CERAMIC VS. FILM: CHOOSING THE RIGHT TECHNOLOGY FOR YOUR SAFETY CAPACITORS

Safety capacitors are designed to help safeguard users and equipment from electrical hazards, even in the event of failure. When selecting a safety capacitor for your application, you typically have two choices in dielectric material – ceramic and film. To select the right technology for your application, it is important to both understand your requirements and the differences between what each material has to offer.

General Considerations for Selecting a Safety Capacitor Technology

When comparing whether to use a multilayer ceramic capacitor (MLCC) or film capacitor for your safety capacitor, you need to consider the capacitor's construction, performance characteristics, and suitability for specific safety roles as well as the capacitor's:

- Temperature range
- Size constraints
- Voltage rating
- Capacitance value
- Cost

Let's further explore the characteristics of both MLCCs and film capacitors.

Ceramic Capacitors

In general, for line-to-ground configurations, or Class Y capacitors, safety requirements dictate that failure must not result in a conductive path that could pose a shock hazard. MLCCs, when properly rated, can meet these requirements. Some benefits of using MLCCs include the following:

- Compact size, allowing for high capacitance in a small footprint, which is ideal for space-constrained designs
- Cost-effective manufacturing makes ceramics attractive for high-volume, cost-sensitive projects
- Low equivalent series resistance (ESR) and equivalent series inductance (ESL) support effective high-frequency EMI suppression

Some challenges with using ceramic include that ceramic generally has a lower voltage rating than film, which can limit its use in high-power designs. Additionally, while some MLCCs can withstand high temperatures and humidity, others may be susceptible to performance drift under environmental stress, which can impact long-term reliability.

As a result, ceramic is well suited for Y1 and Y2 safety capacitors, especially those used in appliances, chargers, or compact consumer electronics where space and cost are driving factors.

Film Capacitors

Film capacitors are most commonly used in Class X applications where they are installed across the AC line. Therefore, these capacitors must be able to withstand large voltage surges and recover from a dielectric breakdown with only a small reduction in capacitance. Advantages of using a film capacitor include the following:

- High voltage tolerance that enables reliable performance
- Self-healing properties that allow the capacitor to recover from small dielectric failures without catastrophic failure
- Excellent stability over time and varying environmental conditions to ensure long service life and consistent safety compliance

Since film capacitors are typically larger in size, it may be challenging to use these capacitors in densely packed assemblies. Film capacitors also typically cost more than ceramic options, which may be a consideration for cost-sensitive markets.

As a result, film is typically a good fit for X1 and X2 safety capacitors used in industrial equipment, power supplies, or any design that must withstand line surges and operate over extended periods.

Selecting the Right Safety Capacitor for Your Design

The choice between using ceramic or film for your safety capacitors requires a clear understanding of the capacitor's role, requirements, and environmental operating conditions. Ceramic capacitors offer compactness and cost advantages, making them well suited for many Class Y roles. Film capacitors, with their robust voltage handling and reliability, are typically the preferred choice for demanding Class X applications.

Capacitor Material	Best Suited For	Strengths	Limitations
Ceramic	Y1/Y2	Small size, low cost, high-frequency performance	Lower voltage handling, environmental sensitivity
Film	X1/X2	High voltage tolerance, self-healing, long-term stability	Larger size, higher cost

Table 1: A side-by-side comparison of ceramic and film technologies for safety capacitors.

At Knowles, our broad portfolio of safety capacitors ensures engineers have the right solution available without compromising on safety, reliability, or performance. In the next post in this series we will get into the details of how to select the appropriate safety capacitor for EMI filtering in the power factor correction (PFC) stage of an AC/DC converter.

Learn more about safety capacitors in general by downloading *The Electrical Engineer's Guide to Safety Capacitors* ebook, or dive into product details by exploring our extensive line of safety capacitors.

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If you need help selecting from our portfolio please contact us and we can guide you through the selection process.

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