Vacuum circuit breakers
Vacuum extinguishing chamber
Characteristics of vacuum circuits breakers:

- Up to 10 000 switching operation without maintenance
- High longevity and operational safety
- Non-burnable
- Without gas and flames emission
- Silent operation
- Low wear out
- Low hub of contacts
- Very low arc voltage and extinguishing energy


And:
[http://www.google.cz/images?hl=cs&gbv=2&rlz=1R2GGLJ_enCZ411&gs_sm=s&gs_upl=2891I2891I0I5031I1I1I0I0I0I172I172I0.1I1I0&q=Vacuum+circuit+breakers&spell=1&sa=X&oi=image_result_group&sa=X](http://www.google.cz/images?hl=cs&gbv=2&rlz=1R2GGLJ_enCZ411&gs_sm=s&gs_upl=2891I2891I0I5031I1I1I0I0I0I172I172I0.1I1I0&q=Vacuum+circuit+breakers&spell=1&sa=X&oi=image_result_group&sa=X)
Application areas:

- Short circuits currents disconnecting
- Cables and out-door lines switching
- Transformers switching
- Generators switching
- Motors switching
- Switching of arc furnaces
- Switching of trolley lines
Principles of vacuum extinguishing chamber

- Extinguishing of electric arc in vacuum
- At contacts disconnecting arise electric arc created by metallic vapours separated from contact material.

- Arc in vacuum has cone shape with top on cathode. Anode contact shape of the arc is big and enable temperature good spreading without overheating of anode surface.
• Under nominal current diffusion type of arc is established over all shape of electric contact.

• When disconnecting current arises over nominal current, arc is by magnetic forces contracted on anode and cathode.
To increase breaker disconnecting ability anode spot must be eliminated. It is possible by means:

- Contact material property
- Contacts shape arrangement
- By means of electro-dynamic forces rotate the arc bottom round the anode
- Contact dimensions increasing
- External magnetic field excitation
Contacts with radial magnetic field for arc rotation achieving

Spiral petal contacts
• To restrict over-voltage at low inductive currents disconnecting, chopped current must be minimised.

• Low arc voltage, short time of arc relates to minimum arc energy and small contacts erosion => extinguishing system is maintenance free.
Fig. 8.6 Vacuum interrupter type PV01 manufactured by GE (USA) [Courtesy GE]
Operational principle of vacuum circuit breaker driving mechanism
Construction of modern vacuum contactors

- Terminals of fix contact
- Drive of moving contacts
- Terminal of moving contacts
Vacuum circuit breaker Siemens 3AH 1

Type 3AH1
maintenance fre

- Durability: 10,000 switching operations
- Application area: from 7.2 kV up to 24 kV.
Typ 3AH1
– with lever drive of moving contacts

Legend:
Type 3AH3
– Circuit breaker for high power applications

Maintenance-free, powerful circuits breaker, ability 10 000 switching operations. Type 3AH3 usable up to 63 kA of short circuit currents and voltage 36 kV. With respect to high efficiency is determined for generator switching and industrial application.

Nevyžaduje údržbu, je extrémně výkonný a je schopen zvládnout až 10 000 spínacích operací. Typ 3AH3 se používá při velkých zkratových proudech do 63 kA a pro jmenovitá napětí do 36 kV. Vzhledem k vysoké výkonnosti je to ideální vypínač pro generátory a pro použití v průmyslu.
Drives of vacuum circuit breakers

Switching by means of spring energy accumulator
Vacuum switch ABB VD4

- VD4 type switching poll creates complete fix maintenance-free switching unit
- Extinguishing chamber is immersed into the peroxides-resin.
- All system is pollution and dust resistant

1- Top terminal
2- Vacuum extinguishing chamber
3- Insulation cover
4- Moving contact pin
5- Bottom terminal
6- Flexible outlet
7- Moving contact compression spring
8- Insulating pull-rod
9- Fixing pole hole with thread
10- Connecting rod with hole for contact drive
Typ 3AH3

- varianta pohonu 3 driving mechanism No 3

  - Pohyb při spínání se přenáší přes spínací tyč (16) a páku (15) na pohoný dřík. Movement transmission to the contacts over switching rod (16) and swipe (15) on driving shaft

Legenda k obrázku:
<table>
<thead>
<tr>
<th>Criteria</th>
<th>SF6 Circuit Breakers</th>
<th>Vacuum Circuit Breakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating energy requirements</td>
<td>Operating Energy requirements are high, because the mechanism must supply the energy needed to compress the gas.</td>
<td>Operating Energy requirements are low, because the mechanism must move only relatively small masses at moderate speed, over short distances. The mechanism does not have to provide the energy to create the gas flow.</td>
</tr>
<tr>
<td>Arc Energy</td>
<td>Because of the high conductivity of the arc in the SF6 gas, the arc energy is low. (arc voltage is between 150 and 200V.)</td>
<td>Because of the very low voltage across the metal vapour arc, energy is very low. (Arc voltage is between 50 and 100V.)</td>
</tr>
<tr>
<td>Contact Erosion</td>
<td>Due to the low energy the contact erosion is small.</td>
<td>Due to the very low arc energy, the rapid movement of the arc root over the contact and to the fact that most of the metal vapour re-condenses on the contact, contact erosion is extremely small.</td>
</tr>
<tr>
<td>Arc extinguishing media</td>
<td>The gaseous medium SF6 possesses excellent dielectric and arc quenching properties. After arc extinction, the dissociated gas molecules recombine almost completely to reform SF6. This means that practically no loss/consumption of the quenching medium occurs. The gas pressure can be very simply and permanently supervised. This function is not needed where the interrupters are sealed for life.</td>
<td>No additional extinguishing medium is required. A vacuum at a pressure of 10-7 bar or less is an almost ideal extinguishing medium. The interrupters are ‘sealed for life’ so that supervision of the vacuum is not required.</td>
</tr>
</tbody>
</table>
### Switching behavior in relation to current chopping

The pressure build-up and therefore the flow of gas is independent of the value of the current. Large or small currents are cooled with the same intensity. Only small values of high frequency, transient currents, if any, will be interrupted. The de-ionization of the contact gap proceeds very rapidly, due to the electro-negative characteristic of the SF6 gas and the arc products.

The pressure build-up and therefore the flow of gas is dependent upon the value of the current to be interrupted. Large currents are cooled intensely, small currents gently. High frequency transient currents will not, in general, be interrupted. The de-ionization of the contact gap proceeds very rapidly due to the electro-negative characteristic of the SF6 gas and the products.

No flow of an ‘extinguishing’ medium needed to extinguish the vacuum arc. An extremely rapid de-ionization of the contact gap, ensures the interruption of all currents whether large or small. High frequency transient currents can be interrupted. The value of the chopped current is determined by the type of contact material used. The presence of chrome in the contact alloy with vacuum also.

<table>
<thead>
<tr>
<th></th>
<th>No. of short-circuit operation</th>
<th>No. full load operation</th>
<th>No. of mechanical operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10—50</td>
<td>10—50</td>
<td>30—100</td>
</tr>
<tr>
<td>No. full load operation</td>
<td>5000—10000</td>
<td>5000—10000</td>
<td>10000—20000</td>
</tr>
<tr>
<td>No. of mechanical operation</td>
<td>5000—20000</td>
<td>5000—20000</td>
<td>10000—30000</td>
</tr>
</tbody>
</table>
Recommended web addresses for self-study
