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TELEGRAPH AND POWER TRANSMISSION INSULATORS

Kovalev D. P., Penzyakov D. I., Yurdanova V. N.
Scientific supervisor - Associate professor Yurdanova V. N.
Siberian Federal University

In high voltage systems containing transformers and capacitors, liquid insulator oil is the typical method used for preventing sparks. The oil replaces the air in any spaces which must support significant voltage without electrical breakdown. Other methods of insulating high voltage systems are ceramic or glass wire holders and simply placing the wires with a large separation, using the air as insulation.

Suspended wires for electric power transmission are bare, except when connecting to houses, and are insulated by the surrounding air. Insulators are required at the points at which they are supported by utility poles or pylons. Insulators are also required where the wire enters buildings or electrical devices, such as transformers or circuit breakers, to insulate the wire from the case. These hollow insulators with a conductor inside them are called bushings.

The first electrical systems to make use of insulators were telegraph lines; direct attachment of wires to wooden poles was found to give very poor results, especially during damp weather.

The first glass insulators used in large quantities had an unthreaded pinhole. These pieces of glass were positioned on a tapered wooden pin, vertically extending upwards from the pole's crossarm (commonly only two insulators to a pole and maybe one on top of the pole itself). Natural contraction and expansion of the wires tied to these "threadless insulators" resulted in insulators unseating from their pins, requiring manual reseating.

Amongst the first to produce ceramic insulators were companies in the United Kingdom, with Stiff and Doulton using stoneware from the mid 1840s, Joseph Bourne (later renamed Denby) producing them from around 1860 and Bullers from 1868. Utility patent number 48,906 was granted to Louis A. Cauvet on July 25, 1865 for a process to produce insulators with a threaded pinhole. To this day, pin-type insulators still have threaded pinholes.

The invention of suspension-type insulators made high-voltage power transmission possible. Pin-type insulators were unsatisfactory over about 60,000 volts.

A large variety of telephone, telegraph and power insulators have been made; some people collect them.

Insulators used for high-voltage power transmission are made from glass, porcelain, or composite polymer materials. Porcelain insulators are made from clay, quartz or alumina and feldspar, and are covered with a smooth glaze to shed water. Insulators made from porcelain rich in alumina are used where high mechanical strength is a criterion. Porcelain has a dielectric strength of about 4–10 kV/mm. Glass has a higher dielectric strength, but it attracts condensation and the thick irregular shapes needed for insulators are difficult to cast without internal strains. Some insulator manufacturers stopped making glass insulators in the late 1960s, switching to ceramic materials.

Recently, some electric utilities have begun converting to polymer composite materials for some types of insulators. These are typically composed of a central rod made of fibre reinforced plastic and an outer weathershed made of silicone rubber or EPDM. Composite insulators are less costly, lighter in weight, and have excellent hydrophobic capability. This combination makes them ideal for service in polluted areas. However, these materials do not yet have the long-term proven service life of glass and porcelain.

The electrical breakdown of an insulator due to excessive voltage can occur in one of two ways:

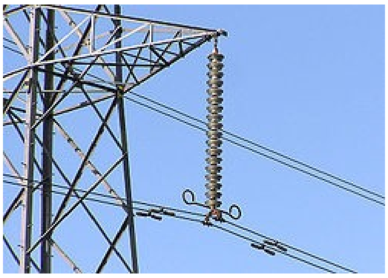
• Puncture voltage is the voltage across the insulator (when installed in its normal manner) which causes a breakdown and conduction through the interior of the insulator. The heat resulting from the puncture arc usually damages the insulator irreparably.

• Flashover voltage is the voltage which causes the air around or along the surface of the insulator to break down and conduct, causing a 'flashover' arc along the outside of the insulator. They are usually designed to withstand this without damage.

Most high voltage insulators are designed with a lower flashover voltage than puncture voltage, so they will flashover before they puncture, to avoid damage.

Dirt, pollution, salt, and particularly water on the surface of a high voltage insulator can create a conductive path across it, causing leakage currents and flashovers. The flashover voltage can be more than 50% lower when the insulator is wet. High voltage insulators for outdoor use are shaped to maximize the length of the leakage path along the surface from one end to the other, called the creepage length, to minimize these leakage currents. To accomplish this, the surface is molded into a series of corrugations or concentric disk shapes. These usually include one or more sheds; downward facing cup-shaped surfaces that act as umbrellas to ensure that the part of the surface leakage path under the 'cup' stays dry in wet weather. Minimum creepage distances are 20–25 mm/kV, but must be increased in high pollution or airborne sea-salt areas.

Higher voltage transmission lines use modular cap and pin insulator designs (see picture above). The wires are suspended from a 'string' of identical disk-shaped insulators which



attach to each other with metal clevis pin or ball and socket links. The advantage of this design is that insulator strings with different breakdown voltages, for use with different line voltages, can be constructed by using different numbers of the basic units. Also, if one of the insulator units in the string breaks, it can be replaced without discarding the entire string. They are constructed of a ceramic or glass disk with a metal cap and pin cemented to opposite sides. In order to make defective units obvious, glass units are designed with Class B construction: an overvoltage causes a puncture arc through the glass. The glass is heat-treated so it will shatter, making the damaged unit visible. However the mechanical strength of the unit is unchanged, so the insulator string will stay together. Standard disk insulator units are 10 inches (25 cm) in diameter and 53⁄4 in (15 cm) long, can support a load of 80-120 kN (18-27 klbf), have a dry flashover voltage of about 72 kV, and are rated at an operating voltage of 10-12 kV. However, the flashover voltage of a string is less than the sum of its component disks, because the electric field is not distributed evenly across the string but is strongest at the disk nearest to the conductor, which will flashover first. Metal grading rings are sometimes added around the lowest disk, to reduce the electric field across that disk and improve flashover voltage.

In conclusion we should underline that insulators are integral parts in any power transmission system. It is important to develop more efficient materials and technologies for production of insulators.