Low Voltage Switchgear

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Low-voltage switchgear is the name typically used for metal-enclosed or metal-clad low-voltage power circuit breaker switchgear rated for 600V alternating current (AC) and below. The metal-enclosed switchgear is completely enclosed on all sides and top with metal sheets and has stationary primary power circuit switching or interrupting elements, or both, with buses and connections. The metal-clad low-voltage switchgear has removable circuit breakers which are housed in individual earthed metal compartments. There are two basic low-voltage switchgear types. They are indoor and outdoor types. Indoor switchgear consists of a front section containing circuit breakers, meters, protection relays and controls, bus section, and cable entrance section. The outdoor section is similar to the indoor switchgear except for a structure that is provided around it for weather-proofing. Bus bars can be made of copper or aluminum. Typically, bare bus bars are used. Nevertheless, insulation can be specified on special orders. The normal clearance between line to line and line to ground is 2 in. to minimize creepage for 600 V rated equipment. The standard high-voltage withstand is 2200V AC for line to line and line to ground for a period of 1 min. Low-voltage switchgear takes on many specific forms and functions that combine metering, monitoring, control, protection, and distribution. Original equipment manufacturers (OEMs) now provide a wide variety of low-voltage switchgear arrangements, some of them very custom, to meet the user's requirements. It is frequent to find installations where few different kinds of circuit breakers, automatic controls, and monitoring elements, and even automatic transfer switches, will be combined in the same line-up. This recent trend in integration has started to confuse the issue as to what low-voltage switchgear really is. It needs to be remembered that switchgear is still some principal combination of metal enclosures with multi-pole circuit breakers. There are many metal-enclosed, dead front, assemblies offered that are switch and fuse combinations. Even though they look like and typically are referred to as switchgear, they are really modern versions of equipment known as switchboards. Like their forerunners, these switchboards do not address the issues with single phasing on branch feeders due to a blown fuse. Nevertheless, the incoming element may have phase loss or blown fuse detection included in it. Regarding current-carrying rating, both fuses and switches have kept pace with the developments in circuit breaker technology. Low-voltage

AC switchgear arrangements are still commonly applied to low-voltage direct current (DC) distribution centers up to 250 V. In the past, manufacturers provided two-pole, draw-out circuit breakers for DC switchgear. Today, the same three-pole design and three-phase bus configuration is provided for both DC and AC usages; with the extra pole either unused or installed in series with one of the others according to the particular manufacturer's application preferences. Direct-acting overcurrent trip elements are not typically offered for the new low voltage power circuit breakers. The direct acting and electromechanical trip elements have been replaced by electronic trip elements for overcurrent protection. Nevertheless, in the insulated low voltage circuit breakers, both electronic and thermal-magnetic overcurrent trip elements are provided. The electromechanical and direct-acting trip elements are still available in the secondary market as a replacement for the older low voltage power circuit breakers.

Low-voltage generator paralleling switchgear continues to become more commonplace as utilities strike agreements for cogeneration contracts. Even though they are similar to unit substation type switchgear, it is vastly more advanced in the protection and control areas. It is typical today to see low-voltage switchgear with protective relaying that used to be found only on medium-voltage switchgear in a utility's generating station.

Low-Voltage Circuit Breakers

Low-voltage circuit breakers that are installed in switchgear or distribution centers are of three types:

1. Molded-case circuit breakers (MCCBs)

2. Insulated-case circuit breakers

3. Fixed or draw-out power circuit breakers

MCCBs

Typically, MCCBs can be found in a wide range of ratings and are normally used for low-current, low-energy power circuits. The MCCBs are equipped with self-contained overcurrent trip devices. Conventional thermal-magnetic circuit breakers use a thermal bimetallic part that has inverse time-current characteristics for overload protection and a magnetic trip part for short-circuit protection. Typical MCCBs with thermal-magnetic trip elements are dependent on the total thermal mass for their proper tripping characteristics. This implies that the adequately sized wire and lug assemblies, which correspond to the rating of the trip element, need to be used on the load terminals of such breakers. Numerous manufacturers are now switching over from bimetallic parts to power sensor (electronic) type trip elements. Magnetic-trip-only breakers do not have a thermal element. These breakers are used only for short-circuit protection. Molded-case circuit breakers that have only magnetic trips are used in motor circuit protection. This configuration is desirable for smaller motors where their inrush current can ruin a delicate thermal element but where protection for winding damage is still required. The breaker provides the instantaneous (INST) protection and fault interruption, and other overload elements in the starter handle the long-time overload protection. Non-automatic circuit breakers have no overload or short-circuit protection. Typically, they are used for manual switching and isolation.

Insulated-Case Circuit Breakers

Insulated-case circuit breakers are molded-case breakers. They use glass-reinforced insulating material for greater dielectric strength. Also, they have push-to-open button, rotary-operated low-torque handles with an independent spring-charged mechanism that provides quick-make, quick break protection. Different automatic trip units are available in the insulated-case breakers. Continuous current ratings reach 4,000A with interrupting capacities through 200,000A. The main differences between insulated-case breakers and heavy-duty power circuit breakers are cost, size, and ease of maintenance. Insulated-case breakers are not made with easy troubleshooting or repairs as the main characteristic whereas, drawn-out power circuit breakers are. To compensate for this disadvantage, many manufacturers now provide a variety of extra parts for insulated-case breakers that can duplicate the characteristics of their more expensive counterparts. Moreover, insulated-case breakers are typically suited to light industry or commercial buildings where common or numerous operations are not expected.

Power Circuit Breakers

Heavy-duty power circuit breakers use spring-operated, stored-energy elements for quick-make, quick-break manual or electric operation. Typically, these breakers have draw-out characteristics whereby individual breakers can be put into de-energized position for testing and maintenance needs. The electrically operated breakers are actuated by a motor and cam system or a spring release solenoid for closing. Tripping action is actuated by one or more trip solenoids or flux-operated elements, typically one for the protective devices on the breaker itself, and another for externally installed controls or protective elements. The continuous frame ratings for power circuit breakers range from 400 to 4,000 A. Some manufacturers have introduced breakers with 5,000 and 6,000 A-frames. Nevertheless, the long-term advantages and overall reliability of these designs have yet to be proven in real operation. Short-circuit interrupting capacities for these breakers are typically 50,000–85,000 A (RMS) for frame sizes up to 4,000 A. Bigger designs have approached 100 kA. Power circuit breakers can be extended for usages up to 200 kA interrupting when provided with assemblies or trucks made to hold Class L, current-limiting power fuses.

Fused Power Circuit Breakers

The trend toward bigger unit substation transformers and bigger connected kVA loads on such substations has provided way to power circuit breakers in tested combination with current-limiting fuses. Typically, this is done in order to increase switchgear short-circuit interrupting rating. This configuration can be used for all frame sizes. The fuses cause the same problems with single phasing as fuses in the switchboards. There are many characteristics that compensate for this issue. First, most fuse assemblies are connected directly to the breakers themselves, so fuses cannot be taken out or installed unless the breaker is out of service. Most manufacturers solve the single-phasing issue by either an electrical or a mechanical means of blown fuse detection, which in turn makes the breaker to trip right after the fuse has cleared. On the bigger frame sizes, where the fuses must be installed apart from the breaker cubicle, the fuse installation is on a truck or roll-out which is mechanically interlocked with the breaker it serves. It needs to be clear that the overcurrent protection for overloads is still handled by the breaker's overcurrent trip elements, and that the fuse is not expected to clear except for the highest short circuits.

Overcurrent Protective Elements

The low-voltage overcurrent protective elements are direct-acting (electromechanical) trip (series trip) and static (electronic) trip. These overcurrent protective elements are used in the power circuit breakers as mentioned above.

Direct-Acting Trip

The direct acting overcurrent trip element is commonly known as a series trip, electromechanical and dashpot trip element. This element uses the force made by the short-circuit current passing through it to trip its circuit breaker by direct mechanical action. These elements are operated by (1) an electromagnetic force made by the short-circuit current passing through the trip element coil (the trip coil is typically connected in series with the electrical circuit or in some situations to the secondary of current transformers) or (2) a bimetallic strip actuated by the head created by the fault current. Typically, the bimetallic strip is connected in series with the circuit. Typically, a combination of thermal (bimetallic strip or equivalent) and INST magnetic trip is used on molded-case breakers to give time delay operation for moderate over-currents (overloads) and INST operation for high- magnitude of short-circuit current. Typically, the thermal trip is non-adjustable in the field or there is some equipment that has a limited range of adjustment, such as 0.8 to 1.25, whereas the instantaneous (INST) trip is available as adjustable or non-adjustable. The adjustable-trip range differs from low to high with several intermediate steps. The number of available steps may differ for different configurations and sizes.

Direct-acting trips on insulated-case and heavy-duty power circuit breakers are electromagnetic. Three trip elements are available as (1) long time delay (LTD), (2) short time delay (STD), and (3) INST. Combinations of these are available to provide protection for over-currents. A trip element is installed in each phase of the electrical circuit. The LTD, STD, and INST trip elements are available in minimum, intermediate, and maximum time bands to allow the coordination of different trip devices in series. All these elements have adjustable settings. The time delay bands are accomplished by the action of the solenoid's pull against springs, pneumatic, or hydraulic elements. Since these devices are completely mechanical, different characteristics cannot be provided in a single trip element. Even though some calibration points and some effects on the time can be changed by adjustments, totally different delay bands can be selected only by physically changing out the trip elements with others of the desired type.

Direct-acting trips are still used for some installations and are still needed on power circuit breakers used on DC unit substations.

Static- and Electronic-Trip Elements

Static-trip elements are totally static. They have no moving parts. These elements use semiconductor-integrated circuits, capacitors, transformers, and other electric parts. Static-trip elements work to open the circuit breaker when the current–time relationship surpasses a predetermined value. The energy needed to trip the breaker is obtained from the protected circuit. No external power, such as DC batteries, is needed. The complete static-trip mechanism consists of:

1. Primary circuit current transformers

2. Static logic box

3. Tripping a

The current tr installed on the circuit breaker primar lement proportional to the primary cur

The static logic It checks the signal, discovers overlo with predetermined settings. The trip and in turn, causes the circuit breake

Manufacturers hav of solid-state trip elements over the to bring protective elements to marke cteristics over the original direct-acting designs