Development of 24-kV Cubicle Type Vacuum-insulated Switchgear (C-VIS) for Overseas Markets

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OVERVIEW: With advanced information-based societies making increased use of electric equipment in the home and in industry, demand for electricity is growing in and outside Japan and this is making it increasingly important that there is a highly reliable supply of electricity. Switchgear are critical components in electric power distribution systems and have an important role in ensuring a stable supply of electricity. In addition to their basic purpose of providing a safe and highly reliable supply of electric power, switchgear must also satisfy requirements of low cost, low maintenance, and environmental performance. It is against this background that Hitachi, with the aim of supporting electricity distribution around the world, utilized its proprietary vacuum technology and its technology for electromagnetic actuators to develop the 24-kV cubicle type vacuum-insulated switchgear (C-VIS) for the international electricity distribution market. The C-VIS complies with IEC standards.

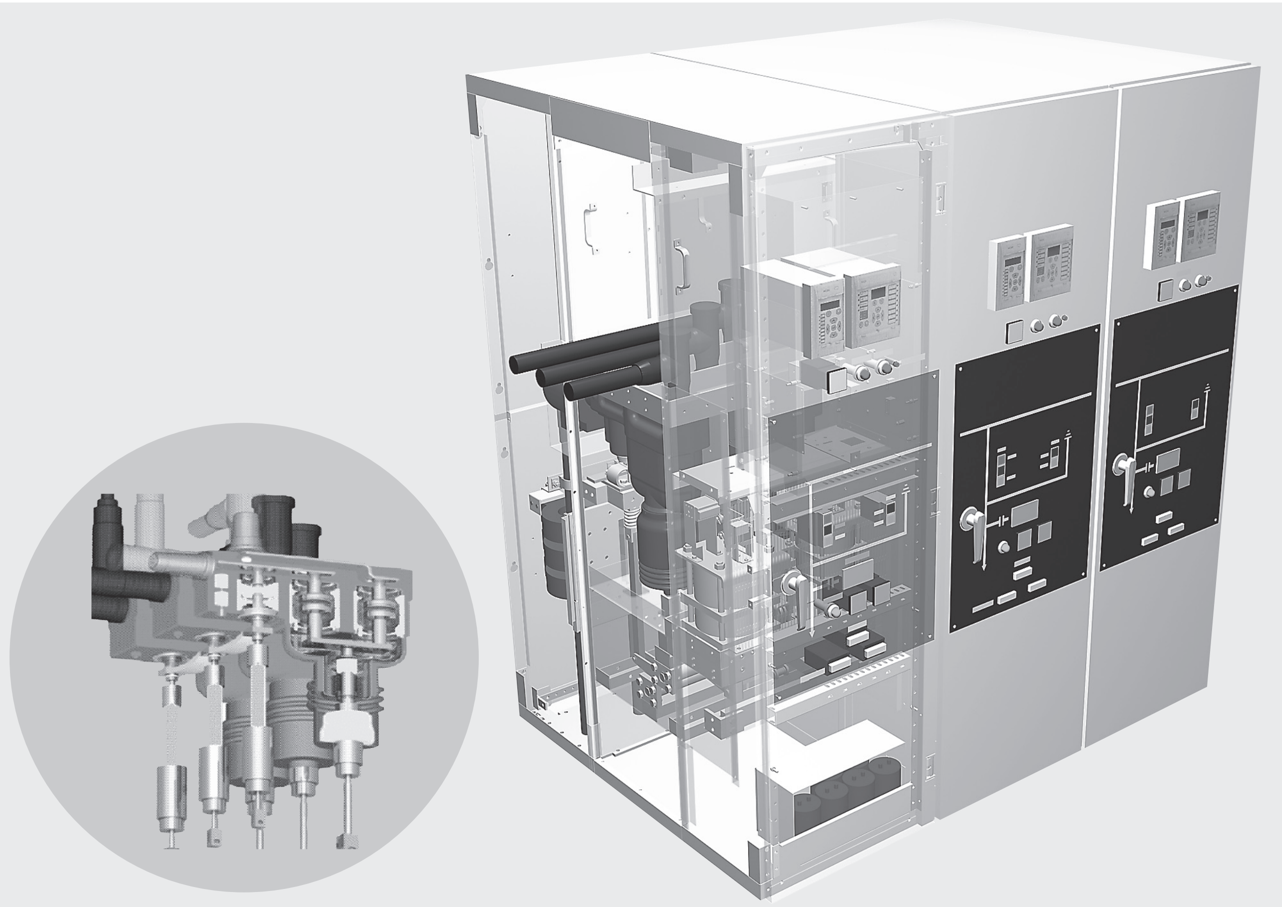

Fig. 1—C-VIS (cubicle type vacuum-insulated switchgear) and its Switch Unit.
A cutaway view of the 24-kV C-VIS is shown. The C-VIS is suitable for a wide range of electric power systems and incorporates a circuit breaker, disconnecting switch, earthing switch, insulated bus bar, and protection relay. The cabinet dimensions are 2,000 mm high × 600 mm wide × 1,300 mm deep.

INTRODUCTION

HITACHI developed the 24-kV C-VIS (cubicle type vacuum-insulated switchgear) to supply electric power systems to markets outside Japan and contribute to important social infrastructure (see Fig. 1).

In addition to the traditional requirements of high quality and reliability, electric power distribution systems have diverse needs that include lower maintenance requirements, more compact designs, and better safety and ease-of-use. In response to the demand in recent years for equipment that is environmentally friendly, vacuum switches have advantages in terms of preventing global warming because they do not use SF_6 (sulfur hexafluoride), a gas with a high global warming coefficient.

As user requirements become ever more diverse, economics too is becoming even more important. Up-front costs have always been a factor but now the reduction of life cycle costs such as maintenance and accident prevention has also become an issue.

Along with the requirement for compatibility so that the switchgear can be connected to other existing units, switchgear often need to be supplied with a short delivery time. Also, recent IEC (International Electrotechnical Commission) standards and customer specifications have emphasized safety performance to protect maintenance and operating personnel from electric shock or pressure rises caused by internal arcing.

The C-VIS complies with IEC standards to ensure it meets these diverse needs of overseas markets.

This article describes the C-VIS and its ability to supply electric power with high quality and reliability.

C-VIS DEVELOPMENT

C-VIS Development Concept

In entering overseas markets for 24-kV equipment, Hitachi chose based on the results of market research to focus development of the C-VIS on environmental friendliness, safety, ease-of-maintenance, life cycle costs, small size, and light weight (see Table 1).

TABLE 1. C-VIS Development Concept

The table lists details of the C-VIS development concepts of "environmental friendliness," "safety," "ease-of-maintenance and low life cycle costs," and "small size and light weight."

Concept	Details
Environmental friendliness	• Product is environmentally friendly because it does not use SF_6 gas in its switches.
Safety	• Arc energy is reduced by a switch unit design that completely separates each phase and prevents inter-phase short circuits.
	• Accidents are prevented by continuous vacuum monitoring.
	• Electric shock is prevented by having no live parts exposed.
Ease-of-maintenance and low life cycle costs	• Gas-less design means gas maintenance is not required.
	• Grease-less mechanism means lubrication maintenance is not required.
Small size and light weight	• Smaller size and lighter weight are achieved by use of vacuum technology and by integrating the circuit breaker, disconnecting switch, and earthing switch.

C-VIS Specifications and Design

The C-VIS has a rated voltage of 24 kV, rated current of 1,250 A, and short-time withstand current of 25 kA 3s. Table 2 shows a comparison of the C-VIS's specifications with those of competing products from other suppliers. The basic equipment design consists of vacuum switch with vacuum sensor, VT (voltage transformer), CT (current transformer), protection relay, voltage detector, and vacuum leak monitoring (see Fig. 2). The switch is made up of a switching unit and an electromagnetic actuator.

TABLE 2. Comparison with Specifications of Competing Products

The comparison shows the superiority of the C-VIS over competing switchgear.

Manufacturer	Hitachi C-VIS	Company A	Company B	Company C
Rated voltage	7.2 / 12 / 24 kV	12 / 24 kV	24 kV	24 kV
Rated current	630 / 800 / 1,250 A	630 / 1,250 A	630 / 1,250 A	630 / 1,250 A
Short-time withstand current	25 kA 3s	25 kA 3s	25 kA 1s	25 kA 2s
Insulator	Vacuum and epoxy	SF_6 gas	Vacuum and epoxy	Dry air
Insulation mechanism	Phase separation	Three phases combined	Phase separation	Three phases combined
Driving mechanism	CB, DS, and ES: Electromagnetically driven (grease-free)	CB: Electrically driven spring DS, ES: Motor-driven (grease lubrication)	CB, DS, and ES: Electromagnetically driven (grease lubrication)	CB: Electrically driven spring DS, ES: Motor-driven (grease lubrication)
Weight	650 - 750 kg	700 kg	700 kg	700 kg
Dimensions (height × depth × width) (mm)	2,000 × 1,300 × 600	2,100 × 1,000 × 600	2,500 × 1,400 × 700	2,400 × 1,750 × 650

CB: circuit breaker DS: disconnecting switch ES: earthing switch

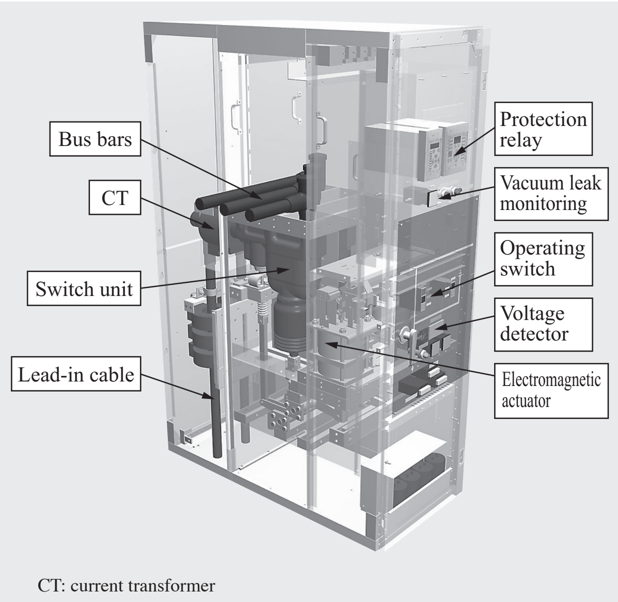

Fig. 2—C-VIS Internal Configuration.
The C-VIS incorporates a circuit breaker and auxiliary equipment.

Hitachi has succeeded in reducing both the equipment size and cabinet installation space by utilizing its proprietary vacuum technology, electromagnetic actuator, and a switch unit that integrates a circuit breaker, disconnecting switch, and earthing switch. Fig. 3 shows the circuit diagram.

The switchgear can be used in combination with incoming panels, feeder panels, and bus section panels with standard designs to configure a wide range of different electric power supply systems.

Technology Used in C-VIS

(1) Electromagnetically operated vacuum-insulated circuit breaker with integrated circuit breaker, disconnecting switch, and earthing switch

Regarding the insulation performance of the C-VIS, an ideal mix of air and solid insulation together with use of vacuum insulation which provides more than three times the insulation of SF_6 gas means that the dimensions of the insulation are approximately 10% smaller than on models that use SF_6 gas insulation. Also, the disconnection function has been integrated into the circuit breaker by use of a three-position (on, off, and disconnected) design which is combined with the earthing switch to form an integrated switch unit (see Fig. 4). The double break design of the circuit breaker is also intended to improve reliability (see Fig. 5).

There is no risk of the switchgear releasing greenhouse gases into the atmosphere because SF_6 gas, which has a high global warming coefficient, is not used. This gasless design also eliminates the need for tasks such as recovering gas or inspecting O rings, gaskets or other seals when performing maintenance or other work. Because the switchgear uses Hitachi's proprietary grease-free hybrid electromagnetic actuator, there is no risk of operation faults caused by grease depletion and the unit can remain in operation over long periods of time without needing to be lubricated at the routine inspections. These features reduce the time spent on maintaining the switchgear.

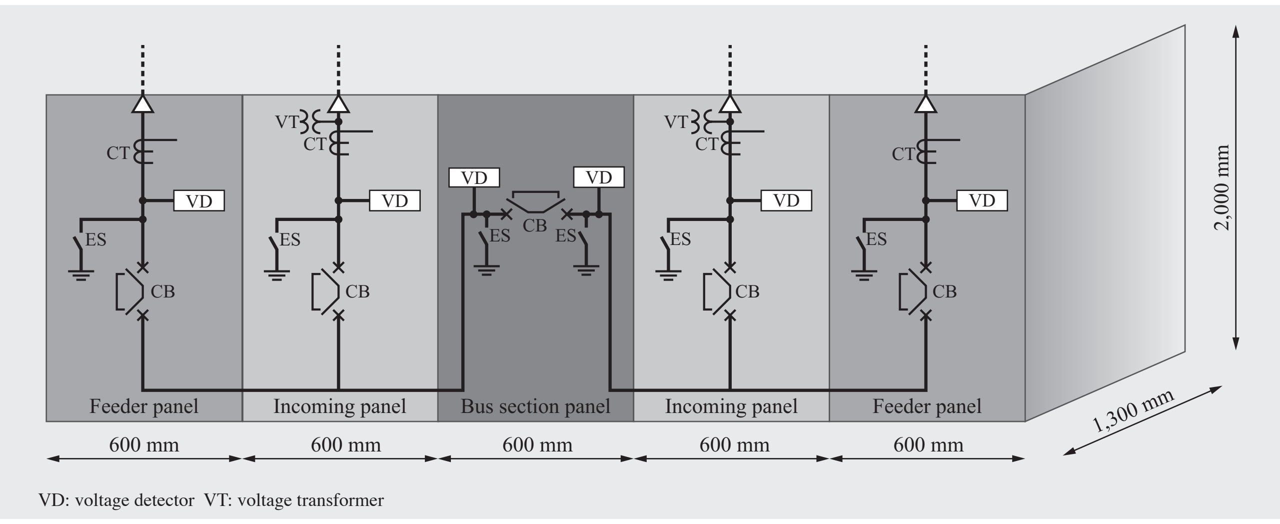

Fig. 3—C-VIS Circuit Diagram.
The switchgear integrates a circuit breaker, disconnecting switch, earthing switch, and auxiliary components.

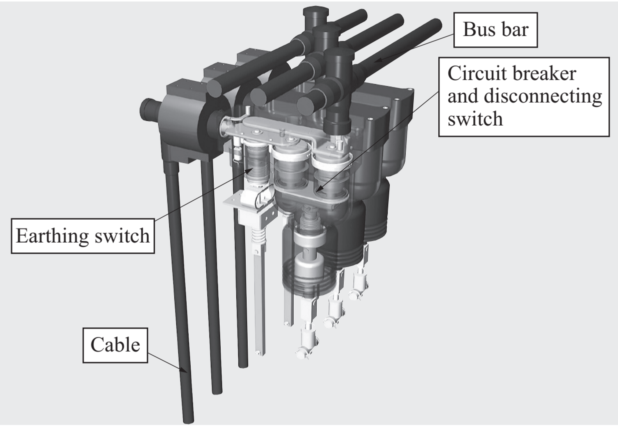

Fig. 4—Switch Unit Structure.
The integrated switch unit combines a circuit breaker, disconnecting switch, and earthing switch.

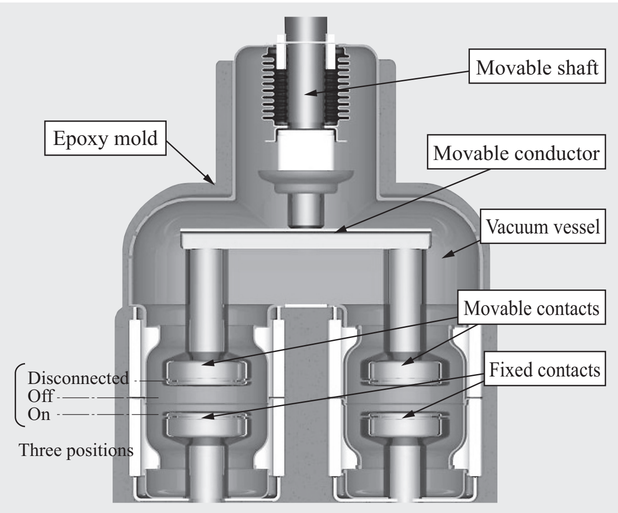

Fig. 5—Outline of Switch Unit.
Reliability has been improved by developing a three-position vacuum switch with double break points.

(2) Separated-phase structure

The switchgear has a separated-phase design to prevent inter-phase short circuit faults. This reduces the arc energy in the event of an accident to approximately 0.7% (for an earth fault current of 2 kA) of the energy for a three-phase short circuit (with a three-phase short-circuit current of 25 kA), and this improves worker safety by protecting them against internal pressure rises caused by the arc energy. Similarly, the risk of electric shock is prevented by having no live parts exposed.

(3) Continuous vacuum leak monitoring

The switch unit incorporates a sensor that can continuously monitor for vacuum leaks and prevent accidents by automatically locking the switch if a leak occurs.

Support for Short Delivery Times

One feature of projects outside Japan is that they frequently require the switchgear to be supplied with a short delivery time. To satisfy this demand, standard specifications have been adopted for the switch unit and enclosure. This has reduced the delivery time by approximately two months compared to previous models with the same rating.

(1) Integration of switching components into a single unit

Because the switching components in the new switchgear have been combined into a single unit, it is possible to produce these switch units in advance based on forecast demand. Although the units take a comparatively long time to assemble, the overall production schedule can be shortened by producing them beforehand. The specifications of the switch units have also been standardized so that two models can cover the full range. The resulting benefits of volume manufacturing improve production efficiency and shorten lead times.

(2) Standardization of switchgear specifications with additional options available

Standardizing the switchgear specifications shortens the design time. In addition to faster design, combining standardized specifications with optional variations can also shorten the lead time prior to the commencement of manufacturing. Standardized specifications allow parts to be shared between different models and this also helps to shorten lead times considerably.

ACTUAL INSTALLATIONS AND FUTURE ISSUES

Actual Installations

The first C-VIS unit was delivered to Singapore where it entered service in June 2008 and continues to operate without problems (see Fig. 6). To date, units are in operation at one site and have been shipped to three other sites where they are being prepared for use.

Orders for the switchgear are increasing and the product is expected to contribute further to markets outside Japan.

Future Issues

Because further improvements in Hitachi's performance on cost will be necessary to achieve overwhelming competitiveness in overseas markets, Hitachi is currently focusing on ways of lowering

Fig. 6—Photograph of First C-VIS Unit.
The photograph shows the first C-VIS unit which was supplied to Singapore.

costs including enhancements to the design and improvements to the manufacturing process.

Hitachi is also continuing development to further extend the C-VIS series and expand its business.

CONCLUSIONS

This article has described the development of the C-VIS which can supply electric power with high quality and reliability.

In a market where cost reduction, concern for the environment, and the diverse needs of modern electric power systems are important factors, Hitachi intends to continue supplying products that contribute to society and provide a high level of customer satisfaction based on Hitachi's core technologies accumulated in its business supplying electric power systems and through its development capabilities for bringing forth new technologies.

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