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Evropské strukturální a investiční fondy
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MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

7. Low voltage electrical appliances

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7.1 Division, function, contacts of electrical appliances

7.1.1. Division a function of electrical appliances

- connecting and disconnecting of no-load electrical circuits
  - disconnecter
- connecting and disconnecting of loaded electrical circuits
  - circuit breaker
  - contactor, relay
  - overcurrent circuit breaker
  - switches (cam switch, limit switch, toggle switch, rotary switch, rocker switch…)
- controlling of electrical circuit or some components
  - controller
  - starter
- protecting of electrical devices and transmission lines
  - overcurrent circuit breaker
  - fuse
  - lightning arrester
- protecting of beings against electrical shock
  - residual-current device (earth-leakage breaker)

7.1.2. Contacts of electrical appliances

Important parts of electrical devices are contacts used in their structure for connecting and disconnecting of electrical circuit. Contacts may be operated by humans in push-buttons and switches, by mechanical pressure or machine cams, and electromechanically in relays and contactors. (https://en.wikipedia.org/wiki/Electrical_contacts). The contacts must realize these requirements:

• permanent flow of the current if contacts are switch – on. So they must carry electrical current well, to drain heat from the point of contact connection away and to be resisting to a corroding medium

• to resist to an electric arc influences (esp. to very high temperatures) within switching – off of esp. short – circuit currents. So they must have a high melting degree.

• mechanical strength

• to be economical

The contacts can be produce from appropriate materials such as:

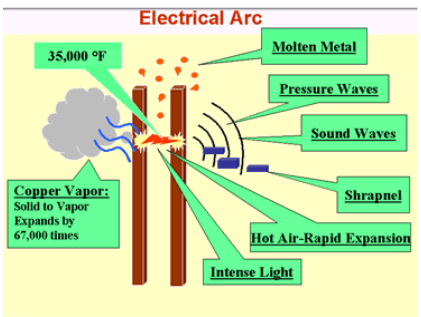
• copper, brass, bronze, alloys with silver

• silver, gold, platinum (separate only in special applications: electronics, microelectronics)

• special metallic mixtures consist of two components, the first one with good electrical conductance (copper, silver) and the second one with good resistance to electric arc influences (tungsten, nickel, graphite, etc...)

7.2 Electrical arc and possibilities of its extinction

During a process of loaded circuit disconnecting by switches, circuit breakers, contactors or protective devices such as fuses, an electric arc appears between disconnecting contacts of the electrical appliance. With respect to the fact the electric arc has negative influences on the appliance (it can even destroy it) and its burning does not interrupt the current in the circuit, it is necessary to extinguish it. From this reason an arc-extinction chamber (arc chute) is used in power appliances for the switch-off (https://en.wikipedia.org/wiki/Arc_suppression).



The possibilities of arc extinction can be as follows:

- prolong its length: pneumatic or magnetic blowout
- arc splitting: arc chute
- cooling: immersion in transformer oil, placing in silica sand (fuse)

7.3 Switchgears: basic overview, construction and usage of contactor and relay

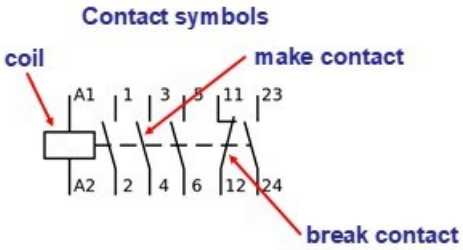
7.3.1. Basic overview

The basic overview according to the type of operation and level of voltage can be:

- manually operated (operated by humans: cam, toggle, rotary switches…)
- automatically operated switches (acting as a sensor, or e.g. limit switch)
- electrically operated (relays, contactor)
- low-voltage (AC L-L rms 50-1000 V)
- medium-voltage
- high-voltage

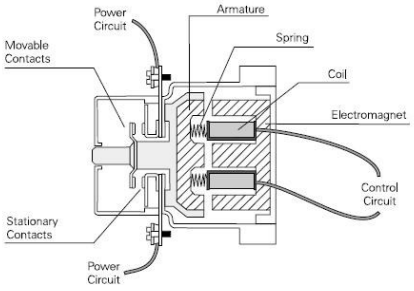
7.3.2. Construction and usage of contactor and relay

Relays are used where it is necessary to control a circuit by a separate low-power signal. The relay has contacts (make and break type), electromagnet (with coil), spring, armature, etc. There are several types of relays such as control, overload protection, safety, time delay relay… (https://en.wikipedia.org/wiki/Relay). Relays are used for e.g. logical control of power systems or complex switching systems (connected into logical systems, not power ones), for detection overload and other faults, in safety systems…





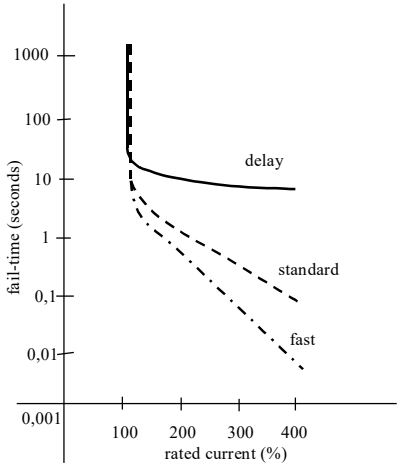
The contactor is a heavy-duty relay with higher current ratings, used e.g. for switching electric motors and lighting loads. But unlike a circuit breaker, the contactor is not intended to interrupt a short circuit current. Unlike relays, contactors are designed with features to control and suppress the arc produced when interrupting heavy motor currents (called as arc chute). It has power contacts, auxiliary contacts (make and break type as the relay), contact springs, electromagnet (with coil), armature, arc chute (https://en.wikipedia.org/wiki/Contactor).



7.4 Protective appliances: fuses and their division and characteristics, principle of circuit breaker

7.4.1. Fuses and their division and characteristics

Fuses are used for a protection of various electrical devices and machines against influences of short – circuit currents. Fuses are the simplest circuit protection appliance. Common fuses have a wire fixed inside of a filler material (silica sand), which helps to contain (by cooling) the electric arc that occurs when the wire melts (https://en.wikipedia.org/wiki/Fuse_(electrical)). For many low power applications the filler material is not required. Fuses can be classified as follows:



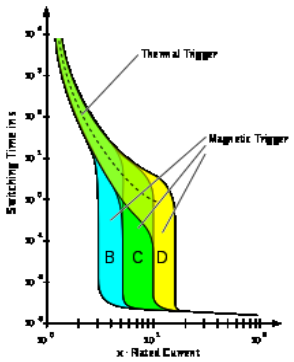
- produced in three basic time delay ratings:
  - delay (for induction motors)
  - standard (power line and appliances)
  - fast (semiconductor devices)
- designed as:
  - tube fuse (electronic and domestic appliances)
  - screw-in fuse (for power line and appliances)
  - industrial fuse (for power line with high currents)
  - automotive fuse (protect the wiring and electrical equipment for vehicles

- characteristic parameters:
  - rated current and voltage
  - breaking capacity (the maximum current that can safely be interrupted by the fuse)
  - the I^2t value (related to the amount of energy let through by the fuse element when it clears the electrical fault)

7.4.2. Principle of circuit breaker

It is designed interrupt current flow after a fault (short-circuit or overload) is detected. After the switch off it can be reset to resume normal operation (unlike the fuse). It contains actuator level (to switch off manually or reset), actuator mechanism (keeps the contacts together against a spring, or apart), contacts (fixed and moving), bimetallic trip (the trip of smaller, longer-term overcurrents), overload trip coil (the rapid trip of short – circuit currents), arc chute (https://en.wikipedia.org/wiki/Circuit_breaker).



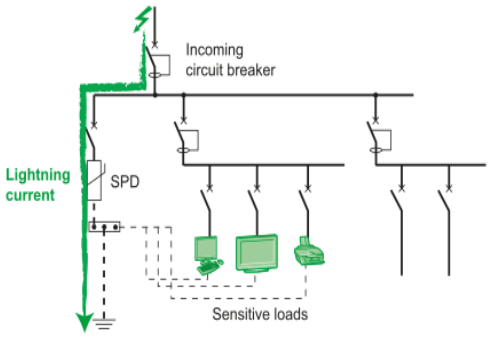


7.5 Overvoltage protective devices, earth-leakage breaker: basics and applications

7.5.1. Overvoltage (surge) protective devices (SPD)

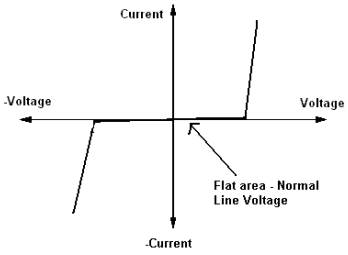
They are used for protecting against electrical surges and spikes, including those caused by lightning (https://en.wikipedia.org/wiki/Surge_protector). These types can be produced:

- metal oxide varistor (=voltage-dependent resistor, limits voltage on its output)
- transient voltage suppression diode (a type of Zener diode, limits voltage spikes)
- gas discharge tube (conducts electric current after becoming ionized by a high voltage spike, shorts voltage to ground)



These characteristic parameters are defined:

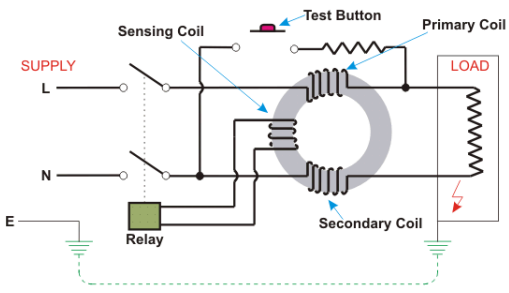
- clamping voltage (a voltage level to switch-on the protector to divert energy from the protected line)
- Joules rating (how much energy a varistor can theoretically absorb in a single event without failure)
- response time (a time to protector response to the surge)



Varistor Volt-Ampere Characteristics Curve

7.5.2. Earth-leakage breaker (Residual-current device)

It is a safety device used in electrical installations to prevent electric shock. It instantly breaks an electric circuit (e.g. within 200 ms) when it detects that the electric current is not balanced between the energized (line) conductor(s) and the return (neutral) conductor, so there is a leakage current resulting in potential harm or death due to electric shock. It consists mainly of three-winding transformer (single-phase type), relay and test button (https://en.wikipedia.org/wiki/Residual-current_device). The defined characteristic parameters:



Working Principle of Residual Current Circuit Breaker

- rated residual operating current (e.g. high sensitivity (HS): 5** – 10 – 30 mA (for direct-contact / life injury protection))
- break time (response speed) (e.g. instantaneous (general use): it must trip within 200 milliseconds for rated current