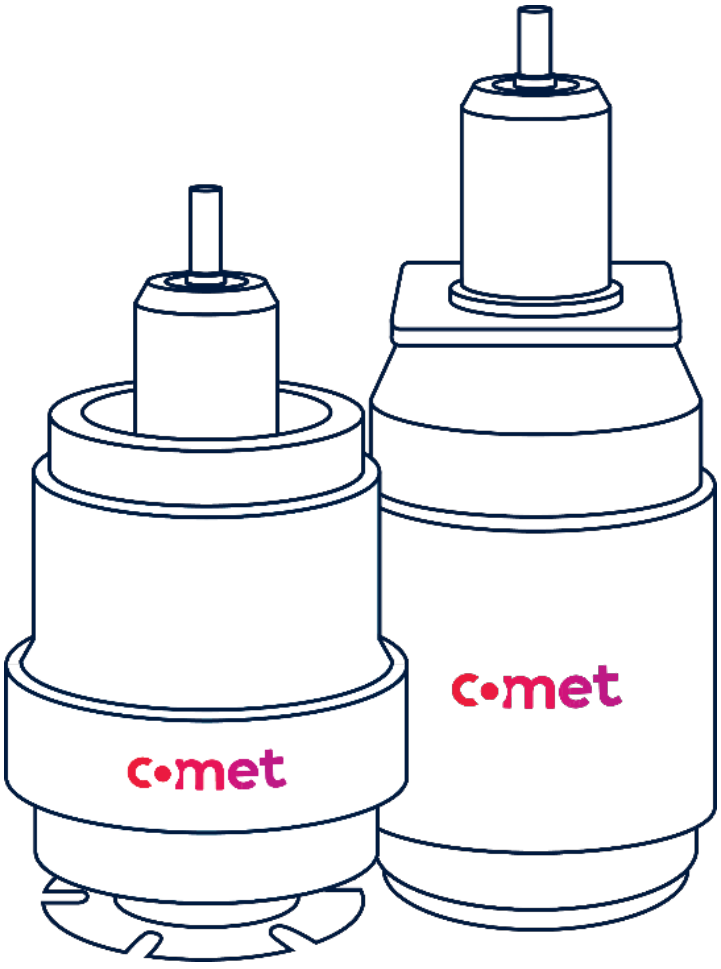
Service Bulletin-06 | Vacuum Capacitors

Vacuum Component Fundamentals



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Vacuum components, among them vacuum capacitors, are costly and can cause problems with operation if not handled properly. Therefore, it is important that a good understanding of their correct handling and care be obtained. Hours of frustration can be avoided, and greatly improved equipment reliability can be obtained, by observing a few simple and readily understandable rules.

Some background information why a vacuum is such an excellent insulator will help.

An electrical spark is said to result from free electrons in the air between two electrically charged conductors being accelerated fast enough to "ionize" the air (free other electrons from molecules of air). In a vacuum there are fewer molecules of air, so it is much more difficult to cause the ionization, and thus a much higher voltage is required to cause the spark to occur. If the vacuum is good (hard), this results in voltage hold-off capabilities such that very high voltages (50'000 volts) may be placed across a distance of 0.8 mm.

It is never possible to remove all of the molecules from any space, but an idea may be obtained by noting that at normal conditions (760 mm Hg pressure) there are about 1.6×10^{21} molecules per cubic inch (16.4 cm^3) of air whereas inside a vacuum vessel with a pressure of 10^{-8} mm Hg there are about 1.6×10^{11} molecules per cubic inch. This is approximately a ratio of one to 10'000'000'000 (10 billion).

The vessel which contains the vacuum (capacitor envelope) **must not leak**. The materials of which it is constructed have been very carefully chosen. All joints between various materials (oxygen free copper, non-porous ceramic insulators, other metals) have been carefully made using very sophisticated techniques which have been developed through years of experience and research.

Additionally, the evacuation process requires great care. The latest evacuation processes are employed lasting almost one full day to arrive at the required vacuum.

During this time the entire capacitor is heated as high as possible for an extended period of time. The purpose of this procedure is to cause the molecules of gas to move more readily toward the exhaust port and also to free molecules which are stuck to the many wall and element surfaces so they, too, may be pumped out.

Obviously, any gas molecules that may be hidden in the metal lattice structure must also be removed while the evacuation system is still connected so that these will not get loose later at an inopportune time.

Since a vacuum component is supposed to withstand a high voltage, a good way to determine its condition is to apply as high a voltage as possible without sparking internally.

If the high voltage source has a very limited current capability (.01 amperes or less), internal sparking may improve the voltage handling capability of the component. However, if the current capability of the high voltage source is too high, internal sparking can easily reduce the hold off voltage of the component and may ruin it.

To understand this, one must realize that the molecules may form clouds or groups of molecules closely spaced. Such grouping may be only momentary, but it represents a location where the vacuum is not as good as at other places. If this "cloud" or concentration should occur a place of high voltage stress, such as between the electrodes of a vacuum capacitor, a spark may occur. This will quickly dissipate the cloud and, if the current capability of the voltage source is low enough, no appreciable heat will occur to melt or heat the electrodes. Once the "cloud" concentration has been dispersed the capacitor will handle an increased voltage.

Another "clean up" process can take place. If a small, very sharp point exists on the surface of a conductor in a vacuum, a spark to this sharp point may melt the tip of the sharp point and round it, thus increasing the voltage handling ability of the component.

So we understand that sparking a vacuum component can raise its voltage handling ability and can improve the component.

If too much current is allowed to pass through the arc, the space between the electrodes may be reduced by excessive melting of the metal. Also, gas trapped within the metal may be released and reduce the vacuum, and therefore its insulating properties. Remember that at a vacuum of 10^{-8} mm Hg it takes **very** little gas to **greatly** reduce the vacuum's insulating qualities.

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