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High Voltage Switches for Railway Field

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Annotation: *This article provides information about circuit breakers, the main switching equipment used in the railway sector.*

Keywords: *circuit breaker, voltage, current, phase, automatic reconnection, rated breaking capacity.*

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Access: High-voltage circuit breakers are the main switching equipment used to connect and disconnect high-voltage circuits in normal and emergency modes. Circuit breakers are divided into oil, air, vacuum, electric and electromagnetic types according to the medium of arc extinguishing.

Circuit breakers also differ according to the following characteristics:

- according to the number of phases: single-phase, two-phase and three-phase;
- according to the place of installation: external and internal;
- according to the control method: lever or remote control;
- according to the disconnection time: fast motion (up to 0.08 seconds), accelerated motion (up to 0.12 seconds), slow motion (up to 0.25 seconds). Circuit breakers must meet the following requirements:
- reliable disconnection of any currents in chains under the conditions guaranteed by the factory;
- short disconnection time;
- ease of viewing and checking contacts;
- fire and explosion safety;
- the ability to control circuit breakers by phase at voltages of 110 kV and higher;
- the possibility of using "automatic reconnection" after a disconnection;
- ease of transportation and use.

All the parameters of the circuit breaker are given in its passport, and the main parameters are given on its label. These parameters describe the reliable operating conditions of the circuit breaker. Below are the important parameters of the circuit breaker:

Nominal voltage Un. According to this voltage, the quality and dimensions of the insulating parts of the circuit breaker are determined, thereby all the dimensions and mass of the circuit breaker are determined. Circuit breakers can be used in equipment with a working voltage lower than the nominal voltage, as this does not cause damage to its insulation. In addition, manufacturing plants

guarantee the operation of circuit breakers at increased voltages (circuit breakers with rated voltage up to 35 kV at voltages up to 20% higher than nominal, and circuit breakers with rated voltage up to 110 and 220 kV are up to 15% higher than rated at voltages of Below are the ratios between nominal and maximum working voltages: 6/7.2; 10/12; 35/40.5; 110/126; 220/252 kV.

Rated current In is the largest current that the circuit breaker can carry for a long time at rated voltage, rated frequency and rated ambient temperature. Thus, the nominal current describes the long-term operation of the current-carrying parts and contacts of the circuit breaker without heating up and determines their dimensions, but does not affect the dimensions of the circuit breaker.

Rated breaking current Inom.uz is the largest current during a short circuit (the effective value of the periodic component of the short circuit current), and the circuit breaker has the ability to reliably break this current at the highest operating voltage of a certain period of operation. There are two operating cycles for AC circuit breakers: with automatic reclosing (AQU) and without automatic reclosing.

Large size high voltage circuit breakers

S-35, MKP-35, MKP-110 and other large-sized circuit breakers are used in 35, 110 kV devices. S-35 circuit breaker consists of three tanks with transition insulators installed in the cover, an electromagnetic guide connected to the phases of the circuit breaker by means of vertical and horizontal rods, a welded frame and a winch attached to the cover for lowering and raising the tanks. The circuit breaker is equipped with a gas outlet, a safety valve, an oil gauge and an oil drain valve. In the operation of the breaker, the upper part of the tank, which is not filled with oil, plays the main role. When the arc is extinguished, the gas pressure is transmitted through the oil to the walls and bottom of the tank. The empty part at the top of the tank allows the oil to expand upwards, resulting in less pressure on the walls and bottom of the tank. If this space is not enough, that is, if the volume of oil is more, the tank may explode. If the volume of the oil is small, the cooling of the generated gases with the oil will not be enough, and as a result of the hydrogen contained in the gas combining with the oxygen in the air, the circuit breaker will explode. Thus, oil circuit breakers can explode both when the volume of oil is low and when there is a lot. Therefore, during their use, the amount of oil is always under control. For this, they are equipped with special oil indicators. Explosion protection is provided by the gas discharge pipe and the safety valves.

Small size high voltage circuit breakers

Currently, small-sized oil circuit breakers are widely used instead of large-sized oil circuit breakers at voltages of 6, 10, 35 and 110 kV. This is due to the reduction of oil volume in circuit breakers, where oil is used only as an arc extinguishing medium, and porcelain insulators are used to insulate current-carrying parts. The volume of oil in such circuit breakers varies from 4.5 to 600 kg, depending on the voltage and power being switched off. The construction of low-volume circuit breakers is simpler than that of large-volume circuit breakers.

Parameters of VMP-10 circuit breaker: Nominal voltage 10 kV; nominal current In = 630 -1500 A; nominal breaking current 20 kA; nominal breaking power 350 MVA; dynamic withstand current 64 kA; thermal endurance current 20 kA; disconnection time 0.12 seconds. VMP-10 circuit breaker has several special types: VMP-10K - for complete distribution devices; VMP – 10T – for regions with tropical climate; VMP – 10U – reinforced circuit breaker.

Electromagnetic and vacuum circuit breakers

Arc extinguishing devices of electromagnetic circuit breakers are slotted or deion cell. Electromagnetic circuit breakers are made for voltages of 6-10 kV and are used for connecting and disconnecting electrical equipment located in rooms in complete distribution devices. Advantages of electromagnetic switches over other switches: relatively small dimensions; fast movement

(breaking time 0.05- 0.06 seconds); explosion and fire safety; the large number of connections. These important qualities of electromagnetic switches made it possible to use them in underground substations of the metro. Nominal parameters of VEM-10 breaker: nominal voltage Un=10 kV; nominal current Inom=1600 A; rated breaking capacity Sn=400 MVA.

Structure of the VEM-10 circuit breaker. Arc extinguishing chambers are attached to the frame mounted on the trolley. They are located directly on fixed contacts. The moving contacts are connected to the conductor through pullers. Movable and fixed contacts are equipped with plugs. The use of plug connections allows to remove the circuit breaker from the complete cell and to repair it in safe conditions and with high labor productivity.

Vacuum breakers

Vacuum circuit breakers are in the form of a hermetic chamber in which air is sucked. The pressure of the chamber environment where the contacts are located is 1.33×(10-2¸10-4) Pa. Therefore, large arcs are not formed when the contacts are separated, because there are very few current-carrying ions in such an environment. As a result, the arc burning duration does not exceed 0.01 s in vacuum chambers. The process of extinguishing the arc is as follows. When the contacts are separated, their contact surfaces become smaller, which leads to an increase in the temperature of the contacted surfaces. Between these surfaces, a bridge of molten metal is formed, which quickly ignites and glows. An arc is formed in the sparking medium of the metal. The strong vacuum spreads the charged particles rapidly across the chamber, and the arc is extinguished at the first crossing of the current from zero. The electrical continuity between the contacts is restored after approximately 10 μs. VVF-27.5 (vyklyuchatel vakuumnyy dlya fiderov tyagovoy podstantsii peremennogo toka) vacuum circuit breakers are used on electrified railways.

Nominal parameters of VVF-27.5 breaker: nominal voltage 27.5 kV; nominal current 1200 A; rated breaking current 18 kA; thermal endurance current 18 kA; dynamic tolerance current - not specified; disconnection time - salt up to 0.05 seconds.

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