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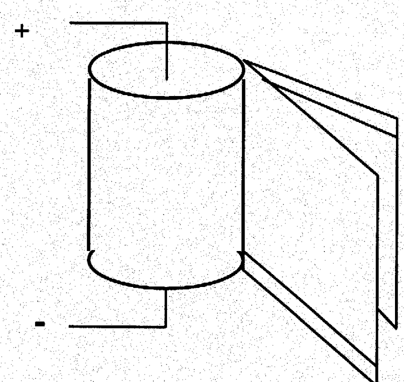
Dry vs. liquid filled capacitors.

Many people question the differences between dry-type and liquid filled capacitors. For an understanding of the significance of the differences, a basic understanding of how capacitors are constructed is required.

A capacitor, by definition, is two metal plates separated by a dielectric. Technically, and practically, the dielectric can be air, a vacuum, a solid or a liquid material, as long as the material is non-conducting. The purpose of the dielectric is to allow opposite charge to develop on the capacitor plates while preventing the passage of that charge from one plate to another. The amount of charge on each plate is a function of the voltage applied across the plates and the distance between them. The electric field which develops between the plates is a gradient, and the strength of that gradient will be influenced by the type of dielectric and its thickness. A good dielectric will be a material which is both thin and an excellent insulator. In order to increase the amount of capacitance per unit volume, it is necessary to reduce the dielectric thickness to a minimum while maintaining the voltage gradient and preventing the passage of charge through the dielectric.

Power factor capacitors are constructed by winding the two capacitor plates and their dielectric into a tightly-packed cylinder. When winding the capacitor plates, each plate is offset slightly so that one end of the cylinder will connect to the edges of one plate while the opposite end of the cylinder will connect to the edge of the other plate. To provide a uniform current density to the edges of the plates, zinc is sprayed onto the end caps such that it makes contact with the entire plate edge. Electrical wires are connected to the zinc end spray.



Prior to 1978, the preferred dielectric was craft paper impregnated with a PCB oil. The paper was used as a "wick" to draw oil between the plates. In 1978, PCB's were banned for use as a dielectric fluid and manufacturers sought other oils with sufficient dielectric properties. The choice of fluid was critical. The fluid had to have good dielectric properties while at the same time a high flash point to prevent fire. One of the most desirable properties of PCB's were their high flash point. In order to avoid the use of fluids entirely, many manufacturers experimented using polypropylene (a plastic) alone as a dielectric. There were many advantages to polypropylene as a dielectric: not only was it an excellent dielectric, it also avoided the requirement for a high flash-point, environmentally safe fluid dielectric.

The new, dry-type capacitor elements used polypropylene as a dielectric substrate to which a metal alloy was sprayed onto one side. The spray was carefully applied to one side of the substrate such that it covered right to the very edge of one end of the substrate, but not to the edge of the other end. Two such metalized polypropylene plates were placed together to form the two plates of the capacitor with the polypropylene dielectric between them. Metal alloy end spray was applied to connect to each plate.

With early dry-type capacitors, it very quickly became apparent that the use of fluid provided other functions than just a dielectric mechanism. The first all-dry elements were relatively inefficient and thus developed a fair amount of heat internally. Manufacturers soon discovered that fluids were required to provide a heat transfer mechanism to prevent premature failure of the element. It should be noted that the fluid did not provide any additional dielectric strength. The polypropylene elements are wound so tightly that there is no possibility of fluid wicking into the element.

Another issue arose from the removal of oil. With the element no-longer immersed in oil, the introduction of oxygen into the container in which the element was housed allowed for corrosion of the end spray region. A material was needed to prevent that introduction to prevent corrosion of the end spray region of the element.

Finally, the most serious issue related to the removal of oil from the capacitor element became apparent. All capacitor elements produce gas as a normal part of their life. As gas is produced, pressure within the capacitor container builds. Approval bodies such as UL and CSA recognize this and mandate that all element manufacturers provide a pressure disconnect means to remove the element from service prior to pressure sufficient to cause case rupture. Many pressure disconnect schemes involve a roll or fold in the wall of the capacitor container which allows for distortion (bulging) of the case as pressure builds up. As the top of the container distorts, it pulls or tears the electrical connection to the element away from the end spray region. A problem arises if this tearing is allowed to occur in the presence of oxygen. The gas produced by the element during its normal life cycle is flammable. If the normal pressure disconnect method results in a spark in the presence of a flammable gas and oxygen, explosion may result. Oil was thus employed to displace the oxygen to prevent such an occurrence.

One of the problems with the use of oil was that of keeping it contained 100% of the time. Normal manufacturing tolerances, corrosion of the containers in harsh environments and mechanical shock and vibration can lead to a breach in the container sufficient to allow the oil to escape. As the oil escapes, oxygen displaces it and all of the problems associated with the need for the oil return. Manufacturers thus continued the development of an all-dry capacitor element design.

As material science matured, better polypropylene dielectric substrates emerged. Thickness' were reduced leading to higher electric gradients which led to greater capacitance per unit volume. Better metalization equipment, finer metal vapors and tighter quality control reduced element losses such that heat dissipation was no longer a problem. Modern potting compounds were developed with properties which allowed the gas produced by the element to escape while preventing larger oxygen molecules from entering the container. The solid epoxy resin potting compounds could not leak from the container. Finally, since all of the modern components are plastics and metals, material disposal is not required to be under the supervision of waste disposal authorities.

There are very few craft-paper capacitor manufactured today. The vast majority of the world market is metalized film polypropylene element design. Of those, the majority use dry potting compounds in place of oil immersion. Although simple in principle, material science and manufacturing techniques have evolved immensely over the past 20 years. Today's capacitor designs equal or surpass the performance of those of only a few years ago. When applied correctly, modern day dry-type capacitors will provide years of trouble free service.

For more information about capacitors and capacitor applications, contact the Power Quality Correction Groupe at 905-678-7000, or fax to 905-678-9873.