# Substations - Volume V: Circuit Interrupting Devices

An Online Continuing Education Course for Engineers

**Course Number: E-4039**

**Credit: 4 Hours / 4 PDH / 4 CPD**

# Substations – Volume V: Circuit Interrupting Devices

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# Preface

This course is one of a series of thirteen courses on the design of electrical substations. The courses do not necessarily have to be taken in order and, for the most part, are stand-alone courses. The following is a brief description of each course.

**Volume I, Design Parameters**. Covers the general design considerations, documents and drawings related to designing a substation.

**Volume II, Physical Layout**. Covers the layout considerations, bus configurations, and electrical clearances.

**Volume III, Conductors and Bus Design**. Covers bare conductors, rigid and strain bus design.

**Volume IV, Power Transformers**. Covers the application and relevant specifications related to power transformers and mobile transformers.

**Volume V, Circuit Interrupting Devices**. Covers the specifications and application of power circuit breakers, metal-clad switchgear and electronic reclosers.

**Volume VI, Voltage Regulators and Capacitors**. Covers the general operation and specification of voltage regulators and capacitors.

**Volume VII, Other Major Equipment**. Covers switch, arrestor, and instrument transformer specification and application.

**Volume VIII, Site and Foundation Design**. Covers general issues related to site design, foundation design and control house design.

**Volume IX, Substation Structures**. Covers the design of bus support structures and connectors.

**Volume X, Grounding**. Covers the design of the ground grid for safety and proper operation.

**Volume XI, Protective Relaying**. Covers relay types, schemes, and instrumentation.

**Volume XII, Auxiliary Systems**. Covers AC & DC systems, automation, and communications.

**Volume XIII, Insulated Cable and Raceways**. Covers the specifications and application of electrical cable.

# Chapter 1: Power Circuit Breakers

By definition, a circuit breaker is a device that closes and opens an electric circuit between separable contacts under both load and fault conditions. The application of circuit breakers involves consideration of the intended function, expected results, benefits to the electric system, and characteristics of both the circuit breakers and the electric system. A photograph of a typical circuit breaker is shown on the right.


In some instances, protective devices of lesser capability and flexibility, such as fuses, circuit switchers, reclosers, etc., may be more desirable or preferred over more complex and costly circuit breakers.

Fuses are often desirable for transformer protection at any location where they are adequate for the thermal load and short-circuit conditions because of their lower cost and smaller space requirements compared to other devices. They are also desirable for their ease of coordination with circuit breakers and relays at other locations on the electric system. Fuses can also be applied as temporary maintenance bypass protection to permit maintenance of circuit breakers. Fuses are also used extensively for sectionalization and branch circuit protection in distribution systems.

Circuit switchers are less costly than circuit breakers and can be applied in much the same way as circuit breakers, subject to limitations in interrupting capability, with the same type of relay control as circuit breakers. Circuit switchers are also supplied without current transformers (circuit breakers are usually supplied with CTs), which are used in conjunction with relays to sense faults. They can be substituted for fuses in transformer bank protection to detect low-voltage-side faults that fuses may not be able to detect. This detection would utilize relay intelligence from the low-voltage side. Circuit switchers also provide excellent capacitor bank switching and protection. In outlying areas of moderate short-circuit capacity, they can often be substituted for circuit breakers. They can be mounted similarly to air-break switches on a substation structure and thus require little or no additional space. The photo on the left shows a typical circuit switcher. This one is manufactured by S&C.

Reclosers are completely self-contained and provide excellent distribution circuit exit and feeder protection. Their ratings are adequate for both load and short circuit on most distribution circuits and overlap the ratings of more costly circuit breakers. Their operation is faster than most circuit breakers, and their sequence of open and close operations is very flexible. Reclosers are available in both single-and three-phase ratings so that they are very useful and adaptable for the entire distribution system at locations where reclosing operation is required.

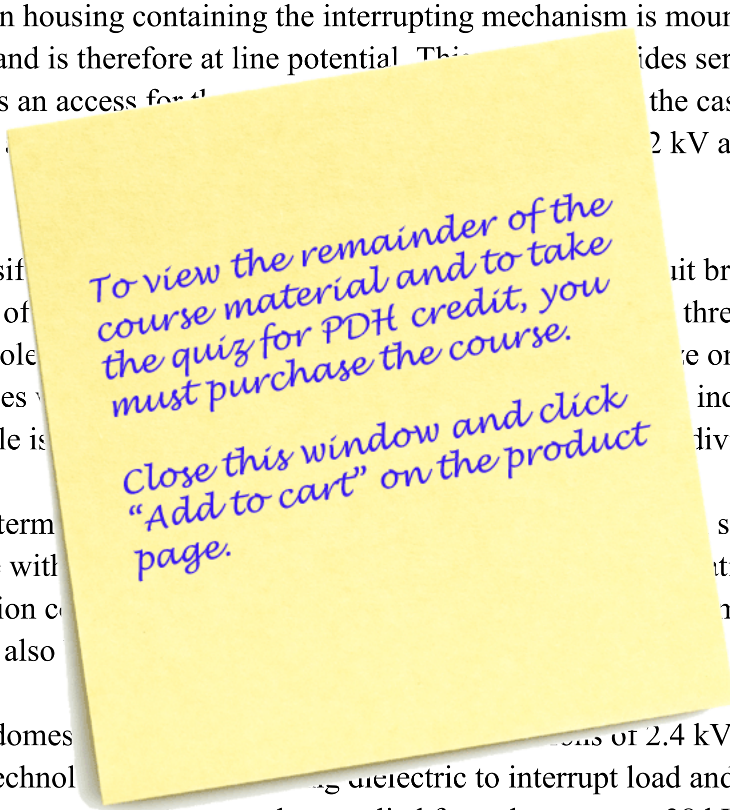
Writing of specifications and selection of power circuit breakers and similar devices should be preceded by electric system studies to determine the parameters of application and operation that have to be satisfied. These include load flow, short-circuit, transient voltage, coordination, and protection studies. ANSI Std. C37.12, "American National Standard Guide Specifications for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis and a Total Current Basis," can be used directly as a model or checklist for the purchase specification. A manufacturer's standard design and construction would normally be considered acceptable.

It is recommended that those responsible for preparing power circuit breaker specifications become familiar with:

1. The C37 series of ANSI Standards covering ratings, testing, applications, specifications, etc.
2. Each specific application and proposed installation.
3. Each prospective supplier's product line of circuit breakers.

**Types of Circuit Breakers**

Breakers are usually classified as *dead tank* or *live tank* construction. *Dead tank* means that the circuit breaker tank and all accessories are maintained at ground potential, and the external source and load connections are made through conventional bushings. *Live tank* means that the metal and porcelain housing containing the interrupting mechanism is mounted on an insulating porcelain column and is therefore at line potential. Thi[illegible] ides serving as an insulating support, may act as an access f[illegible] the case of air circuit breakers, it acts as [illegible] 2 kV are of "live tank" construction.




In addition to classif[illegible] uit breakers are also classified in terms of [illegible] three-pole, single-throw, and independent-pole [illegible] e one mechanical device to trip all three poles [illegible] independent-pole operation, each pole is [illegible] dividual pole.

Each user must determ[illegible] select a type of circuit breaker acceptable with [illegible] tibility with planned or existing substation c[illegible] maintain the circuit breaker. Cost may also [illegible]

Most, but not all, domes[illegible] of 2.4 kV through 24.9 kV utilize a vacuum technol[illegible] dielectric to interrupt load and fault currents. Although outdoor vacuum breakers can be supplied for voltages up to 38 kV, $SF_6$ is more commonly used for voltages from 34.5 kV to 765 kV. $SF_6$ breakers are available in 15 kV to 242 kV ratings in single tanks and in 15 kV to 800 kV ratings in three, individual pole, tanks. Although $SF_6$ breakers are available in single-tank designs, the trend is toward a three-tank design. $SF_6$ breaker manufacturers have been able to reduce the size of the interrupting chambers, making the three-tank design more economical.

$SF_6$ circuit breakers are available with three operating mechanisms:

1. Pneumatic,
2. Hydraulic, and
3. Spring-operated.