Thermal Edge Inc.™
TEMPERATURE CONTROL SOLUTIONS FOR ELECTRICAL ENCLOSURES

# THERMAL MANAGEMENT GUIDE

## Meeting Control Panel Space Requirements and Avoiding Overheating

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# Introduction

Floor space comes at a premium in most manufacturing areas. Designers are driven to reduce costs by fitting control panels into tight spaces while still complying with safety and regulatory requirements. Using smaller electrical enclosures to save space is an option, but they often present other challenges in maintaining safe operating temperatures for electrical components as set by the manufacturers' guidelines.

The miniaturization of electrical equipment and devices such as VFDs and PLCs has resulted in a dramatic increase in heat generated inside electrical enclosures. Component manufacturers recommend enclosure temperatures be kept below 95°F (35°C). Unless control panels are properly planned, designed, and monitored, excessive component temperatures can lead to premature failure, thus jeopardizing long-term reliability and leading to increased operating costs.

Regardless of the business sector, even a brief malfunction of an electrical component can result in major financial repercussions for a company. For this reason, control panel cooling requirements should be determined early in the design process.

# Considering Proper Control Panel Cooling During the Design Phase

Evaluating environmental operating conditions is the first part of the design phase. If extreme conditions such as heavy dust, rain, snow, or corrosive conditions exist, the NEMA rating standards for enclosures should be reviewed. The ratings are designed to protect electrical components and property from damage.

Understanding the potential heat load generated from electrical equipment inside an enclosure is the second key component to control panel design. Other factors influencing the heat load include ambient temperature, solar heat gain, and the type and size of the cabinet to be used.

Saving space in a control panel often means installing several heat-generating components in very close proximity with one another. Although this practice is ideal for saving space, it creates a heat dissipation problem due to more heat-generating components in a smaller enclosed space. In this case, introducing an enclosure cooling solution for temperature control is necessary.

## Guidelines for Reliable Operation

Once the heat load calculations have been performed and a good design layout has been made, there are a few basic guidelines to follow that will ensure long-term reliable operation:

1. The heat load in the enclosure may not exceed the cooling capacity of the cooling device used.
2. The enclosure must be sealed to prevent the ingress of dust.
3. Electrical component manufacturers' specifications generally indicate the maximum allowable enclosure air temperatures are 95°F (35°C) to 104°F (40°C).
4. When using fans for cooling, filters should always be used and regularly maintained to avoid dust buildup on components.
5. It's preferable to distribute airflow evenly across the control panel rather than directing airflow straight toward an active and hot electrical component.
6. Some electrical components have their own separate fan for ventilation. Take note of the component's airflow direction so as not to direct air from the cooling device directly toward the component.
7. Wiring can also affect enclosure temperature. Properly cabling wires and routing bundles along enclosure corners keeps wires from resting on components and helps minimize airflow restriction.

Failing to properly plan for cooling or omitting any of these important points during the design phase can potentially lead to component failures, unplanned maintenance, and costly downtime.

# Common Problems When Cooling is an Afterthought

## Natural Ventilation Is Rarely Sufficient

If conditions are ideal, natural ventilation may be enough to keep a control panel operating at safe temperatures; however, this is rarely the case. If a component fails, it is generally related to excessive enclosure temperatures. Nearly all control panels require some degree of additional cooling.

Depending on the heat load and other additional environmental factors, components can be cooled by employing filtered fans, air-to-air heat exchangers, or air conditioners.

## Equipment Failure Is Costly

Repairing or replacing electrical components as a result of heat damage can get expensive. Yet, replacement parts and labor alone are not the biggest expenses associated with electrical equipment failure. Component failures also pose higher maintenance costs, worker safety hazards, plant shutdown, and, worst of all, customer inconvenience. Customers looking to competitors to have their demands met can result in long-lasting negative effects for your business.

Although control panel cooling is sometimes an afterthought during the design phase, using heat load calculations and planning ahead to incorporate proper cooling can be the best starting point to achieving longer component life and reliable operation.

# How to Incorporate Thermal Management into Design

To ensure continuous and reliable operation, electrical equipment must be protected from overheating by complying with manufacturer's temperature specifications. Besides designing the control panel in such a way to help keep temperatures under control, considering ways to keep control panel equipment clean and free of contamination is equally important.

With proper planning and design, maximizing the space between components for proper thermal management is an easy and worthwhile task. Several ways to incorporate thermal management into panel design to meet these requirements are:

1. **Provide sufficient clearance** both above and below the components per manufacturer's recommended minimum distance. Maintaining a large enough space between components keeps them from transferring heat between one another via convection.

2. **Avoid stacking heat producing components** one above the other, and allow an unrestricted flow of air behind components whenever possible.

3. **Adequate air circulation** between components and throughout the interior of the enclosure must be ensured to keep hot spots from forming in any localized area. You may need to increase enclosure size to increase air space around each component and improve the overall cooling effect. If this is not possible or sufficient, a cooling solution must be added.

4. **Lay out electrical components to allow air flow** from the enclosure's bottom to the top. When employing filtered fans for cooling, the inlet should be located in the lower section of the control panel and the exhaust toward the top utilizing the natural upward flow of heated air.

5. **Keeping inlet and exhaust air vents far apart** is a must to allow adequate airflow along the entire control panel area. The cool air supplied by the inlet will help dissipate heat radiating from electrical components and expel the heated air out through the exhaust. By including this concept in the design right away, a filtered fan cooling system may allow for additional components to be added in the future without having to upgrade to a larger enclosure.

# How to Incorporate Thermal Management into Design *(Cont.)*

The external footprint of the enclosure also must be considered if an active cooling solution is needed. External footprint considerations should include:

**1**

**Allow enough room** in case cooling devices must be added at a later date, thus increasing the size of the control panel footprint. Planning ahead for additional space, if needed, is crucial.

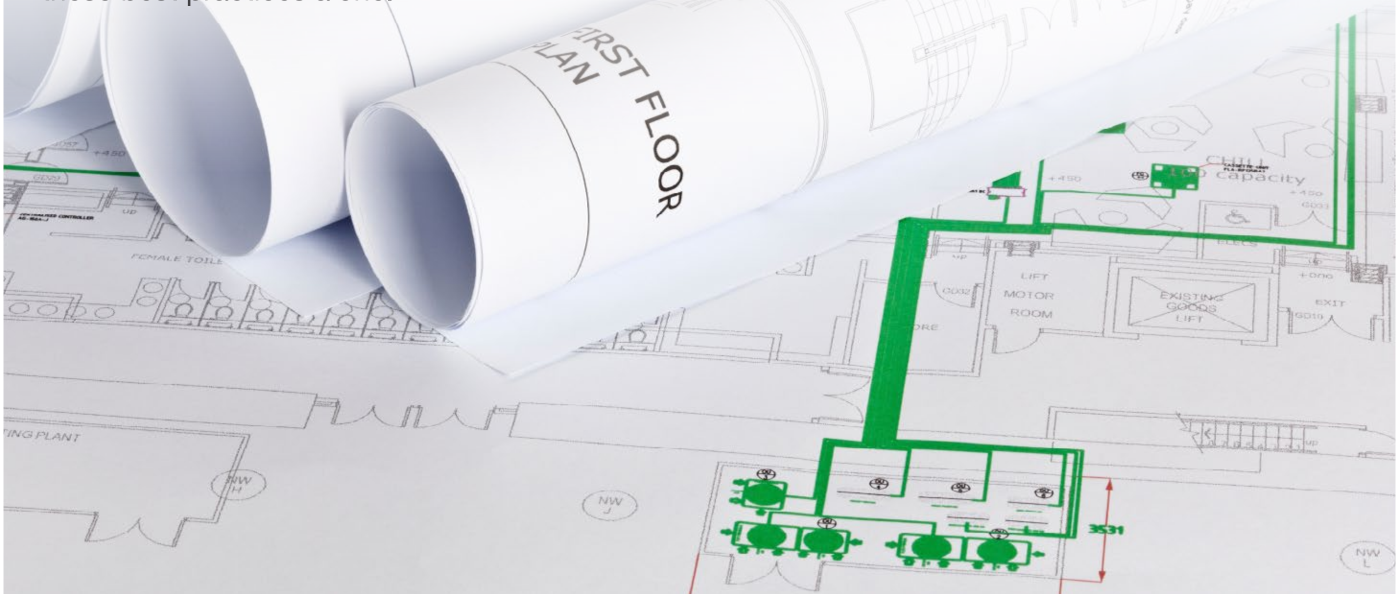
**2**

**Consider how the control panel will be mounted.** Whether the panel is mounted to the wall, floor, or even a pole can make a big difference in the design.

**3**

**Relocate the control panel.** An entirely different location that offers a more favorable ambient temperature environment for better heat dissipation can solve many problems with high temperature.

The ability to effectively use natural convection to cool components would be the perfect low-cost method for a control panel setup. These solutions will work in ideal situations in which space requirements are not a concern. They are good best practices even in a densely packed enclosure, but in a real-world situation, it is not always possible to sufficiently protect electrical equipment with these best practices alone.



# Ideal Control Panel Setup (Without Space Constraints)

Not long ago, setting up a control panel without space constraints and without active cooling was an easy and acceptable practice. Due to cost cutting, the positioning of control panels farther away from higher-temperature production areas is no longer common. More than ever, control panels are now exposed to higher temperatures and harsher environmental conditions, thus requiring the use of sealed enclosures that require active cooling.

More sophisticated electrical equipment producing higher heat loads inside enclosures are being used. The more modern drives (VFDs) and controllers (PLCs) have lower maximum operating temperatures than the older electromechanical devices. The regular use of these newer devices in temperatures ranging above their design limits not only reduces their lives, but malfunctions can also occur more often.

**Even without space constraints, modern control panels have higher heat loads that must be actively cooled.**

# Real-World Control Panel Setup Considerations

The ability to plan ahead and consider control panel cooling options during the design phase helps optimize the overall cooling system operation. However, in the real world, designers may find themselves in a bind because of project issues limiting their options.

Common project complications that impact thermal management may include:

1. **Incorrect ambient temperature and solar heat gain values:** The ambient temperature may be higher than expected due to the control panel's proximity to other heat-producing equipment, and because exposure to solar radiation may be greater than expected.
2. **Project changes:** As the plant design progresses, additional heat-producing components may be required to be installed on the control panel.
3. **Equipment changes:** Electrical components or specifications or may change to a larger size, thus increasing heat load.
4. **Unspecified environmental conditions:** Particular environmental conditions must be specified. The presence of dust, dirt, and corrosive chemicals can adversely affect electrical component cooling.
5. **Plant layout changes:** Last-minute changes to the plant layout may move the control panel to a different location where panel size may be restricted. The designer may require using a smaller enclosure.

These potential project issues can have a dramatic effect on thermal control management. Electrical equipment could overheat due to an increase in heat gain or because of the lower thermal capacity of a smaller enclosure.

Control panel designers may need to resort to other options when fitting more heat-generating equipment into a smaller space. When the spacing between components is already at a minimum and the hotter, more robust components must be placed at the top of the control panel, an active cooling solution may be needed.

## How to Ensure Safe and Efficient Operation in a Space-Limited Enclosure

Laying the groundwork early in the design phase is a crucial step to ensure safe and efficient operation in a space-limited enclosure. A correctly sized cooling unit for a small electrical enclosure is more than just an accessory: It is often the backbone of an entire operation. Trouble-free production is only possible if the components inside the enclosure are properly cooled.

## How to Cool a Small Space with Abundant Heat-Generating Equipment

Compact air conditioners are the perfect cooling solution when control panels are located alongside other equipment and access is difficult. These small-profile cooling units are powerful but lightweight, specially designed to be mounted on small and narrow side panels or even doors. Compact units are available to use with NEMA types 4, 4X, and 12 enclosures.

If conditions and space allow, products available to cool small enclosures are filtered fans, air-to-air heat exchangers, and standard size air conditioners.

# How to Determine the Right Kind of Temperature Control Solution for Your Design

Identifying environmental conditions where the control panel will be installed is the first and most important step. All factors impacting thermal management must be considered when determining the right kind of temperature control solution for your design.

Important factors to know that impact control panel cooling include:

- **The ambient temperature range and humidity levels**
- **Levels of dust and dirt**
- **Exposure to solar radiation**
- **Exposure to rain, snow, and wind**
- **Presence of corrosive chemicals and oils**
- **Environment requiring wash-down with high-pressure wash**
- **Amount of natural ventilation available**

Before considering any control panel layout design, a complete and accurate heat load calculation must be done by adding together the heat dissipation of all electrical equipment. The online Enclosure Temperature Management Calculator is the most effective method available to calculate the required cooling capacity to maintain safe operating temperatures for electrical components.

After the heat load has been calculated and the environmental conditions are known, it can be determined if the control panel can be naturally ventilated, can be ventilated by filtered fans, or will require a closed-loop cooling system. Additionally, construction materials, type of finish, and the required NEMA rating of the enclosure can also be determined. Each NEMA rating has a different specification designed to help protect electrical equipment, personnel, and property from damage.

# How to Determine the Right Kind of Temperature Control Solution for Your Design *(Cont.)*

## NEMA Type 1

NEMA Type 1 electrical enclosures provide the least amount of protection and are primarily used for indoor commercial applications. Because they are already operating in relatively protected environments without exposure to airborne contaminants or splashing liquids, filtered fans are typically used to cool these enclosures.

The filtered fans draw cool ambient temperature air into the enclosure from the bottom and push heated air out through the top. By continuously displacing the hot air, a safe control panel temperature is maintained.

## NEMA Type 3R

NEMA Type 3R electrical enclosures can be used indoors or outdoors as meter cabinets or utility box applications. These enclosures are designed to withstand rain, snow, and wind exposure. NEMA Type 3R enclosures are commonly cooled by shroud-equipped filtered fans.

## NEMA Type 4

NEMA Type 4 electrical enclosures are designed to withstand all types of weather and hose directed wash environments. To ensure the unit remains contaminant-free, a closed-loop cooling system must be used.

Depending on the ambient temperature, either air-to-air heat exchangers or air conditioners can be used for NEMA Type 4 enclosures.

- **Air-to-air heat exchangers** can be used to cool these enclosures if the ambient temperature isn't excessive. The heat inside the enclosure is transferred out to the ambient air via a thermally conductive, phase-changing liquid. With air-to-air heat exchangers, no air transfer exists between the enclosure and the environment, thus making them ideal for use in unclean locations.
- **Air conditioners** should be used to cool these enclosures if the ambient temperature is excessive, primarily due to high solar heat gain or surrounding equipment. Enclosure air conditioners are ideal for areas with more dust, particulates, and dispersed oil in the air.

## NEMA Type 4X

NEMA Type 4X is similar to the NEMA Type 4 enclosure specifications but provides additional protection against corrosion. NEMA type 4X enclosures are ideal for use in harsh environments such as marine, industrial food processing, oil and gas drilling, and refining.

## NEMA Type 12

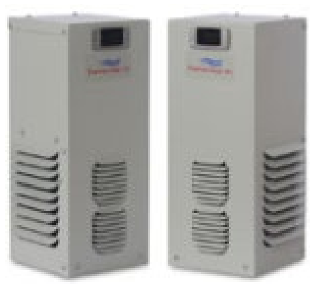
NEMA Type 12 enclosures are designed to be dust-tight for indoor use. Although they do provide protection against some splashing, they are not as watertight as NEMA Type 4 enclosures. NEMA Type 12 electrical enclosures require a

# Conclusion

Proper control panel cooling must start at the design phase in order to meet space requirements and avoid overheating. Temperature control is a crucial component in the design of control panels. Electrical components are designed to work within a specific temperature range, and the heat they dissipate while operating must be removed in order to avoid equipment failure. Leaving control panel cooling as an afterthought can lead to equipment damage, thus resulting in higher operating costs.

Using the Enclosure Temperature Management Calculator on the Thermal Edge website is a great place to begin with proper control panel design. Once the proposed location and environmental conditions are known, the required NEMA rating of the enclosure can also be determined, which leads to determining if the control panel can be naturally ventilated, can be cooled by filtered fans, or requires a closed-loop cooling system.

If you need help designing the ideal control panel for your application, talk to the professionals at Thermal Edge. Our experts will help guide you from start to finish of your design project to ensure your control panel, regardless of size requirement, will be properly cooled to provide safe, long-term, and reliable operation.



Find the right
**Thermal Management Solution**
for your Control Panel Design.

**Use the Enclosure Temperature Management Calculator Today ▸**