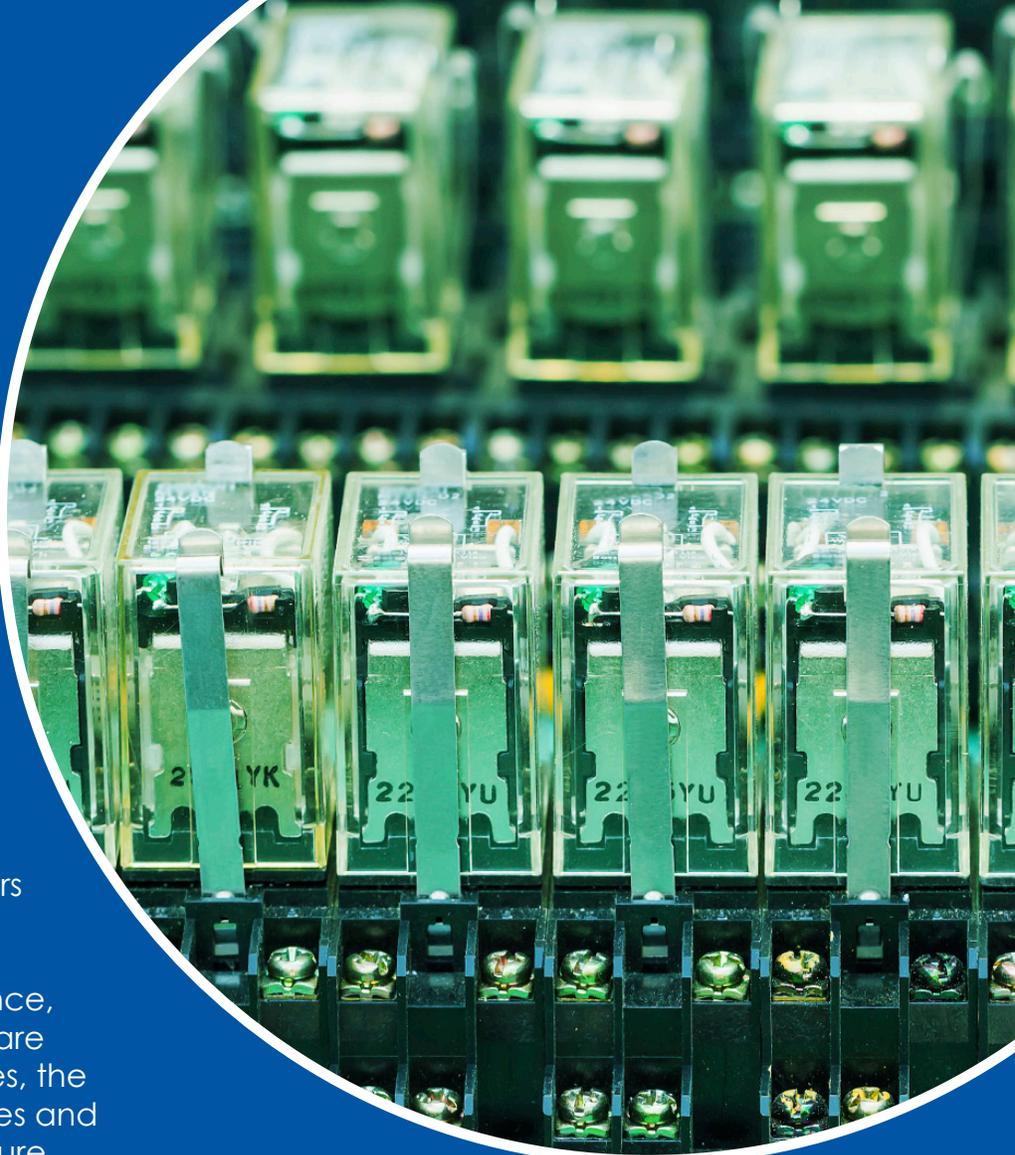




Thermal Edge Inc.™
TEMPERATURE CONTROL SOLUTIONS FOR ELECTRICAL ENCLOSURES

TEMPERATURE CONTROL FOR ELECTRICAL ENCLOSURES: WHY YOU CAN'T IGNORE IT



INTRODUCTION

Electrical equipment is almost always specified by manufacturers for operation within an optimal temperature range in which the equipment's reliability, performance, efficiency, and physical integrity are protected. At higher temperatures, the efficiency of equipment decreases and component damage or even failure may result. A modern VFD typically has an efficiency of 93-97 percent¹ and is designed for operation below 40 °C (104 °F)². For every degree increase above the operating temperature, efficiency is derated by 2 percent.

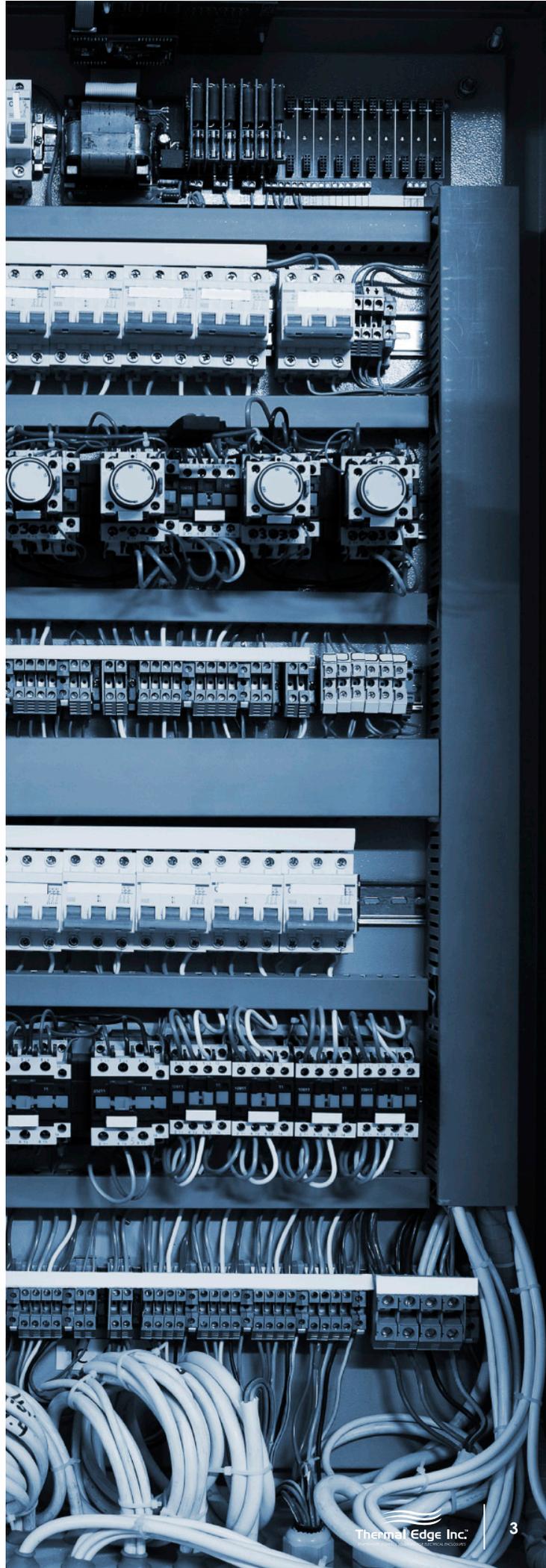
In addition to an increased risk of equipment failure, high operating temperature has resulted in long-term costs due to decreased reliability and lifespan. For a business, this could mean unexpected costs associated with frequent maintenance, component failure, additional downtime for spare parts, and, in some cases, replacement of the entire system. Fortunately, this added cost, which can range from tens of thousands to hundreds of thousands of dollars, can be avoided with a little foresight by including a temperature control system in specifications.

TEMPERATURE RELATED CAUSES OF ELECTRICAL EQUIPMENT DAMAGE

The lifetime and failure-free operation time of electrical equipment is strongly dictated by environmental conditions and the mode of operation. Each component or type of electrical equipment has its own maximum operating temperature as specified by the manufacturer. For instance, variable speed drives, contactors, and power supplies can operate between 40 °C (104 °F) and 50 °C (122 °F); electrical batteries, have a lower temperature threshold of 30 °C (86 °F)³.

High operating temperature can increase the potential dangers to equipment operation. Some of the common risks associated with high internal heat are:

- **Unexpected Equipment Shutdown** – Some manufacturers program equipment components to toggle off at high temperatures.
- **Deteriorated Equipment Performance** – High temperature can cause erratic equipment performance, often leading to undesirable results. VFDs are derated for operation at temperatures above their normal range. The accepted standard has been derating drive efficiency by 1% for every degree above 40 °C.
- **Equipment Damage** – Equipment operating at beyond its manufacturer-specified operating temperatures can become damaged, often requiring repair or even replacement. PLCs and electrical loop controllers do not have high temperature tolerance.
- **Shortened Equipment Life** – Constant exposure to high temperature intensifies aging of equipment. Components work harder at high temperature and, thus, experience more wear-and-tear, resulting in shortened equipment lifetime.



- **Fire Hazard** – Rare but not uncommon, excessive heat inside an enclosure could result in melting of equipment parts and even fire.

Most manufacturers emphasize the effect of temperature on their equipment by including a performance-derating factor for high-temperature operation. Therefore, identifying the most critical component and controlling the temperature to match the component's operating temperature range is important.

Low-temperature environments have a different effect on electrical equipment. The two main areas of concern for equipment operating at low temperature are safety and function. The common risks associated with low temperature are:

- **Equipment Startup Issues** – Starting motors and variable frequency drives at low temperatures is difficult because oil and grease lose their lubricating properties.
- **Material Properties** – Low temperatures have a dramatic effect on material properties—particularly plastics and elastomers used in the construction of electrical equipment—thus making them unsafe and unsuitable for use.
- **Arcing Due to Condensation** – Water vapor in the air condenses at low temperature. Insulators lose their properties at low temperature. The combined effect of conductors in contact can cause arcing issues and increase the risk of fire.
- **Ice Formation** – Formation of ice on the equipment casing increases the risk of short circuiting and breakdown of electrical circuitry.

HUMIDITY: A CONSEQUENCE OF FLUCTUATING TEMPERATURES

Manufacturers typically specify a relative humidity of $60\% \pm 30\%$ at a temperature of $30\text{ }^{\circ}\text{C}$ ($86\text{ }^{\circ}\text{F}$) to $40\text{ }^{\circ}\text{C}$ ($104\text{ }^{\circ}\text{F}$) without the presence of condensation for normal operation of electrical equipment⁴. Though outdoor equipment is more threatened by humidity and condensation, indoor equipment in highly humid locations is also susceptible to failure without a proper condensate management system. Humidity in the enclosure can be detrimental to electrical equipment in the following ways:

- **Corrosion**– Water in contact with unprotected metallic surfaces of electrical equipment causes corrosion. Corroded joints in sensitive equipment may be irreparable, thus requiring replacement and ramping up costs.
- **Electro-Migration** – The presence of an electric field and moisture can cause electro-migration that can be seen as the formation of pits and dendrites on metal surfaces in contact with an insulator.
- **Moisture Absorption** – Polymers used in electrical equipment for insulation purposes lose their properties when they absorb moisture in the air. This can expose the equipment to a variety of problems.

- **Short-Circuiting**–

Moisture in the air (usually mixed with particulate matter) is a good conductor of electricity. When water droplets come in contact with electrical circuits, they can cause short-circuiting or total breakdown of the circuit components.

- **Premature Aging** –

Humidity increases aging of equipment by increasing the rate of wear-and-tear of components.

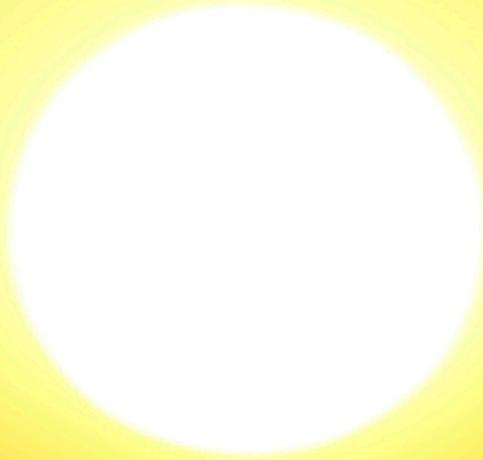


WHERE IS ENCLOSURE HEAT AND HUMIDITY GENERATED?

Temperature control is critical in protecting electrical equipment, but what factors contribute to heat and humidity and should be accounted for in specifications?

HEAT LOAD FROM THE ELECTRICAL EQUIPMENT

The primary source of heat comes from the electrical equipment itself within the enclosure. How does your electrical equipment generate heat? As you know, the second law of thermodynamics puts a limit on the amount of useful work that can be derived from a machine; it follows that no system can operate at 100 percent efficiency. Thus, the remaining energy is used to overcome friction or released into the environment as lost heat. This lost energy increases the temperature of the enclosure air and the temperature of the components of your equipment, thus creating a vicious cycle of heat generation. For instance, a 10 kW variable frequency drive dissipates over 300 W (1025 BTU/hr) of heat within an enclosure. Assuming a medium-sized enclosure has the dimensions of 48"×36"×16", there is a temperature increase of 30 °F within the enclosure⁵.



HEAT TRANSFER FROM THE ENVIRONMENT

The secondary source of heat load in an enclosure comes from the environment. The common sources of external heat are:

- **Heat Transfer Due to Ambient Temperature**

When the external ambient air is hotter than the equipment's operating temperature, heat transfer will cause an increase in the enclosure's internal air temperature. The rate of heat flow depends on the magnitude of the temperature difference and the enclosure's material and medium of insulation lining. To put this in perspective, a temperature difference of 15 °F between the enclosure air and ambient air can contribute to 5.1 BTU/H for every square foot of surface area of your enclosure. Assuming a medium-sized enclosure, this translates to almost 220 BTU/H of additional heat that must be dissipated to the external air.

- **Solar Heat Gain**

The incident radiation from the sun can cause a dramatic increase in internal temperature of an outdoor enclosure. The extent to which solar heat gain can increase enclosure temperature depends on factors such as the location of the enclosure, insulation coating on the enclosure, color and texture of the enclosure outer body, ambient temperature and humidity, air composition in the location, altitude, and wind parameters. Assuming there is no internal heat from equipment, to maintain a medium-sized black outdoor enclosure at ambient temperature, 1308 BTU/hr of heat would need to be eliminated. With a gray outer body, you would have to dissipate only 838 BTU/hr.

- **Equipment Located in the Vicinity of the Enclosure**

Indoor and outdoor enclosures are commonly located alongside other equipment. The thermal footprint of industrial equipment such as blast furnaces, industrial ovens, and foundry equipment in the vicinity of the enclosure can increase its internal temperature.

WHY NATURAL CONVECTION CAN'T PERFORM A JOB NEEDING ACTIVE COOLING

A general misconception is assuming the heat dissipated by the equipment is not significant enough to warrant the installation of an active temperature control system. More often than not, engineers eliminate heat by increasing the size of the enclosure and/or adding a ventilation system that makes use of natural convection. Surprisingly enough, although this is the lower-cost option, it is an insufficient method for many applications as equipment evolves to require active temperature control.

There are several impediments to using natural convection as a solution to enclosure temperature control, including:

HOT SPOTS

Heat inside an enclosure rises to the roof. Without a ventilation system that accounts for this, there will be a temperature differential between regions inside the enclosure. This phenomenon can result in thermal hot spots that can spiral into a cascading temperature increase in these regions. Hot spots are undesirable because they could lead to temperature related equipment failure.

ABSENCE OF EARLY WARNING

The absence of an active cooling system makes it impossible to cool the enclosure to below ambient temperatures. This can result in poor equipment performance and even failure if the ambient temperature is higher than the specified operating temperature of the equipment. Further, high heat inside enclosures cannot be recognized immediately because natural convection does not use metrological equipment or digital controllers to send out high-temperature alarms.

ENVIRONMENTAL LIMITATIONS

Natural convection relies too much on wind patterns, indoors and outdoors. Consequently, any change in wind pattern can result in insufficient cooling of the enclosure. The reliance on air for natural convection extends to air composition as well. Enclosures located in harsh environments such as petrochemical plants or coal mines cannot depend on natural convection for efficient cooling because it can result in contamination of the enclosure. The use of filters with natural convection is limited because there is no fan to actively move air through the enclosure. There is an inherent pressure drop in the flow that is associated with all filters: the finer the filter, the greater the pressure drop. For natural flow, any impedance to results in a reduction of air flow; therefore, the choice of filters is limited to coarser filters.

Lastly, some applications require sealed enclosures, in which case a closed loop cooling system is mandatory. Natural convection requires larger enclosures and an effective ventilation system that allows cool, clean and dry air for heat dissipation. Space constraints and extreme ambient conditions may prove unfavorable for natural convection to cool the enclosure.

WHAT A TEMPERATURE CONTROL SYSTEM CAN DO FOR YOU

Temperature control solutions range from simple filtered fans to heat exchangers and air conditioners. The choice of a solution depends on the application itself. Depending on the sophistication of the solution and application requirements, the costs vary. For instance, a filtered fan is suitable for use in applications requiring low to moderate heat dissipation, located in a cool, clean and dry air environment. For extreme conditions and hazardous locations such as coal mines and petrochemical plants, an air-to-air heat exchanger or an air conditioner that has been designed for operation in such conditions would be required.

No matter the application, an efficient temperature control system improves reliability and lifespan of the enclosure system by:

- Controlling the temperature within the enclosure to meet the operating temperature requirements of the most critical component
- Minimizing pollutants, dispersed oil, and moisture from the air inside the enclosure
- With some manufacturers, reducing humidity and handling the condensate in an efficient manner that does not require water drains or energy consumption
- Enabling you to monitor and control the enclosure temperature and air conditioner performance remotely
- Efficiently protecting equipment from possibly hazardous ambient conditions
- Reducing utility costs associated with low-efficiency performance of equipment at high temperatures
- Minimizing maintenance costs and the need for repair and replacement of components
- Eliminating costs of failed equipment that result in downtime

ABOUT THERMAL EDGE

Thermal Edge manufactures cutting-edge temperature control solutions to handle electrical enclosure cooling requirements. Our temperature control products include filtered fans, air-to-air heat exchangers, air conditioners, and custom enclosure system packages.

We at Thermal Edge provide comprehensive, highly efficient air conditioners with a fully integrated energy saving condensate management system. Our innovative designs are packaged with a thermal expansion valve that enables our air conditioners to operate over a broad temperature range and adapt to fluctuating heat loads at a higher efficiency.





Thermal Edge Inc.TM

TEMPERATURE CONTROL SOLUTIONS FOR ELECTRICAL ENCLOSURES

If you need help selecting the right temperature control solution for your application, talk to the professionals at Thermal Edge. Our experts will work with you from beginning to end to ensure that you have the most cost-effective solution for your application. We also work with engineers who design electrical enclosures to help determine the right temperature control solution early in the design process.

Get in touch with us today to review case studies that are similar to your application, review product literature, or schedule a consultation.



Get a Quote for an Enclosure Cooling System

[Get a Quote >](#)

REFERENCES

1 Wilson, Doug. "Determining the Panel Heat Load." Plant Services. N.p., 2010. Web.

2 "Installation Manual." Franklin Control Systems (n.d.): n. pag. Print.

3 "Control Panel Technical Guide." Schneider Electric (n.d.): n. pag. Web. <http://www2.schneider-electric.com/documents/interactive-publications/thermal-management-solution/control_panel_technical_guide/files/docs/all.pdf>.

4 "Condensation in Electrical Enclosures." Schneider Electric Blog. N.p., 28 Oct. 2013. Web. 01 May 2015.

5 Adjustable Speed Drive Part-Load Efficiency. Washington, D.C.: United States. Dept. of Energy, 2008. Web.