

MANAGING & MAINTAINING TEMPERATURE IN ENCLOSURES

MAXIMIZING THE LIFE AND EFFICIENCY OF ELECTRICAL COMPONENTS

INTRODUCTION

Electrical components experience increased stress with elevated temperatures. As a rule of thumb, an electronics' life is cut in half for every 18°F (10°C) over room temperature. In order to maximize the life cycles of your electronic devices and keep your business running, it is recommended to adequately control the temperature of your electrical components.

SOURCES OF HEAT

Temperature elevating heat sources include many of the components that typically populate an electrical enclosure. These components include:

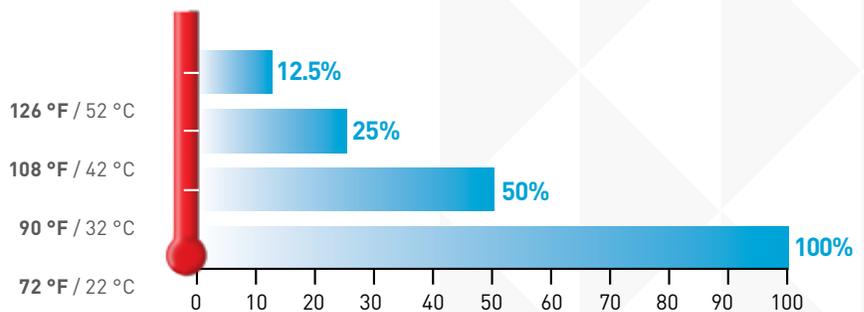
- AC power supplies
- Controllers, drives and servos
- Transformers and rectifiers
- Processors and server racks
- Radio equipment

Heat is also generated from these sources outside the enclosure:

- Solar heat gain
- High ambient temperature
- Welding processes
- Paint oven
- Blast furnace
- Foundry equipment

TRENDS TOWARD MORE HEAT

With expanding deployment of smaller, more powerful and more portable mission-critical electronics into increasingly harsh environments and conditions, cooling and thermal management is now a primary engineering consideration. The density of modern electronics in smaller cabinets intensifies heat issues that can compromise component performance.



Electronics Life Expectancy = %

Source: Digital Equipment Corporation

CONSEQUENCES OF EXCESS HEAT

Excess heat can adversely affect industrial controls, creating the potential for these consequences:

- De-rated drive performance
- Intermittent fluctuations in I/C-based devices
- MTBF decreases exponentially
- Catastrophic component failure
- Warranty revocation
- Component replacement costs
- Late shipments
- Customer dissatisfaction
- Lost revenue
- Service outages
- Hours of factory downtime

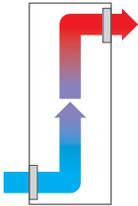
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COOLING OPTIONS

Managing electrical component temperatures can be accomplished in a variety of ways. One way is when air in the enclosure is exchanged with ambient air from the immediate surroundings; this is known as open loop cooling. A simple open loop cooling system filters incoming air, but will not be able to lower the air temperature below ambient temperature. This provides an inexpensive cooling solution for light heat loads. However, there are potential drawbacks to this method. Open loop cooling allows small amounts of dirt, dust, potentially corrosive elements, water vapor and other gases/vapors to infiltrate the enclosure. Consider open loop cooling for applications where the surrounding air is clean, cool and when it is acceptable for the temperature inside the enclosure to be slightly higher than the temperature outside.

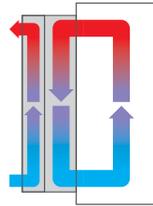
With greater heat loads, or to maintain a controlled environment inside the enclosure, a closed loop cooling system may provide the best results. The two main closed loop cooling solutions are air conditioners and heat exchangers. Air conditioners can maintain an enclosure's internal temperature at or below the maximum ambient temperature. Air conditioners can be a traditional refrigerant-based design or a thermoelectric-based design. They can also remove moisture from the enclosure, which can be beneficial in some applications. Heat exchangers will always allow the internal temperature inside the cabinet to be higher than the surrounding ambient temperature.

OPEN LOOP COOLING



A common open loop cooling system consists of a filter fan to introduce cool ambient air into the lower corner of the enclosure and an outlet grill in the upper corner from which the warm air is exhausted. The initial purchase cost and the ongoing costs are traditionally lower with open loop cooling when compared to closed loop cooling systems. Open loop cooling components are smaller and lighter, simplifying installation. Either DC or AC power supply is typically available and little noise is generated by open loop cooling. Users should consider the fact that open loop cooling will not protect against corrosive elements or control the enclosure humidity level. Regular filter replacement is necessary because electrical components will run somewhat hotter than with a closed loop cooling system, which creates an overall shorter component life.

CLOSED LOOP COOLING



In closed loop cooling, the sealed integrity of the cabinet will be maintained with either an air conditioner or heat exchanger, protecting the equipment from dirt, dust, corrosive air and wind-driven rain. Any holes or cutouts in an enclosure must be filled with a device that has the same (or better) Type rating. The enclosure takes the rating of the lowest rated component that penetrates the surface. Closed loop air conditioners and heat exchangers are available with the same ratings necessary to maintain the original rating and integrity of the enclosure. Compared to open loop systems, closed loop systems are larger and heavier, tend to have higher up-front costs and have higher energy consumption.

If an enclosure has a higher heat load and/or if the cabinet needs to maintain an internal temperature below a maximum ambient temperature, an air conditioner is the best closed loop cooling option. An air conditioner can also help to control moisture with a

condensate drain line or an active condensate evaporator.

On some air conditioner models, the condenser coil is treated with a coating to limit dust buildup; therefore, those units do not require ongoing filter cleaning. Most air conditioners are offered in 115 V, 230 V single phase or 460 V 3-phase AC models. DC powered units are becoming increasingly available.

If the enclosure can operate above the maximum ambient temperature and moisture control is not required, then a heat exchanger may be an appropriate choice. Heat exchangers are an inherently simpler product, with fans being the only moving devices. 115 V or 230 V AC powered models, and DC powered models are typically available. DC models have the added advantage of speed control of the fans, so the heat exchanger runs quieter when the heat load is reduced.



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HOFFMAN THERMAL MANAGEMENT SYSTEM CHARACTERISTICS

COOLING SYSTEM TYPE	TECHNOLOGY DESCRIPTION	HEAT REMOVAL RANGE	INDICATIONS FOR USE	TYPICAL APPLICATIONS	COOLS BELOW AMBIENT	COOLS ABOVE AMBIENT	CLOSED LOOP
Air Conditioners	Forced air Refrigerant-based	High	Hot Environments (typically over 35 °C/95 °F) High Heat Load (300 W-17,300 Watt) Dirty or Corrosive Air Harsh/Humid Environments	Indoor or Outdoor Industrial enclosures Telecommunications Wastewater treatment Metal working Oil rig/refinery Foundry	✓		✓
Thermoelectric Coolers	Peltier effect No moving parts or liquids	Low	Small Enclosures Low Heat Load (60-200 Watt) Remote/ DC-powered applications	Indoor or Outdoor Telecommunications Battery cabinets Industrial enclosures Security systems	✓		✓
Air-to-Air Heat Exchangers	Closed loop No liquids	Moderate	Cool Air Environment Moderate Heat Load (7-151 Watt/C) Dirty or Corrosive Air	Indoor or Outdoor Telecommunications Light-duty manufacturing		✓	✓
Air-to-Water Heat Exchangers	Close-coupled water cooling No moving parts exposed to environment	Highest	Very Hot Environments High Heat Load (870-12,500 Watt) Extremely Dirty/Dusty Air	Extreme conditions where air conditioners would be subject to failure Automotive manufacturing Machine tool Packaging Paper mill	✓		✓
Filter Fans, Blowers, Impellers or Direct Air Cooling Systems (DACS)	Forced, fresh air Open loop	Low to Moderate	Cool, Clean Air Environment	Industrial manufacturing Outdoor telecom Data networking		✓	
Vortex Coolers	Requires compressed air source Forced air No liquids or moving parts	Moderate	Hot Environments (typically over 35 °C/95 °F) Heat Load (up to 1,465 Watt) Dirty or Corrosive Air Harsh/Humid Environments	Heavy manufacturing Metal working Oil rig/refinery Paper mill Foundry Hazardous location models available	✓		✓
Conductive (no cooling unit)	Passive Heat radiates through enclosure walls	Very Low	Cool Air Environment (<25 °C/78 °F) Low Heat Load (<50 Watt)	Where enclosed components operate within recommended temperature range		✓	Per enclosure rating

CONCLUSION

The ultimate goal of any enclosure thermal management systems is to protect the internal electronics and maximize their useful life. Maximum heat loads, maximum ambient temperature, maximum allowable internal temperature, humidity control, dust control, up front capital costs, and operating costs, all factor into a decision when choosing the right solution for a particular application.

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