Changes for the Better

MITSUBISHI ELECTRIC

MITSUBISHI VACUUM INTERRUPTERS

RELIABLE

Features of Mitsubishi Vacuum Interrupters (VIs)

Compact & Lightweight

Mitsubishi Electric utilizes advanced technology, including the latest in contact materials, arc control and insulating technologies resulting in compact and lightweight vacuum interrupters.

High reliability

Mitsubishi's distinguished manufacturing process system and over 40 years of experience have established high reliability and an extremely low failure rate. Mitsubishi Electric is the leading manufacturers of vacuum interrupters in the world.

Wide range

Mitsubishi vacuum interrupters have various ratings from 1.5 kV to 84 kV, up to 63 kA short-circuit current, and up to 4,000 A rated current. Applications include vacuum circuit breakers, load break switches, vacuum contactors, and comply with JEC, IEC, ANSI, GB, and DL standards and so on. Our high technology enables the following features and more.

* High number of operations
* High number of interruptions
* Low chopping current
* Low contact welding force

History and over 40 years of experience

Since vacuum interrupters were first launched, tremendous strides have been made in Japan. Mitsubishi Electric began the research and development of vacuum interrupters in the early 1960s. Since its first vacuum interrupter entered the market in 1965, Mitsubishi Electric has continued to play a pioneering role in the field. Since then, over 40 years of experience and up to date technologies result in compact and extremely reliable vacuum interrupters making Mitsubishi Electric the leading vacuum interrupter company in Japan. Mitsubishi vacuum interrupters are in service in equipment such as vacuum circuit breakers, vacuum contactors, and load break switches all over the world.

Mitsubishi Vacuum Interrupter (VI) History

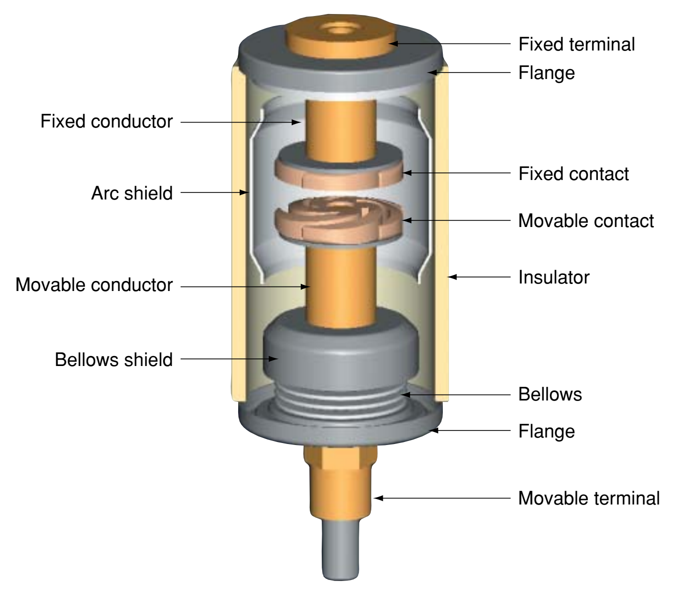
1953	Rectifier tubes such as Ignitron and Thyratron began being manufactured.
1962	Basic research of VI started in R&D.
1965	6.6 kV Glass vessel type VI was developed.
1968	Metallic vessel type VI was developed.
1970	36 kV-25 kA VI was developed.
1973	Ceramic vessel type with Cu-Cr spiral contact was developed. 7.2kV-40kA VI was developed.
1980	VI export to European customers started. 12kV-50kA VI was developed.
1982	7.2 kV-12.5 kA low surge type VI was developed.
1985	Total production quantity exceeded 0.5 million.
1988	Production quantity of VI exceeded 0.1 million per year.
1989	VI plant transferred to Marugame works. Total production quantity exceeded 1 million.
1995	Obtained ISO 9001 certification.
1998	7.2kV-40kA low surge VI was developed. Obtained ISO 14001 certification.
2004	Total production quantity exceeded 2.5 million.

Vacuum interrupter structure

Fundamentally, a vacuum interrupter consists of a ceramic insulator and two flanges, an arc-shield, bellows, movable and fixed terminals, and two contacts. An ultrahigh vacuum is maintained inside the vacuum insulator. Contacts are closed and opened by the motion of a movable terminal, which is connected to the operating mechanism. The bellows enable the movable terminal to move while still maintaining the vacuum. When the contacts are closed, a current flows through the fixed terminal and the movable terminal. When the contacts separate, the current is cut off. An arc-shield protects the ceramic insulator from losing its dielectric properties due to the metal vapor which is produced by the contacts during interruption. These parts are brazed together in an ultrahigh vacuum furnace.

The materials of vacuum interrupter parts are carefully selected to enable excellent electrical characteristics and long life. All the vacuum interrupter's parts except the guide are made of gas-free materials. The insulator is made with a high percentage of alumina containing ceramics. Also, each part of the vacuum interrupter is RoHS compliant (enforced in July 2006 in Europe).

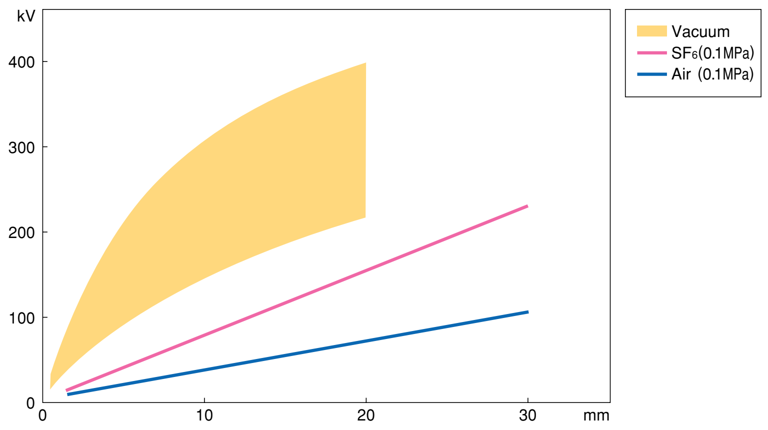
Basic structure of vacuum interrupter



Advantages of a vacuum

The dielectric strength of a vacuum is superior to other mediums such as air, SF_6 gas or oil. The high dielectric strength of a vacuum allows vacuum interrupters to have a very compact design. Also since the arc voltage is very low in a vacuum and insulation recovery after interruption is very fast, the energy of the arc between the contacts is much smaller than in other mediums and the arcing time is very short. As a result, vacuum interrupters can break a large current within a short time with low contact erosion. Additionally, since the interruption takes place within a sealed vacuum bottle, vacuum interrupters enable safe operation and long life, are maintenance free, and do not discharge any hazardous elements.

Dielectric strength

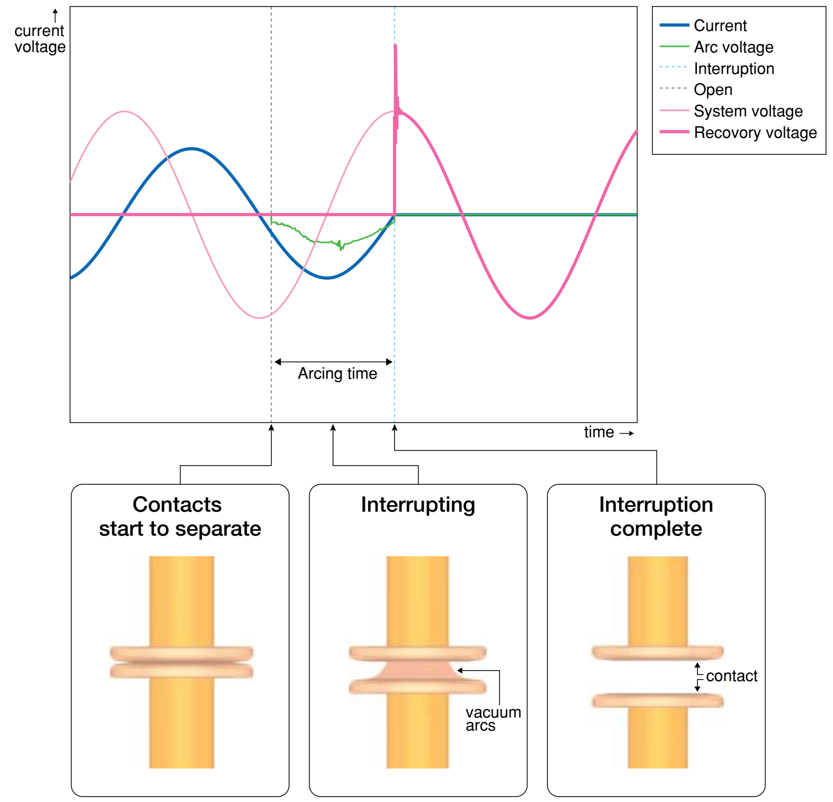


The interruption of vacuum arcs

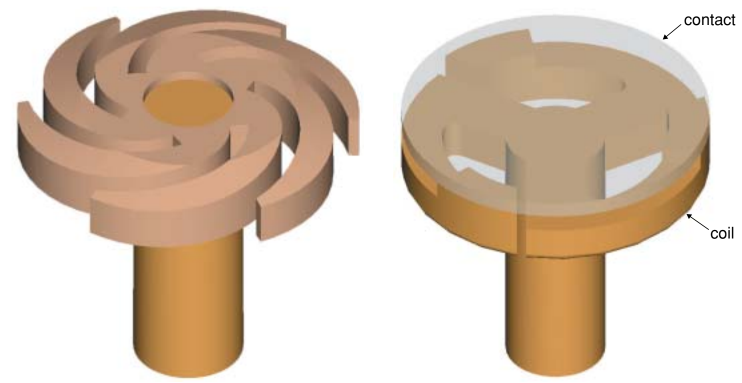
When the contacts separate, an arc appears between the contacts and is maintained until the next current zero point. This arc melts the contact material and results in metal vapor. If the arc remains stationary at one point, too much metal vapor is produced due to the local overheating of contacts. As a result, the interruption capacity decreases. Therefore, it is very important to prevent local overheating.

When the current is small and the contact is large enough, the arc will spread by itself, and the interruption is completed successfully. However, if the current is increased, the arc tends to contract and remains stationary at a certain point. Therefore the arc control structure must be effective in increasing the interruption capacity. Mitsubishi Electric uses magnetic field arc control technology. Spiral contacts generate a radial magnetic force to rotate the arc, and the axial magnetic field (AMF) contacts diffuse the arc by axial magnetic force. These contact structures enable a high interruption capacity and a compact design.

Interruption oscillograph



Contact structure



Spiral contact
Current flow along the spiral contact generates radial magnetic field to rotate an arc.

AMF contact
Current flow along the coil generates axial magnetic field to diffuse an arc.

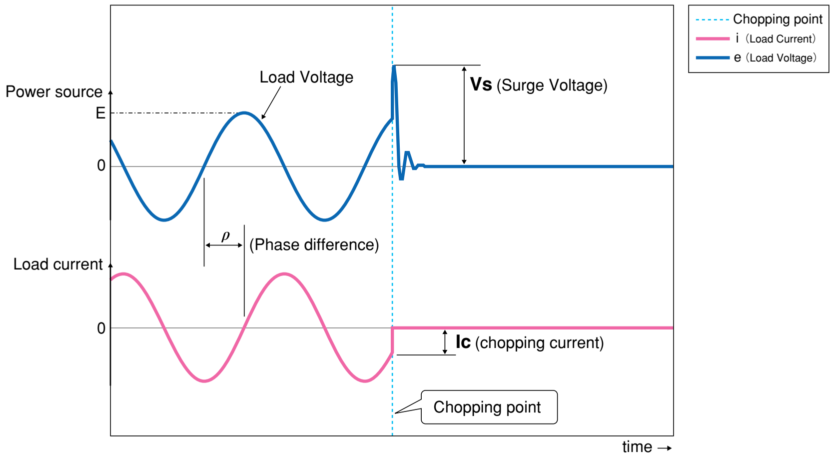
Research and Development

Mitsubishi Electric has established consolidated designing and testing methods to develop reliable products. Mitsubishi vacuum interrupters are designed based on several types of analysis and are examined from all angles. To develop even better vacuum interrupters, Mitsubishi Electric conducts research and development on everything from basic research to the development of application techniques. This includes the development of new materials, research on contact configuration through observation of arcing, and studies of interruption performance.

Contact material technology

The contact material is one of the most important factors which determine the fundamental electrical performance of vacuum interrupters such as interruption capacity and dielectric strength. Furthermore, low residual gas is required to ensure long life. Mitsubishi Electric has developed contact materials and powder metallurgy which produce features such as low welding force low chopping current, high dielectric strength, and high interruption capacity.

Surge voltage



Small currents tend to be cut off before the current falls to zero because of the high dielectric strength of the vacuum. At that time, surge voltages occur on the load devices, depending on the chopping current and the surge impedance of the circuit. Since the surge voltage can affect load devices, generally surges are prevented by surge protective devices including CR suppressors. However, Mitsubishi contact material technology limits this effect by reducing the chopping current.

Insulation technology

Mitsubishi vacuum interrupters are designed using electrical field analysis, based on thousands of studies and a vast amount of test data. High voltage and current conditioning technology enable reliable and high withstand voltage vacuum interrupters. Mitsubishi's high insulating technology allows vacuum interrupters of up to 84 kV of rated voltage.

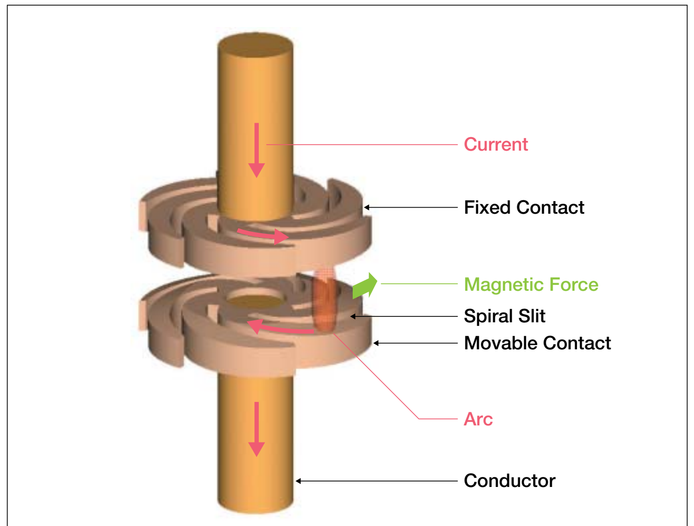
Dielectric test cell

Arc control technology

Controlling arc behavior during interruption is greatly effective in increasing interruption capacity. The shape of the contacts is designed by magnetic and electrical field analysis, and then the arc behavior is confirmed by high speed video cameras. A large amount of data and a broad range of experiments minimize the diameters of the contacts and vacuum interrupters. Mitsubishi Electric is committed to ongoing research and development aiming to minimize the sizes of vacuum interrupters to meet even the most demanding requirements.

Optical observation of arc motion

The vacuum interrupter's contacts and conductors are installed in a demountable chamber, and breaking tests are carried out in the chamber, which is kept a high vacuum. The arc motion during the interruption can be observed through a window by high-speed video cameras.

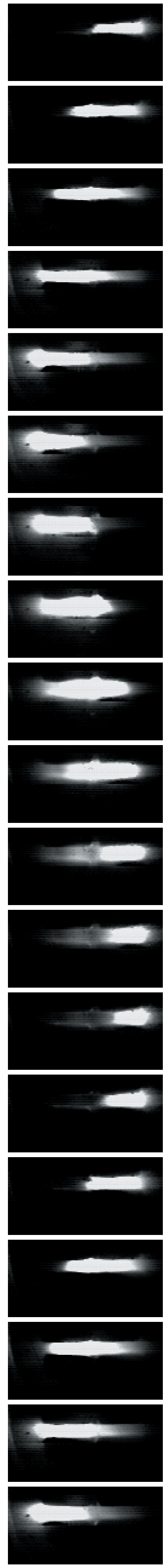


Current flow during the interruption

In the case of spiral contacts, an arc between the contacts rotates along the circuit of contact by the radial magnetic force, which was generated by the current flow along the spiral contact.

Demountable chamber

Arc motion of spiral contacts.
An arc appears between contacts when the contacts separate. Then the arc rotates along the contact circuit by the magnetic force.



Manufacturing process

Mitsubishi Electric's many years of experience has established reliable and up-to-date manufacturing procedures. Mitsubishi's strict manufacturing process system results in an extremely low failure rate.

The strictly controlled materials for vacuum interrupter parts are checked by measurement or mil sheet. Then the parts are washed by an automatic chemical surface treatment to clean and treat the surface. They are then assembled in a clean room in which the dust level is controlled. Then the assembled parts are brazed in an ultrahigh vacuum furnace. Vacuum furnaces are under an ultrahigh vacuum to degas the residual gas in the parts. The continuous vacuum furnaces have a preparation room, a heating room, and a cooling room. Products are conveyed from one room to another automatically. Since the heating room is not exposed to the air during the process, the room always maintains a clean atmosphere. The brazing time of a continuous type furnace is much shorter than a batch type furnace, so it can provide a large amount of products efficiently. All the data during the brazing is recorded and the quality of the vacuum in the furnace is measured to check the vacuum furnace atmosphere. The products are checked at every step, and only products which pass stringent checks can proceed to the next procedure based on ISO 9001.


Contact machining center without machining oil


Automatic chemical surface treatment


Assembly in a clean room


Continuous vacuum furnace

Testing and Measurement

Routine testing of every single vacuum interrupter includes dielectric characteristics and vacuum degree check.
After assembly, conditioning by very high voltage to clean contact surfaces and dielectric tests are performed on each vacuum interrupter to ensure high dielectric strength. The degree of vacuum is measured by magnetron method several times and a leakage test is also performed on each vacuum interrupter. Various tests and measurements are performed to ensure high reliability.


Automatic conditioning and electrical testing device


Mechanical test and conditioning device


Fitting of a guide, measurement of vacuum degree and bellows force are carried out automatically

Applications

Mitsubishi vacuum interrupters are widely used in vacuum circuit breakers, load break switches, vacuum contactors, load tap changers, railway applications and auto reclosers. Mitsubishi vacuum interrupters are accepted worldwide, and have gained a highly regarded reputation for high performance and reliability.

6.6 kV Vacuum contactor

7.2 kV Vacuum circuit breaker

72/84 kV Gas insulated switchgear

12 kV Metal clad switchgear

24 kV Gas insulated switchgear

24 kV Vacuum circuit breaker

7.2 kV High-speed vacuum circuit breaker

* Interruption completes within a cycle so that a system which changes over power lines within a short time can be designed.

42 kV Load break switch

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