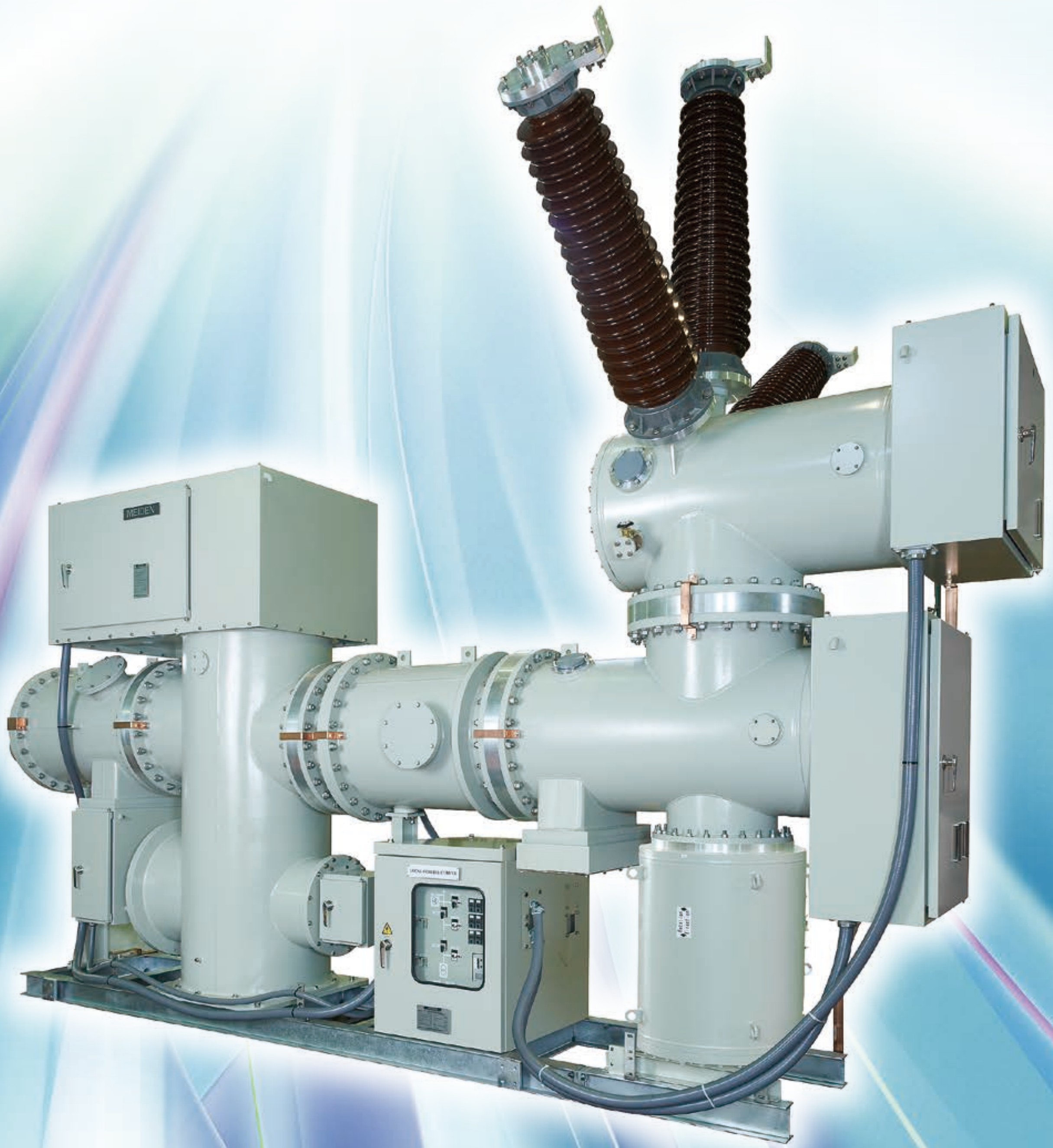
123/145kV
SF_6 Gas-Insulated
Switchgear incorporating VCB

V-GIS

MEIDEN
Quality connecting the next

145kV-1250～2000A-31.5/40kA



1. General

The circuit breaker technology has evolved along with that of the power systems as their transmission voltage has become higher and short-circuit capacity has increased. When we summarize this process we see the technology have developed to meet the following new requirements among others: higher transmission voltage in larger short-circuit capacity, higher speed, compactness, improved reliability that reduces maintenance requirements, and complexing site requirements. From the perspective of the circuit breaker technology, this is a history of an obsessive quest for a high-insulation medium with a superior arc extinguishing capability. In other words, the fault current breaking conditions have become tougher as the transmission voltage has become higher and networking of power systems have become more common, and circuit breakers must now have among its essential requirements less arc energy properties and faster insulation recovery capabilities when breaking fault currents.

The Vacuum Circuit Breaker (VCB) possesses the most effective insulation medium and the fastest insulation recovery of any type of circuit breakers, and satisfies all fault current breaking requirements.

Additionally, the features unique to the VCB can be summarized as follows.

1. A complete self-extinguishing property that makes the VCB the only breaker capable of handling an evolving fault.
2. Low arc energy property offers a long service life of the contacts.
3. Easy maintenance results in the lowest running (maintenance) cost of any type of breakers.

Table 1 summarizes the history of the VCB and important events in the circuit breaker technology.

Year	VCB development	Important events
1890	Patent for arc extinguishing in a vacuum	Formation period of the electricity industry, up to 1000V. A combination of fuses and air-break switches
1900 1920		Parallel switching OCBs developed (hydroelectric power at 10kV or above). OCBs explosions were common Arc-extinguishing chamber OCBs developed
1926	Solensen conducts power system experiments and discovers more breaking capacity in vacuum than expected	
1930		Cell-type OCBs developed Magnetic blow-out circuit breaker developed
1935		Air-blast circuit breaker developed
1950	GE selects electrode materials and establishes processing technology (Lee, Cobine)	Ultra-high voltage transmission network built Tank OCBs with BCTs developed Multi-break air-blast circuit breaker developed SF_6 Gas Circuit Breakers (GCBs) developed (single pressure system)
1960	US based Jennings develops a 10kV-250A vacuum switch	Ultra-extra high voltage transmission systems built Multi-break minimum-oil OCB developed Dual-direction blow nozzle continuous air-charge system resistance air-blast circuit breakers developed
1965	3.6kV / 7.2kV VCB developed (single-break)	Dual pressure multi-break GCBs developed
1970	36kV VCB developed (single-break)*	
1973	84kV VCB developed (single-break)*	168kV single-break single-pressure GCBs developed
1977	145kV VCB developed (double-break)*	
1978	168kV VCB developed (double-break)*	
1979	Single-break 120/123kV VI developed*	
1989	204kV VCB developed (double-break)*	
1995	Miniaturized high-voltage VI*	Axial magnetic-field electrode method improves the breaker performance Miniaturization advances
2002	84kV high-voltage ceramic VI developed*	High-voltage vacuum insulated compatible 84kV ceramic VI developed
2010	Advances in 84kV high-voltage ceramic VI miniaturization and increased capacity*	New electrode materials developed Axial magnetic-field vacuum arc optimized
2014	145kV single break ceramic VI developed*	Electric field analysis, magnetic field analysis

Note: Items marked with an * indicate that the development for higher voltage applications has been undertaken by Meidensha after 1970.

Of particular interest in Table 1 is that when the necessity of circuit breakers was first conceived, it was considered that the ideal circuit breaker that was arc-free could be made in perfect vacuum and research on this ideal circuit breaker has continued non-stop all the way up to the present.

Also, the trend towards an oil-less, arc distinguishing high-insulation medium is evident. That is, development has advanced from oil to compressed air to SF_6 gas and finally to vacuum.

Global trends now require circuit breakers that meets the requirements for resource conservation and environmentally friendly performance, and the VCB answers these concerns.

Against such background and history, Meidensha has constantly been making VCB history and taking the lead in the VCB development. Most recently, we have introduced a GIS incorporating the VCB.

Concept

Drastic saving for ***installation space*** **1*

Highly resistant to adverse environments, high safety

Easy *to maintain*

Increased ***reliability*** *by applying VCB*

Note: *1 comparison with Conventional Substation

Features

145kV single-break vacuum circuit breaker

I. VCB has a extremely low contact erosion and a long service life
   1) 10,000 operations at the rated current
   2) 30 operations at the rated short-current breaking current

II. Excellent fault current breaking capability against multiple-lightning strikes

III. No decomposed SF_6 produced during the current breaking process
   *Focus on VCB, recorded up to 204kV Live tank Type CB

High quality and reliability

I. Manufactured under Meidensha's time-proven quality control systems

II. Minimum site assembly work required

III. Designed and developed based on many years of Meidensha's technical experience and expertise in design and manufacture of GIS/C-GIS incorporating VCBs

Easy to maintain and Environment-friendly

I. Easy to maintain and a long service life
   High-quality and long-life grease and O-rings

II. Enviornment-friendly.
   Minimum use of SF_6 gas at a low pressure for insulation only

2. Technical Specification

Table 2 **Gas Insulated Switchgear (GIS) V-GIS**

Model			GKS-14V	
Rated voltage		(kV)	123	145
Rated current		(A)	1250/2000	
Rated frequency		(Hz)	50/60	
Rated breaking current		(kA)	31.5/40	
Rated short time withstand current		(kA-sec)	31.5/40-3	
Insulation level (Between phases, phase to earth)	1min power frequency (kV rms)		230	275
	Lightning impulse (kV peak)		550	650
Insulation level (for DS) (Across the isolating distance)	1min power frequency (kV rms)		265	315
	Lightning impulse (kV peak)		630	750
Rated control/operating voltage		(Vdc)	Control voltage: 110 Operating voltage: 110	
Rated gas pressure (at 20°C) SF_6 gas insulation	VCB		0.16MPa · G	
	Others		0.5MPa · G	
Applicable standards	IEC62271-203(2011)			
Installation location	Indoor/outdoor			

Table 3 **Vacuum Circuit Breaker (VCB)**

Model			VBU-120732B/VBU-120740B
Rated voltage		(kV)	123/145
Rated current		(A)	1250/2000
Rated breaking current		(kA)	31.5/40
Rated short time withstand current		(kA-sec)	31.5/40-3
Rated making current		(kA)	80/100
Operating duty			O-0.3s-CO-15s-CO
Operating mechanism	Opening		Spring
	Closing		Motor charged spring
Applicable standards			IEC62271-100(2012)

Table 4 **Disconnecting Switch (DS)**

Model		GDT-120732MA/GDT-120740M
Rated voltage	(kV)	123/145
Rated current	(A)	1250/2000
Rated short time withstand current	(kA-sec)	31.5/40-3
Operating mechanism		Manual / Motor-drive
Applicable standards		IEC62271-102(2013)

Table 5 **Maintenance Earthing Switch (ES)**

Model		GEF-12032HA/GEF-12040H
Rated voltage	(kV)	123/145
Rated short time withstand current	(kA-sec)	31.5/40-3
Operating mechanism		Manual
Applicable standards		IEC62271-102(2013)

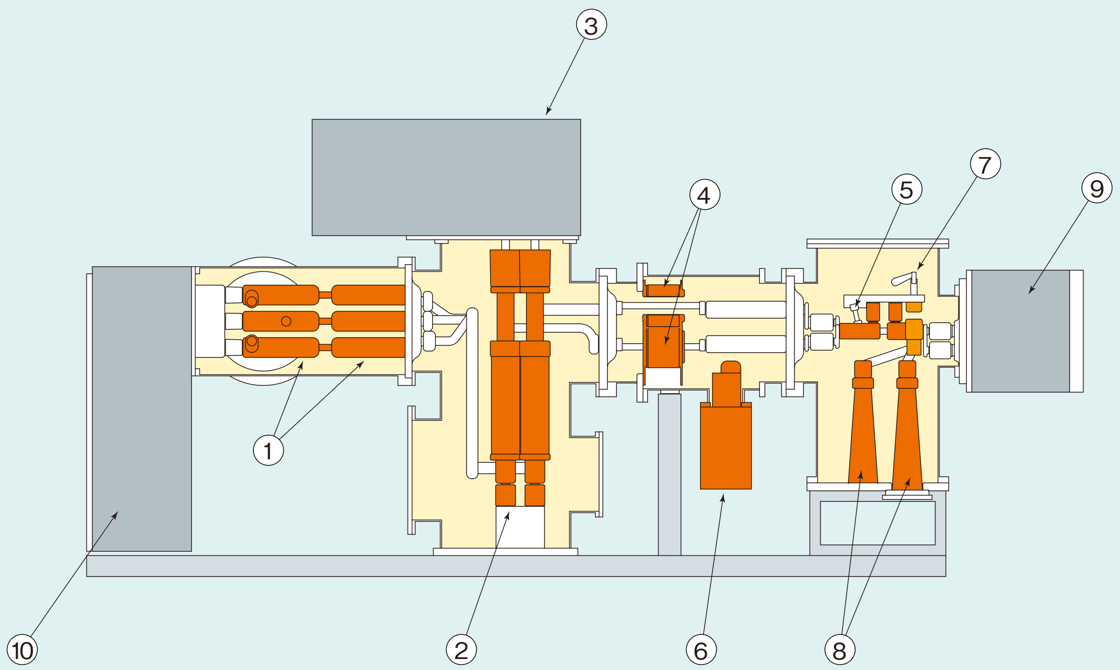
Table 6 **High Speed Earthing Switch (HSES)**

Model		GECF-12032BA/GECT-12040B
Rated voltage	(kV)	123/145
Rated short time withstand current	(kA-sec)	31.5/40-3
Rated making current	(kA)	80/100
Rated electromagnetic coupling induced current		1kV , 50A
Rated electrostatic coupling induced current		3kV , 0.4A
Operating mechanism		Motor charged spring
Applicable standards		IEC62271-102(2013)

3. Equipment Design

The GIS is constructed with standardized units such as the busbar unit with a disconnecting switch, VCB unit with an earthing switch, disconnecting switch unit with an earthing switch, etc.

This GIS can be applied to various system configurations by combining those standardized units.
Fig. 1 shows a typical configuration of a feeder bay.



①	Busbar with DS/ES	⑥	ES
②	VCB	⑦	HSES
③	VCB operating mechanism	⑧	Cable End
④	CT	⑨	VT
⑤	Line DS	⑩	Local Control Cabinet

Fig. 1 Typical Configuration of GIS

Circuit-Breaker

The feature of this GIS is the employment of a Vacuum Circuit Breaker (VCB). The Vacuum Interrupters (VI) used on this VCB is of the single-break Axial Magnetic Field (AMF) electrode type. Fig2 shows a 145kV single-break VI and Fig3 shows an example of AMF electrod SF_6 gas is used for insulation purpose only.
The VCB offers high performance and high reliability, featuring:-
Rated current breaking capability, even if SF_6 gas has leaked
Multiple lightning fault handling capability
An electrical motor charging spring stored energy type operating mechanism.
Unlike pneumatic and hydraulic operating mechanisms the motor charging spring stored energy mechanism offers easy maintenance and reduction in maintenance time and cost.
The optimised alignment of the VCB and DS, etc. is designed based on 3D electric field simulations, which also ensures high accuracy and reliability of the insulation design.
Fig4 shows an example of a magnetic field analysis for axial magnetic field, electrodes and observed arcs.

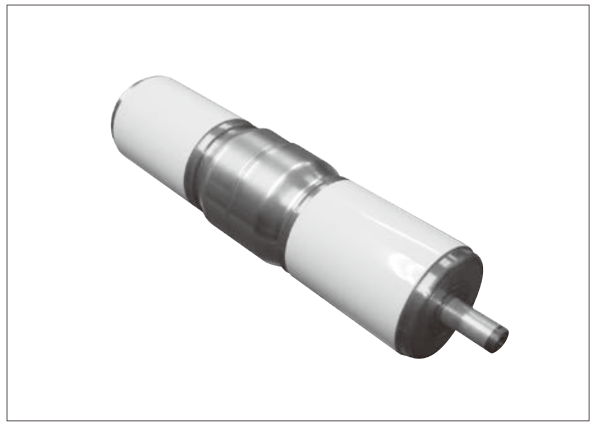


Fig. 2 145kv Single-Break VI

Fig. 3 AMF Electrode

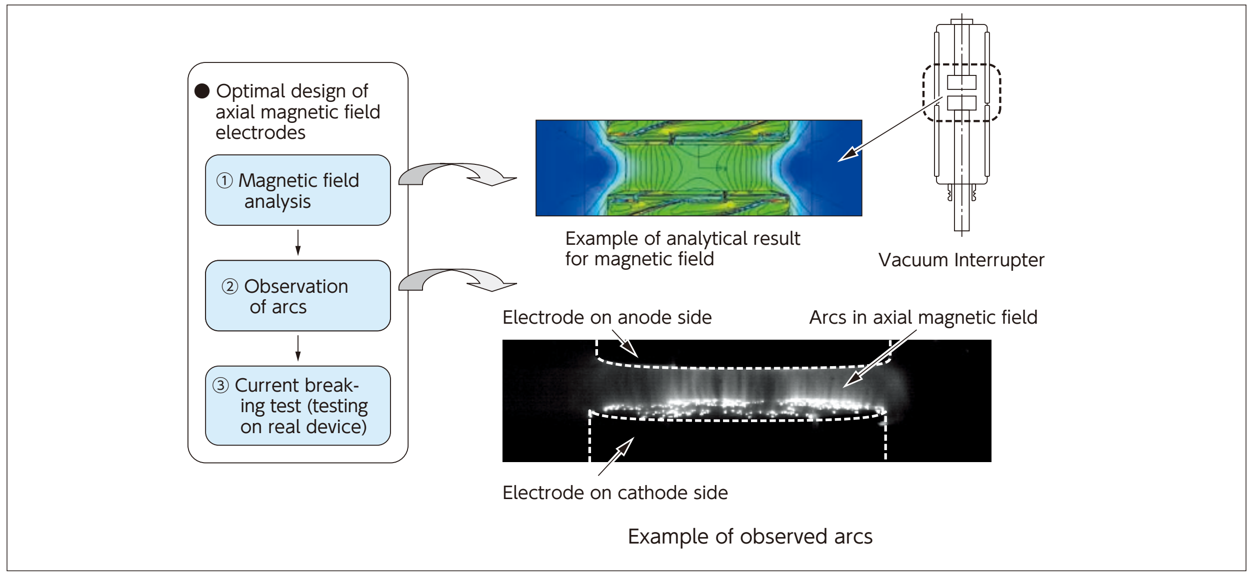


Fig. 4 Example of Magnetic Field Analysis for Axial Magnetic Field Electrodes and Observered Arcs.

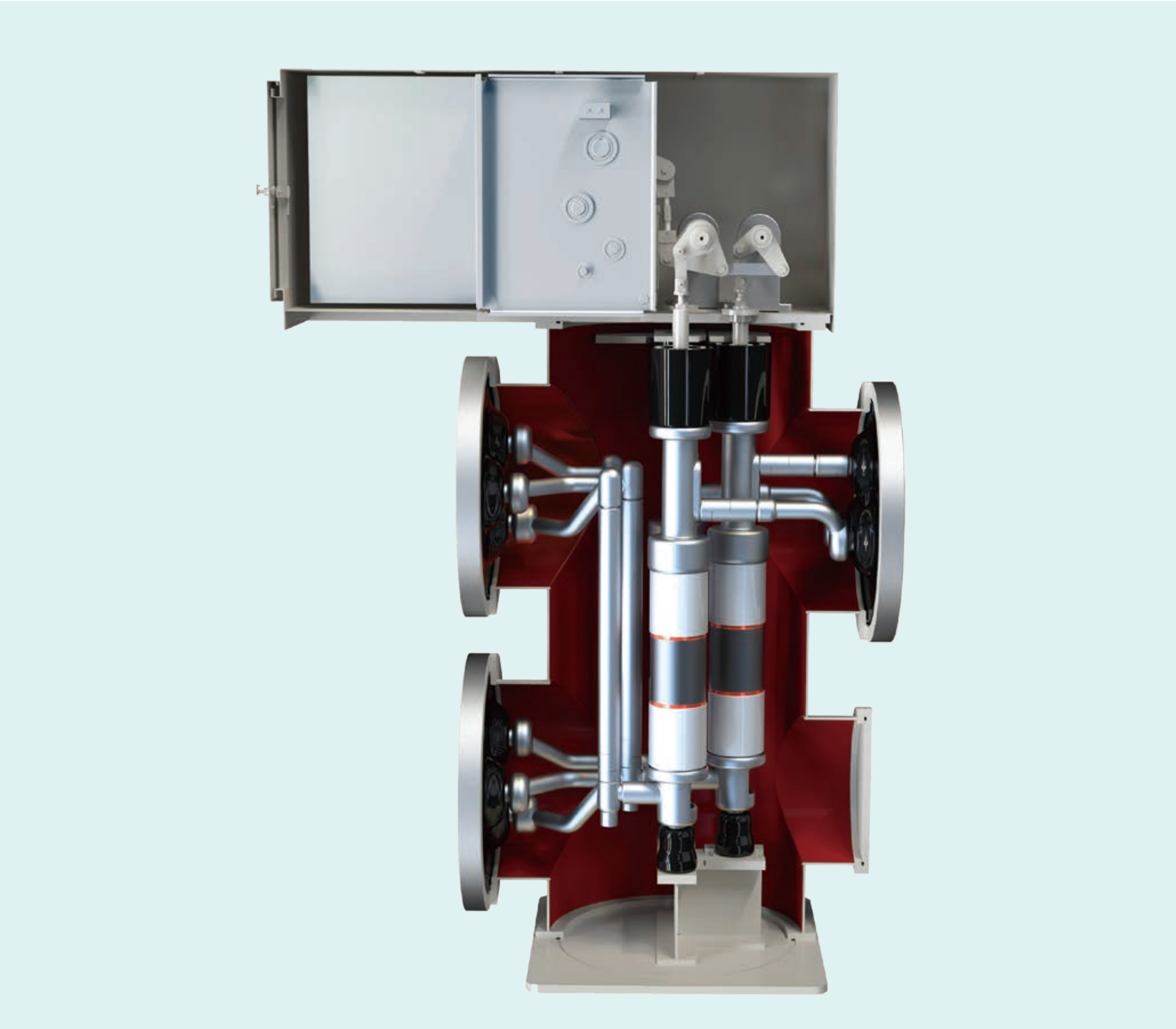


Fig. 5 VCB unit

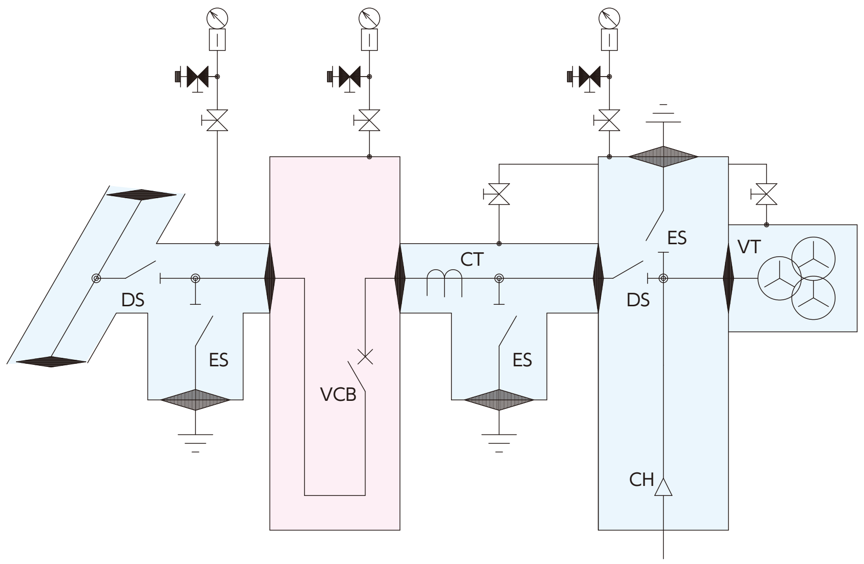
Table 7 **Advantages of VCB over GCB**

Class	Item		VCB	GCB *1	Note
Maintenance	Number of operations (time)	At rated current (2000A)	10000 times	2000 times	VCB has an extreme low contact erosion and a long service life.
		At rated short-circuit breaking current (31.5/40kA)	30 times	10 times	
	Overhaul of interrupter		Unnecessary	Every 2000 operations	VCB is maintenance free.
	Environmental impact (Decomposition of SF_6 gas)		None	At each switching and current breaking	No gas treatment is required
Operational energy			Under 50%	100%	The operational energy of VCB is less than half that of GCB.
Multiple lighting fault handling capability			Excellent Arcs are self-quenching in Vacuum (Vacuum diffusion)	Poor Additional arc quenching mechanisms are required	VCB is capable of handling multiple lightning faults because of its inherent vacuum diffusion effect

*1 Comparison with Meiden-brand GCB

Gas Monitoring System

For continuous monitoring of SF_6 gas, each gas compartment is provided with a temperature compensated gas-density meter, as the insulation capability of a GIS largely depend on SF_6 gas.
SF_6 gas is used to have a function, as an insulating medium, at a rated gas pressures of 0.16MPa (gauge) and 0.50MPa (gauge) for the VCB unit and the other units respectively.
Each gas-density meter initiates an alarm on the local control panel in the event of a deviation from the rated gas pressure.
A signal from the gas-density meter will activate the fault indicator for an alarming low gas pressure situation of each gas compartment.



GAS PRESSURE (at 20℃)

Name of unit	Rated gas pressure (MPa・g)	Alarm gas Pressure (MPa・g)
Circuit-breaker unit	0.16	0.14
Other units	0.50	0.45

GAS BOUNDARY SYMBOLS	
	Gas sealing spacer
	Stop valve (Normally open)
	Stop valve (Normally close)
	Gas supply inlet
	Gas density monitor with temperature compensation

Fig. 6 Gas Monitoring System

Maintenance

All live parts in SF_6 Gas Insulated Switchgear are not affected by external environmental conditions such as air pollution, excessive moisture, salty air, etc.
Therefore, no inspection/maintenance for equipment/devices inside the SF_6 gas compartments is usually required until the number of operations of a switching device reaches to the specified number of operations.
Only external inspection/maintenance such as checking of gas pressure monitors, greasing of the operating mechanism, etc. is normally required without opening the gas compartments.
On the other hand, the contents of inspection / maintenance vary depending upon the operating conditions, thus, the frequency and type of inspections needs to be determined to suit the operating conditions.

Recommended inspection/maintenance:

(1) In the Routine Inspection, which is recommended to be made every six (6) years, each SF_6-gas-filled area should be checked and confirmed that the specified gas pressure is maintained. Also, an operating characteristic test of the operating mechanism must be done.

(2) In the Periodic Inspection, which is recommended to be made every twelve (12) years, the same inspection as the above routine inspection should be done and any worn parts should be replaced with new parts.

(3) A special inspection must be made when a fault is found, and when the specified maximum number of operations is reached. It is recommended to make inspection/maintenance on primary components such as the VCB when 30 times of full fault current interruptions is reached, and the DS when 2000 times of mechanical operations is reached.

Details of inspections/maintenance are described in the instruction manual.

Table 8 **Recommended inspection/maintenance**

Type of inspection	Frequency of Inspection	What is to be made in inspection / maintenance
Patrol inspection	Daily	External visual inspection with the breaker being kept in service.
Routine inspection	Every six (6) years	The GIS must be taken out of service before inspection/maintenance is carried out. · Operating mechanism check · Operating characteristic test of the operating mechanism · External inspection
Periodic inspection	Every twelve (12) years	The GIS must be taken out of service before inspection/maintenance is carried out. · Operating mechanism check · Operating characteristic test of the operating mechanism · External inspection · Replacement of worn parts with new ones, such as door-sealing packings etc.
Special inspection	When the specified maximum number of operations is reached	Before starting inspection, ensure to: · Take out the GIS out of service · Evacuate SF_6 gas · Open the gas compartment · Dismantle the current breaking section for inspection (Replace the whole parts) · Replace any worn parts with new ones

Life Cycle Cost (LCC)

Maintenance Low Life Cycle Cost !

■ Overhaul of Interrupter (Circuit Breaker Portion)
VCB is maintenance free.

Item	VCB	GCB*1
Overhaul of Interrupter	Unnecessary	Every 2,000 Operations or 18th Years

Maintenance schedule (period) of various CB

	VCB	GCB*1
Purpose	General	General
6th years	Routine	Routine
12th years	Periodic	Periodic
18th years	Routine	Overhaul
24th years	Periodic	Periodic
30th years	End of life	

*1 Comparison with Meiden-brand GCB

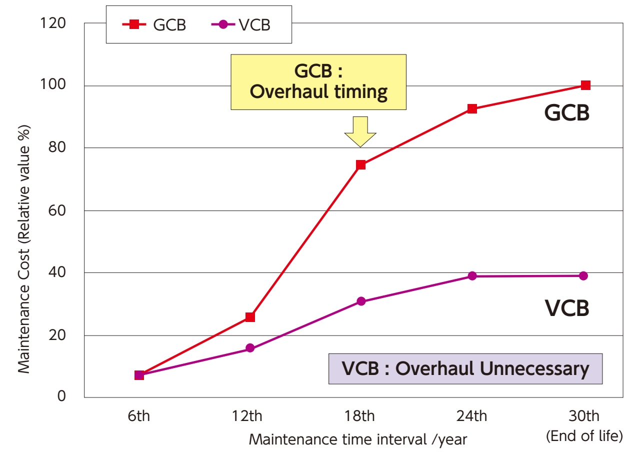


Fig. 7 Maintenance cost (VCB and GCB)

Therefore, VCB is superior to the conventional GCB in Labor Cost & Time Saving.

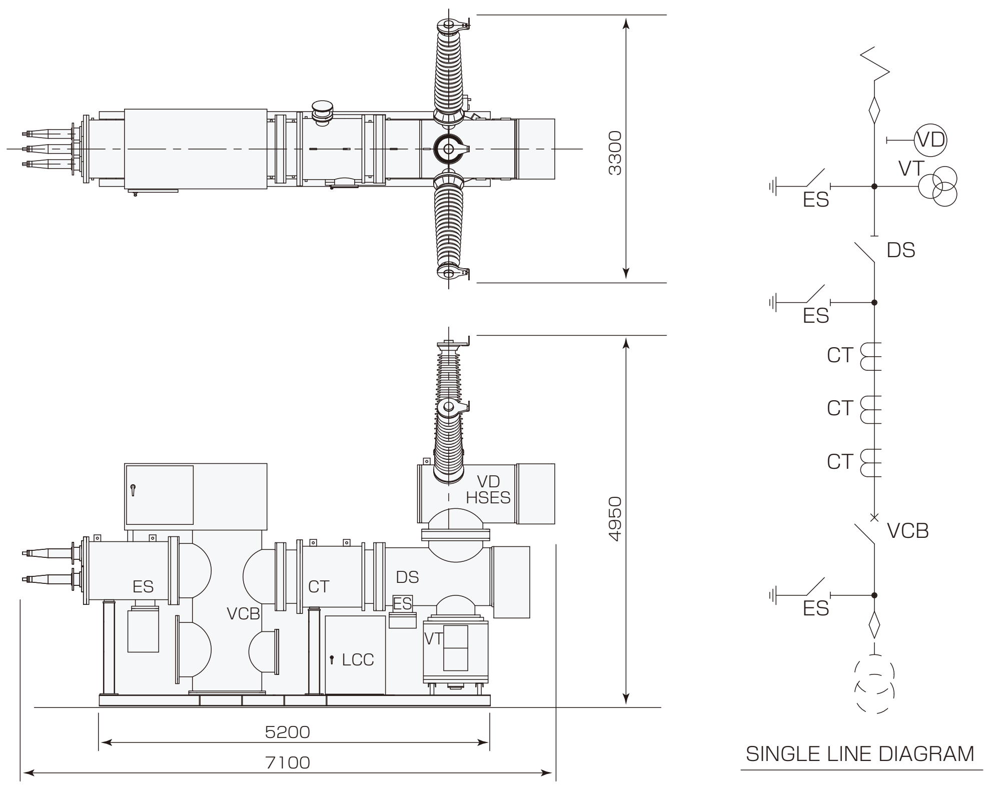


Fig. 8 Configulation example

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