Elimsan Vacuum Circuit Breakers

Vacuum Circuit Breaker
With Side - Wall Operated Mechanism
With Front Operated Mechanism

Standard
IEC 62271-100
Elimsan Vacuum Circuit Breakers
Features of Vacuum Circuit Breakers (VCB)

Arc extinguishing in vacuum media technique, known as the most reliable method among arc extinguishing techniques under medium voltage, is increasingly expanding its area of use. As an arc extinguishing medium, vacuum has an indisputable superiority. As a result of more developed material technologies, today vacuum interrupters up to 126 kV voltage levels are being used with circuit breakers. In the near future, it is planned to develop 170 kV vacuum circuit breakers and higher than 170 kV as the first target.

Most important reasons to prefer vacuum circuit breakers for medium voltage level production, conduction and distribution systems are as follows: they provide user safety, need low mechanical operating power and are small in size. Obtaining high voltages with small dimension is another distinguishing property of vacuum circuit breakers. Contacts last longer than other known breaker types, they do not require servicing, do not include any gas or lubricant, they are environmental friendly; these are other reasons to prefer vacuum breakers. Contact materials which evaporate from cutting surfaces during cutting return to contact surfaces when arc is extinguished. Return to the former insulation level after arc is extinguished takes a much shorter time.

Advantages of Vacuum Circuit Breaker

Vacuum circuit breakers break failure currents in the shortest time in a most reliable manner. After breaking the current arc goes out automatically very fast and insulating feature of the medium is recovered in a moment. Therefore vacuum breaker has superior ability to break subsequent failure currents.

Pressure in the vacuum interrupter in a vacuum circuit breaker is min. 1x10⁻³ milibars. This pressure level is the minimum operating pressure for vacuum interrupter and electrical resistance of such a vacuum medium is 100 kV/cm.

Thanks to special contact materials, current discontact values are decreased, thus, excessive voltage increases in the system are avoided.

Metal steam which follows breakage of short-circuit currents intensifies in very short periods and former resistance value of the medium is restored. Vacuum level in interrupter is warranted as 20 years.

Another advantage of vacuum breaker is that there is no risk of explosion in cylinders. In the case that vacuum breaker interrupter is broken for any reason, due to present vacuum, cylinder will sink concavely. Materials chopped from contact during breaking are again intensified on the contact surfaces, hence, contact life is long.

Electrical life of vacuum breakers can rise up to 100 breaks at rated short circuit currents.
Technical Data

<table>
<thead>
<tr>
<th></th>
<th>12</th>
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<th>24</th>
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<tr>
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</table>

Areas of Use

- Metal-Enclosed Switchgears
- Metal Clad Switchgears
- Open Type Distribution
- Transformer Centers
- Industrial Plants
- Cradle Type Breakers
- Seconder Protection Systems
- Cement Factories

Standards

- IEC 62271 - 100
- TS EN 62271-100
Features of Vacuum Interrupters

Arc in vacuum is generated by vaporization of contact material which is chopped from contacts. High dielectrical resistance of vacuum allows distance between contacts to be as short as 10-20 mm. Energy conversion of metal steam arc is very low due to its small size and low resistance.

When current is appx. zero, arc goes out and most of the metal steam is condensed on the contacts that generate it. Thus, contact materials evaporated in the vacuum are reclaimed in highly pure and valuable contact surfaces and contacts are reserved from burning and wearing.

In entire current area of separation interval, dielectrical current is generated right after the arc goes out; hence, vacuum breakers can be used to break excessively high capacitive currents.

Contacts over which current flows are separated and an arc discharge is created. In currents up to 10 kA, it continues in a scattered manner on arc surface between contacts until current becomes zero. Heat density, hence, contact burning is negligible.

In currents over 10 kA arc is compressed with the magnetic field pressure that it generates and a thin bunch is created.

Arc continues in a compressed manner and it causes quick evaporation of more contact materials at the flammation point of arc due to high flow density. Thus, when arc becomes zero, it is more difficult to go out. Therefore, to avoid excessive heat in the contact parts which carry arcs, contact types are preferred which create magnetic fields that ensure arc rotation. When flow becomes zero, arc is reduced, condensed and rotating, after when it assumes sparse discharge. Thus, contact burning is decreased and dielectrical resistance of separation interval after arc is went out is increased so that breaking capacities of arc extinguishing cells are raised to the level that vacuum breakers should have.
Arc Extinguishing in Vacuum

Vacuum cell consists of a container whose air is completely discharged which includes two opposite electrodes, one of which is stationary and the other is propelled through an external propeller mechanism, and a ceramic cylinder. The metal bellows, whose one end is connected to the shaft of moving contact, and the other end is connected to the container whose air was discharged, ensures the impermeability between the section whose air is discharged and the environment.

Metal cylinder which is placed as insulated from contacts constitutes the condense screen. When current-passing contacts are separated, an arc discharge is created over which the current between electrodes will flow until the current is equal to zero, when, arc discharge is also extinguished as a result of the conditions in the cell. Penetration resistance of separation interval is generated right after the arc goes out. Metal steam wastes turn to contacts or condense on metal cylinder.

Arc discharge is done through multiple parallel arcs whose number depends on the total current. Metal steam which leaves contacts constitutes electrical load carriers. As there is vacuum around the arc in separation interval, diffusion speed of these metal particles is very high.

Thus, penetration resistance of separation interval is generated fast.

For functioning of vacuum cell, purity of these metals is highly important in terms of gases and gas combinations in the cell. During evaporation of metals which are chopped from contact along the arc, these gases are released and increase residual gas pressure in the cell.

Economic manufacturing of contact materials which release negligible gas when evaporated depends on inventing technology fit for highly costly and lengthy researches. Pressure less than $10^{-3}$ mbar is required for functioning of arc extinguishing cell. When vacuum cell is being manufactured, $10^{-9}$ starting pressure is obtained. Considering that $3 \times 10^{-13}$ mbar vacuum leak is seen per second in one liter volume, pressure of the arc extinguishing cell reaches $10^{-3}$ mbar in 20 years.

Change in Dielectrical Strenght of Air With Pressure (Paschen Curve)
(Contact Material = Copper Separation Interval = 10 mm)
Gas removal property of contact material during breakage-closing causes decrease of the pressure in arc extinguishing cell. In this case, it takes a few centuries to reach $10^{-3}$ mbar pressure limit.

Materials used in vacuum breaker arc extinguishing cell are carefully selected. Contacts should have the following properties:

- High Permeability
- Non-Boiling
- High Opening Capacity
- Low Chopping Current
- Resistance to Fire

These desired properties are ensured through copper-chromium alloy obtained by means of joint works with major metallurgy companies.

Figure 1 Breaking principle of vacuum breakers
Breaking of Cable Charging and Line Charging Currents

Besides physical events created by breakage of capacitor battery currents, in networks whose star points are not earthed, short-circuit failures between phase and earth, in the phase when arc first went to, 1.4 times more collection pole voltage is generated. The recovery voltage in single-phase circuit is:

\[ U_r = 2 \sqrt{2} U \]

Breaking of Capacitor Bank Currents

Excessively high transient recovery voltages generated when capacitive currents are interrupted always pose a threat to the system. Insulation of between contact distance must be ensured right after the arc is extinguished, so that penetration of separation interval by network voltage and generation of undesired voltages in the circuit can be avoided. In cases when one or more condenser batteries are closed parallel on a condenser battery in the circuit, high frequency balancing currents are generated which are impact-type forcing the breaker to short circuit currents. This is a factor to be taken into consideration when scaling arc extinguishing cells. Restrictive measures are taken according to IEC standards in order to avoid damages by such short-circuit currents which raise very fast to other parts of the plant.

Vacuum breakers are especially preferred when breaking capacitive currents. They can open even the highest capacitive powers before arc is sparked again and undesired excessive voltages are generated in the circuit.

Breaking of No Loaded Transformer Currents

Selection of appropriate contact material and chopping current is minimized in Elimson insulated pole vacuum breakers. Over voltages that can be generated while unloaded working transformer currents are broken are very small relative to the breakers working on other breaking principles. Therefore, protectors from excessive voltages is not needed.

Breaking of Switching Current and Inductive Currents With Magnetic Air Gaps

Over voltages are generated when breaking and closing High Voltage switching devices which are interrupted or which during starting, as well as inductance currents which have magnetic air intervals. Such over, as voltages are avoided by specially designed zinc oxide (ZnO) surge arresters.

Breaking of Out of Phase

In this case, as can be seen in Figure-2, generated maximum short circuit current is times the tri-phase short circuit current in rated voltages. This problem is taken into consideration in special tests.

Double Earth Fault Currents Switching

Network conditions under which opposite phases are generated are shown in single-pole principle diagram in Figure-2. Under these conditions, when current is broken, asynchronous voltages in chopped network parts leads to too high recovery voltages.
Breaking Short Circuits
Which Generate Too High
Starting Elevation Transient
Recovery Voltages

One of the most important features of vacuum breakers is their ability to break currents with transient recovery voltages with too high starting acceleration. Starting acceleration of recovery voltages generated right after the failures after major inductance (i.e. transformers) can be well above the values defined in IEC 62271-100 and they can even reach a few kV / µs figures.

Mechanical Features

Low contact movements in vacuum breaker ensures that mechanism works with lower spring power. Thus, mechanism and movement components are strained less. Thanks to this characteristic, life of the mechanism changes between 10,000 and 20,000, this result ensures that motor power needed to set the mechanism remains low, too.

Spring-type Mechanism

Spring mechanism works upon the principle that closing springs set by motor or manually set opening springs when breaker is closed. In this case, opening and closing springs of closed breaker are waiting in ready status. Breaker can make “Open – t – Close / Open – t’ – Close / Open”

Operation Steps

Opening Time : Interval of time between the instant of energising the opening release and the instant when the arcing contacts seperated in all poles.

Breaking Time : Interval of time between the beginning of the opening time and the instant of final are extinction in all poles.

Closing Time : Interval of time between energising the closing circuit and the instant when the contacts touch in all poles.

Circuit Breaker Operation

Vacuum breakers consist of two major parts. First of them are vacuum poles, and the second is breaker mechanism. Poles consist of contacts and arc extinguisher parts. Mechanism parts are designed so as to perform opening and closing at poles in a synchronized manner. (difference between phases is not more than 5 msn.) opening and closing processes are performed through springs which can be charged by motor or manually. First, closing spring is charged. If closing button is pressed, opening spring is charged while contacts are closing. Thus, it becomes ready to open the breaker.

Mechanical Locking

There is a locking mechanism which prevents the breaker from turning off when opening button is pressed and key is turned at the arrow direction and the key is removed. Thanks to this lock, breaker can be serviced in a safe environment and chopper mechanisms can be used for locking depending on the needs of the system.

Auto Reclosing

Breaker opened due to short-circuit failure can be closed again in certain intervals in line with adjusted times. Therefore, the network is protected against lengthy power losses.
Accessories

Turn-on coils, turn-off coils, auxiliary commutators, anti-pumping relays and spring set motor are standard equipments for an Elimsan insulated pole vacuum breaker.

Opening and Closing Coils

All spring vacuum breakers are equipped with standard opening and closing coils. Opening and closing coils are controlled from command buttons from an auxiliary current source or protection relay contacts. Coils can be connected to alternative or direct current sources. Opening and closing coils can only be under voltage for a very short time, thus, they are connected to the command circuit through auxiliary contacts. When opening and closing process is completed, they are left without voltage by the auxiliary contact in coil circuit.

Spring charging motor

With Elimsan spring-set vacuum breakers, standard spring charging motor is used to set the closing spring. Closing spring, which can be set in as short as 6 seconds after powering of the motor, also sets opening spring simultaneously when it is closing. By manual and motor setting, Elimsan vacuum breakers are compatible with SCADA systems.

Auxiliary switch

Auxiliary switch are propelled directly by the shaft of breaker depending on the breaker (whether turned on or off). Unless otherwise defined in the order, 80 + 8C auxiliary contact are mounted on the breakers and number of contacts can be raised up to 20 depending on the order.

Anti-pumping relay

It is the equipment which prevents turning off after a turn on-off cycle, despite the presence of turn-off signal.
Elmsan Vacuum Breaker Type Coding

- Elmsan Vacuum Breaker
- Direction of Mechanism: R (Right), L (Left), F (Front)
- Rated Current: 06 (630A), 12 (1250A), 25 (2500A)
- Short-Circuit Breaking Current: 08 (8 kA), 12 (12.5 kA), 16 (16 kA), 25 (25 kA), 31 (31.5 kA)
- Rated Voltage: 2 (12 kV), 3 (17.5 kV), 4 (24 kV), 5 (36 kV)

Technical values that should be reported in the order:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Rated Current</td>
<td>.......... [ A ]</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>.......... [ kV ]</td>
</tr>
<tr>
<td>Short Circuit Breaking Current</td>
<td>.......... [ kA ]</td>
</tr>
<tr>
<td>Opening Coil Voltage</td>
<td>.......... [ V ]</td>
</tr>
<tr>
<td>Closing Coil Voltage</td>
<td>.......... [ V ]</td>
</tr>
<tr>
<td>Motor Voltage</td>
<td>.......... [ V ]</td>
</tr>
<tr>
<td>Frequency</td>
<td>.......... [ Hz ]</td>
</tr>
<tr>
<td>Temperature</td>
<td>.......... [ °C ]</td>
</tr>
<tr>
<td>Altitude</td>
<td>.......... [ m ]</td>
</tr>
<tr>
<td>Customer Acceptance</td>
<td>Yes / None</td>
</tr>
<tr>
<td>Type of Mechanism</td>
<td>Spring Mechanism</td>
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<tr>
<td>Label Language</td>
<td>Turkish – English – French</td>
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</table>
Elimsan
Front-Mechanism
Vacuum Circuit
Breaker

Superior Vacuum Technology
Long Life
High Performance
Front-Mechanism Breakers

Metal clad, cradle and cassette type breakers, front-mechanism and insulated poled vacuum breakers designed for using in open switch type units are called “front-mechanism breakers” as breaker poles are queued behind the mechanism. All physical characteristics but size of front-mechanism breakers are identical to “side-mechanism” breakers.

Elevation envisaged for standard use of Elimsan EVB series breakers is 1000 m. If the area where breakers are used is higher than 1000 ms, corrected network frequency resistance voltage is obtained by multiplying with the factor seen in figure 4 and these test voltages apply to the routine tests of these breakers.

Where,

\[ H = \text{altitude in meters} \]

\[ m = 1 \text{ value referred to power frequency and lightning impulse withstand voltages and those between phases} \]

\[ \text{correction factor } Ka = e^{\frac{H-1000}{8150}} \]
Elimsan Vacuum Circuit Breakers

Electrical Circuit

Elimsan front-mechanism and insulated pole vacuum breakers have electrical installation given in Figure-5 as standard. Technical figures in these installations can be customized according to the buyer's project. Standard electrical connection diagram, which is shown below, is delivered to the customer as stuck onto the cover of each breaker. Setting motor and turn-on and turn-off coil voltages of vacuum breakers are determined by the customer in the order.

<table>
<thead>
<tr>
<th>Motor voltage</th>
<th>Minimum and maximum operating voltages</th>
<th>Motor power</th>
<th>Most preferable AG breaker</th>
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<tbody>
<tr>
<td>24 V DC</td>
<td>20 V to 26 V</td>
<td>350 W</td>
<td>8A</td>
</tr>
<tr>
<td>48 V DC</td>
<td>41 V to 53 V</td>
<td>350 W</td>
<td>6A</td>
</tr>
<tr>
<td>60 V DC</td>
<td>51 V to 66 V</td>
<td>350 W</td>
<td>4A</td>
</tr>
<tr>
<td>110 V DC</td>
<td>93 V to 121 V</td>
<td>350 W</td>
<td>2A</td>
</tr>
<tr>
<td>220 V DC</td>
<td>187 V to 242 V</td>
<td>350 W</td>
<td>1.6 A</td>
</tr>
<tr>
<td>110 V AC</td>
<td>93 V to 121 V</td>
<td>400 VA</td>
<td>2 A</td>
</tr>
<tr>
<td>230 V AC</td>
<td>187 V to 244 V</td>
<td>400 VA</td>
<td>1.6 A</td>
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</table>

Figure-5 Vacuum Breaker Electrical Connection Diagram
### Dimensions of Front-Mechanism Vacuum Breaker (mm)

<table>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<th>L</th>
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<th>N</th>
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</thead>
<tbody>
<tr>
<td><strong>12 kV</strong></td>
<td>466</td>
<td>150</td>
<td>387</td>
<td>62</td>
<td>352</td>
<td>600</td>
<td>184</td>
<td>485</td>
<td>228</td>
<td>420</td>
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<td>530</td>
<td>136</td>
<td>325</td>
<td>98</td>
<td>203</td>
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<tr>
<td><strong>17.5 kV</strong></td>
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<td>275</td>
<td>560</td>
<td>96</td>
<td>599</td>
<td>461</td>
<td>180</td>
<td>754</td>
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<td>465</td>
<td>474.5</td>
<td>920</td>
<td>168.5</td>
<td>306.5</td>
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<tr>
<td><strong>24 kV</strong></td>
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<td>250</td>
<td>540</td>
<td>83</td>
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<td>600</td>
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<td>951</td>
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<td>485</td>
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<td>371</td>
</tr>
</tbody>
</table>
Elimsan Side Mechanism Vacuum Circuit Breakers

Maximum switching
Minimum servicing
High safety
Side-Mechanism Vacuum Breakers

Elimsan Side-mechanism vacuum breakers are designed for use in especially air-insulated metal covered modular cells. One of the most important features of this design is that side-mechanism SF6 gas breakers already existing in the system can be replaced with side-mechanism vacuum breakers without any extra installation costs.

Tests
Elimsan side-mechanism vacuum breakers and Elimsan front-mechanism vacuum breakers are produced according to IEC 62271-100 standards and tested in most respectable laboratories of the world. They are used safely in Turkey and other countries. Every vacuum produced conforming to international standards are subjected to following routine tests.

- routine tests in the main circuit
- dielectrical tests in auxiliary and command circuit
- measuring the resistance of main circuit
- design and visual check
- measuring turn-on and turn-off times
- mechanical operation test

Commissioning Controls

When commissioning circuit breakers whose installation has been completed, following checks have to be made if Elimsan personnel is not present.

- conformity of installation to Elimsan standards
- soundness of paint and other types of anti-corrosives
- correct conductive connections
- correct working of signals
- grounding connections
Servicing

Basic reason for economy of vacuum breakers is ease of servicing. Normally, vacuum breakers should not be replaced during the lifetime of breaker. Number of turn-on and turn-off processes allowed under certain voltages can be seen in the following diagram.

When these figures related to the life-time of vacuum breakers are compared to the vacuum types working on other principles in the network points where multiple turn-on-off processes are witnessed, it becomes obvious that vacuum breakers are more economic. In network points which do not witness too many turn-on and turn-off processes, loss of network section which is powerless during servicing propeller mechanism and maintenance costs should be taken into consideration.

When the fact that propeller mechanism should be serviced after each 10,000 turn-on-off processes or 10 years is taken into consideration, it becomes obvious that cost of such servicing is negligible. When long operation time is considered, this economic feature must be taken into account. Mechanism can process 10,000 turn on and turn-off without a single servicing.

After 10,000 turn-on-off processes, if servicing is required, lifetime of the breaker raises to 20,000 turn-ons. Another factor which increases the life-time of the breaker is to prefer low-power springs which are used to move contacts. Low-power springs are another factor which increase the number of turn-on-off processes.

Depending on the place it is used, vacuum has to be greased once or twice a year. Temperature must be between 25 °C and 40 °C so that turn-on-off operations of the mechanism are performed regularly.
Ellmsan Vacuum Circuit Breakers

Dimensions of Side-Mechanism Vacuum Breakers (mm)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
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<td>352</td>
<td>611</td>
<td>159</td>
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<td>467</td>
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<tr>
<td>17.5 kV</td>
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<td>352</td>
<td>611</td>
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<td>224</td>
<td>637</td>
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</tr>
<tr>
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<td>224,50</td>
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<td>387</td>
<td>989,50</td>
<td>108</td>
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