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Low voltage bushing of power transformer

Electric bushings are essential components for a wide range of electrical equipment, such as power transformers, bypass reactors, circuit breakers and capacitors. These seemingly simple devices perform the critical function of transporting high voltage current through equipment compartments. They perform this function by providing an insulating barrier between the living conductor and the metallic body (conductor) of the electrical appliance (which is earthly potential). Power transformer bushings The highlighted electric bushings can be broadly divided into two main categories, depending on how they are built and assembled: Mass or Non-condenser Type condenser type as the electric bushings work The video below is an extract from our Online Video Course of the Electric Bushings Course. Bulk bushings A bulk bushing consists of a central driving rod usually manufactured from copper or aluminum, which is wrapped by an insulator. The surrounding insulator can be manufactured from porcelain or composite resin silicon rubber. Although the traditional porcelain insulator offers mechanical robustness and a long service life, the application of silicon rubber is becoming increasingly popular due to its lower cost, ease of handling and its surface hydrophobitude (which reduces the risk of pollution-related flashovers). Due to dielectric force limitations, the use of bulk bushings is restricted to system voltages of 72 kV and below. 11 kV Type of condenser bushing At higher system voltages, condenser bushings are used. Compared to bulk bushings, condenser bushings are relatively complex in their construction. To cope with the high electrical field stresses generated at high voltage, the condensing bushings are formed from an isolated core of the degree of internal capacitance, which is sandwich between the transport tube of the central current and the external insulator. The condenser core consists of coaxial layers of electric-grade Kraft paper and conducting aluminum foil inserts of varying lengths. The aluminum foil inserts are located at fixed radial intervals, which assists in the distribution and stabilization of the electric field through the insulation of the bushing. These driving inserts mimic the capacitive elements (connected in series) that connect the high-voltage conductor of the bushing to the ground. For this reason, condenser bushings are sometimes referred to as hooded bushings. Cross section of the condenser bushing To further increase the dielectric force of a bushing, the condenser insulation is saturated with mineral oil, or curable epoxy resin; these two technologies are referred to as oil-impregnated paper (OIP) and resin-impregnated paper (RIP), respectively. The material of the external insulator is invariably porcelain for OIP condensers and for RIP condensers, both serving the same purpose of limiting the flow of leakage current and preventing external flashovers. The OIP condenser bushings are also equipped with a Expansion chamber to allow oil volume fluctuations (expansion/contraction) due to varying temperature (a conservative tank in an energy transformer performs a similar purpose). Oil condenser mount flanges are equipped with a test tap (more on that below) and additional space for the installation of a ring-type current transformer (CT). The internal connection terminals are equipped with stress shields to limit high potential stresses inside the oil-filled enclosure. Condition assessment The test tap is connected to the outermost condenser sheet and is used to perform two important benchmark measurements. These measurements are capacitance (C) and dissipation factor (tanδ); both tests are used to determine the insulation condition of a bushing. Any increase in c and/or tanδ values indicates deterioration of insulation, moisture intake and/or short circuit of condenser sheets. Insulation resistance tests, partial discharge measurements and thermographic inspections are also useful aids in assessing the condition of a bushing. Applications In the energy engineering industry, the most common applications for bushings are: Air-oil – used in outdoor air insulated substation (AIS) equipment, such as transformers and shunt reactors etc. Air-gas - used in gas insulated substations (SS) and SF6 circuit breakers. Air-to-air - used for external connections for internal connections, e.g. wall bushings. Installation of an Air-to-Oil Condensing Bushing Transformer Requirements The design of any type of electric bushing takes into account the following requirements and aspects: The central conductor of a bushing must be able to carry the anticipated load, or fault currents, without overheating the surrounding insulation (which can lead to abnormal loss of life). For any transformer, the conductive rod of a low voltage (LV) bushing is required to carry a higher current than its high voltage (HV) partner. Consequently, the conductive rod of an LV bushing is always thicker (has a larger diameter) than its HV butt. The internal insulation of a bushing must be able to withstand the transient electric field nominal stresses that placed it on it. These tensions arise due to the potential differences between the living conductor and the grounded external environment. The internal insulation of a bushing should also limit the onset of partial discharges (PD), which can cause progressive deterioration of the insulation. The external insulation of a bushing should provide enough dry arc distance to withstand lightning and alternate impulses. The external insulation should also provide an adequate creep distance (leakage distance) to prevent excessive flow of leakage current; the leakage current may result from a combination of pollution build-up (dirt, sand, salt, etc.) and/or Environment. Bushing Dry Arcing and Creepage Distance mechanical stresses that will be placed on the bushing during seismic events and short circuit. The design and construction of a bushing must be robust enough to withstand the rigors of transportation, handling and installation. Want to know more about electric bushings? Then check out our Introducing to Electric Bushings video course! We offer high voltage and low voltage bushings designed for use in transformers mounted on pads or surfaces. The bushings insulate the current transport conductor from the tank allowing the end of both the air side conductor and the transformer cables. Both high and low voltage bushings comply with ANSI/IEEE standards. One inch and five inch of low voltage are molded from a nylon resin reinforced in glass and high temperature. The inch bushing and a quarter of low voltage is molded from a polyester resin. All low voltage bushings provide a shovel terminal for internal connection and a threaded stallion for external connection. Product scope: Voltage: through 600 V Current: 600 A to 2,000 Technology: no condenser This article has several problems. Please help improve it or discuss these topics on the conversation page. (Learn how and when to remove these template messages) This article needs additional citations for verification. Please help improve this article by adding quotes to reliable sources. Unsourced material can be challenged and removed. Find sources: Electric Bushing - news · newspapers · books · scholar · JSTOR (October 2012) (Learn how and when to remove this template message) This article may require cleanup to meet Wikipedia's quality standards. The specific problem is: the article needs wikilinking, formatting and maybe an expert from a relevant project Please help improve this article if you can. (October 2012) (Learn how and when to remove this template message) (Learn how and when to remove this template message) Variety of small ceramic bushings for voltages from a few hundred to a few thousand volts. High voltage bushings in a utility transformer in an electrical substation. These probably operate at several hundred thousand volts. In electric power, a bushing is a hollow electric insulator that allows an electrical conductor to pass safely through a driving barrier, such as the box of a transformer or circuit breaker without making electrical contact with it. Bushings are typically made of porcelain; although other other isolating materials are also used. Explanation All materials that carry an electrical charge generate an electric field. When an energized conductor is near a potential terrestrial material, it can form very high field forces, especially where field lines are forced to bend sharply around the ground material. The bushing controls the shape and strength of the and reduces electrical stresses in the insulating material. Bushing condenser A bushing must be designed to withstand the strength of the electric field produced in insulation, insulation, any earth material is present. As the strength of the electric field increases, leak paths can develop within the insulation. If the energy of the leak path overcomes the dielectric force of the insulation, it can drill through the insulation and allow the electrical energy to lead to the nearest grounded material, causing burning and arcing. A typical bushing design has a conductor, (usually copper or aluminum, occasionally from other conductive materials), surrounded by insulation, except by the ends of the terminal. In the case of a bus stop, the driver terminals will support the bus bar in its location. In the case of a bushing, a fastening device will also be attached to the insulation to keep it in its location. Typically, the attachment point is integral or wraps the insulation on part of the insulated surface. The insulated material between the attachment point and the conductor is the most stressed area. The design of any electric bushing must ensure that the electrical resistance of the insulated material is able to withstand the penetrating electrical energy passing through the conductor, through any highly stressed areas. It should also be able to withstand, occasional and exceptional moments of high voltage, as well as normal continuous service withstand the voltage, as it is the voltage that directs and controls the development of leak paths and not current. Insulated bushings can be installed inside or outside, and insulation selection will be determined by the location of the installation and the electrical service service on the bushing. For a bushing to function successfully over many years, insulation must remain effective in both composition and design form and will be key factors in its survival. Bushings can therefore vary considerably in both material and design style. Types of porcelain insulation The first bushing designs use porcelain for internal and external applications. Porcelain was originally used due to its properties of being immune to moisture once sealed by fired enamels, and low manufacturing cost. The main disadvantage with porcelain is that its small linear expansion value must be accommodated using flexible seals and substantial metal fittings, both presenting manufacturing and operational problems. A basic porcelain bushing is a hollow porcelain shape that fits through a hole in a wall or metal box, allowing a conductor to pass through its center, and connect at both ends to other equipment. The bushings of this type are often made of burnt porcelain in wet process, which is then glazed. A semi-conductive enamel can be used to help equalize the potential electrical gradient along the length of the bushing. The interior of the porcelain bushing is often filled with oil to provide additional insulation and the bushings of this construction widely used up to 36 KV where higher partial discharges are allowed. When partial discharge is required to fit the IEC60137, paper paper Insulated resin conductors are used in conjunction with porcelain for unheated internal and external applications. The use of resin (polymer, polymer, composite) of insulated bushings for high voltage applications is common, although most high-voltage bushings are usually made of resin-impregnated paper insulation around the conductor with porcelain or polymer weather sheds, to the outer end and occasionally to the inner end. Other initial form of paper insulation was paper, however, the paper is hygroscopic and absorbs moisture that is harmful and is disadvantaged by inflexible linear designs. The technology of molten resin, has dominated isolated products since the 1960s, due to its flexibility of shape and its greater dielectronic strength. Usually, paper insulation is subsequently impregnated with oil (historically), or more commonly today with resin. In the case of resin, the paper is coated with a phenolic resin to become synthetic resin bonded paper(SRBP) or impregnated after dry winding with epoxy resins, to become Resin Resin Impregnated Paper or Epoxy Resin Impregnated Paper (RIP, Rip). Isolated SRBP bushings are typically used up to voltages around 72.5 kV. However, above 12 kV, there is a need to control the external electric field and balance the internal storage of energy that marginalizes the dielectric strength of paper insulation. To improve the performance of insulated paper bushings, metal sheets can be inserted during the winding process. These act to stabilize the generated electric fields, homogenizing internal energy using the capacitance effect. This feature resulted in the condenser/capacitor bushing. The condenser bushing is made by inserting very thin layers of metallic aluminum foil into the paper during the winding process. Inserted conductive sheets produce a capacitive effect that dissipates electrical energy more evenly across the insulated paper and reduces the stress of the electric field between the energized conductor and any grounded material. Condensing bushings produce electrical stress fields that are significantly less potent around the fixing flange than leafless designs and, when used in conjunction with resin impregnation, produce bushings that can be used in service stresses above one million with great success. Resin insulation Since the 1965s, resin materials have been used for all types of bushings up to the highest stresses. The flexibility of using a form of rodable insulation has replaced paper insulation in many areas of the product and dominates the existing insulating bushing market. Just like paper insulation, control of electrical stress fields remains important. Resin insulation has higher dielectric resistance than paper and requires less stress control in below 25 kV. However, some higher-rated compact and exchange-rate designs have grounded materials closer to the bushings than in the past, and these designs may require stress control screens on resin resin bushings as low as 12 kV The attachment points are often integral to the main resin shape, and present fewer problems to grounded materials than the metal flanges used in paper bushings. However, care should be observed in the designs of insulated resin bushings that use screens released internally in such a way that the benefit of controlling the electric stress field is not defined by the increase in partial discharge caused by the difficulties of eliminating micro voids in the resins around the screens during the casting process. The need to eliminate voids in the resin becomes more sensitive as stresses increase, and it is normal to revert to impregnated resin, frustrated paper insulation for bushings valued above 72.5 kV. Bushings in small ferroresonant transformer bushings In single-phase distribution transformer, 20 kV bushings on transformers and cables 110 kV bushings on a construction wall Bushings for 110 kV and 220 kV Bushings in 380 kV transformer and GIS Bushing connection in 1 MV AEG utility transformer, Germany, 1932 Bushing failure The dry bushingOil full oil filled with cleaning bushings sometimes fails due to partial discharge. This is sometimes due to the slow and progressive degradation of isolation over many years of energized service; however, it can also be a rapid degeneration that destroys a good bushing in a matter of hours. Currently, there is great interest from the electric power supply industry in monitoring the condition of high voltage bushings. However, some bushings that fail at the beginning of service are due to failures in voltage control or performing essential maintenance, while others relate to incipient fault mechanisms incorporated into manufacturing. This view is evidenced by the minority of bushing failures around the world. Central Electricity Generation References
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