WHITEPAPER

COOLING GUIDE FOR HOSTILE ENVIRONMENTS

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Introduction

Electrical enclosures house heat-producing power and control components, such as programmable logic controllers, computers, microprocessors, variable frequency drives, and power conversion and storage devices. These enclosures provide protection from hostile environments that may contain vapors, rain, dust, and particulate matter in the surrounding air. However, the components often generate damaging high temperatures within the enclosure, and, if not properly dissipated, may cause premature failure or process shutdown. Specialized cooling equipment designed to withstand the harshest ambient conditions must be incorporated into these applications to prevent this from happening.

Heat generated by wastewater treatment processes and corrosive fumes created by oil refineries are examples of hostile environmental conditions which may adversely affect the performance of the sensitive components or controls inside an electrical enclosure. The presence of hazardous airborne particulates compound the difficulty of controlling the temperature of the electronics being housed, while also highlighting the importance of selecting an enclosure cooling system that can withstand such a severe environment.

Efficient, trouble-free cooling and environmental protection of sensitive equipment can be assured if the cooling system is designed at the outset to operate under the most adverse anticipated conditions. This is also more cost-effective than having to add proper cooling devices on a retrofit basis.

Basic Cooling Techniques

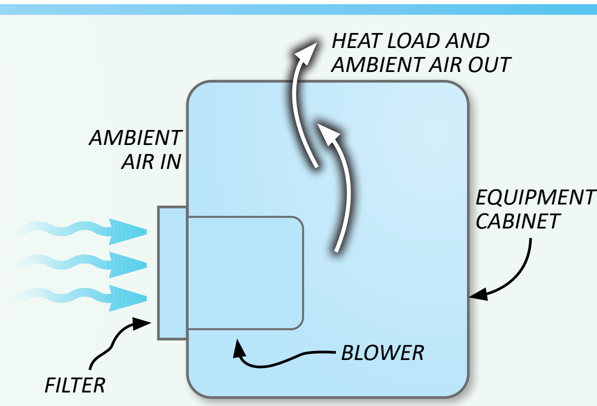
There are several types of enclosure cooling options that can be utilized depending on the application. These most popular systems include:

1. Forced-Air Cooling	**3.** Water-to-Air Heat Exchangers
2. Air-to-Air Heat Exchangers	**4.** Special-Purpose Air Conditioners

1. Forced-Air Cooling

If the installation will be in a clean, non-hazardous atmosphere with an acceptable ambient temperature range, a simple forced-air cooling system (Fig. 1) utilizing standard blowers or fans (and possibly a low-cost air filter) will adequately meet the need for heat removal of typical electronic equipment.

Figure 1*- The forced convection technique uses ambient air to cool electronic equipment. Incoming air can be filtered before being blown throughout the enclosure.*

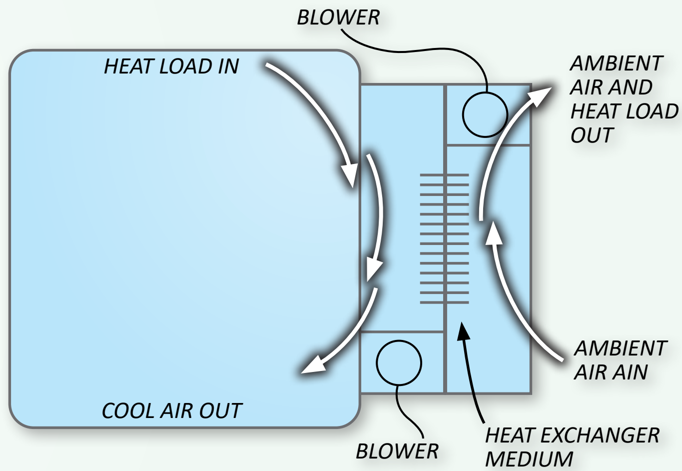


2. Air-to-Air Heat Exchangers

In the past, air-to-air heat exchangers were typically limited to applications where the peak ambient air temperature was below the maximum permitted in the electrical enclosure. As higher anticipated ambient temperatures were encountered, the size of the heat exchangers that were required to ensure adequate heat removal continued to grow. At a certain point, heat exchangers for some applications became impractical because of the size of the equipment needed to meet the cooling requirements.

Over the years, heat exchanger design (Fig. 2) has greatly improved to allow for cooling capacities in small, compact units, giving the designer an economical answer to many cooling problems that previously could only be met using special-purpose air conditioners.

__Figure 2__- In an air-to-air heat exchanger system, heat from air surrounding the controls is removed via specially designed heat tubes and fins, before being routed back into the enclosure.



To accomplish this, Kooltronic developed an innovative design where the ratio of the heat-transfer surface area to total volume of the heat exchanger was substantially higher than previously available. Such a high ratio is made possible through the use of heat tubes as an essentially loss-free means of transporting heat between the many individual fin surfaces where air is the ultimate heat sink. The heat tubes, mounted vertically between the ambient air path and the enclosure to be cooled, contain a heat transport fluid. The warmer air exhausted from the cabinet to the heat exchanger is directed past the tubes, causing the heat transport fluid to boil. The resultant vapor rises to the upper portion of the tubes, where it is condensed, and heat is transferred to the ambient air flowing past the tubes in a continuous process.

3. Water-to-Air Heat Exchangers

If ambient air cannot be utilized directly, water-to-air heat exchangers (Fig. 3) are an efficient cooling method that uses a water supply to remove heat from the closed-cycle cooling air circulated within the

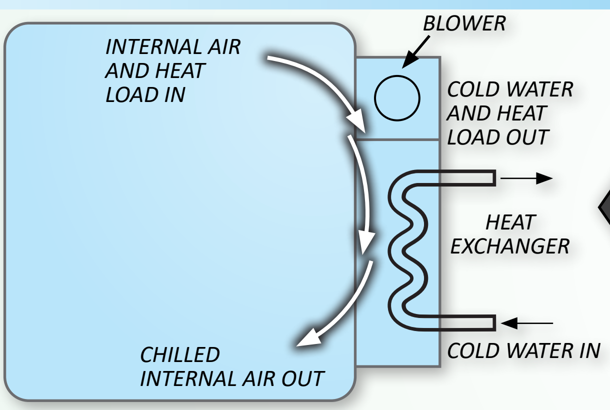
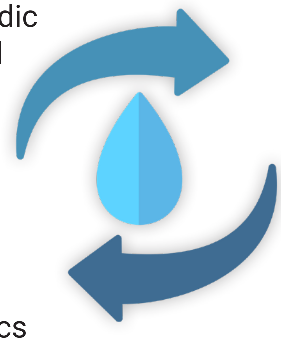


__Figure 3__- A water-to-air heat exchanger uses a steady supply of water to dissipate heat within an electrical enclosure by circulating water through a finned-tube coil. As heated air from the enclosure passes through the coil, the water absorbs the heat and carries it away. This continuous process results in cooler air which is then forced back into the enclosure and through heat-producing components.



enclosure. Water-to-air systems are easy to install and typically only require periodic maintenance. The requirements for the water used are that it be reasonably clean and have a temperature low enough to ensure proper operation of the cooling system under the most severe anticipated conditions.

In a water-to-air heat exchanger, the coil transfers heat between the water and air and provides a cooling air path which is augmented by natural convection; this also protects the electronics from possible water leakage from the coil. Cooling air is best introduced at the lowest point in the enclosure and returned to the cooling package from as high in the electrical enclosure as possible. Thus, air flow within the electronics proceeds from bottom to top, and it capitalizes on the buoyancy forces of natural convection and the momentum of the blower-induced air circulation.

Since electronic equipment or electrical cabinets may not be hermetically sealed, or must occasionally be opened for maintenance, many water-cooled heat exchanger packages (as well as other closed-loop cooling systems) incorporate an internal air filter to help protect against any impurity that may have entered the enclosure.

4. Special-Purpose Air Conditioners

Air conditioners used for cooling equipment housing sensitive electronics differ radically from familiar room or comfort cooling air conditioners. While the air conditioning system in a home or office building may only operate for a few months out of the year, enclosure air conditioners (Fig. 4) may be tasked with operating every day, and, therefore, are constructed with long-lasting electrical components, high quality motors, and an outer cabinet that can resist corrosion and withstand severe environmental conditions. Depending on the application, these specialized air conditioners may be subject to rain, washdown, corrosive environments, and periods of motion or vibration. Additionally, these air conditioning units will operate at as low as -20°F ambient.

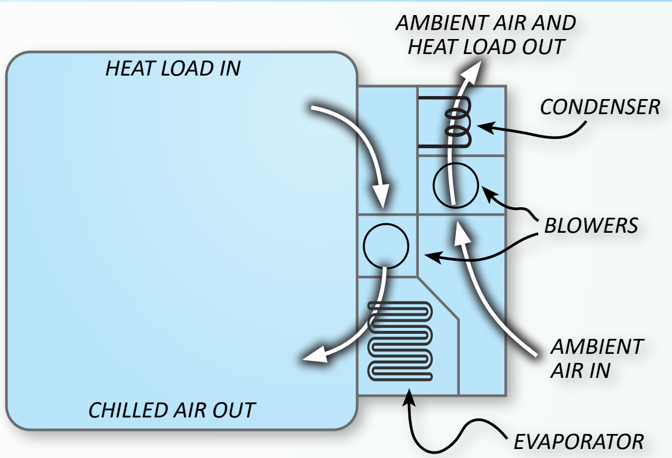


***Figure 4**- In an enclosure air conditioner, components such as a compressor, condenser coil, evaporator coil and two blowers combine to cool air circulating in the cabinet.*

When harsh environments are involved, conditions are such that both the ambient air contamination level and temperature are unsatisfactory, and usable cooling water is not available or desirable, specially packaged closed-loop air conditioners must be used to properly protect the electronics. A closed-loop cooling system maintains the optimal temperature within a sealed enclosure while keeping out warmer ambient air, humidity, dust, and other airborne contaminants. In a typical enclosure air conditioner, heat is transferred from the components by circulating air around and through them. The air is then cooled, dehumidified, and returned to the enclosure without the admission of air from outside the enclosure. By circulating cool, clean air within an electrical enclosure (and through heat-producing elements), closed-loop cooling systems help to protect sensitive electronic components and prolong their lifespan despite the challenges the outside environment may create.

Blog Post: What Makes an Enclosure Air Conditioner Unique?

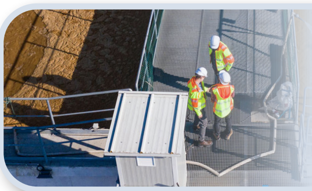
Enclosure air conditioners typically carry agency markings such as UL (Underwriters Laboratories), which tests and certifies products for safety. The NEMA (National Electrical Manufacturers Association) rating signifies the air conditioner's ability to withstand certain environmental conditions and should be matched to the enclosure or cabinet being cooled.

Corrosive Atmospheres

Corrosive environments, such as those found in acid plants and the chemical processing industry, usually preclude the use of forced convection cooling, as these corrosives or airborne contaminants generally cannot be easily filtered out when deploying this method of cooling.

If the corrosive atmosphere is normally within an acceptable temperature range, heat exchangers can be an option to provide cooling for electrical enclosures. However, when both high temperature and corrosives are present, and when cooling water is not available, air conditioners must be utilized to cool the heat-producing components.

Whichever method is used to cool systems installed in corrosive atmospheres, the cooling equipment must be fabricated of appropriate corrosion-resistant materials or employ suitable surface treatments to ensure trouble-free operation over a long period of time. The types of materials used in the cooling system components will depend on the particular corrosives encountered, severity of contamination, and heat ranges involved.



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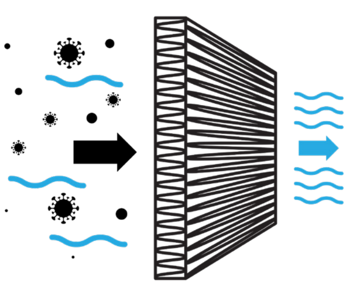
Filtration of Cooling Air



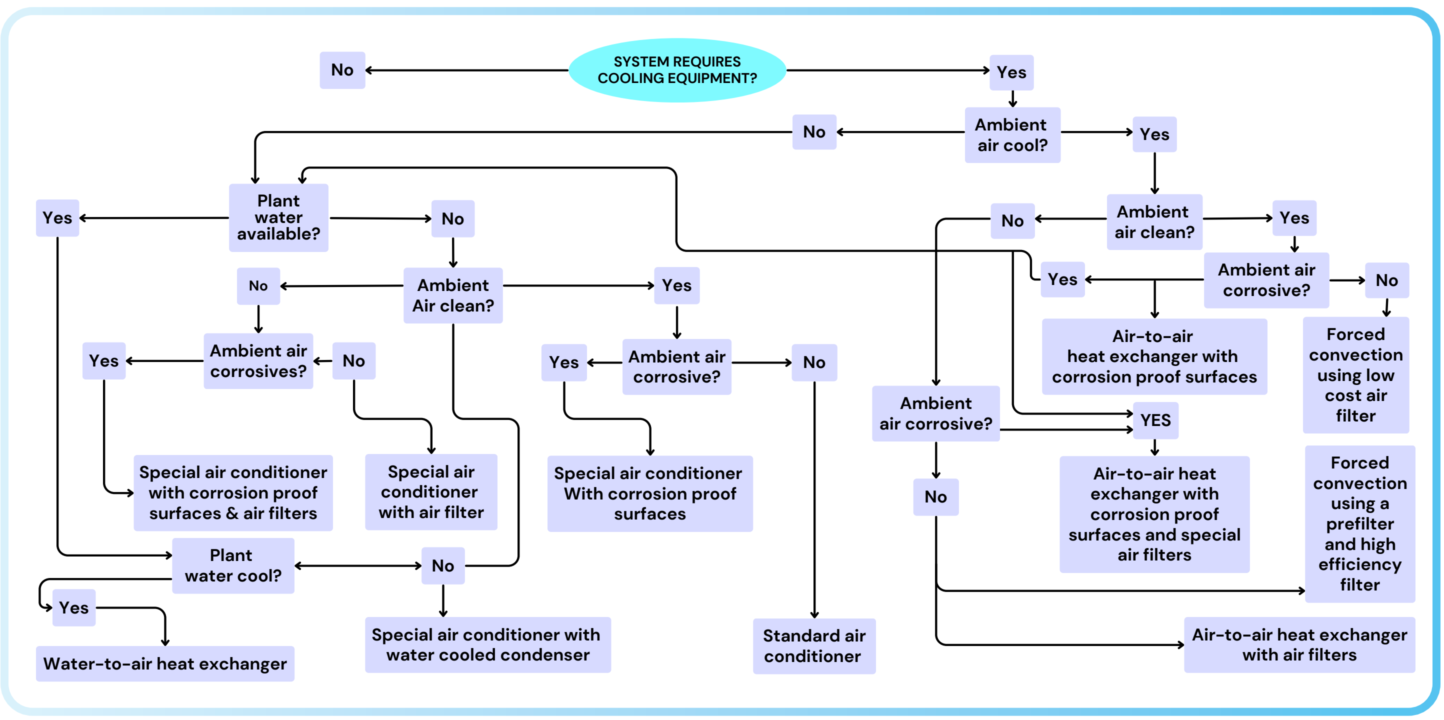
Generally, contamination can be broken down into two major categories: airborne particulate matter and corrosives. In many cases, particulate matter can be filtered out and the air made safe for cooling electronic equipment. Filtering of air for forced convection cooling requires careful consideration of the airborne pollutants that will be encountered in the installation as these cooling devices draw ambient air to cool electronic devices or equipment. If the application consists of corrosives or a more hazardous environment, closed-loop cooling units, such as air conditioners, would be required as these units create a tight seal with the enclosure and the heat is removed from the equipment being cooled without introducing ambient air into the enclosure. Filters are still required to protect against other general contaminants, such as dust and dirt, that may be in the air, and usually consist of a multi-layer grid of sturdy corrugated aluminum, securely held in a one-piece aluminum frame.

Once a cooling unit is installed, the system must be rigorously maintained; filters must be monitored and cleaned or replaced according to a regularly scheduled preventive maintenance program. If this is done, it will increase the operational efficiency of the cooling unit and decrease the required draw, therefore, making the unit more energy efficient, decreasing the time it takes to reach the desired temperature within the enclosure, and extending component lifespan. Since environmental conditions vary depending on the application, the frequency of replacing filters is not the same for all equipment. As a general principle, regular filter maintenance is suggested every six months. Filter maintenance may be required more or less frequently depending on the conditions unique to the application's location and operating environment. For example, enclosure cooling units operating in locations with a lot of dust, soot, dirt, or other airborne contaminants should have their filter replaced at a minimum frequency of 1-3 months. However, enclosure cooling units operating in clean, particulate-free locations can generally go longer without filter changes but should not exceed six months without at least a visual inspection.

Summary

Keeping your electrical components cool in a harsh environment can pose challenges, but selecting the appropriate solution and properly maintaining the system can improve efficiency and prolong the life of the components. Let the cooling experts at Kooltronic help you find the solution that is right for you.

Electronic Designer's Guide to Cooling Systems Selection



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