New 36kV Cubicle Type IEC Standard Compliant Gas-Insulated Switchgear (C-GIS)

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Abstract

Recent Transmission and Distribution (T&D) equipment is required to pursue the reduction of installation space, capacity expansion to meet the increased demand for power, and reliability improvement for a stable power supply. Against such background, we developed a new type of 36kV Cubicle type Gas-Insulated Switchgear (C-GIS) which applies the IEC standard featuring a compact design, large capacity, and high reliability. The new 36kV (C-GIS) features equipment volume is reduced by 36% compared with the conventional model by our compact design efforts, the capacity is increased to the rated current of 2500A, and high reliability is realized to the level of the international standard IEC class (circuit-breakers): E2・C2・M2.

This 36kV C-GIS underwent a type test at the KEMA High Power Testing Laboratory in the Netherlands, a third party organization for type test certification testing, and passed all testing categories: short-circuit breaking test, withstand voltage test, temperature rise test, and mechanical operation test. We acquired the complete type test certificate for this equipment.

1 Preface

The switchgear is key equipment in order to build Transmission and Distribution (T&D) systems. It is required to offer a variety of outstanding features in terms of compact and light design, reliability, safety, and labor saving for maintenance and inspection. Recently, it became necessary to build bigger capacity T&D systems for the expansion to increase energy efficiency in various industrial fields such as power generation, power distribution, and petrochemical plants.

We developed a Cubicle type Gas-Insulated Switchgear (C-GIS) whose main circuits are accommodated in a sealed container and insulation is maintained in SF_6 gas. These are of medium-voltage classes (12/24/36kV) featuring further compact design, higher reliability, and less labor hours for maintenance and inspection, compared with our conventional air-insulated cubicles. This equipment has been delivered to many of our customers such as power companies and private sectors.

Recently, we have developed another new type of IEC standard compliant 36kV C-GIS. This switchgear retains the same ratings (31.5kA/2500A) as those of conventional models, yet attains further compactness (reduction of 36% volume compared with conventional models) and meets the requirements of the circuit-breaker classes (E2・C2・M2) stipulated by the IEC international standard. This switchgear underwent the type test at the KEMA High Power Testing Laboratory in the Netherlands, a third party organization for type test certification, and passed all the testing categories of short-circuit breaking test, withstand voltage test, temperature rise test, and mechanical operation test executed in accordance with IEC62271-200 and other relevant standard specifications. We acquired the complete type test certificate for this equipment. This paper introduces construction of the new 36kV C-GIS and its features.

2 Ratings and Construction

Fig. 1 shows construction diagrams of the newly developed 36kV C-GIS which applies the IEC standard. Table 1 shows the ratings of the respective components.

Like conventional models, this switchgear comes in a construction separating the Vacuum

Circuit-Breaker (VCB) compartment and the main busbar compartment by a gas section. By optimizing current carrying performance and insulation, we attempted to reduce equipment height and depth and realized a compact design by reducing 36% off the volumetric ratio. In the VCB compartment, a VCB is accommodated. A disconnecting switch with an earthing switch (EDS) is installed in the main busbar compartment. Both the VCB and EDS are part of the unit system combining the operating mechanism part and the high-voltage conductor part. This system is designed for easy assembling and compatibility with the same rating power equipment.

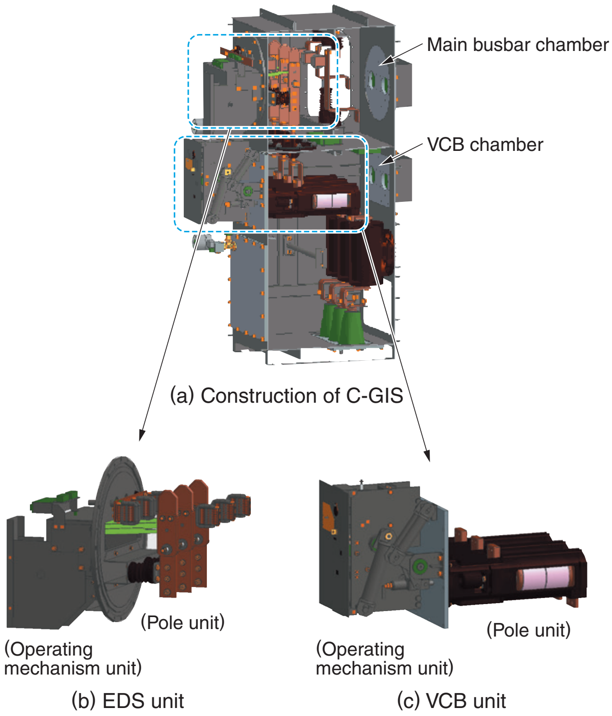

Fig. 1 **Construction (1250A)**

Internal construction of the switchgear, EDS unit, and VCB unit is shown.

Table 1 **Ratings**

Ratings of the switchgear, VCB, and EDS are shown.

Switchgear	Type	BGB-36
	Rated voltage	36kV
	Rated normal current	1250/2000/2500A
	Rated short-time withstand current	31.5kA-3s, 82kA, peak
	Applicable standards	IEC62271-200
VCB	Type	VGB-33
	Rated voltage	36kV
	Rated normal current	1250/2000/2500A
	Rated short-circuit breaking current	31.5kA
	IEC class	E2, C2, M2
	Type of operating mechanism	Motor-charged spring stored energy
	Applicable standards	IEC62271-100
EDS	Type	DGB-33
	Rated voltage	36kV
	Rated normal current	1250/2000/2500A
	Rated short-time withstand current	31.5kA-3s, 82kA, peak
	Operating system	Motorized/manual mechanism
	Applicable standards	IEC62271-102

3 Features

3.1 Switchgear Compact Design

The latest copper-chromium electrodes are made of a material alloy that has outstanding welding resistance. Since these electrodes are used, it became possible to achieve 33% off of the compact design of a Vacuum Interrupter (VI) in volumetric ratio and 27% reduction of pressing force compared with conventional models. As a result, it became possible to use the operating mechanism with minimal operating force and a more compact VCB unit was realized. In addition, the axial magnetic field electrodes were used for conventional vacuum interrupters. The newly developed equipment uses traverse magnetic field electrodes. The latter electrodes can reduce the VI contact resistance by 50% and this feature has made it possible to increase the current to be carried as a result of the reduction of heat generation while a high current is carried.

Each unit was designed by a three-dimensional electric field strength analysis and electric field distribution between the tank and other structures can be optimized, whereby securing the required insulation performance. Fig. 2 shows an example of the result of electrical field analysis for the movable

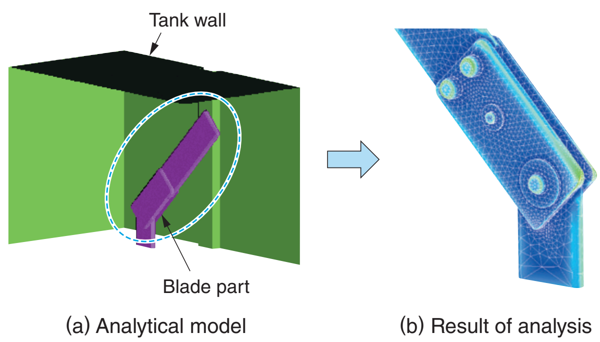

Fig. 2 **Electrical Field Analysis (EDS Movable Electrode)**

The result of three-dimensional electric field strength analysis is shown for the movable blade side of the EDS unit.

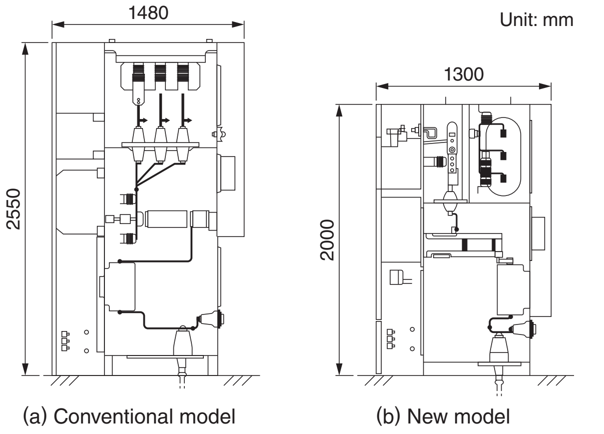

Fig. 3 **Comparison with Conventional Models (1250A)**

Comparison of the new model with conventional models is shown in regard to external dimensions. Compared with conventional models, the new model realized a 36% reduction in volumetric ratio and an 18% reduction in installation space.

electrodes of the EDS unit. This analysis realized an optimum distance between the tank and the end part of the movable electrode.

As described above, the new 36kV C-GIS has achieved a 36% reduction in volumetric ratio and an 18% reduction in installation space compared with conventional models. Fig. 3 shows the comparison drawing.

3.2 Capacity Expansion (Rated Current of 2500A)

Fig. 4 shows countermeasures against temperature rises in 2500A unit. Compared with conventional models, the new 36kV C-GIS achieved a remarkable compact design. If the same rated current of 2500A as that of conventional models is taken into consideration, however, the density of heat generation is increased resulting in a new challenge to take adequate countermeasure against a resultant temperature rise. For this 2500A model, therefore, some measures were newly taken such as the reduction of main-circuit resistance, the application of a heat sink, and an adequate allocation of conductors. For the main-circuit resistance, cross-sectional areas and routes of conductors were optimized. This method realized a 20% reduction compared with former methods. The heat sink was positioned to a high gas temperature part (above the VCB chamber) and we increased heat dissipation area by 10%. Furthermore, conductors are reasonably allocated according to temperature distribution inside the tank. This treatment improved the effect of heat dissipation due to heat conduction and convection. By taking such measures, a temperature rise was lowered around the movable contact area where the temperature is highest. All in all, we were able to average temperature distribution.

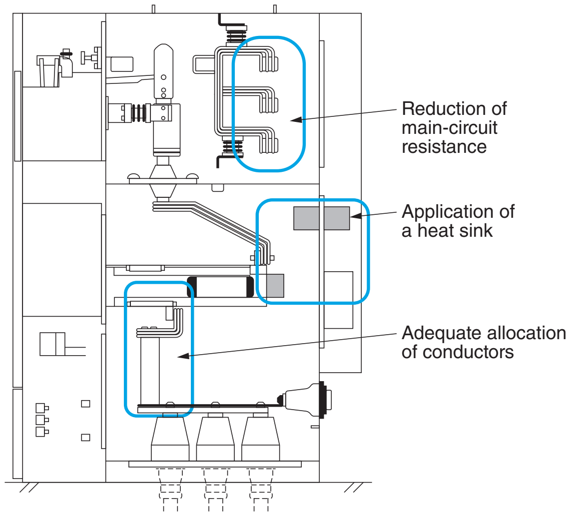

Fig. 4 **Countermeasures against Temperature Rises in 2500A Unit**

Countermeasures against temperature rises in the 2500A unit are shown. (Reduction of main-circuit resistance, application of a heat sink, and adequate allocation of conductors)

Table 2 **Classification of Reliability Evaluation for IEC62271-100**

Design classes in IEC Standard are shown. Class 2 means a higher rank.

Category	Classes and their contents
Mechanical endurance performance	M1: General-purpose circuit-breakers which went through 2000 times of mechanical type test. M2: Long-life circuit-breakers which went through 10,000 times of mechanical type test.
Electrical endurance performance	E1: Circuit-breakers having basic electrical endurance performance. E2: Circuit-breakers where no particular maintenance is required for the current breaking parts of the main circuit during the expected operational life. These circuit-breakers are designed so that other parts may require the least minimal maintenance either. (Circuit-breakers with high electrical endurance performance)
Capacitive current switching performance	C1: Circuit-breakers with a low probability of restriking during the interruption of capacitive current. C2: Circuit-breakers with a very low probability of restriking during the interruption of capacitive current.

3.3 Reliability (IEC Class Compliant)

Nowadays, the market demands labor saving in maintenance and inspection and a longer operational life for the VCB. The IEC Standard 62271-100 shows the classification of reliability levels and applications. Table 2 shows the classification of reliability evaluation according to the IEC Standard.

Table 3 Comparison of IEC Classes between Conventional Models and New Model

Comparison of IEC classes is shown between conventional models and the new model. For the new model, we cleared the requirements of Class 2 in all categories.

Model	Conventional model	New model
Mechanical endurance performance	M1	M2
Electrical endurance performance	E1	E2
Capacitive current switching performance	C1	C2

Table 3 shows IEC class comparison between conventional models and the new model.

In order to apply the E2 and C2 Classes to the newly developed 36kV C-GIS, we optimized the switching speed and VI stroke curves so that improvement of short-circuit breaking performance can be achieved. To realize requirement clearance of the M2 Class, we examined stresses to be generated in each part to determine the product life against the repeated stress. For any part where impact may be exerted, we predicted the expected impact values and examined them based on the past testing data. This product is therefore capable of withstanding the mechanical endurance against 10,000 times of breaking operations.

In conclusion, the new 36kV C-GIS realized high reliability in terms of mechanical and electrical endurance performance as well as capacitive current switching performance. The above coincides with our R&D programs for its compact design and large capacity.

4 Test Result

The new 36kV C-GIS proved to have good performance by a series of type tests and practical performance tests based on the IEC62271-200 (switchgear), 100 (VCB), and 102 (disconnecting switch and earthing switch). In addition, it cleared all the testing categories of the short-circuit breaking test, withstand voltage test, temperature rise test, and mechanical operation test conducted by the KEMA High Power Testing Laboratory in the Netherlands, and we received the complete type test certificate. Fig. 5 shows a scene of the withstand voltage test carried out at the KEMA testing site.

Fig. 5 A Testing Scene at the KEMA Testing Site (Withstanding Voltage Test)

A view of lightning impulse withstand voltage test is shown and this was conducted at the KEMA High Power Testing Site.

5 Postscript

We developed the IEC standard compliant 36kV C-GIS featuring a compact design, large capacity, and high reliability. Since the VCB and the EDS went through the unit design and we retained the compatibility with other the same rating equipment. Thus, we can make fittings with the requirements from our customers. Equipment configuration of the developed equipment is for single buses. In order to provide products that satisfy other requests from our customers, however, we will promote the development of product lineups such as the double busbar type, etc.

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