Achieving Optimal Performance from Thermal Management Products

Design engineers face many challenges with the layout of electrical and electronics cabinets, and a frequent question addresses the location of thermal management products. The goal is to position the equipment so as to provide adequate protection from temperature extremes as well as preventing the formation of condensation.

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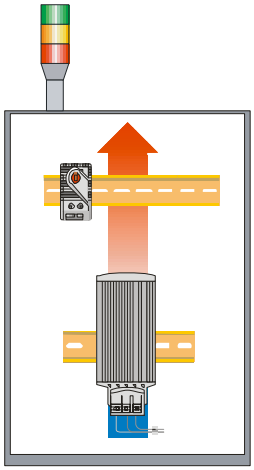
Heating and cooling devices in enclosures are designed to protect electrical and electronic components from low and high temperatures, as well as moisture. However, even with the appropriate equipment and controls, problems may arise due to incorrect positioning within the cabinet.

Heating

As the requirement of heaters for the prevention of condensation formation becomes more widely acknowledged, engineers and design teams must consider the equipment placement in an enclosure along with the devices they are intended to protect. It is not uncommon to find systems added after the fact, fitted into whatever space remained. While this may be the only solution available, it could potentially be the cause of other problems such as creating “hot spots” or “heat nests” near temperature sensitive electronics.

Ideally, most heaters will perform optimally when mounted near the bottom of an enclosure and used in conjunction with a separate controller such as a thermostat and/or hygrostat. With the controller located in an area of the cabinet that is representative of the average temperature or humidity requirement, the heater should then be placed in a position near the bottom but not directly beneath the controller (see Ill. 1). This placement will ensure that the controller is not influenced by direct heat from the heater.



Ill. 1

For smaller areas such as shown in Ill. 1, convection heaters will generally provide adequate heating power to maintain temperature and humidity control. For example, a 36”x 24”x 24” free-standing, insulated stainless steel enclosure with a desired interior temperature of 45°F with an ambient temperature of 25°F will require a 100W heater:

Power (W) = (enclosure surf. area) x (delta T) x (heat transmission coefficient)

= (28.8 sq. ft) x (11.1 K) x (0.325 W/sq.ft K)

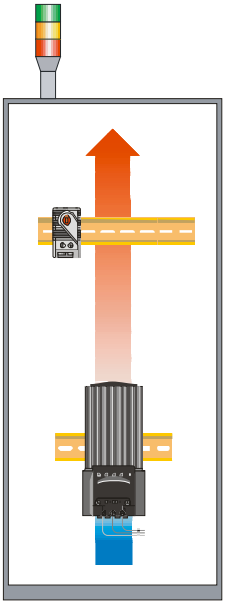
= 104W

In the case of Ill. 2 shown below, with all other parameters remaining the same, the height has been increased to 72” thereby increasing both the air volume and the surface area. Accordingly, the required heating power has also increased:

Power (W) = (encl. surf. area) x (delta T) x (heat transmission coefficient)

= (50.4 sq. ft) x (11.1 K) x (0.325 W/sq.ft K)

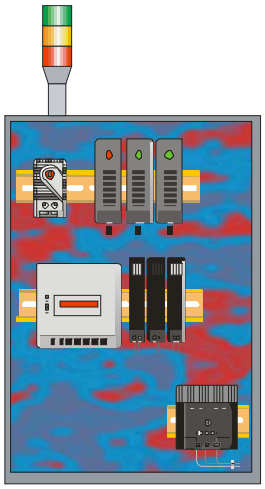
= 182W



Ill. 2

For larger cabinets with greater heating power requirements, convection heaters are not a practical solution. As Ill. 2 shows, the most effective heat distribution is accomplished by a fan heater with greater air circulation to ensure rapid and efficient control of the temperature and/or humidity.

However, as mentioned previously, space for a tall heater is not always available. Packing densities have increased as more equipment is designed into smaller spaces. In the case of the enclosure shown in Ill. 1, only 100W of heating power is required, but as shown below in Ill. 3, the high packing density limits the available space for a convection heater.



Ill. 3

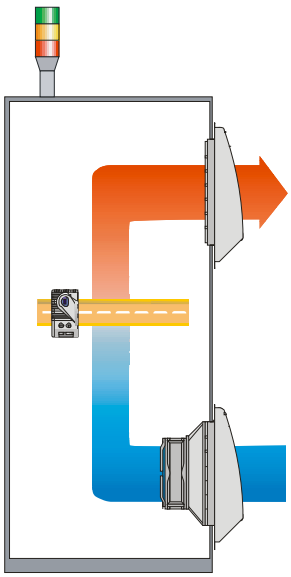
The alternative is a compact fan heater positioned to provide adequate heat distribution throughout the cabinet. The position of the controller can vary depending on the air flow and temperature gradient, providing that it is not impacted by direct heat.

In any circumstance where a heater is required, the location of all other equipment relative to a heater should be carefully considered. Most heater manufacturers recommend a minimum distance of 2” (50 mm) from components inside an enclosure. However, the temperature sensitivity of each component should be assessed along with the heater temperature profile to ensure no damage will occur.

Cooling

Enclosure cooling solutions range from louver plates to heat exchangers and high performance air conditioning systems. In all cases, the intent is to remove excess heat from the cabinet interior. Whether naturally or mechanically achieved, the basic principle of heat rising is utilized.

One common and simple method is by using forced air ventilation, which is most effectively achieved with filter fans. Since outside air is introduced into a clean sealed environment, high efficiency filters are required to maintain that integrity. An example of a typical layout is shown in Ill. 4.



Ill. 4

This arrangement with the filter fan (air intake) at the bottom and the exhaust filter near the top is highly effective by using cooler ambient air to displace the warmer air inside the enclosure. The exhaust filter is typically mounted as close to the top of the cabinet as possible to take advantage of natural convection forces, and should also be located as far as possible from any heat producing components. If designed properly, the air path created by the filter fan system will pass through critical areas that are to be cooled, allowing for maximum cooling efficiency. Ideally, a control thermostat should be located in one of the critical areas where it will turn the fan on and off when temperature set points are reached.

Many other arrangements are possible, even so far as letting ventilation occur naturally. One such system would allow for passive cooling by letting the warmer air escape through a roof-mounted vent. Again, the key is that cooler air is used for displacement, so an intake filter would be required near the bottom of the cabinet.

Conclusion

Designing the layout of cabinets and enclosures that house sensitive electronic components is a challenging task. While it may seem a less important consideration than many other aspects of proper control system design, the suitable placement of heating and/or cooling components can have a major impact on system operations. Following these simple guidelines will help ensure system functionality and long service life.