[**为什么需要高电压输电**]: Demand for high-capacity transmission increases rapidly. High voltage ensures the long-distance power transmission and with low losses, and is convenient to create large-scale power networks.

CH1 气体放电

[自持放电]self-sustained discharge: When the applied voltage reached a certain level, the discharge can keep continue and the current can be maintained whatever the external ionization factor is on or removed.

[电子崩]electron avalanche: The electron avalanche caused by collision ionization allows the initial electrons to multiple significantly in the electric field.

[电子碰撞电离系数α] electron collision ionization coefficient(E 影响大): the average number of collision ionization occurred when an electron travels of 1cm along the field. //If each collision ionization only produces one new electron, α represents the number of new produced electrons per unit length path in the direction of electric field from one electron.

[α测量]:experiment results of I~d can be shown in logarithm figure. And the slope of the straight line represents α.

[二次电子崩]secondary electron avalanche: Positive ions collide with the cathode causing the cathode to release electrons, and recombination produced photons irradiate to cathode.

[阴极表面电离系数]γ(the ionization coefficient on the cathode surface): the number of free electrons released from the cathode per collision of positive ions.

[流注发展过程]development of (+/-) streamer: 1-initial(main) electron avalanche 2-secondary electron avalanche 3-streamer.

[电晕放电]corona discharge(高气压极不均匀场): In extremely non-uniform field, when the voltage reaches a certain level, there is a thin luminescent layer near the high field strength electrode before the air gap breakdown.

[极性效应]polarity effect: Due to the different polarity of high field strength electrodes, the polarity of space charge is different, and the impact on discharge development is different, resulting in different corona inception voltage and different air gap breakdown voltage for electrodes of different polarity.

[输电线电晕]不利影响 the photon, thermal and other effect during the gas discharge and the chemical reaction will cause power loss. **改善措施** adopt split conductor, large cross-section conductor and conductors with expanded diameters.

[先导通道]leader channel: at the root of the streamer, there would be thermal ionization. The channel with thermal ionization is the leader channel.

[主放电]main discharge: The strong discharge propagates in the opposite direction along the leader channel to the rod electrode, while neutralizing the excess space charge in the leader channel.

CH2 电压波形

[放电时延]time lag of discharge(雷电冲击电压): **存在原因** Gap breakdown requires not only sufficient voltage, but also sufficient time; after the voltage reaches static breakdown voltage, it needs a period of time to breakdown. **组成** Time lag of discharge t_d = statistical time lagt_s + formation time lag t_f. **电场分布对时延的影响** Uniform/slightly non-uniform electric fields are dominated by t_s with short time lag, while extremely non-uniform electric fields are dominated by t_f with long time lag.

[U50]: When this voltage is applied to the gap, the breakdown and not breakdown probability are both 50%.

[伏秒特性]V-t characteristic: **定义** Relationship curve between the maximum value of voltage appearing on the gap and the time of gap breakdown.**为什么采用** Due to time delay of discharge, the air gap breakdown takes time. Different application time will result in different breakdown voltage. So, using breakdown voltage only can't describe the insulation characteristics of the gap precisely. Thus, we need v-t characteristic.

CH3 高压外绝缘，绝缘子

[**外绝缘的两个组成部分**]outdoor insulation: insulation along the surface of insulators and air gap insulation.

[**绝缘子的作用**]function of insulators: mechanical connection, electrical insulation.

[**不同绝缘伞的原因**]different **sheds**: to provide necessary surface insulation adapt to outdoor operating conditions such as rain and pollution.

[**沿面闪络电压比击穿电压低的原因**]: the voltage distribution along the dielectric dividing surface is non-uniform.

[污闪定义]pollution flashover: Due to the pollution accumulation and moisture, the surface insulation of the insulator decreases significantly, causing flashover under operating voltage.

[**污秽闪络危害大的原因/污秽闪络特点**]:**1-**All insulator strings in large area face the same pollution and wetting condition;**2-**Pollution flashover occurs under operating voltage, not like lightning strikes disappear very quick;**3-** After the pollution flashover trip out, the wet condition and pollution layer still exist, and the reclosing success rate of switchgear is low.

[**污闪电压低的原因**]:**1-**The voltage to form a dry band and the dry band arc is not high; **2-**The voltage to maintain the surface arc propagation is also not high

[**污闪电压和什么有关**]: string length (total creepage distance), pollution degree

[**提高污闪电压措施**]:

1-Reduce pollution accumulation

Choose shed with open profile, or cleaning pollution with and without energized

2-Reduce the wetting of insulators

Choose an anti-fog shed profile, or use semiconducting glaze

3-Increase the total creepage distance of insulator string

Choose insulators with large creepage distance, or adding more insulator pieces

4-Using hydrophobic coatings

Silicone oil, RTV coating; silicone rubber insulators (new generation organic~)

CH4 液体固体电介质

[**电介质**]dielectrics: Solids, liquids and gases that have no conductive electrons, and can be polarized in an electric field, are called dielectrics.
[**电介质极化**]: The dipole moment formed along the electric field due to the micro-displacement of positive and negative charges, or the phenomenon of induction bound charges on the surface of the dielectric is called dielectric polarization.
[**累积效应**]cumulative effects: Under highly non-uniform electric field or impulse voltage condition, the dielectric may experience a partial breakdown many times. The effect of partial breakdown leading to a gradual decrease of insulation performance is called cumulative effect.
[电介质的耐热性]heat resistance: Maximum allowable temperature to ensure reliable and safe operation of dielectrics.
[**耐热等级]thermal rating**: In order to *make the insulating materials have an economic and reasonable lifetime*, the insulating materials are divided into grades according to their thermal resistance degree. **作用** it can *同上*, and regulate the maximum continuous operating temperature.
[**耐寒性**]cold resistance: Cold resistance is the lowest permissible temperature at which insulation material ensures safe operation at low temperatures.

CH5 绝缘检测诊断

----绝缘电阻、泄漏电流（吸收比、极化指数）----
[**吸收比**]absorptance: the ratio of insulation resistance $R_{60''}$ and $R_{15''}$.
[**极化指数**]polarization index: the ratio of insulation resistance $R_{10'}$and $R_{1'}$.
[**为什么吸收比极化指数能反映绝缘状态**] Even if the insulation partly gets damp, the absorption current will still decay rapidly, which will cause the absorptance ratio or the polarization index to decrease.
[**为什么测量泄漏电流能更好反映绝缘状态**] The applied test voltage in the measurement of the leakage current is higher than that of the insulation resistance test.
----电介质损耗角正切（dielectric loss angle tangent）----
[**为什么测量 tanδ能反映绝缘**] If the insulation is damp or degraded, tanδ will rise obviously. The δ~U curve can also help to judge whether partial discharge occurs.
[**为什么用反接西林电桥**]Reverse Schering Bridge: in field experiments, many test specimens have only one end grounded. It is impossible to change them to ground insulation, only the grounding point of the bridge circuit can be changed.
----局部放电(PD)测量----
[**局部放电**]partial discharge: The phenomenon of partial repeated breakdown and discharge extinguished occurs due to weaknesses within the internal insulation of electrical equipment under a certain external applied voltage
[**预加电压的作用**]role of pre-applied voltage: excitation of the local defects.

CH7 高电压测量

[**球隙法需要满足什么条件**才能满足规定不确定度](**直流高压下 1 中 5 改为 4**):

1- Ratio between sphere gap spacing S and sphere diameter D should not exceeds *5*
2- Under non-standard air conditions, corrections for air pressure, temperature and humidity are needed.
3- Pre-discharge and radiation exposure are needed to reduce the dispersion of the results.

[**反击**]**ground counter attack/back strike**: Large current flows through the grounding resistor, causing the ground potential rise of the device.

举例:(雷电) When the lightning current flows into the earth, the ground potential of the lightning strike point rises quickly, and a reverse overvoltage is formed between the transmission line and the earth.

(实验室测量装置): In high voltage measurement, the risen ground potential of the weak measuring devices will cause damage to components or severe signal distortion.

CH9 雷电过电压及其防护

[**避雷器工作原理**]surge arrester: Under normal circumstances, surge arrester is not conducted/only negligible current flow through the surge arrester. When the lightning overvoltage is higher than the action voltage, (the series gap breakdown,) due to the good V-I characteristic, the large current flows into the ground and the overvoltage could be limited to a certain level. After the impulse voltage dies out, the arrester cut off the power-flow current at the first zero-cross, and then the system can continue to operate normally.

[**雷击线路的后果**]: **1-**short circuit ground fault. After the insulator flashover, the (induced) lightning current flows into the ground. Then conductor is short circuit to the ground, forming a follow up current, tripping the relay protection. **2-**Some of the overvoltage waves continue to spread to the nearby two substations.

[**感应过电压为什么是正极性的**]: Induced overvoltage is generated by electromagnetic induction, its polarity is opposite to that of lightning current, while most of the lightning current is of negative polarity.

[**直击导线过电压为什么是负极性**]:the polarity of the overvoltage is the same as the polarity of the lightning current.

[**雷击塔顶过电压为什么是正极性**]: When lightning strikes the top of the tower, the insulator's potential at the suspended end at the top of the tower is negative, while the conductor end is positive, which is close to the conditions of the positive polarity impulse test of the insulator string.

[**雷击输电线路每次都跳闸吗**]no. If the lightning current exceeds the lightning withstand level, there would be flashover on the insulators. However, the duration of the lightning overvoltage is extremely short, only when the flashover channel develops into a stable power frequency arc will lead to the line trip.

CH10 操作过电压&绝缘配合(insulation coordination)

[**操作过电压倍数**]**multiple** of switching overvoltage: The magnitude of the switching overvoltage is expressed as multiples of the peak of maximum phase to ground voltage of the equipment at the point of overvoltage occurrence.

[**断路器接到跳闸信号能否立刻跳闸**]**trips**: No. After receiving the trip command, there will be a period of time before the circuit breaker contacts move. And the circuit breaker is first mechanically separated, only at the current zero-cross can the arc be extinguished, realizing the electrical separation.

[**断路器重合闸好处**]**reclosing** of the circuit breaker: in most of the transmission line fault occasions, the duration time is very short, after the circuit breaker trips, the insulators and air gap insulation can recover quickly, and the reclosing after a short period of no current time is likely to be successful. Reclosing can greatly improve the reliability of the power system.

[**绝缘配合定义**]insulation coordination: Based on the various subjected voltages of equipment in the system (normal working voltage and overvoltage), and the characteristics of the voltage limiting device and the insulation characteristics of the equipment to determine the necessary insulation withstand level of the equipment, to reduce the probability of insulation damage and non-continuous operation caused by various voltages acting on the equipment to an economically and operationally acceptable level.

[**绝缘配合基本原则**]principles: **Technically** handle the coordination relationship between various voltages, voltage limiting measures, and equipment insulation withstand level; **Economically** coordinate the relationship between equipment investment costs, operation and maintenance costs, and the cost of accident losses (reliability).

[**电气设备的绝缘水平**]insulation level of electrical equipment: The insulation level expressed in kV by the test voltage that the equipment can withstand (without flashover, discharge, or other damages). //对应的试验: The test corresponds to lightning impulse test(BIL), switching impulse test(BSL), short-term (1min) power frequency test(power frequency insulation levels) and slightly longer power frequency tests under special circumstances.

[**我国变电站绝缘配合原则&制定过电压保护策略**]

Basic **principles** of **insulation coordination** in **substations** in China:

``For systems ≤ 220kV, the insulation level of electrical equipment is mainly determined by lightning overvoltage;

``For EHV systems ≥ 330kV, switching overvoltage becomes the main contradiction

Strategies for the **determination** of overvoltage protection: **1-**The first step is to use parallel reactors to limit the power frequency overvoltage to a certain range. **2-**Second, control the switching overvoltage within a certain range through circuit breaker parallel resistance or improving circuit breaker performance. **3-**Then, lightning arresters are used as backup protection (lightning arresters do not need to act frequently under switching overvoltage).

变电站设备的绝缘水平 the insulation level of substation equipment is determined by the residual voltage (protection level) of the surge arrester under lightning impulse.

[**我国架空线绝缘水平的确定**]

Basic principles of insulation coordination for transmission lines in China:

After integrating different voltage and wind speed combinations, maintaining a certain lightning withstand level and controlling a certain lightning trip rate;

In polluted areas, the outdoor insulation level is determined by the highest operating voltage.