**Exercises on High Voltage Engineering (June 5, 2025):**

**Exercise 10-1:** What are the main categories of power switchgears? What are their main application situations?

(1) Circuit breaker: Capable of breaking and closing large fault currents as well as normal load currents.

(2) Load switch: Can only break and close normal load currents.

(3) Disconnector (Isolating switch): When closed, it can carry normal current and specified short-circuit current, but it cannot be used to break or close current. It is only used to isolate live parts during maintenance to ensure the safety of personnel. It has no arc-extinguishing capability and provides a clearly visible break point.

(4) Earthing switch: Provides protective earthing for equipment or circuits under maintenance.

(5) Contactor: Capable of breaking, closing, and carrying normal current, used in applications requiring frequent operation and control.

**Exercise 10-2:** After receiving the trip signal, can the circuit breaker be disconnected at the same instant? What are the benefits of the reclosing function of circuit breaker?

(1) They cannot be disconnected at the exact same instant because after the circuit breaker receives the trip command from the relay protection, it takes some time for the breaker contacts to start moving. The breaker first undergoes mechanical separation, and only when the current crosses zero does the arc extinguish, achieving electrical separation.

(2) In most cases, transmission line faults are temporary, such as those caused by lightning strikes or strong winds. These faults last only briefly. After the circuit breaker trips, the insulation performance of the line's insulators and air gaps can quickly recover. If the breaker automatically recloses after a short dead time, the reclosing attempt is usually successful. The use of automatic reclosing significantly improves the reliability of the power system.

**Exercise 10-3:** What are the main factors that determine the overvoltage amplitude of energizing an unloaded line? How to suppress this type of overvoltage?

(1) Influencing factors: Closing phase angle, line losses, residual voltage variations on the line, and non-simultaneous operation of three-phase circuit breakers.

(2) Mitigation methods: First, use shunt reactors to limit power frequency overvoltages within an acceptable range. Then, employ circuit breaker parallel resistors or improved breaker performance to restrict switching overvoltages to a certain level. Finally, use surge arresters as backup protection.

**Exercise 10-5:** Which factor determines the insulation level of OHL in polluted areas or the areas where switching overvoltage is limited to low values?

(1) For transmission lines, their insulation level is determined by considering a combination of different voltage and wind speed conditions, while maintaining a certain lightning withstand capability and controlling the lightning trip-out rate within specified limits.

(2) In polluted areas, the insulation level of transmission lines is primarily determined by the system's maximum operating voltage.

**Exercise 10-6:** What is the meaning of "insulation level" for electrical equipment?

The insulation level of electrical equipment is represented by the test voltage values that the equipment can withstand (without experiencing flashover, discharge, or other damage).

**Supplementary Exercise:** What is the basic principle of substation insulation cooperation in China? What is the basic principle of transmission line insulation coordination in China? Why do substations and lines follow different insulation coordination principles?

(1) Substations: For 220kV and below systems, the insulation level of electrical equipment is primarily determined by lightning overvoltages. For EHV systems at 330kV and above, switching overvoltages become the dominant factor. Their insulation level is determined by the residual voltage (protective level) of surge arresters under lightning overvoltages.

(2) Transmission lines: The insulation level is determined by maintaining a specific lightning withstand capability and controlling the lightning-induced trip-out rate, considering combined voltage and wind speed conditions. In heavily polluted areas, the external insulation level of power systems is governed by the maximum operating voltage.

(3) Reason: Transmission line insulation levels generally don't require coordination with substation insulation, as they are typically designed to ensure a certain lightning withstand capability. Moreover, transmission line insulation belongs to the self-restoring insulation type.