

Enclosures for Solar Applications

A Guide to Selecting the Ideal Enclosure Material

WHITE PAPER

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Solar energy is one of the fastest growing renewable energy segments. With a focus on commercial, residential and utility, solar application solutions must be flexible enough to keep pace with rapidly emerging demands. Balancing current needs for sustainable energy sources against increasing power demands has led to an unprecedented expansion of renewable energy technology development and rapid deployment. Protecting vital controls, instruments and distribution equipment in solar applications requires flexible and durable enclosure solutions.

In order to ensure continued operation of critical electronic and networking equipment in these applications, designers must select the ideal electrical enclosures that assist with solar thermal and tracking systems. With today's offerings of enhanced enclosure material alternatives, system designers can select and implement enclosure solutions that better protect sensitive electronics, resist environmental elements and enhance energy-efficient operations.

When evaluating electrical enclosure solutions, designers must contemplate several factors, such as the environmental conditions the electrical enclosures will operate under, the available material options that best address the environment and application, solar load considerations and the total cost of implementation. Understanding the benefits, advantages and limitations associated with various enclosure material options and solutions aids the designer in selecting the ideal electrical enclosure for virtually any solar application.

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Challenges with Solar Applications

Solar powered projects can be costly during initial implementation, and may require many years (even decades) before yielding a solid return on investment. Therefore, it is imperative that systems operate flawlessly from the time of installation. Selecting the appropriate electrical enclosure that enhances the performance, longevity and durability of the solar equipment enclosed is critical.

While solar power is an excellent source of energy, these applications are often located outdoors, exposing electrical enclosures, and the equipment within, to harsh environmental elements and demands. Whether for large, on-grid photovoltaics systems or concentrated solar power systems, designers want to implement electrical enclosure solutions that perform reliably, often under punishing conditions that exist in outdoor applications. These conditions can include UV radiation and temperature extremes, wind with blowing rain, snow, dust and dirt and salt spray in coastal regions.

Given the range of environmental challenges that exist, designers that address these elements with the appropriate



Designers must select the ideal metallic or non-metallic enclosure material for each individual solar application for the highest level of durability and longevity.

enclosure material option will optimize and enhance their enclosure solution, leading to the lowest total cost over time including maintenance and replacement. For instance, ultraviolet light (UV) energy may degrade enclosure appearance and breakdown the physical substrate of some non-metallic materials. Sodium chloride (salt) in the air may cause extensive corrosion and component failure in mild steel painted enclosures or impact the appearance of stainless steel enclosures over time. Selecting the right enclosure material for the environment and application will provide the intended protection and years of reliable service from the enclosure and equipment inside.

Metallic vs. Non-Metallic Material Selection

Electrical enclosures are expected to perform for years, maintaining their integrity in the face of environmental aversion. Understanding how metallic and non-metallic materials perform when subjected to external elements and corrosive agents is crucial when selecting the proper material for individual applications. For instance, painted mild steel may be an acceptable solution for most indoor applications, but for outdoor applications, materials such as stainless steel and non-metallic enclosures provide superior protection against corrosion.



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Metallic Enclosures

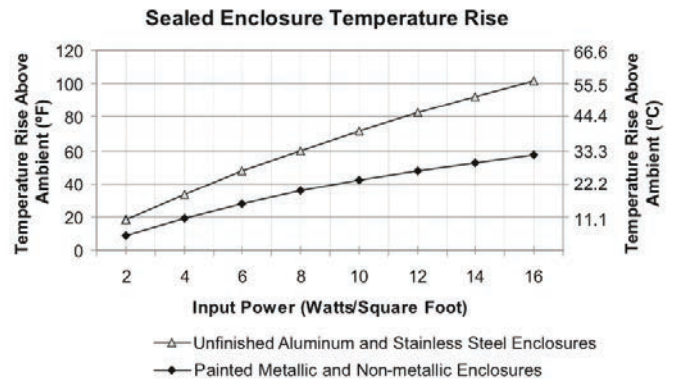
For solar applications located in an indoor protected area or without extreme environmental conditions, painted mild steel is a cost-effective material option. Painted mild steel will deliver an adequate level of protection for solar applications in general indoor and outdoor conditions where potential corrosion is not a concern. In wet or coastal environments with salt in the air, mild steel performance will be compromised and begin to corrode, exposing the electronics within and potentially causing equipment malfunction. This leads to additional maintenance costs, potential system downtime and even enclosure replacement, which could increase future expenditures required to keep equipment up and running.

Alternatively, stainless steel enclosures can provide a high degree of corrosion protection against abusive outdoor environments. Stainless steel enclosures are robust and rigid in design and perform well against a wide assortment of chemicals and corrosive agents, such as sodium chloride. Stainless steel maintains a good appearance, is acceptable for use in direct sunlight and in applications with temperature extremes. In these environments, stainless steel provides enhanced durability compared to mild steel. Their design and construction allows stainless steel enclosures to perform reliably in a wider variety of applications than mild steel enclosures. Although stainless steel has higher initial installation costs, maintenance and replacement expenses are reduced over the life of the installation.

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Non-Metallic Enclosures

Enclosures molded out of non-metallic materials, such as fiberglass, polyester or polycarbonate, are used in many of today's solar applications. The particular performance and weight characteristics of these materials provide certain advantages over metallic materials. These materials are corrosion resistant and have UV stabilizers and flame retardancy additives in their formulations for enhanced performance in indoor and outdoor applications. Each material offers varying amounts of impact resistance and flexibility that allow the enclosure to withstand impacts without denting and operate in a wide range of temperature extremes.



Fiberglass

Fiberglass enclosures are molded from a thermoset polyester resin with embedded glass strand fibers for strength and rigidity. This corrosion-resistant material provides superior chemical resistance, withstands a wide range of temperatures and performs well in outdoor applications. Fiberglass enclosures are typically formed in one of two ways: compression molding or a spray-up process.

In the compression molding process, a material known as sheet molding compound (SMC), which is a pigmented polyester resin with impregnated glass-fibers, is formed into a sheet of material. UV inhibitors and aluminum trihydrate can also be added to the formulation to provide increased degrees of UV resistance and flame retardancy. The final formulated material is then laid into a precision-designed mold that, under the process of heat and pressure, forms an enclosure with part uniformity and material consistency. The glass strands provide a combination of exceptional strength with flexibility.

While providing durability and strength, fiberglass enclosures are susceptible to a phenomenon called fiberbloom. This occurs over a period of years when fiberglass is continually exposed to UV light. The UV rays erode the protective resin gel covering the glass fibers on the outside of the enclosure,

eventually exposing the glass fibers which exhibit a snowflake like appearance (fiberbloom). Although the enclosure integrity is still intact, the appearance is no longer attractive. Once fiberbloom has occurred, the enclosure is more difficult to clean and it may irritate skin if handled without gloves. Additionally, fiberglass, like painted steel and other materials, will eventually discolor from UV exposure.

Polyester and Polycarbonate

The use of polyester, polycarbonate or hybrid polycarbonate/polyester blends for non-metallic enclosures provide new alternatives to fiberglass and stainless steel for corrosion resistance. These materials offer a wide range of performance characteristics and may prove to be a more cost-effective solution in some applications. Thermal plastic enclosures are molded by injecting the thermoplastic material into a mold, and the finished product is an attractive, uniform enclosure with a material that exhibits high impact resistance, electrical insulation properties and good chemical and moisture resistance to a wide range of corrosive agents and atmospheres.

Polyester and polycarbonate materials provide superior impact resistance and can withstand rough handling and hard impacts without cracking or breaking. Fiberglass, on the other hand, gets its rigidity and strength from the glass, which can be broken by hard impacts. Since polyester and polycarbonate do not include glass, they can be easily modified with common hand tools providing clean cuts with minimal tool wear and essentially no irritating dust.

Weight Considerations

Along with knowing and understanding the various material performance capabilities, designers should take into consideration the weight of each material. Non-metallic enclosures provide weight advantages over mild steel and stainless steel.

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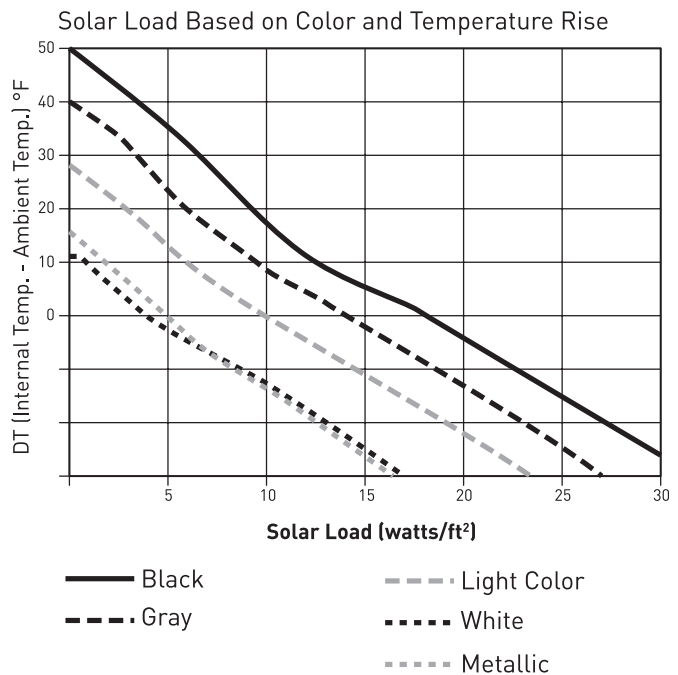
For example, if a polyester object weighs one pound, a fiberglass object of the same size will weigh 1.5 pounds. The object would weigh 2 pounds if made of aluminum, but it would weigh 6.5 pounds if fabricated from steel. If the bare enclosure itself is heavy, once it is filled with equipment it can present handling, mounting and productivity obstacles—particularly if the application requires a wall- or pole-mounting. With this in mind, designers should always take both the weight of the electrical components and the expected mounting configuration into consideration when selecting an enclosure material.



Enclosure solutions that perform reliably under punishing conditions existing in outdoor applications, such as UV radiation and temperature extremes, wind with blowing rain, snow, dust and dirt and salt spray in coastal regions.

Managing Solar Load for Outdoor Applications

As mentioned above, electrical enclosures used in solar applications are often located outside. Consequently, maintaining safe temperatures inside an enclosure is critical to ensuring the continued performance of the electronics housed within. The rise in temperature above the outdoor ambient temperature inside the enclosure is caused by internal equipment heat dissipation and solar energy absorption. The enclosure color can have the most significant impact. This is illustrated in the chart below, which demonstrates temperature rise based on enclosure color when exposed to the daytime sun.



To meet aesthetic requirements, lighter colors may not be an option, therefore adding solar shielding can have a favourable reduction in solar loading. Solar shielding shades the enclosure usually in the form of an added surface that provides roughly 1-inch of airspace between the enclosure and the shield. This airspace is generally ventilated which allows heat generated

internally to conduct out. Testing has demonstrated that with all sides solar shielded, solar loading was reduced by as much as 40-50 percent. However, adding solar shielding to enclosures is typically only applicable to mild steel or stainless steel enclosures where standoffs can be added to the external surfaces to mount the shields.

The addition of insulation can also dramatically reduce the solar load. Unlike solar shields, insulation reduces the external solar load from the sun, but, at the same time, does not allow heat generated internally by components to get out. Insulation is a good option when used in conjunction with an active cooling system, such as an air-conditioner, heat exchanger or ventilation system.

Looking Ahead

As alternative energy sources, such as solar power, continue to increase in prevalence, selecting the proper electrical enclosure material will be a critical part of solution implementation. Knowing the advantages and limitations of each material ensures the continued performance of networking and control equipment and improves the overall productivity of solar applications.



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