ADVANCED COOLING TECHNOLOGIES

The Thermal Management Experts | www.1-ACT.com

SEALED ENCLOSURE COOLERS: EFFECTIVE THERMAL SOLUTIONS FOR HARSH ENVIRONMENTS

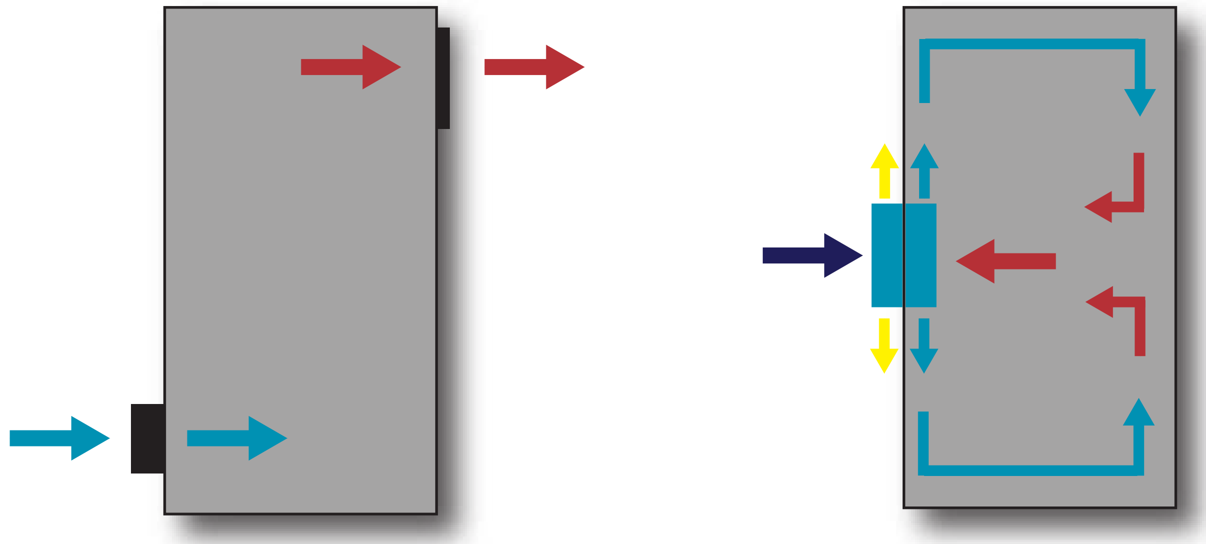
All electronics dissipate waste heat. In typical high-power electronics cabinets this waste heat can become significant, in the range of 100's to 1,000's of Watts. At these levels dissipating the waste heat becomes a critical design issue. Most cabinets that operate in controlled indoor environments use fan filter systems, which duct ambient air through the cabinet, because they are the most effective and efficient way of dissipating the waste heat load. This is also feasible for some outdoor applications assuming rain guards and filters are used.

However, in many applications such as dirty / dusty environments, hose down / wash down facilities in the food industry, harsh outdoor applications, and many others it is not possible or advisable to allow ambient air to flow through and cool the sensitive and expensive components inside your enclosure. The best way to protect electronics is to use a sealed cabinet that does not allow any contaminated ambient air, even filtered air, from entering the cabinet. This is where sealed air-to-air heat exchangers, or sealed enclosure coolers, become an invaluable part of the overall system.

SEALED AIR-TO-AIR HEAT EXCHANGERS

As shown in Figure 1, sealed air-to-air heat exchangers efficiently remove heat from sealed electronics enclosures by simply transferring heat from a heat sink inside the cabinet through a sealed wall to a heat sink outside of the cabinet. This is different than fan filter systems which cool the cabinet by drawing external ambient air directly through the cabinet.

In the simplest sealed heat exchanger systems heat is transferred by straight conduction. An alternate version relies on heat pipes instead of conduction to transfer the heat from the inside to the outside of the cabinet. Examples of both of these types of heat exchanger are shown in Figure 2.



Enclosure with Fan Filter System

Enclosure with Sealed Enclosure Cooler

Figure 1: Flow Through, Fan Filter System and Sealed Enclosure Cooler Air Flow Diagrams

Both of these types, as well as other true heat exchangers are called “above ambient” solutions. Meaning the inside cabinet temperature must be hotter than the ambient air in order to work. Many ask, “why do I need a heat exchanger if my cabinet is hotter than the outside air, why can’t I just transfer heat from the cabinet walls?” Heat will be transferred through the walls but the amount of heat that can be transferred is dependent upon the surface area, which can be a limiting factor. An air-to-air heat exchanger adds a lot of available surface for heat transfer in a very compact assembly. The following example demonstrates this.

Figure 2: Heat Sink Cooler Heat Exchanger (left) and Heat PIpe Cooler Heat Exchanger (right)

AN EXAMPLE OF BENEFITS FOR SEALED AIR-TO-AIR HEAT EXCHANGERS IN CABINET THERMAL MANAGEMENT

The cabinet shown in Figure 3 has a variable frequency drive and controllers that dissipate 1,000 Watts of waste heat. Assuming the front and 2 sides are available for heat transfer, the cabinet has 1.4 m^2 of surface area. The equation for calculating the amount of heat dissipated from the cabinet is:

EQUATION 1

Q= h*A*Dt

Where:

Q = Power in Watts

h = effective heat transfer coefficient ($W/m^2 °C$)

A = Surface Area (m^2)

Dt = Temperature Difference (°C) = TCabinet – TAmbient

For cabinet cooling applications with relatively small inside to outside gradients two assumptions greatly simplify the calculation and provide fairly accurate results. First, we assume there is a good internal circulation fan on the inside of the cabinet which is a requirement for any electronics with moderate heat dissipation. This will provide a high heat transfer coefficient on the inside of the cabinet, and thus this can be neglected in our simplified calculation. Second for modest temperature gradients radiation can be accounted for by a linear relationship instead of the temperature gradient to the fourth power. This greatly simplifies the calculation and allows us to account for radiation in the simplified form as shown in Equation 1.

That said, a reasonable effective heat transfer coefficient for natural convection and radiation of the outer surface of cabinets is about 6 W/m2°C. So, solving for the temperature gradient in the example:

TEMPERATURE GRADIENT
Dt = Q/(h*A)
Dt = 1,000W/(6 W/m2°C * 1.4 m2)
Dt = 119°C

Assuming a maximum ambient temperature of 50°C results in an internal ambient air temperature of 169°C. This is far too hot for most electronics. Adding a simple small conduction cooled Heat Exchanger with a conductance of 50 W/°C in parallel with the cabinet from the example which has an added conductance of 8.4 W/m^2. Results in a temperature gradient of:

TEMPERATURE GRADIENT
Dt = Q / (C1 +C2)
Dt = 1,000W / (50+8.4)
DT = 17°C

Resulting in an internal cabinet air temperature of 6°C which is much more acceptable for most electronics.

SUMMARY

As shown in the example, the thermal benefits of above ambient cabinet coolers are significant. Proper thermal management of electrical enclosures is critically important to assuring long term reliability of the components housed in the enclosure. The equipment and installation cost of these simple heat exchangers is minimal, and they maintain the NEMA rating of the cabinet. Sealed cabinets eliminate maintenance associated with filters, and prevent dust, dirt, water and corrosive atmospheres from entering the enclosure which significantly extend the life of the electronics. Cabinet mounted air-to-air heat exchangers are a simple and cost-effective solution for sealed cabinet applications. There are a variety of products and helpful online tools for calculating thermal loads and selecting the appropriate sized heat exchangers.

ADVANCED COOLING TECHNOLOGIES

The Thermal Management Experts | www.1-ACT.com

Advanced Cooling Technologies, Inc. | 1046 New Holland Avenue, Lancaster, PA 17601, USA

Phone: 717.295.6061 | Fax: 717.295.6064 | ISO 9001 & AS9100 Certified | ITAR Registered