

Thermoelectric Cooling : A Closer Look

Thermoelectric cooling can be the best choice for harsh military and aerospace environments, especially in remote, hard-to-reach locations. At times thermoelectric technology is overlooked due to upfront cost or power requirements. However, the latest improvements to the technology make a second look worthwhile.

By EMILY HUTENSKY

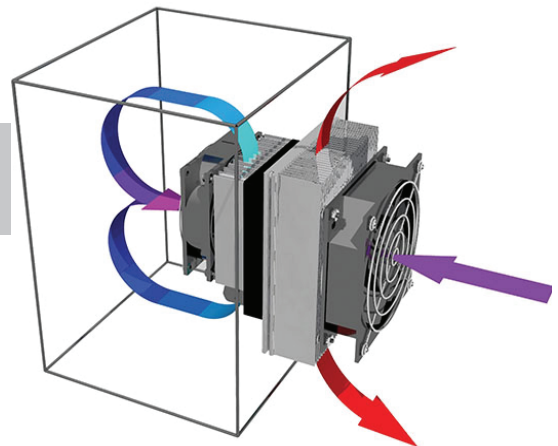
OPENING AN ENCLOSURE and blowing a fan on heat sensitive components to avoid over-heating is never advisable. Exposing equipment to ambient dirt and debris can cause damage over time and it can increase the risk of shock to those working around the area. For these reasons, it is best to have an active cooling system in place as part of your enclosure. A few different cooling technologies are outlined below.

Vapor-cycle air conditioners have their place but are a maintenance challenge when placed in hard-to-access, remote areas. Whether it is difficult installation, refrigerant leaks due to nearby vibrations, expensive compressor replacements or all of the above, end users can find refrigerant based cooling to be inconvenient and expensive to maintain in certain applications.

Heat exchangers and heat pipes are limited in performance due to ambient conditions. Certain applications will require more cooling than these technologies can provide. Note as well that compressed air products will require the expense of maintaining a compressed air supply.

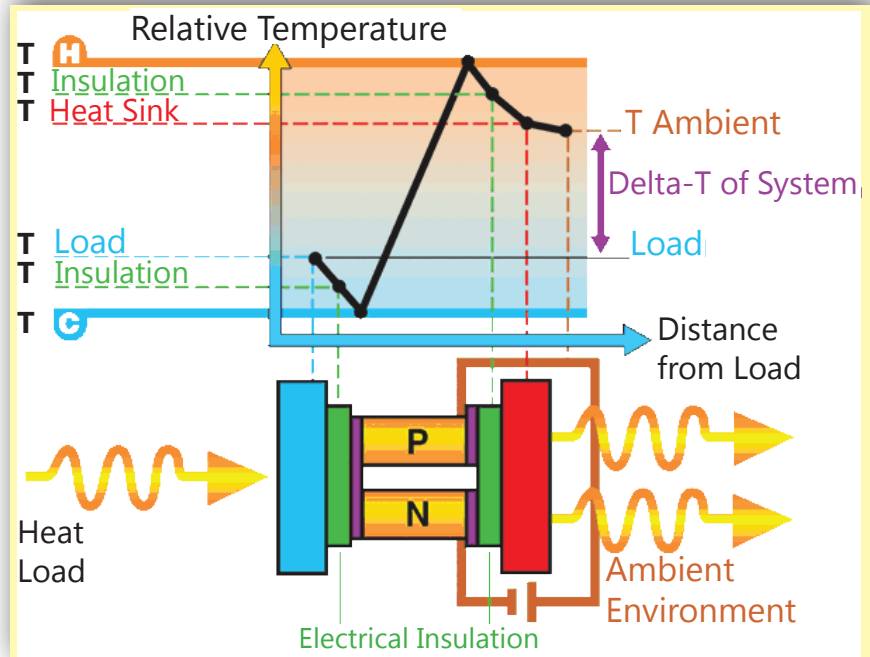
Thermoelectric technology has seen advances and improvements in recent years. In addition, maintenance costs are minimal to none and performance excels in high ambient conditions.

Thermoelectric air conditioners create a closed loop system. There is no exchange of ambient air into the enclosure.



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The cooling is created via the Peltier effect: a solid-state method of heat transfer through dissimilar semiconductor materials. The three main working parts in a thermoelectric cooling system are a cold junction, a heat sink, and a DC power source. Two dissimilar conductors replace refrigerant in both liquid and vapor form. The cold sink (evaporator surface) becomes cold through absorption of energy by the electrons as they pass from one semiconductor to another, (instead of energy absorption by a refrigerant as it changes from liquid to vapor). The DC power source pumps the electrons from one semiconductor to another, and the heat sink (condenser) discharges the accumulated heat energy from the system.



Real World Use & Application Examples

Industries across the board have a need for thermoelectric cooling in certain applications. The greatest amount of use comes from the military and aerospace industries. Harsh field environments are common in these industries. Thermoelectric cooling is prized for its reliability and its performance under such harsh conditions.

The life expectancy of a thermoelectric device is exceptionally high due to its solid state construction. For individual thermoelectric modules, mean time between failure (MTBF) from 2000,000 to 3000,000 hours (at room temperature) and 100,000 hours at (at 80°C ambient) have been calculated. In a military or aerospace application, this reliability is critical. Thermoelectric air conditioners will reliably protect mission critical electronics, with very little required maintenance.



Military transit case cooling example. Thermoelectric air conditioners can be built for mobile applications, full shock & vibration, and corrosive environments such as salt spray and blowing sand.

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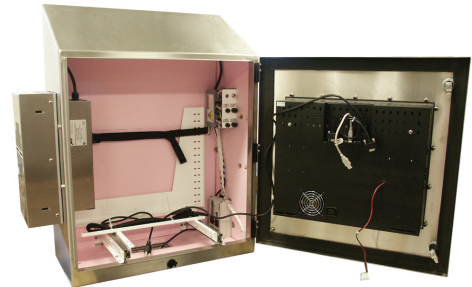
Cooling electronics equipment in NEMA-4X and CID2 enclosures poses additional risks from the ambient conditions. Thermoelectric air conditioners will maintain the NEMA-4X and CID2 enclosures, keeping ambient heat and environmental debris from entering the enclosure. Thermoelectric air conditioners actually **perform better** in higher ambient temperatures (see performance curve, last page). Corrosive ambient conditions such as blowing sand or salt spray do not pose a threat. Nor does shock and vibration exposure. Military-grade sealed fans and components are used in some thermoelectric air conditioners to meet these harsh conditions.

Another application example is the food and beverage industry, in which thermoelectric air conditioners are often used as part of a plant's automation system. Cooling sensitive instrumentation equipment, control computers, thin clients and monitors, thermoelectric products excel in high ambient temperatures and can maintain NEMA-4 and NEMA-4X enclosures in wash down and corrosive areas.



Left: cooling control electronics in a beverage plant.

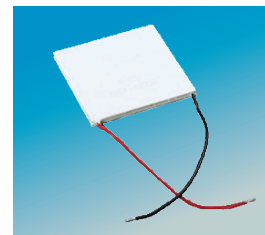
Right: cooling communications equipment in a poultry plant.



Why Thermoelectric?

Thermoelectric air conditioners are environmentally friendly. Free of refrigerants or other ozone depleting chemicals, thermoelectric coolers are solid-state products. There is virtually no maintenance associated with a thermoelectric cooler. There is no filter to change, no compressor and the only moving part is the fan. This also means a long life expectancy.

*Single
thermoelectric module*

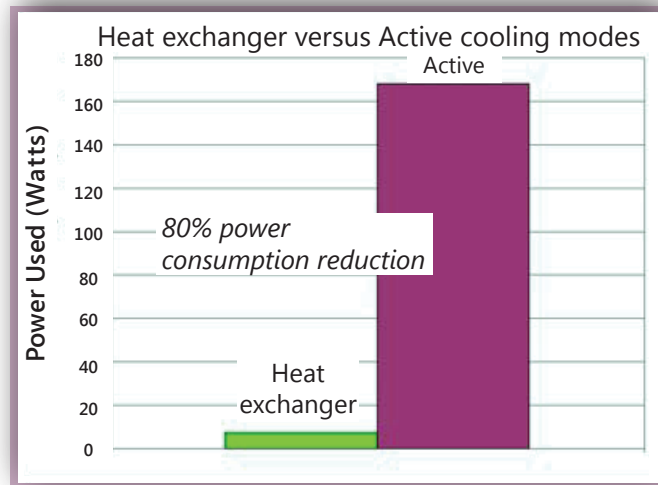


Performance ratings and power efficiency ratings are significantly improved from what was available in the past. It is now possible to get up to a half ton of cooling from a thermoelectric cooler. This allows for thermoelectric cooling to be used in applications

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as small as camera housing (typically 100 to 200 BTU/hr) or as large as communications and equipment enclosures (typically 3,500 to 6,000 BTU/hr). Some coolers can offer a power saving heat exchanger mode. In low demand situations, power consumption can be reduced by as much as 80%.

The reduced need for maintenance and replacement parts must be considered as part of the value added to using the technology. Under normal conditions, a thermoelectric air conditioner may last 7 years (or much longer in many cases), without requiring a repair. Such repairs are likely to be simple, such as replacing a fan.



*power efficiency example:
teca model AHP-470*



Even small (100 or 200 BTU/hr) thermoelectric air conditioners can be built to thrive in harsh military conditions.



Today thermoelectric technology can be used in ever broader applications thanks to the advent of higher performance products. Up to 6,000 BTU/hr of cooling is now possible with thermoelectric technology.

Recent Changes to Thermoelectric Technology

In recent years, there have been innovations and improved products in the thermoelectric market. In the past, thermoelectric air conditioners were limited in performance to about 2,000 BTU/hr. Now, increasingly efficient designs are allowing for air conditioners with up to a half ton of cooling. This is partly design innovation but also due to higher quality, more robust materials that are now available to manufacturers. This includes high efficiency heat sinks and thermoelectric modules with significantly increased reliability and efficiency. Thermoelectric coolers can cool more, they are able to cool more

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efficiently and can be used as heaters by reversing the polarity of the thermoelectric module (without sacrificing reliability). This allows more thermoelectric products to offer both cooling and reliable heating as the demand exists. By using the thermoelectric modules for heating, efficiency is increased since electric heaters are not needed. Using advanced materials in combination with innovative designs any thermoelectric solution is, today, able to offer tighter and more precise temperature control.

Choosing a System : Factors to Consider

1. The Crucial Importance of Fan Type

Fan type is easily the component an end user should want *most* to ask about when shopping for an enclosure cooler. The IP (Ingress Protection) standard describes a uniform system for classifying the degree of protection provided by a given enclosure of electrical equipment. The first number refers to the level of protection against penetration of solid objects into the enclosure. The second number refers to the level of protection against penetration of liquids into the enclosure.

Air conditioners should - and often do - have *both* internal and external IP ratings. The external rating is most influenced by the fan selection of the hot side of the air conditioner (the side that is external to enclosure). Shipboard or desert environments call for hot side fans that can withstand corrosives such as salt spray or blowing sand. Rugged mobile applications require shock and vibration protection which affects both hot side and cold side fan choice.

Therefore, it is quite crucial to check with the manufacturer about what type of fan is being used in an air conditioner and what other choices might be available. There are industrial fans, fans sealed from water, fans protected from water AND corrosives (such as salt, sand) and lastly, MIL-spec fans. Any of these will offer some protection however the higher the IP rating of your enclosure, the more rugged a fan you will require in your air conditioner in order to maintain the integrity of your enclosure.

NEMA Rating	IP Rating
1	10
2	11
3	54
4	56
4X	66
6	67
12	52
13	54

Note: The comparison chart above is an approximation

Thermoelectric air conditioners are meant to maintain the enclosure rating and operate in that environment. Check the product literature or discuss your environment with the air conditioner manufacturer to ensure the air conditioner you choose will be suitable.

2. How much cooling is needed

The total load is created by: the heat your equipment is generating as well as ambient conditions, delta-T, enclosure size, etc. The amount of cooling required will be determined by many factors including the details of the enclosure and surrounding environment. There are many sizing tools available online, free from thermoelectric air conditioning manufacturers and enclosure manufacturers.

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3. Allowable Enclosure Temperatures

Thermoelectric air conditioners are often used to cool equipment to below ambient. Most electronics are rated to operate safely up to 110F or so. Therefore 95F might seem like a warm set point but actually, cooling to 95F is more than cool enough to keep electronics happy and running. Using an air conditioner that is too large can mean less efficiency. Cooling significantly below ambient than what is needed can cause excessive condensation.

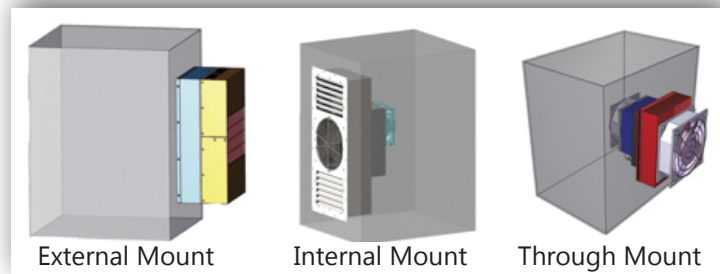
In other words, design for allowable conditions both inside and outside the enclosure. This includes basing maximum allowable internal temperature around the known operating limits of your equipment rather than an arbitrary temperature. Do not forget to consider the minimum allowable enclosure temperature. If heat is needed in winter months, an air conditioner with heat function can be considered.

4. Ambient Temperature Range

Along with understanding the environment, know what the ambient temperature range is expected to be. In an outdoor application this range might be much larger than anticipated. Planning for the worst case scenario is advisable.

5. Mounting style

A thermoelectric air conditioner will be designed by the manufacturer to be mounted part way through the enclosure ("through mount"), external to the enclosure ("flush mount") or inside the enclosure



("internal" or "recessed" mount). Operation in any orientation is possible. Typically through mounted systems are the least expensive and offer greater cooling capacity. Although the true driving factor when choosing ought to be the design of the enclosure and location of other equipment. The air conditioner will perform best where there is adequate air flow. Choose the mounting style which gives both the hot side and cold side of the air conditioner at least several inches of breathing room whenever possible.

6. Input Voltage

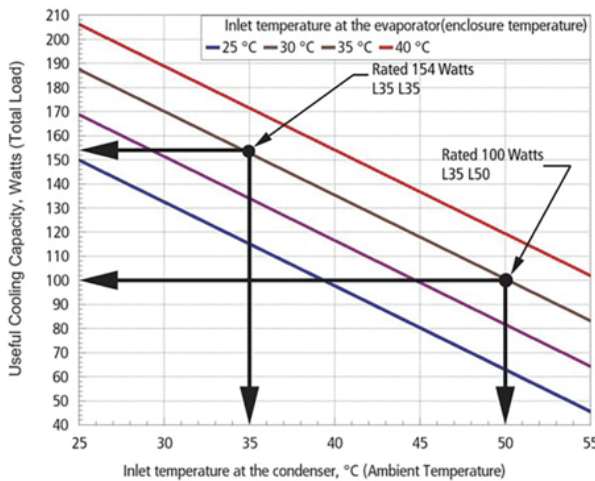
Most thermoelectric air conditioners are available in a multitude of input voltages. Systems with more cooling capacity are likelier to be 120 or 240 VAC although this is not always so. Larger systems running off of 24 VDC will naturally have a higher current draw as there are more thermoelectric modules used to obtain the cooling capacity. If using VDC input, any power supply added to the enclosure interior will add to the total heat load. This is an important consideration when determining the cooling requirement.

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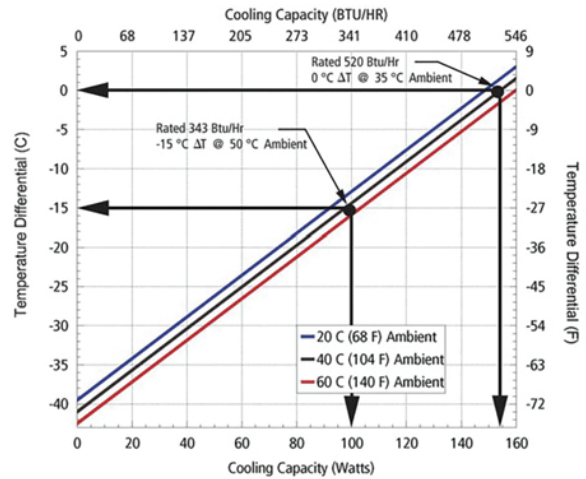
7. What to Notice Regarding Air Conditioner Specs

Currently, more conventional performance curves referencing the DIN 3168 L35L35 and L35L50 ratings are shown on air conditioner specifications. However, traditional curves referencing delta-T are still used. Be aware of what type of curve is being used and be sure you are comparing "apples to apples" when reviewing performance specs from different manufacturers. Ensure you are comparing air conditioners using the same rating method.

Example: Performance curve per Din 3168:



Traditional performance curve



Summary

Thermoelectric cooling remains somewhat of a specialty method of cooling. It is more expensive to manufacture compared to other cooling technologies. It is also incredibly reliable and requires virtually no maintenance. The initial purchase price is well justified by the lack of maintenance costs in the long run and the ease of use. It is best suited to harsh outdoor environments or to applications where low maintenance is required. Considering the improvements to the technology and the designs, there are now more reasons to consider it and many more places where it can be used.

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