THERMAL MANAGEMENT DESIGN GUIDE OVERVIEW

Incorporating thermal cooling within an enclosure can lengthen system life and increase control line reliability. The accumulation of heat in an enclosure is potentially damaging to electrical and electronic devices. Overheating will shorten the life expectancy of costly electrical components and can lead to catastrophic failure. It is, therefore, important that system designers be aware of the temperature implications of their designs prior to implementation and, where necessary, take steps to reduce heat build-up inside the enclosure.

Extreme temperatures can have the following effects on industrial control equipment:
- Catastrophic failures can occur
- Silicone material properties can change
- Drive performance is de-rated
- I/C-based devices may experience intermittent fluctuations in output and voltage migration
- Mean Time Between Failure (MTBF) decreases exponentially

The costs when a line goes down due to temperature extremes are:
- Productivity losses
- Increased labor costs
- Increased scrap
- Opportunity losses
- Component costs
- Missed ship dates
- Decreased customer satisfaction

TYPES OF COOLING

Open Loop: Utilizes the ambient or outside air, filtered or unfiltered, to cool the electronics
Closed Loop: Maintains the sealed integrity of the cabinet while utilizing the internal cabinet air to cool the electronics
Active Cooling: An external device enhances the cooling process
Passive Cooling: Cooling occurs via natural convection and heat dissipation

AIR CONDITIONER

Closed Loop System: Can maintain a Type 3R, 12, 4 or 4X rating and can create an environment cooler than ambient. This is an ideal type of cooling which creates a more reliable system and improves equipment life cycle. A typical internal temperature design point is 85-95 F. Hoffman air conditioners are designed for continuous operation in ambient environments up to 125 F or 131 F, depending on the model.

For sizing and selecting an air conditioner, refer to the Hoffman Thermal Management Catalog, or go to hoffmanonline.com to use the Thermal Management Sizing and Selection Software.

When an electrical enclosure wall is penetrated with an opening it must be covered by a rated part. All of the above cooling systems have been designed and certified to be used on electrical enclosures and maintain the product Type Rating identified on the corresponding product specification sheet.

VORTEX COOLER

Closed Loop System: Can maintain a Type 12, 4 or 4X rating and can create an environment cooler than ambient. This is an ideal type of cooling for smaller enclosure applications where compressed air is available.

HEAT EXCHANGER

Closed Loop System: Maintains a sealed system that will match the Type rating of the heat exchanger. Temperature will always be greater than ambient. Equipment inside the enclosure must be evaluated to sustain a worst-case temperature rise above ambient.
For sizing and selecting heat exchangers, refer to Heat Exchangers Sizing and Selection.

FILTER FAN AND EXHAUST

Open Loop Systems: Usually only used in relatively clean Type 1 or Type 3R environments where the temperature inside the enclosure will always be greater than outside the enclosure. Equipment inside the enclosure must be evaluated to sustain a worst-case temperature rise above ambient.
For sizing and selecting filter fan packages, refer to Fans, Blowers, Louvers and Vents Sizing and Selection.

FINDING THE RIGHT THERMAL MANAGEMENT SOLUTION

To determine the best thermal management products for the application, the user needs to define information about the environment, enclosure and the equipment inside. Use the form below in conjunction with Hoffman's online Thermal Management Sizing and Selection Software.

Project Environment/Thermal Evaluation Data Form
Environment
System Location: Indoors, outdoors shaded or outdoors direct sunlight

Environment: Corrosive, dust, grit, dirt, oily-cutting fluids, washdown, dripping water, freezing rain or other

Open Loop _____ or Closed Loop _____ System

Enclosure
Size: _____ H x _____ W x _____ D = _____
Determine the area that allows heat transfer and identify any dimensional limits of thermal system.

Type Rating: _____ (Typically Type 1, 3R, 12, 4, or 4X)

Enclosure finish/color: __________
(external color will effect solar load if in direct sunlight; if internal finish is metallic, the passive cooling of the enclosure is less)

Equipment
Internal Heat Load: _____ (determine the full-load heat produced by the major power-consuming components; then add an additional 25 percent for passive components and connections)

Determine the level of protection the equipment needs based on the environment.

Identify the most sensitive components relative to temperature or humidity and determine the upper and lower temperature extremes.

Available Power: _____ Volts

Temperature Limits
Cooling Extremes
__________ Maximum temperature outside the enclosure

__________ Maximum allowable temperature inside the enclosure (85–95 F is a typical value used to provide a reliable system and maximize the system's life)

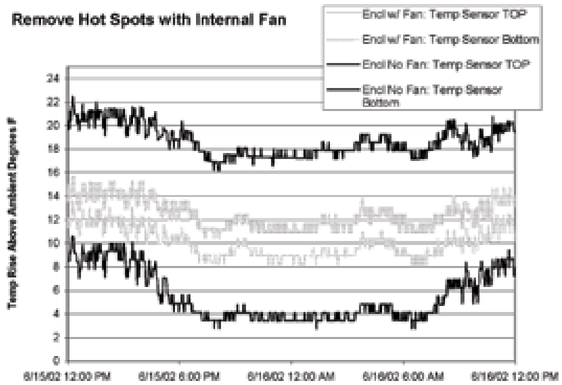
Heating Extremes
__________ Minimum temperature outside the enclosure

__________ Minimum allowable temperature inside the enclosure (heaters are frequently required to maintain temperatures above minimum start-up and to remove condensation)

INTERNAL CIRCULATING FANS

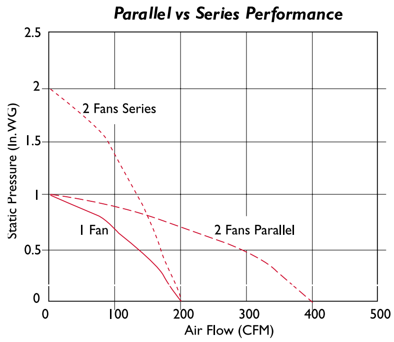
The use of circulating fans in an enclosure will improve heat dissipation by as much as 10 percent. Circulating fans are most commonly employed to eliminate hot spots inside an enclosure.

The graph below illustrates the temperature rise of two identical enclosures except one has an internal circulating fan. Each enclosure has two temperature sensors, one located near the top and the other near the bottom. The top and bottom black curves reflect the temperature in the enclosure without an internal fan. Adding a circulating fan removed the heat stratification.



MULTIPLE AIR MOVERS FOR OPEN LOOP SYSTEMS

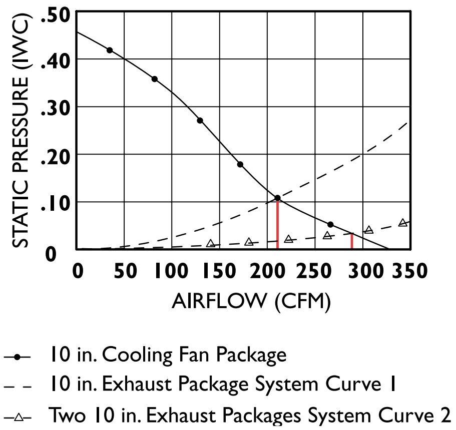
Air movers can be combined in series or parallel, as this may provide the optimum solution. In addition, a degree of redundancy in the event of fan failure can be a benefit. The graph illustrates how airflow performance changes when air movers are placed in series or parallel with one another in a system.



MULTIPLE EXHAUSTS FOR OPEN LOOP SYSTEMS

This performance curve shows that adding a second 10-in. exhaust package provides an increase in airflow from 215 CFM to 290 CFM. The intersection point of the fan curve and the system curve approximates the CFM performance.

Performance Curve for a 10" Cooling Fan Package and System Curve With Exhaust Grills



ACOUSTICAL NOISE

Acoustical noise is typically measured by the Sound Pressure Level (Lρ), expressed in decibels and is dependent upon the distance from the source as well as its surroundings.

The Sound Pressure Level is defined as:
$L\rho = 10 \log (\rho^2/\rho_o^2)$
Where:
Lρ = Sound pressure level (dB)
ρ = Measured sound pressure (Pascals)
ρ_o = Sound reference level 20 μN/m²

Noise Generated by Air Movers
There are many different ways to reduce the noise generated by an air mover. Some of the more common are:

- Avoid obstructions to airflow
- Run larger fans at lower speeds
- Lower the system impedance
- Minimize inlet losses and obstructions

The most significant factor influencing the noise from a given air mover is the speed of rotation. This is given by the following equation:
$dB_2 = dB_1 - 50 \log (rpm_1 / rpm_2)$
Where:
dB_1 = Sound pressure of the air mover operating at rpm_1
dB_2 = Sound pressure of the air mover operating at rpm_2
rpm_1 = Operating speed of impeller at condition 1
rpm_2 = Operating speed of impeller at condition 2

Therefore, a blower at half speed will be 15 dB quieter than at full speed. Airflow will also be half and, since static pressure is a squared function of speed, it is reduced by a factor of four.

Decibel Loudness Comparisons

Decibels (dBA)	Loudness Comparisons
10	Grand Canyon at night
20	Quiet basement
30	Quiet bedroom (at night)
40	Typical living room
50	Background music
60	Average human voice
70	Airplane interior noise
75	EPA recommends protection for 8-hour exposure
80	Kitchen garbage disposal
90	Lawn mower
100	Leaf blower
110	Rock concert
115	OSHA forbids unprotected exposure

Sound and Distance **When the distance from a Point source doubles, the sound level decreases six decibels.**

Sound Level	Distance
95 decibels	50 feet
89 decibels	100 feet
83 decibels	200 feet

Addition and Subtraction of Decibel Levels **Doubling sound energy yields an increase of three decibels. In this example, each source is 50dBA. Note the characteristics of logarithmic addition or subtraction of decibel levels.**

Number of Sources	Decibel Level
1	50 dBA
2	53 dBA
4	56 dBA
8	59 dBA