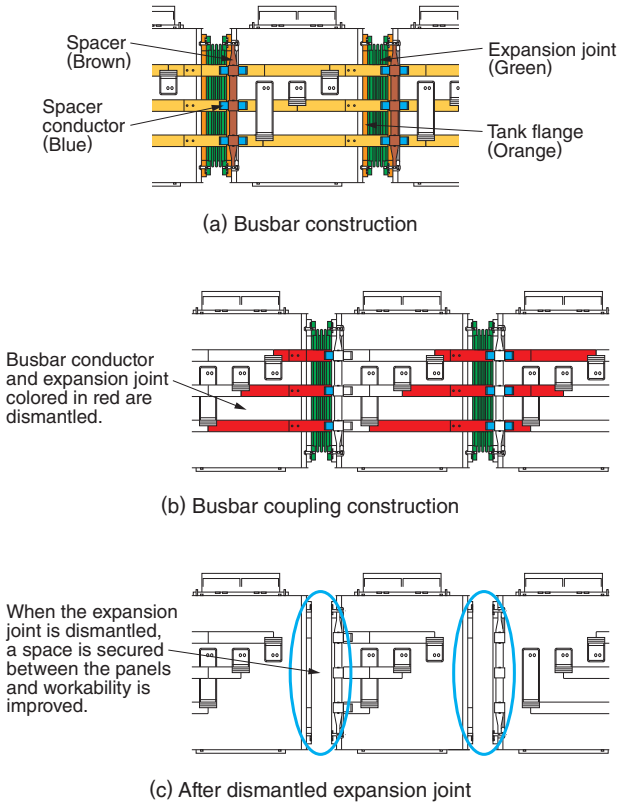


Fig. 4 Images of Intermediate Panel Replacement

As a result of using busbar coupling system with bellows, workability has been improved in the case of the intermediate panel replacement.

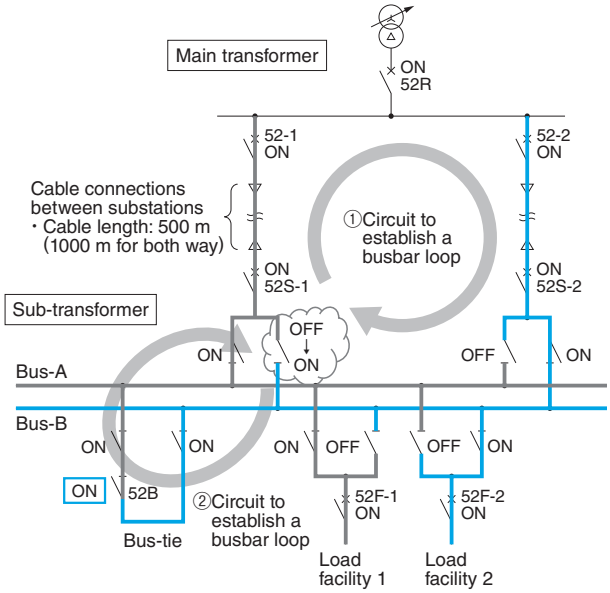
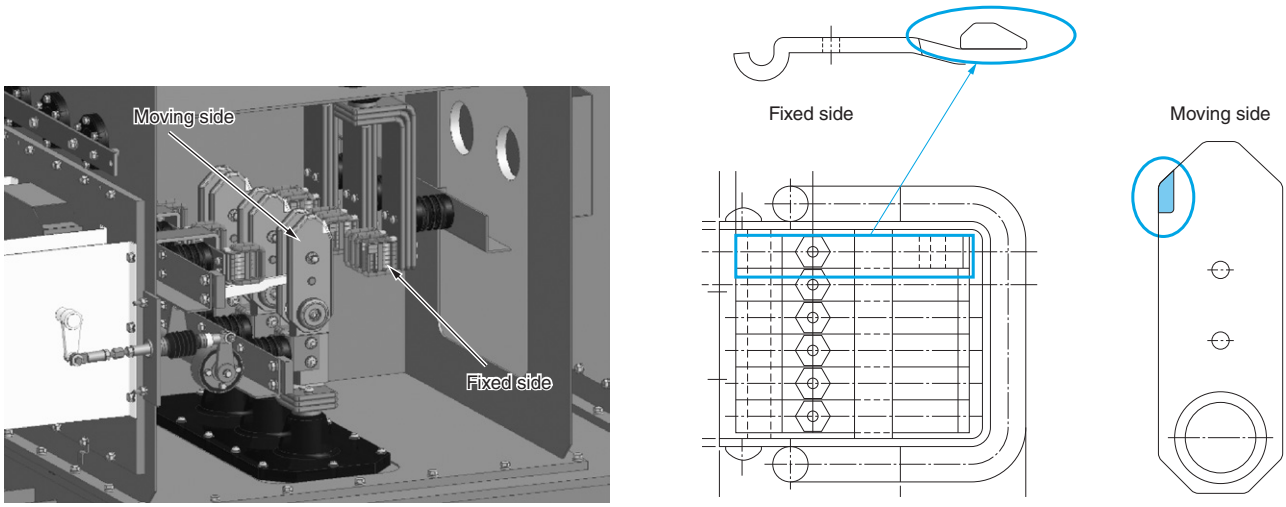


Fig. 5 Loop Circuit

The assumed busbar loop is shown.

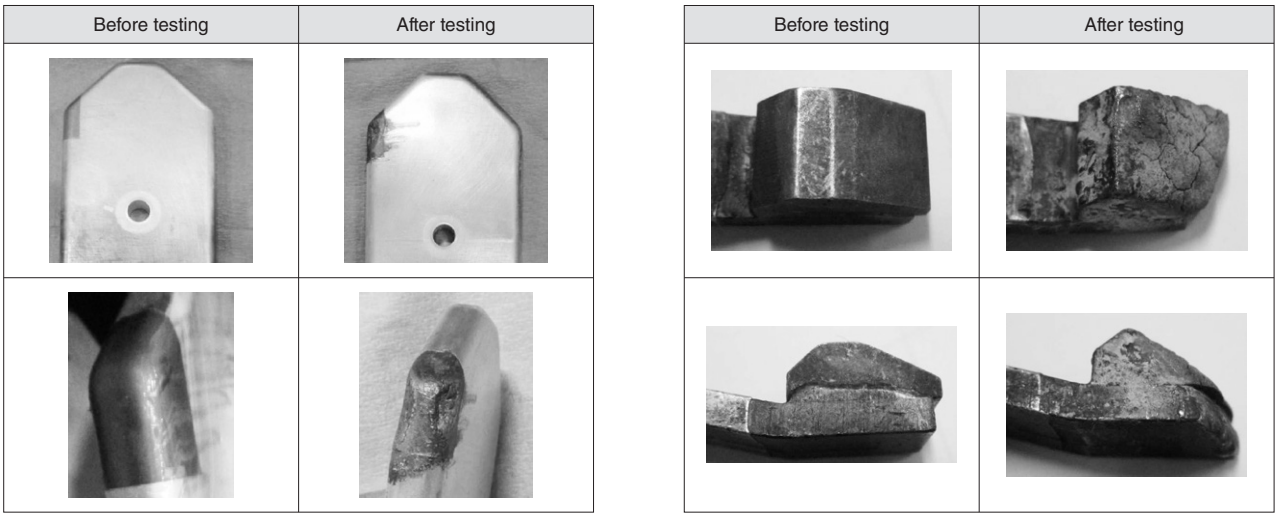
ductor wear due to the arcs. **Fig. 6** shows the construction of the arcing section. Conforming to the test procedures complied by the Japanese Electrotechnical Committee (JEC), the switching test was carried out 200 times under the conditions of a recovery voltage of 100 V and a bus-transfer current of 2000 A. The equipment satisfied the standard specifications(※1). **Fig. 7** shows the arcing section after the bus-transfer current switching tests.



(a) Arcing mounted EDS unit　　(b) Arcing section

Fig. 6　Construction of Arcing Section

To reduce contact wearing due to arcs, arcing sections are provided to conductors.



(a) Moving-side arcing section　　(b) Fixed-side arcing section

Fig. 7　Arcing Section after Bus-Transfer Current Switching Tests

The practical testing was carried out to confirm that all the factors specified by the relevant JEC Standard are complied.

4　Postscript

We realized a compact and mass saving design of the 20 GB. This was made possible by an optimized main circuit design by using analytical technologies such as CFD and by making limited to 800 A specifications. In addition, to meet the high reliability demands of our customers, we developed a 24 kV double busbar type C-GIS for Japan Market by adopting the units used for the 30 GB. We supplied the first unit of both products, and they are in service.

Going forward, we will continue to develop products that meet the needs of our customers.

(Note)

※1. The relevant standard stipulates that equipment shall be capable of circuit making and breaking in the middle of testing and that there shall be no remarkable characteristic changes that may hinder normal operation after the testing.