
TECHNICAL NOTE

Comparison of switchgear bushing materials

Epoxy, glass polyester (GPO) or porcelain

Frequently, inquiries arise regarding the supplementary advantages brought to customers by epoxy bushings. What distinguishes epoxy bushings from glass polyester (GPO) or porcelain alternatives in terms of benefits?

Epoxy, glass polyester (GPO), and porcelain are all materials commonly used for manufacturing bushings in switchgear applications. Each material has its own set of characteristics, advantages, and disadvantages. Let's compare them in terms of technical aspects.

Dielectric Strength

- Porcelain: Offers good dielectric strength, making it suitable for high voltage applications but porcelain bushings are more prone to developing surface defects that can lead to electrical breakdowns. Furthermore, historical data indicates that porcelain exhibits inferior performance in corona extinction testing and partial discharge testing.
- GPO: Offers moderate dielectric strength, suitable for medium voltage applications.
- Epoxy: In terms of electrical performance, epoxy bushings showcase remarkable characteristics. They possess a high dielectric strength and exhibit minimal partial discharge, offering higher dependability and effective operational performance. Epoxy demonstrates superior dielectric strength compared to both porcelain and GPO, as indicated in Table 1.

Mechanical Strength

- Porcelain: High compressive strength and but lower flexural, bending, and tensile strength compared to GPO and Epoxy.
- GPO: Good mechanical strength and can be reinforced for increased strength.
- Epoxy: Epoxy material offers superior tensile and bending strength in comparison to porcelain. Epoxy bushings demonstrate enhanced durability and resilience when compared with their porcelain counterparts. They showcase a flexural strength that can outperform porcelain by up to 15 times, highlighting their ability to withstand significant stress before experiencing fracture or deformation.

Thermal Performance

- Porcelain: Exhibits good thermal stability and can handle high temperatures.
- GPO: Generally has lower thermal resistance compared to porcelain.
- Epoxy: Shows good thermal performance but may have limitations compared to porcelain.

Moisture Resistance

- Porcelain: Highly moisture-resistant and suitable for outdoor applications.
- GPO: Susceptible to moisture absorption over time, potentially affecting its electrical properties.
- Epoxy: Generally, moisture-resistant, but long-term exposure to moisture might impact its properties. For switchgear installed indoors, or in outdoor enclosures where the temperature, moisture and other climate factors are controlled, it provides excellent performance.

Environmental Resistance

- Porcelain: Resistant to UV radiation, chemical exposure, and environmental pollutants.
- GPO: Can be formulated with enhanced environmental resistance, but not as inherently resistant as porcelain.
- Epoxy: When compared to porcelain and GPO, it is more resistant against ultraviolet light, chemical exposure, and environmental pollutants.

Weight

- Porcelain: Heavier compared to epoxy and GPO.
- GPO: Lighter than porcelain but heavier than some epoxy formulations.
- Epoxy: Relatively lightweight compared to porcelain and GPO materials. Epoxy makes up less than 70% of the weight of porcelain.

Manufacturing Flexibility

- Porcelain: More complex and labor-intensive manufacturing process.
- GPO: Can be molded into various shapes with relative ease.
- Epoxy: Offers greater flexibility in shape and design due to its molding capabilities. Epoxy is easier to manage in terms of dimension and shape than porcelain.

Cost

- Porcelain: Generally, more expensive due to the complex manufacturing process, high risk of getting damaged during manufacturing, assembly, and operation.
- GPO: Typically, more cost-effective compared to porcelain.
- Epoxy: Offers a balance between cost and performance.

Maintenance

- Porcelain: Requires minimal maintenance and has a long service life, but there is a high risk of getting damaged, cracked, or chipped, which may require replacement.
- GPO: May require more frequent maintenance and replacement compared to porcelain.
- Epoxy: Maintenance requirements for epoxy bushings are lower than those for porcelain and GPO bushings.

Application

- Porcelain: Often used in high voltage and outdoor applications where mechanical strength and reliability are crucial.
- GPO: Suitable for medium voltage applications where cost-effectiveness and moderate performance are acceptable.
- Epoxy: Commonly used in medium to high voltage applications where weight, flexibility, and cost are factors.

Summary

Epoxy materials offer the best overall choice when considering the characteristics that are most important to medium voltage metal-clad switchgear. In summary, the empirical data substantiates the enhanced performance of epoxy bushings compared to porcelain and GPO bushings concerning their longevity, weight, maintenance requirements, cost-efficiency, and electrical capabilities. Epoxy is particularly well-suited for medium voltage ANSI metal-clad switchgear due to its exceptional dielectric strength, mechanical resilience, and resistance to high-power arcs. These qualities are of paramount importance in switchgear applications where safety, reliability, and performance are non-negotiable.

With the industry's progression towards more sophisticated and dependable electrical systems, epoxy bushings are poised to have a substantial impact on driving this advancement. Epoxy resin bushings exhibit resistance to high-power arcs and possess a longer dry arcing distance in comparison to porcelain and GPO material bushings, making them a safer and more reliable choice for critical switchgear applications.

Moreover, historical data indicates that porcelain exhibits inferior performance in corona extinction testing and partial discharge testing compared to GPO and epoxy, further underscoring the superiority of epoxy in ensuring the integrity of MV ANSI metal-clad switchgear. Furthermore, epoxy bushings offer a more reliable, robust, and adaptable solution, meeting the stringent demands of modern medium voltage metal-clad switchgear. Table 1, Properties Comparison, shows a summary of the properties of each material, where it becomes evident that epoxy consistently offers good performance when compared to porcelain and GPO materials.

Table 1 Properties comparison

Properties	Porcelain	Glass poly	Epoxy
Dielectric Strength	●	●	●
Mechanical Strength	●	●	●
Thermal Performance	●	●	●
Moisture Resistance	●	●	●
Environmental Resistance	●	●	●
Weight	●	●	●
Manufacturing Flexibility	●	●	●
Cost	●	●	●
Maintenance	●	●	●
Application	●	●	●

Legend:

- Best (Dark Green)
- Good (Light Green)
- Average (Yellow)

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