



Designing Component Enclosures with the Elements in Mind - A Complete Guide

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In addition to the impacts of natural factors including UV radiation, solar heat, moisture, wind, and natural disasters, it's important to also consider artificial aspects that may detract from a panel's operational integrity. Factors such as chemical presence, Electromagnetic Interference, and ingress requirements can also have a negative impact on the enclosure's performance, necessitating further, more substantive considerations during the design process.

Furthermore, determining the climate and environmental factors of the device's surroundings will help dictate the need for a cooling system, water or dust-tight seals, the need for additional corrosion resistance, and any potential alterations to the component's layout within the enclosure itself.

This article is meant to help designers plan their electrical or component enclosures to best survive in outdoor environments, therefore reducing the chances of equipment failure, damage to the device, and inefficient operation.

How Ambient Temperatures Affect Heat Load

Despite a sealed electrical enclosure being protected from environmental damage, the system's internal temperature can be directly influenced by a multitude of factors, including internal heat load, rate of heat dissipation within the enclosure itself, and the ambient temperature of the external environment.

When standard silicon components reach an operating temperature higher than 85 degrees Celsius, their lifespan [decreases by 40% with every 10-degree increase in temperature](#).

However, the main threat of system failure and damage due to heat comes from within the enclosure itself. Several factors contribute to heat accumulation in an electrical component, including:

- Wattage of electronics
- Size of the enclosure
- Passive airflow within the enclosure
- Cable management and space between components

Ambient temperatures can also drive the internal temperature of an enclosure down. If the ambient temperature is lower outside of the enclosure, an air-to-air heat exchanger can ventilate the enclosure and keep operating temperatures within safe levels.

If the ambient temperature of the enclosure's environment exceeds that of the enclosure's internal conditions, using an enclosure air conditioner or active cooling system may be required for effective long-term use.

Cooling Options for Enclosures

1. Indoor Conditions

In normal indoor locations where contamination or dirt are not a concern, a NEMA-12 enclosure with an acceptable enclosure cooler will provide reliable protection from overheating. NEMA-12 enclosures can be equipped with air-to-air heat exchangers or air conditioners with little modification required.

2. Outdoor Environments

Unlike indoor locations, outdoor environments can wreak havoc on electrical enclosures and control panels unless the proper requirements are met. These are just a few of the potential hazards to the performance of outdoor component enclosures to consider while designing your product:

a. Wind - Wind itself isn't an issue for well-designed electrical enclosures in outdoor environments. Issues arise as a result of the particles of dirt, dust, or foreign debris that enter an enclosure due to an improper or broken seal. These can interfere with cooling and heat transfer systems, clog ventilation mechanisms, and reduce the effective lifespan of your unit.

b. Rain - Even enclosures under covered areas are susceptible to splashing water, humidity, and driving rain that can enter the unit's sides and damage the components inside.

c. Heat - Heat load is among the most important considerations while selecting a cooling system for your enclosure. In addition to the heat generated by the unit itself, solar heat gain must be taken into consideration.

d. Cold - In Northern environments, cold temperatures may have a more detrimental impact on your unit's relative performance than heat gain. Condensation and ice can build up on the outside of component enclosures, necessitating an additional heating unit to keep internal temperatures within acceptable operational limits.

e. Vandalism and Theft - While many forms of vandalism are benign and do not impact the operational integrity of enclosure units, theft and damage to enclosures is a serious concern for most organizations working in a public or outdoor setting. Secured enclosures limit access to vital controls and components, but designers can help fight against vandalism and theft by building in security systems, alarms, monitoring devices, and remote controllers to the equipment inside. Furthermore, NEMA-12 and NEMA-4 enclosures provide a high level of protection against forced entry to a unit thanks to their air and moisture-tight seals.

f. Accidental Physical Damage - In warehouse or outdoor work areas, enclosures are prone to accidental damage due to collisions with heavy machinery, equipment, and vehicles. Selecting a high-strength material and protecting enclosures with metal cages or gates may offset the chances of accidental damage due to collision.

Outdoor electrical enclosures typically need a NEMA-4 cooling system, but in environments with high humidity, moisture, and direct contact with water (marine environments), NEMA-4X

enclosure ratings are the best option.

Best Materials for Outdoor Component Enclosures

1. Steel - Each variation of steel comes with its own specific properties, which can be an advantage for customers who know precisely which type they require based on their unique project. Commonly used steel variants in enclosure and front panel design include mild steel, type 304, and type 316.

Stainless steels, which provide additional protection against corrosion due to the presence of chromium, nickel, and molybdenum, are usually far costlier than mild steels due to the cost of nickel and are more suited for use in humid or corrosive environments than mild steel.

2. Aluminum

Both raw and anodized aluminum variants are often used in front panel and enclosure designs thanks to the affordability and versatility of the material. Most designers choose anodized aluminum due to its increased durability and appearance, but those planning to add custom branding or colors to their enclosures may opt for raw aluminum as part of the initial design.

3. Fiberglass

Fiberglass is perhaps the most popular non-metallic material used in enclosure design thanks to its high resistance to impact and overall rigidity. Furthermore, the material's resistance to corrosion makes it an ideal choice for covered or protected outdoor applications. Fiberglass, however, is susceptible to damage due to direct exposure to sunlight over long periods of time.

4. Polyester

A relative newcomer to the enclosure and front panel industry, polyester is light, durable, and highly effective at combating corrosive and humid environments. However, its cost and rarity may make it harder to find in most supply shops. It can also be damaged due to sunlight over a long period of time, so any outdoor applications should include protection from the sun.

5. Polycarbonate

Polycarbonates have a high resistance to impact and physical damage, making them an ideal selection for enclosures in outdoor or heavily-trafficked work areas. Polycarbonate enclosures also [perform well in high temperature environments](#) and are very resistant to acidic conditions. Organic solvents and strong alkalis can reduce the material's effectiveness.

Cooling Options for Outdoor Component Enclosures

Removing generated heat from inside your enclosure is vital to ensuring its long-term operational capabilities. Four basic types of cooling solutions exist to prevent excess heat from damaging your critical components:

1. Passive Convection Cooling

Filtered ventilation grilles or automatic louvers can open up the enclosure and allow heat to radiate through the surface and safely exit the unit.

2. Active Convection Cooling

Forced air cooling solutions can be implemented in enclosure design to move clean, cool air into the enclosure and allow it to reduce the internal temperature of the enclosure. Using a controlled

fan and filter with an adequate grille or vent will provide adequate cooling capabilities in most environments.

3. Closed Loop Cooling

Essential in extreme environments, closed loop cooling keeps outside air and internal air separate. Air conditioners and heat exchangers are considered closed loop cooling solutions.

4. Vortex Coolers

Creating a stream of cold air from a supply of compressed air, vortex coolers provide high-performance cooling in harsh environments without the need for a closed-loop system (as the air entering the enclosure is filtered).

About NEMA Requirements

The National Electrical Manufacturer's Association (NEMA) is responsible for providing ratings by which consumers can determine [which enclosures offer the best level of protection](#) for their desired use.

NEMA-1: Designed for indoor use. Provides basic level of protection against human contact with potentially hazardous components and protects components from physical contact.

NEMA-2: Offering the same level of protection as NEMA-1, NEMA-2 enclosures are also meant for indoor use. NEMA-2 enclosures add another degree of protection to sensitive internal components by guarding against light amounts of moisture.

NEMA-3: NEMA-3 enclosures are meant for either indoor or outdoor use and are identical to NEMA-2 standards, but carry more protections against water, dust, dirt, rain, and snow, but will not protect against ice formations.

NEMA-3S and NEMA-3R: NEMA-3S enclosures are the same as NEMA-3, but add an extra level of protection against ice. NEMA-3R units mimic the capabilities of NEMA-3, but do not provide protection against windblown dust and dirt.

NEMA-3X, NEMA-3RX, and NEMA-3SX: Same as NEMA-3, except each added designation signifies an additional level of protection against corrosion.

NEMA-4 and NEMA-4X: NEMA-4 is the same as NEMA-3 but adds protection against contact with pressurized water. NEMA-4X is identical to NEMA-4 but adds protection against corrosion.

NEMA-6: NEMA-6 enclosures are designed for outdoor use, but can be used indoors. These enclosures are rated to defend against physical contact, pressurized water, falling dirt, ice formation, and temporary or short-term submersion to a limited depth.

NEMA-6P: These are the same as NEMA-6 enclosures but adds further protection against submersion and corrosion.

NEMA-12: NEMA-12 enclosures offer protection against objects, human contact, dirt, dust, moisture, and drips in indoor environments.

NEMA-13: Same as NEMA-12 enclosures but with an additional level of protection against splashes and spraying of oil or coolant liquids.

Interested in learning more about building the ideal component enclosure? [Contact Front Panel Express](#) today to get started or [download Front Panel Designer](#) for a free estimate on your custom design.

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