Enclosure Cooling

You need to cool down

Heat inside an enclosure can decrease the life expectancy of controlling units such as your PLC, HMI, AC drives and other items. Excessive heat can cause nuisance faults from your electrical and electronic components: for example, overloads tripping unexpectedly. Heat will also change the expected performance of circuit breakers and fuses, which can cause whole systems to shut down unexpectedly. So, if you have any electronic equipment or other heat sensitive devices, you may need cooling.

What causes all that heat?

There are basically two sources that can cause the enclosure's internal temperature to rise above the ratings of the control equipment.

Internal Sources

The same items that can be damaged by heat may also be the source of the heat. These include items such as:

- Power supplies Servos
- AC Drives/inverters Soft starters
- Transformers PLC systems
- Communication products HMI systems
- Battery back-up systems

External Sources

Other sources of heat that can cause the internal temperature of your enclosure to rise above a desired level involve the external environment. These include items such as:

- Industrial ovens
- Solar heat gain
- Foundry equipment
- Blast furnaces

Get the heat out

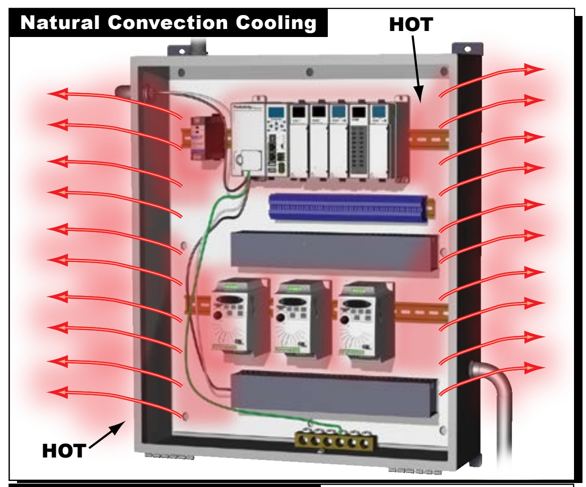
How do you get the heat out of your enclosure and away from those critical components? There are several basic cooling methods available, depending on the cooling requirements and the enclosure environment.

Radiation and Natural Convection Cooling

If the ambient temperature outside the enclosure is cooler than the inside of the enclosure, some heat will be radiated into the atmosphere from the surface of the enclosure. In environments where dust and water intrusion is not a concern, louvers can be added to allow outside air to flow through the enclosure via natural convection - the movement of air due to it's expansion (reduced density) when it's heated and contraction (increased density) when it cools.

On a large scale, natural convection can be a powerful force - it's one of the primary drivers of our weather. But on the scale of an electrical enclosure, its cooling capacity is very limited. For larger heat loads, a more powerful cooling system may be needed.

Since they create openings in the enclosure, louvers are typically limited to NEMA 1 and/or NEMA 3R applications. However, some louvers have optional filters that can be added to maintain NEMA 12 protection.

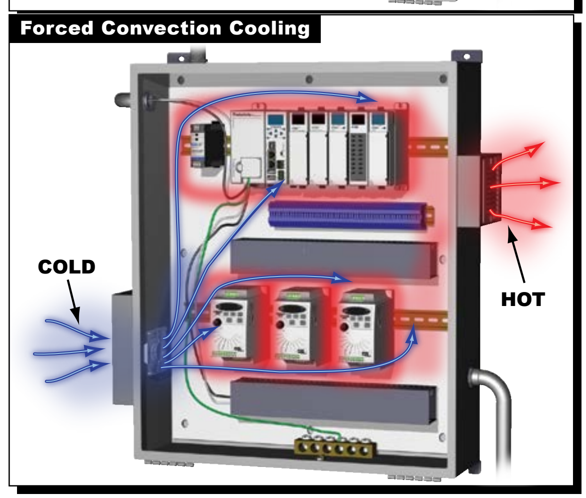


Forced Convection Cooling

The next step up from natural convection is forced convection cooling. The basic cooling mechanism is the same: cooler air from outside the enclosure passes through the enclosure to remove the heat. The difference is that the air is mechanically forced through the enclosure by a filter fan. The fan produces higher air flow rates than natural convection, which in turn increases the amount of heat removed.

As with natural convection cooling, the ambient air temperature must be lower than the desired enclosure temperature for forced convection to be effective.

A typical forced convection system consists of a fan and a grille, with a filter on the intake device and either a filter or louvers on the exhaust device. The filters and louvers allow the enclosure to maintain NEMA 12 protection. In NEMA 4 or NEMA 4X environments, hoods can be added to both the fan and the grille to prevent the ingress of water.



Enclosure Cooling

Closed Loop Cooling

If the environment is harsh, with heavy dust and debris or the presence of airborne chemicals, or there are wash-down requirements, the cooling system must be able to keep the ambient air separate from the air inside the enclosure.

Closed loop systems, which include heat exchangers and air conditioners, circulate the internal air and ambient air through separate chambers connected by a refrigeration system that transfers heat from the internal air stream to the external air stream. Heat exchangers and air conditioners are both closed loop cooling systems. The primary difference in the two is the refrigeration system.

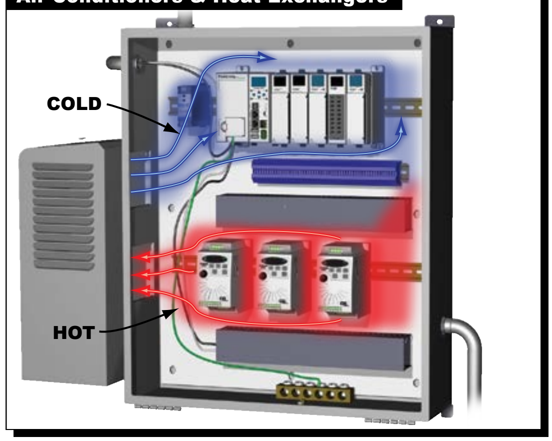
The refrigeration system in a heat exchanger is a set of sealed tubes of alcohol. Heat absorbed from the internal enclosure air boils the liquid alcohol at the bottom of the tube, causing it to rise to the top. The heat is then rejected to the cooler ambient air stream, causing the alcohol to condense back to a liquid and fall to the bottom.

Heat exchangers are very efficient because the refrigeration system has no moving parts - the only moving parts are the two fans. But for the heat to transfer through the system, the ambient air must be colder than the air inside the enclosure, just as it must be for filter fans.

Enclosure air conditioners function in the same manner as a residential or automotive air conditioner, with refrigeration loop powered by a compressor. The refrigerant absorbs heat from the internal air at the evaporator coil and rejects it to the ambient air at the condenser coil. Unlike heat exchangers, they can provide cooling even if the ambient temperature is higher than the enclosure temperature. They can also be scaled to handle larger heat loads than any other cooling system.

Enclosure air conditioners are available for NEMA 12, NEMA 4 and NEMA 4X applications.

Air Conditioners & Heat Exchangers



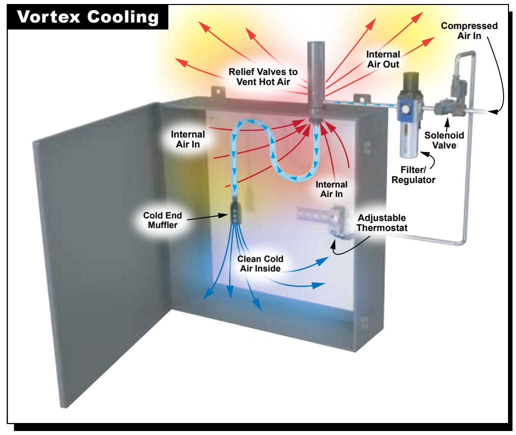
Vortex Coolers

Vortex coolers create a stream of extremely cold air from a supply of filtered compressed air. The cold air is injected into the enclosure, displacing warm air which is exhausted back through the vortex cooler. While not a closed-loop system, they can be used in the same harsh environments since the cold air injected into the enclosure is filtered air from a compressed air system, not ambient air. Vortex coolers can also be used where the ambient temperature is higher than the enclosure temperature.

Since vortex coolers prevent the ingress of ambient air or sprayed water and are made from corrosion-resistant materials, they can be used on NEMA 4X enclosures in harsh, wash-down, and/or corrosive environments.

Vortex coolers are commonly used in lieu of a small or medium enclosure air conditioner in applications where there isn't adequate space to mount an air conditioner, provided there is an adequate supply of compressed air.

Vortex Cooling



Thermoelectric Coolers

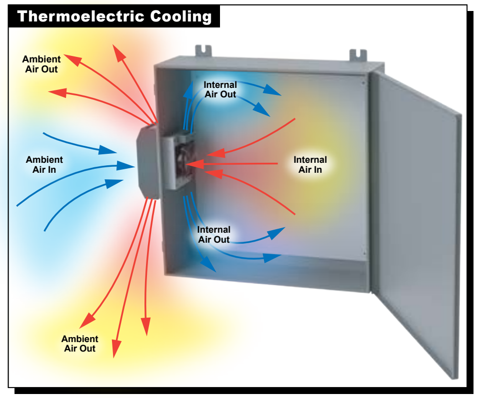
Another alternative to a conventional air conditioner is a thermoelectric cooler, which is sometimes referred to as a Peltier cooler. They function in a manner similar to an air conditioner or heat exchanger, with fans inside and outside the enclosure, but with a thermoelectric unit replacing the fluid-based refrigeration system.

The thermoelectric units consist of an array of semiconductors sandwiched between two ceramic plates. When a DC current is applied to the semiconductor array, heat is driven from one plate to the other, creating a cold side and a warm side. This is known as the Peltier Effect. Fans circulate air across each of the plates, allowing the cold plate to absorb heat from the enclosure and the warm plate to reject it to the ambient air.

Like vortex coolers, thermoelectric coolers can be used with NEMA 4X enclosures in harsh, wash-down, and corrosive environments, and where the ambient temperature exceeds the enclosure temperature.

Thermoelectric coolers are an alternative to air conditioners in small cooling capacity applications where there isn't adequate space for an air conditioner.

Thermoelectric Cooling



Selecting an Enclosure Cooling Device

Cooling Basics

To select the proper cooling device for your enclosure, you need to determine how much heat the device must remove from the enclosure to maintain the desired internal temperature, which is the sum of two component heat loads: **Internal Heat Load** and **Heat Transfer Load**.

Internal Heat Load (Q_i)

The sum of all heat generated by the components within the enclosure. This can be calculated by adding the maximum heat output for each device installed in the enclosure (the worst-case conditions for the enclosure). The maximum heat output is typically specified in watts in the manufacturer's documentation. If it is not, contact the manufacturer to request the heat output or for guidance on how to measure or calculate it.

Heat Transfer Load (Q_x)

The heat gained (positive heat transfer) or lost (negative heat transfer) through the enclosure exterior surface with the surrounding ambient air. This can be calculated with the following formula:

***$Q_x = kA\Delta T$* (BTU/h),** where:

***k* = heat transfer coefficient (BTU/(h·ft²·°F))**

The heat transfer coefficient is a measure of how easily an enclosure conducts heat from the internal air to the external air, which varies with the enclosure material. Suggested values for various enclosure materials are provided below:

Enclosure Material	k, BTU/(h·ft²·°F)
Painted carbon steel	0.97
Stainless steel	0.83
Aluminum	2.1
Polycarbonate, fiberglass, PVC, ABS	0.62

***A* = exposed enclosure surface area (ft²)**

The total surface area of a rectangular enclosure is:

A = 2HW + 2HD + 2WD, where:

H = height

W = width

D = depth

But it's important to properly account for any surfaces that are against walls or floors, as those surfaces will absorb/reject heat from adjacent surfaces at a different rate (that is, have a different k value) than the exposed surfaces. Quantifying that difference is far beyond the scope of this document, but the q value for those surfaces will usually be less than the value for exposed surfaces. Therefore, the conservative design approach should be to ***exclude those surfaces when $\Delta T < 0$ and use the total surface area when $\Delta T > 0$.***

The equations for excluding those surfaces in several common situations are listed below.

Wall-mount (excludes back of the enclosure)	$A = HW + 2HD + 2WD$
Freestanding enclosure (excludes the bottom of the enclosure)	$A = 2HW + 2HD + WD$
Freestanding enclosure against a wall (excludes both the bottom and back)	$A = HW + 2HD + WD$
Freestanding enclosure in a corner (excludes the bottom, back, and one side)	$A = HW + HD + WD$

Using these formulas as written will produce answers in either in² or mm², depending on the enclosure. To convert to ft² use the appropriate conversion:

1 ft² = 144 in²

1 ft² = 92,900 mm²

Selecting an Enclosure Cooling Device

$\Delta T = T_A - T_E$, where T_A is maximum ambient air temperature (°F) and T_E is maximum allowable enclosure air temperature (°F)

Note that ΔT may be negative if the ambient temperature is less than the enclosure temperature. When this is the case, the heat transfer load will also be negative, meaning that the ambient air is providing some degree of cooling. Whereas a positive ΔT indicates that the ambient air is warming the enclosure.

A positive ΔT also indicates that neither a fan nor a heat exchanger is a viable cooling device for this application. Both devices exchange heat between the interior and exterior of the enclosure. Since heat will always move from the higher temperature material to the lower temperature, these devices will add heat to the enclosure which will raise the internal air temperature, not lower it.

The maximum allowable enclosure air temperature will typically be dictated by the maximum operating temperature of the components inside the enclosure. Be sure to choose the component value with the lowest maximum operating temperature.

Required Cooling Capacity (Q_r)

The required cooling capacity (Q_r) for an enclosure is simply the sum of the Internal Heat Load and the Heat Transfer Load. However, as presented these values cannot be simply added since one is typically given in watts and the other in BTU/h. Additionally, fan and heat exchanger sizing formulas require the total heat load in watts, while the cooling capacities of vortex coolers are generally expressed in BTU/h. However, the cooling capacities of air conditioners and thermoelectric coolers may be expressed in either unit, or sometimes both. Apply one of the following conversions to the heat loads to add them:

1 W = 3.41 BTU/h ***Q_r (BTU/h) = Q_i x 3.41 (BTU/h)/W + Q_x***

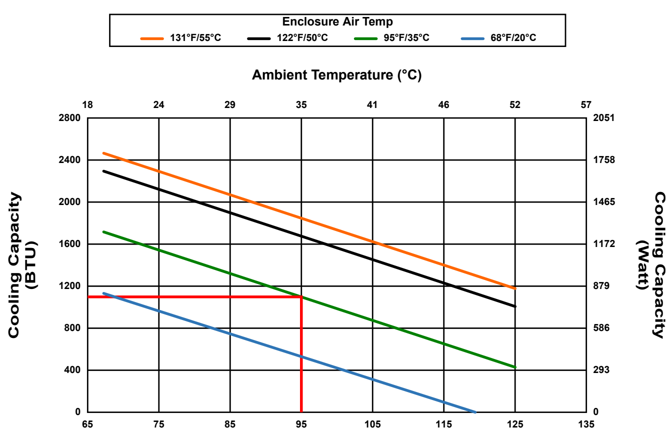
1 BTU/h = 0.293 W ***Q_r (W) = Q_i + Q_x x 0.293 W/(BTU/h)***

Vortex Cooler Selection

Once the required cooling capacity has been calculated, selection of a vortex cooler is simple – just select a cooler with a nominal cooling capacity greater than the calculated requirement.

Air Conditioner and Thermoelectric Cooler Selection

Selecting an air conditioner or thermoelectric cooler is more complex because their performance depends on both the ambient temperature and the enclosure temperature. Generally, more strenuous operating parameters (higher ambient temperature, lower enclosure air temperature) will reduce the unit's performance. For this reason, manufacturers publish curves that graphically describe the unit's cooling capacity over a range of conditions. Here's an example:



As indicated by the red lines, this air conditioner would be able to remove 1000 BTU/H when the ambient temperature is 95°F and enclosure air temperature is 95°F. If the ambient temperature was only 75°F, the cooling capacity of the unit would increase to approximately 1105 BTU/H as the lower ambient temperature increases the unit's condenser's ability to reject heat to the surrounding atmosphere. Conversely, at a 95°F ambient temperature and a 68°F enclosure air temperature, the unit's capacity would be reduced to approximately 945 BTU/H, as the lower enclosure air temperature would reduce the heat transfer rate between the internal enclosure air and the unit's evaporator coils.

To determine if an air conditioner or thermoelectric cooler meets application requirements, simply plot the two maximum temperatures used in the ΔT calculations and read the corresponding cooling capacity on the y-axis of the chart. If that value exceeds the required cooling capacity, the air conditioner will be adequate for the application. If not, select a larger capacity unit.

Selecting an Enclosure Cooling Device

The 95°F/95°F point is typically used as the nominal cooling capacity of the unit. But always keep in mind that any nominal capacity only represents one set of operating parameters. If those parameters to not match the actual application conditions, the actual performance of the air conditioner/thermoelectric cooler will be different.

Never rely solely on a nominal cooling capacity when selecting an air conditioner or a thermoelectric cooler! The nominal capacity is solely intended to provide an approximation to get the user "in the ballpark" of the selection process.

In addition to the required cooling capacity, an air conditioner or thermoelectric cooler should also maintain the NEMA rating of the enclosure. Ideally, it should also operate on a voltage already available within the enclosure to avoid necessitating a transformer or power supply.

Air Conditioner Selection Example

A NEMA 12 Wiegmann N12302412 wall-mount enclosure (30 in high x 24 in wide x 12 in deep) contains a GS4-4060 AC drive (60 HP 460V) that has a maximum allowable operating temperature of 104°F and is inside a plant with a maximum ambient air temperature of 115°F.

The GS4-4060 specifications table indicates its maximum Watt Loss to be 1147 W.

Internal heat load:

$$Q_i = 1147\ W \times 3.413\ (BTU/h)/W = 3914\ BTU/h$$

Heat load transfer:

$$k = 0.97\ BTU/(h{\cdot}ft^2{\cdot}°F)$$

$\Delta T = 115°F - 104°F = 11°F$ (Reminder: ΔT >0 means that fans or heat exchangers will not cool the enclosure!)

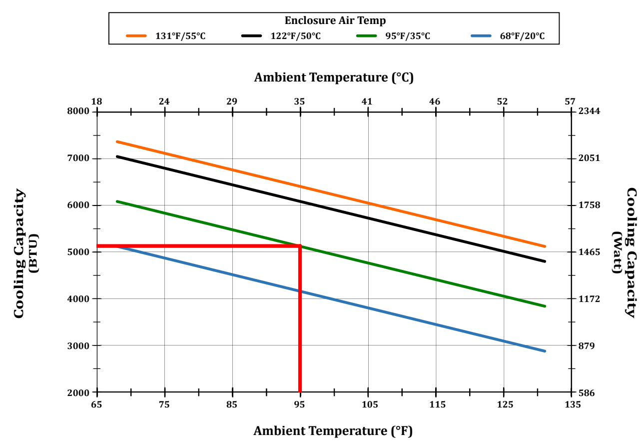
$$A = [2(30\ in \times 24\ in) + 2(30\ in \times 12\ in) + 2(24\ in \times 12\ in)]/144\ in^2/ft^2 = 19\ ft^2$$

$$Q_x = kA\Delta T = (0.97\ BTU/(h{\cdot}ft^2{\cdot}°F))(19\ ft^2)(11°F) = 202\ BTU/h$$

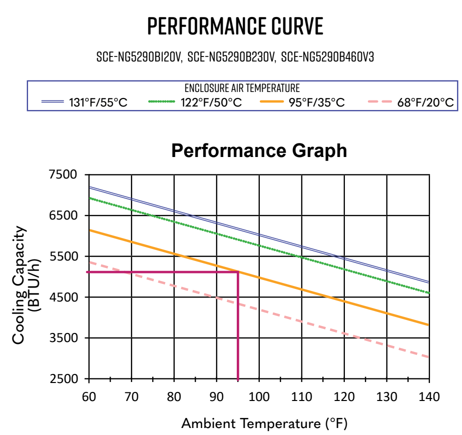
Required cooling capacity:

$$Q_r = Q_i + Q_x = 3914\ BTU/h + 202\ BTU/h = 4116\ BTU/h$$

AutomationDirect offers several NEMA 12 460VAC models that meet or exceed 4605 BTU/h at 104°F. The curves for the appropriate sizes of some of these series are shown below.



The NEMA 12 460VAC selection from this series is SCE-AC5100B460V.



The NEMA 12 460VAC selection from this series is SCE-NG5290B460V3.

Selecting an Enclosure Cooling Device

Heat Exchanger Selection

Heat exchanger capacities also depend on the internal enclosure air temperature and the ambient temperature, but the dependency is a simple linear relationship between the capacity and ΔT. So rather than graphing the cooling capacity of the heat exchanger, it is simply expressed in terms of W/°C and compared to the value of $-Q_r/\Delta T$.

To convert ΔT from °F to °C, use the conversion 1°C = 1.8°F.

Note that this simplified conversion only works for temperature differences. It does not work for measured temperatures since 0°F ≠ 0°C. DO NOT apply this conversion directly to the ambient and enclosure air temperatures. Only apply it to ΔT.

Heat Exchanger Selection Example

A NEMA 12 Wiegmann N12302412 wall-mount enclosure (30 in high x 24 in wide x 12 in deep) contains a GS4-4010 AC drive (10 HP 460 volt) that has a maximum allowable operating temperature of 104°F and is in a plant that has a maximum ambient air temperature of 90°F.

The GS4-4010 specifications table indicates its maximum Watt Loss to be 292 watts.

Internal heat load:

$Q_i = 292\ W$

Heat load transfer:

$k = 0.97\ BTU/(h \cdot ft2 \cdot °F)$

$\Delta T = 90°F – 104°F = -14°F$ (Since ΔT <0, a heat exchanger is a potentially valid cooling device)

$\Delta T = -14°F/(1.8°F/°C) = -7.8°C$

$A = [(30\ in \times 24\ in) + 2(30\ in \times 12\ in) + 2(24\ in \times 12\ in)]/144\ in^2/ft^2 = 14\ ft^2$

$Q_x = kA\Delta T = (0.97\ BTU/(h \cdot ft^2 \cdot °F))(14\ ft^2)(-14°F) = -190\ BTU/h \times 0.293\ W/(BTU/h) = -56\ W$

Required cooling capacity:

$Q_r = Q_i + Q_x = 292\ W - 56\ W = 236\ W$

$-Q_r/\Delta T = -236\ W/-7.8°C = 30\ W/°C$

A Stratus heat exchanger with a capacity of at least 30 W/°C is needed, such as a TE30-030-17-04.

Selecting an Enclosure Cooling Device

Fan Selection

A fan cools the enclosure simply by displacing the hot air within the enclosure with cooler air from the outside. Combining the specific heat of air, the density of air, and various conversion factors into a single coefficient gives a simple equation for correlating a fan's required airflow rate to the enclosure's required cooling capacity:

$$F_r = -(3.17\ CFM\cdot°F/W)Q_r\ /\ \Delta T$$

Once the fan airflow requirement is determined, fan selection is simply a matter of finding a fan with an airflow greater than the required airflow. Most applications will require an accompanying grille and one or more filters which will restrict airflow to some degree. (Exceptions would be a NEMA 1 enclosure or a similar circumstance where an open vent can be used for exhaust/makeup air.) Therefore, the fan selection should almost always be made based on the "Airflow with Grille and Filters (CFM)" column of the specifications, not the fan's Free Airflow.

Fan Selection Example

A NEMA 12 Wiegmann N12302412 wall-mount enclosure (30 in high x 24 in wide x 12 in deep) contains a GS4-2025 AC drive (25 HP 230 volt) that has a maximum allowable operating temperature of 104°F and is in a plant that has a maximum ambient air temperature of 92°F.

The GS4-2025 specifications table indicates its maximum Watt Loss to be 733 watts.

Internal heat load:

$$Q_i = 733\ W$$

Heat load transfer:

$$k = 0.97\ BTU/(h\cdot ft^2\cdot°F)$$

$$\Delta T = 92°F - 104°F = -12°F \text{ (Since } \Delta T < 0\text{, a fan is a potentially valid cooling device)}$$

$$A = [(30\ in \times 24\ in) + 2(30\ in \times 12\ in) + 2(24\ in \times 12\ in)]/144\ in^2/ft^2 = 14\ ft^2$$

$$Q_x = kA\Delta T = (0.97\ BTU/(h\cdot ft^2\cdot°F))(12\ ft^2)(-12°F) = -163\ BTU/h \times 0.293\ W/(BTU/h) = -48\ W$$

Required cooling capacity:

$$Q_r = Q_i + Q_x = 733\ W - 48\ W = 685\ W$$

Required air flow:

$$F_r = -(3.17\ CFM\cdot°F/W)(685\ W)/-12°F = 181\ CFM$$

Possible 230VAC fan & grille combinations include:

- Stego 018840-40 exhaust fan with 118840-30 grille (187 CFM)
- Fandis FF20A230UE1 intake fan with FF20U grille (209 CFM)
- Stego 018740-30 intake fan with 118740-00 grille (220 CFM)
- Stego 018840-00 exhaust fan with 118840-30 grille (243 CFM)
- Fandis TP19U230B1 roof-mount exhaust fan with FF20U grille (297 CFM)

Industrial strength cooling options for your enclosure from AutomationDirect

stratus thermal management

Heat Exchangers

- For NEMA 4 and 4X enclosures
- Closed loop cooling
- Energy efficient: uses approximately the same power as a filtered fan system
- 120VAC and 24VDC models available
- UL
- Made in the USA

Made in the USA UL

Air Conditioning Units

- For NEMA 12, 4, 4X type enclosures
- Digital temperature controller
- Active condensate evaporation system
- High unit efficiency
- Tough industrial construction
- Compressor protection system

stratus thermal management

Made in the USA UL

Enclosure Vortex Coolers

- For NEMA 12, 4, 4X type enclosures
- Operates on compressed air
- Stainless steel construction
- No moving parts, no maintenance required
- Vortex coolers can be “resized” for changing applications by simply replacing the generator inside the cooler. No need to purchase a new unit
- Replacing the vortex generator takes minutes

Made in the USA UL

Seifert Thermoelectric Cooling Units

- For NEMA 4, 4X, and 12 enclosures
- Stainless steel housing
- 170, 340, 510, 680 BTU/H cooling capacity
- Recessed mounting
- No maintenance required
- 24VDC and 120VAC power options

SEIFERT thermal innovations

Enclosure Air Conditioners

Applications

Designed to maintain the temperature inside an electrical enclosure at or below a safe level for the enclosed equipment, while maintaining a closed loop environment inside the enclosure to keep out contaminates that can be in the ambient air. Can be used in environments such as steel, food processing, petro-chemical, cement, paper/pulp and plastics industries, provided there are no corrosive gases or liquids that could damage internal components.

Construction

- Free-standing rigid chassis for easy installation and maintenance
- All mounting hardware, full-size template and instruction manual included
- Power input terminal block on all models
- All Type 4 and 4X models come with condenser coils coated with an electrically applied corrosion-resistant coating

Features

- Programmable temperature controller with visible alarm features in a 0.57 x 0.29in [14.5 x 7.3 mm] panel
- 70˚F to 95˚F (20˚C to 35˚C) temperature control range
- 50˚F to 125˚F (10˚C to 52˚C) ambient temperature range
- Pre-wired for external alarm monitoring connections (22 AWG three-conductor cable, 7 ft (2.3 m) long)
- Active condensate evaporation system with safety overflow
- Protective coated condenser coils on NEMA 4 and 4X for corrosion resistance
- Thermal expansion valve for maximum efficiency over wide range of temperatures and loads
- Anti short-cycle compressor protection
- High and low refrigerant cut-outs with fault indication
- Highly energy-efficient compressors
- UL/cUL listed

TA10-060-26-12 shown

Stratus Air Conditioners General Specifications

Part Number	Nominal Cooling Capacity	Operating Voltage	Inrush Current (A)	Running Current (A)	Recommended Fuse Size/Time Delay (A)	SCCR (A)	Connection	Refrigerant	Refrigerant Amount (oz)
TA10-010-16-xx	1480 BTU/H	115VAC/60Hz	14.50	3.44	12	*	Spring terminal block 24-8 AWG	R134a	4.00
TA10-010-26-xx		230VAC/60Hz	14.00	2.67	7	*			
TA20-010-48D-xx	1500 BTU/H	48VDC	-	3.50	8 (fast acting)	*			6.00
TA20-010-16-xx	1690 BTU/H	115VAC/60Hz	10.10	2.70	5	*			
TA10-015-16-xx	1725 BTU/H	115VAC/60Hz	14.60	3.44	12	*			7.75
TA10-015-26-xx		230VAC/60Hz	13.30	2.67	7	*			
TA10-027-16-xx	2680 BTU/H	115VAC/60Hz	10.00	3.20	8	*			13.25
TA10-027-46-xx		460VAC/60Hz	2.64	0.80	2	*			
TA20-020-16-xx	2705 BTU/H	115VAC/60Hz	10.63	4.10	5	*			
TA20-020-26-xx		230VAC/60Hz	8.84	2.00	4	*			9.75
TA10-033-16-xx	3300 BTU/H	115VAC/60Hz	16.00	4.80	12	*			14.25
TA10-033-46-xx		460VAC/60Hz	16.00	1.30	3	*			
TA10-020-26-xx	3585 BTU/H	230VAC/60Hz	13.65	3.07	7	*		R422d	9.75
TA10-040-26-xx	4000 BTU/H	230VAC/60Hz	13.41	3.07	6	*			13.25
TA10-050-16-xx	4390 BTU/H	115VAC/60Hz	23.42	7.26	12	*	Spring terminal block 16-6 AWG		12.50
TA10-050-26-xx		230VAC/60Hz	19.15	3.76	10	*			
TA10-050-46-xx		460VAC/60Hz	9.18	1.86	5	160kA			
TA10-045-16-xx	4535 BTU/H	115VAC/60Hz	32.30	6.82	12	*	Spring terminal block 24-8 AWG	R134a	14.00
TA10-045-46-xx		460VAC/60Hz	7.74	1.70	3	*			
TA10-059-16-xx	5910 BTU/H	115VAC/60Hz	32.30	6.14	12	*	Spring terminal block 16-6 AWG		15.00
TA10-060-16-xx	7580 BTU/H	115VAC/60Hz	42.41	7.83	25	*		R422d	18.00
TA10-060-26-xx		230VAC/60Hz	21.15	4.80	12	*			
TA10-060-46-xx		460VAC/60Hz	10.13	1.80	5	160kA			

Note: * Voltage variation no greater than ± 10% from nameplate rating and Frequency variation no greater than ± 3Hz from nameplate rating.

SoliTherm® Thermoelectric Coolers

SEIFERT thermal innovations

Applications

Thermoelectric elements utilize the Peltier Effect to create a temperature difference between the internal and ambient heat sinks, making internal air cooler while dissipating heat into the external environment. Fans assist the convective heat transfer from the heat sinks, which are optimized for maximum flow.

The Seifert SoliTherm® Peltier thermoelectric coolers can be mounted in nearly every position (except roof mounting) because they don't have a compressor or any moving parts aside from the fans. Depending on the application, condensation management may need to be considered. Seifert SoliTherm thermoelectric coolers are available as recessed with the internal heat sink and fan inside the enclosure and the ambient components on the outside. But, frames are available for external mounting. These thermoelectric coolers are resistant to extreme ambient conditions and can operate effectively even in environments that are dusty and oily. They comply with European standards IEC/TC 62610-1 and IEC/TC 62610-3, and can be used for both indoor and outdoor applications.

Construction

- Recessed mounting (flush-mounting kit sold separately)
- Cooling capacities from 100 to 680 BTU/H [30W to 200W]
- Operating Temperature Range: -4°F to 149°F [20°C to 65°C]
- AISI 304 stainless steel housing
- Condensate tray and drain sold separately
- Mounting nut torque: 3.3 lb·ft [4.5 Nm]
- Connection: Terminal block
- 24 VDC units require thermostat for set-point control

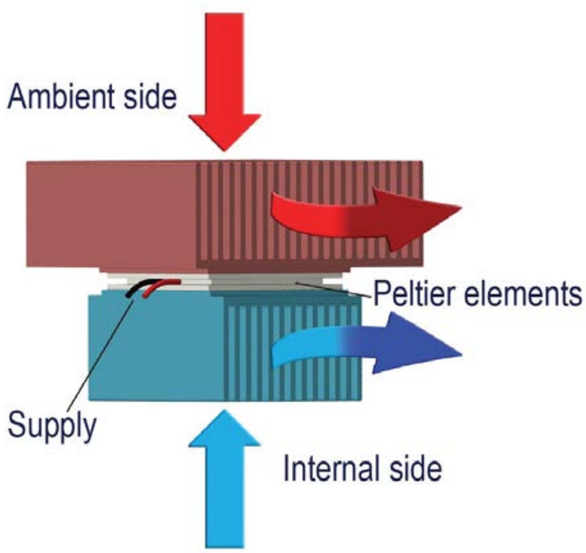
Agency Approvals

- CE, RoHS
- UL Recognized File number: SA32278
- NEMA 4X
- IP 66

SoliTherm® Thermoelectric Cooler General Specifications							
Part Number	*Nominal Power / Max (W)*	*Cooling Capacity*	*Operating Voltage*	*Inrush Current (A)*	*Max Current (A)*	*Recommended Fuse Size (A)*	*Integral Thermostat*
3035303	44 - 52	100 BTU/H [30W]	24 VDC	4.0	2.2	5	No
3050303	58 - 60	170 BTU/H [50W]		3.7	2.5	4	
3102303	115 - 118	340 BTU/H [100W]		7.4	4.9	8	
3152303	170 - 180	510 BTU/H [150W]		11	7.5	10	
3200303	260 - 280	680 BTU/H [200W]		17	11.6	16	
6105313	125 - 139	340 BTU/H [100W]	120 VAC	1.6	1.2	2	Yes
6105323			230 VAC	0.8	0.6	1	

Notes: Power and Cooling Capacity values are for 95°F [35°C] internal and ambient temperatures. Refer to Performance Graphs for values corresponding to other conditions.
Fuses are Class T Time Delay.

Airflow Example



THERMOELECTRIC COOLING PRINCIPLE

Vortex Coolers

Applications

Compressed air cooling is used where conventional enclosure cooling byair conditioners or heat exchangers is not possible. (Examples: Small to medium size enclosures, nonmetallic enclosures, and areas where the size of cooling devices is restricted)

Mounting holes

- Mounts in a 0.25in [6 mm] electrical conduit knockout

Agency Approvals

- UL Recognized component [File E329932]UL/ NEMA 4, 4X

c UL US

Features

- Relief valves and seals built into the vortex coolers which enable the units to maintain the sealed nature of NEMA enclosures
- No freon
- Small physical size
- Creates cool air without refrigerants (no CFCs, HCFCs)
- Exceptionally reliable - no moving parts and virtually no maintenance
- No fans
- Stainless steel construction
- All replacement generators fit any of the vortex coolers. No need to purchase a new cooler if you need to change your cooling capacity
- 5-year warranty

Requirements

- Uses clean, dry, oil-free compressed air (80 to 100 PSIG / 70° F or below) required to achieve published BTU/H ratings. Lower pressures and/or higher temperatures will reduce BTU/H rating
- A 5-micron water and particulate removal filter must be installed prior to any vortex cooler operation
- An oil removal filter can be installed between the 5-micron filter and the Vortex Cooler if oil is present in the compressed air line
- Thermostats, filters, regulators, and valves that work with Stratus Vortex Coolers are sold separately. Kits that include these items are listed later in this section
- Operation above 100 PSIG is not recommended. The use of a pressure regulator will be necessary for higher pressures
- How vortex coolers create cold air

Compressed air is injected into the vortex tube at extremely high speeds and that creates a cyclone, or vortex, spinning a million revolutions per minute. Part of the air is forced to spin inward to the center and travels up a long tube where a valve turns the spinning column of air inside itself. The inside column of air gives up its heat to the outside column. The cold air is directed out the cold end of the Vortex Tube and the hot air is directed out the other end of the Vortex Tube. And since there are no moving parts there is little need for maintenance.

Part Type	Part Number	Price	Description	Capacity BTUH [W]	Air Consumption SCFM [SLPM]
Vortex Coolers	TV08-005-4X	$362.00	Stratus vortex cooler, stainless steel body. For NEMA 4/4X/12 enclosures. Distribution tube and muffler included.	500 [147]	8 [227]
	TV10-006-4X	$362.00	Stratus vortex cooler, stainless steel body. For NEMA 4/4X/12 enclosures. Distribution tube and muffler included.	600 [176]	10 [283]
	TV15-010-4X	$362.00	Stratus vortex cooler, stainless steel body. For NEMA 4/4X/12 enclosures. Distribution tube and muffler included.	1000 [293]	15 [425]
	TV25-018-4X	$362.00	Stratus vortex cooler, stainless steel body. For NEMA 4/4X/12 enclosures. Distribution tube and muffler included.	1800 [528]	25 [708]
	TV35-025-4X	$362.00	Stratus vortex cooler, stainless steel body. For NEMA 4/4X/12 enclosures. Distribution tube and muffler included.	2500 [732]	35 [991]
Replacement Generators	TV08-G	$11.25	Stratus vortex generator, replacement, polypropylene, white. Fits all Stratus TV series vortex cooler bodies.	500 [147]	8 [227]
	TV10-G	$11.25	Stratus vortex generator, replacement, polypropylene, orange. Fits all Stratus TV series vortex cooler bodies.	600 [176]	10 [283]
	TV15-G	$11.25	Stratus vortex generator, replacement, polypropylene, red. Fits all Stratus TV series vortex cooler bodies.	1000 [293]	15 [425]
	TV25-G	$11.25	Stratus vortex generator, replacement, polypropylene, blue. Fits all Stratus TV series vortex cooler bodies.	1800 [528]	25 [708]
	TV35-G	$11.25	Stratus vortex generator, replacement, polypropylene, yellow. Fits all Stratus TV series vortex cooler bodies.	2500 [732]	35 [991]

Enclosure Cooling – Selecting a Heat Exchanger

Heat Exchanger Selection

To select the proper size heat exchanger, the worst-case conditions should be considered. For a heat exchanger to work, the ambient air temperature must be lower than the desired internal enclosure air temperature.

There are three main factors in choosing a heat exchanger for an uninsulated metal NEMA rated enclosure located indoors:

- Internal heat load
- Delta T
- Heat load transfer

Internal Heat Load

Internal heat load is the heat generated by the components inside the enclosure. This can be determined by a few different methods. The preferred method is to add the maximum heat output specifications that the manufacturers list for all the equipment installed in the cabinet. This is typically given in Watts.

Delta T (ΔT)

Delta T = maximum allowable internal enclosure temperature °F – maximum outside ambient temperature °F.

Heat Load Transfer

Heat load transfer is the heat lost (negative heat load transfer) or gained (positive heat load transfer) through the enclosure walls with the surrounding ambient air. This can be calculated by the following formulas:

Surface Area (sq. ft.) = 2 [(H x W) + (H x D) + (W x D)] / (144 sq. inches/sq. ft.)

Note: Only include exposed surfaces of enclosue in calculations. Exclude surfaces such as a surface mounted to a wall.

Heat Load Transfer (W/°F) = 0.22 W/°F sq. ft. x surface area

Note: Use 0.22 Watts/°F sq. ft. for painted steel and non-metallic enclosures. Use.10 Watts/°F sq. ft. for stainless steel and bare aluminum enclosures.

Cooling Capacity

Once you have determined your Internal Heat Load, the Heat Load Transfer and the Delta T, you can choose the proper size unit by calculating the needed cooling capacity.

Cooling Capacity (W/°F) = Internal Heat Load / ΔT - Heat Load Transfer

Heat Exchanger Selection Example

A NEMA 12 Wiegmann N12302412 enclosure (30 in [762 mm] high x 24 in [610 mm] wide x 12 in [305 mm] deep) contains a GS3-4010 AC drive 10 HP 460 volt) that has a maximum allowable operating temperature of 104°F and is located in a warehouse that has a maximum outside ambient air temperature of 90°F.

Power to be dissipated is stated in the specifications of the GS3-4010 and is found to be 345 watts.

Internal heat load:

Internal Heat Load = 345 Watts

Delta T:

ΔT (°F) 104°F – 90°F = 14°F

Heat load transfer:

Surface Area (ft.2) = 2 [(30 x 24) + (30 x 12) + (24 x 12)] / 144 sq. inches = 19 ft.2
Heat Load Transfer = 0.22 x 19 ft2 = 4.2 Watts/°F

Cooling capacity:

Cooling Capacity = 345 Watts/14°F - 4.2 Watts/°F = 20.4 Watts/°F

In this example, you are able to determine that a heat exchanger, with a capacity of at least 20.4 Watts/°F is needed, such as a Stratus TE30-030-17-04 or a Saginaw Enviro-Therm SCE-HE24W120V.

*This selection procedure applies to metal and non-metal, uninsulated, sealed enclosures in indoor locations. This selection procedure gives the minimum required size; be careful not to undersize when purchasing.

Air To Air Heat Exchangers

Consider a Better Solution: Air to Air Heat Exchanger

- Always closed loop
- Low cost
- Easier to mount on only one side of your enclosure
- Energy efficient; uses no more power than a filtered fan system
- Filter-free; no diminished cooling capacity

Applications

A closed loop cooling system which employs the heat pipe principle to exchange heat from an electrical enclosure to the outside.

Construction

- Heat pipe technology
- Closed loop design

Listings

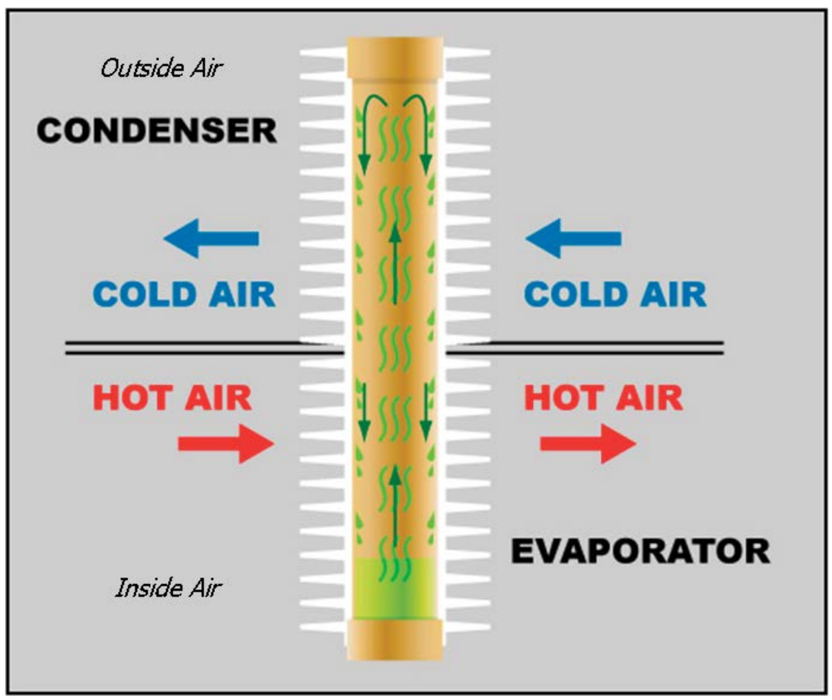
- UL File: SA34086
- Made in USA

Features

- All units are available in NEMA 4 and 4X
- Available in 120 VAC and 24 VDC
- Motors have a sealed overload protector
- Finned evaporator and condenser sections provide a closed loop
- Coil systems use aluminum end plates and baffles which improve conduction and reduce corrosion for longer life
- UL/cUL listed

Tall, compact, and deep body styles shown

Air to Air Heat Exchange



The Air to Air Heat Exchanger is a closed loop cooling system which employs the heat pipe principle to exchange heat from an electrical enclosure to the outside. Where ambient temperatures are suitable for heat pipes, they are the most efficient method of cooling as the waste heat is the engine which drives the system. The only power requirement is to operate two circulating fans or blowers.

Heat pipes have a liquid refrigerant under a partial vacuum inside sealed tubes. They operate with a phase change process which is much like that of mechanical air conditioning, but without the compressor. Each heat pipe has an evaporator section and a condenser section which are separated by a permanent baffle so as to provide a closed loop. The bottom of each heat pipe is in contact with heated air from the electrical enclosure. When the enclosure air reaches approximately 75° F, the refrigerant changes to vapor phase (boils) and the vapor (steam) rises to the top of the tube which is in contact with cooler outside (ambient) air.

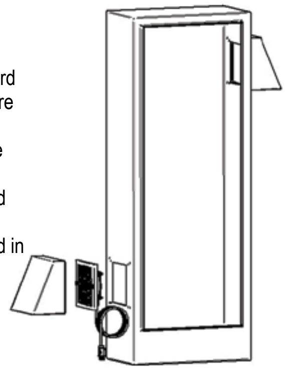
When the outside air temperature is lower than the enclosure temperature, the refrigerant vapor gives up heat to the outside air and returns to the liquid phase. It then falls to the bottom and repeats the cycle endlessly so long as there is a negative temperature differential between the enclosure and outside. Heat pipes will not operate in reverse cycle so heat cannot be transferred from the ambient to the interior of the enclosure. Although the operation is self limiting, thermostatic control can be used to shut off the fans when not needed.

The Stratus design has a top-to-bottom enclosure air flow pattern with maximum separation of the inlet and outlet. This design pulls the hottest air from the top of the enclosure and returns the cooled air from the bottom of the heat pipe to the enclosure. The air flow on the ambient side is bottom in, top out, so that the hotter discharge air moves up and away rather than being recirculated.

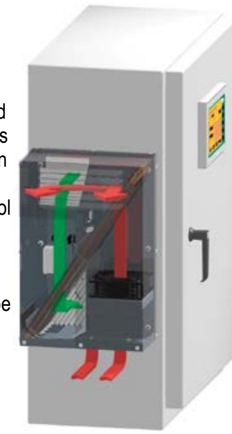
The units use aluminum end plates and baffles which improve conduction and reduce corrosion for longer life. The center aluminum baffle, which is swaged into the heat pipe coil, provides an air tight seal between the two air systems.

Air To Air Heat Exchanger Specifications

In this image, a standard installation shows where the dirt and particulate will enter the enclosure and be pulled in by the fans on your drives and devices. Filters or not, contamination is invited in by this open loop approach.



In this image, a standard installation demonstrates the closed loop condition maintained by the Air to Air Heat Exchanger. Cool air inlet and outlet vents are completely covered by the heat exchanger. This provides NEMA type 4 or 4X.



Stratus Air to Air Heat Exchangers General Specifications

Part Number	TE20-015-17-04	TE20-015-17-4X	TE20-015-24D-04	TE20-015-24D-4X	TE30-030-17-04	TE30-030-17-4X	TE30-030-24D-04	TE30-030-24D-4X	TE40-050-17-04	TE40-050-17-4X	TE40-050-24D-04	TE40-050-24D-4X
Price	$1,800.00	$1,881.00	$1,853.00	$1,933.00	$1,860.00	$1,996.00	$1,912.00	$2,043.00	$2,433.00	$2,530.00	$2,560.00	$2,657.00
Operating Voltage Range (V)	± 10%											
Inrush Current (Start Up Current) (A)	1.92		3.90		1.92		3.90		2.59		9.70	
Loading Current (Running Current) (A)	0.37		0.80		0.37		0.80		0.47		1.94	
SCCR (Short Circuit Current Rating) (A)	Refer to Footnote 1											
Recommended Circuit Protection Device Rating (A)	1.5		2.5		1.5		2.5		2		6	
VA Rating (W)	42		20		42		20		56		47	
Refrigerant Type (oz)	Methanol (0.41)		Methanol (0.41)		Methanol (0.81)				Methanol (1.22)			
Watts/°C (F°)	22 (12)				44 (24)				71.6 (40)			
Free Air Flow (CFM)	131		127		131		127		211		235	
Weight Without Packaging (lbs)	16				19				32			
Body Style	compact				deep				tall			
Material Type	[2]CRS with ANSI 61 gray powder coat	[3]Stainless Steel	[2]CRS with ANSI 61 gray powder coat	[3]Stainless Steel	[2]CRS with ANSI 61 gray powder coat	[3]Stainless Steel	[2]CRS with ANSI 61 gray powder coat	[3]Stainless Steel	[2]CRS with ANSI 61 gray powder coat	[3]Stainless Steel	[2]CRS with ANSI 61 gray powder coat	[3]Stainless Steel
Voltage/Hz	120 VAC 50/60		24 VDC		120 VAC 50/60		24 VDC		120 VAC 50/60		24 VDC	
Maximum Ambient Temperature	160°F (71.1°C)											
Agency Approval	UL File: SA34086											

Notes: [1] SCCR rating is based on the SCCR rating for the circuit protection device installed in the panel / enclosure per UL50 and UL508a to protect the AC unit Typically 10KA for Fast Acting Fuses.
[2] Cold-rolled steel with ANSI-61 gray polyester powder coating inside and out.
[3] Fabricated from 16-gauge 304 stainless steel.