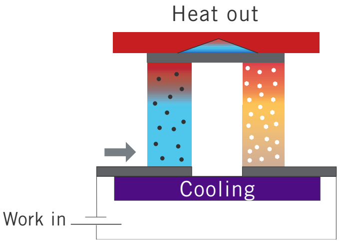
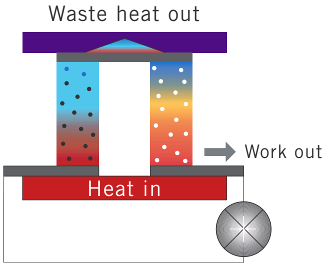
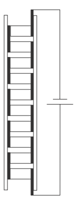
Thermoelectrics and how it works

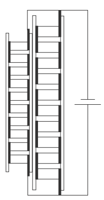


Heat Pump (Refrigerator) Peltier (1834)
The thermoelectric Peltier effect is the most direct way to utilize electricity to pump heat. Electric current (work input) forces the matter to approach a higher energy state (black dots) and heat is absorbed (cooling).
The energy is released (heating) as the matter approaches a lower energy state (white dots). The net cooling or heating effect is proportional to the electric current and Peltier coefficient.



Power Generator Seebeck (1822)
Thermoelectric material can also be used to generate electricity. Some of the heat input is converted to electric current (work), as the higher energy matter (black dots) releases energy and cools to a lower energy state (white dots). The net work is proportional to the temperature difference and Seebeck coefficient.

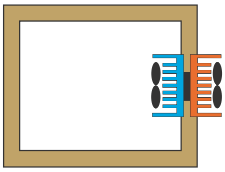

Single stage


Multistage

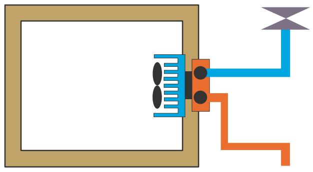
Thermoelectric modules
The material used at working temperatures up to 150ºC is normally bismuth telluride, doped to obtain p (positive) and n (negative) semi-conducting properties.
A number of pn-couples, thermally parallel and electrically in series, are sandwiched between ceramic plates.
The maximum temperature differential (ΔT_{max}) between the cold and the warm side of a Supercool single stage module is up to 75ºC at warm side temperatures of 25ºC or ΔT = 85ºC at a warm side temperature of 50ºC. By increasing the number of stages in a multistage arrangement, you also increase maximum ΔT.

Guidelines for selecting your TE system

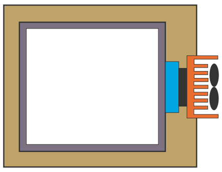
Below you see different types of TE assembly principles and how they can be employed. What type of assembly is suitable for your application?



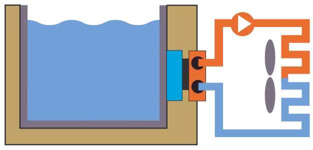
AA = Air to Air system
Air in an enclosure is cooled and the heat is dispersed to the surrounding Air.



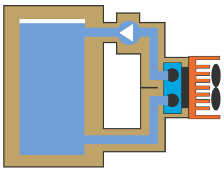
AL = Air to Liquid system
Air in an enclosure is cooled and the heat is dissipated to the Liquid from a tap.



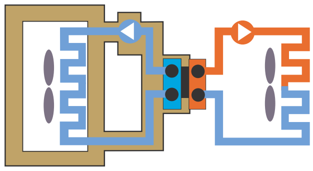
DA = Direct to Air system
Solid surfaces are cooled Directly and the heat is dissipated to the surrounding Air.



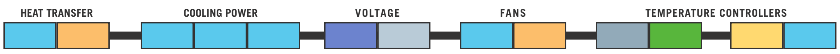
DL = Direct to Liquid system
The solid surface is cooled Directly (it can then cool any other substance). The heat is dispersed to a Liquid.



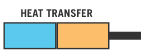
LA = Liquid to Air system
The Liquid circuit is cooled gradually and the heat is dispersed to the surrounding Air.



LL = Liquid to Liquid system
The Liquid circuit is cooled gradually and the heat is dispersed to a Liquid.

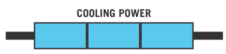


For a detailed description of our assembly product code, please visit our website.



Heat transfer methods

The Cold Side can be designed as follows:
A = Air cooling. D = Direct cooling of solid.
L = Liquid cooling. The warm side is normally cooled by an Air heat sink (A). However, Liquid heat sinks (L) can be used when you need a compact system or in a laboratory, for example, where process water is available.
All our heat sinks are made of aluminum extrusions with excellent thermal transfer.
Furthermore, anodization provides superior environmental protection. And if your application calls for custom designed heat exchangers, be sure to ask us. They're available on request.



Cooling (heating) power

When you know the cooling power (P_C) needed at a maximum specified temperature difference (ΔT) in your application, you can select the correct size and type of TEA.
For information on cooling power versus ΔT, we refer you to the diagrams for each assembly type.
According to th e Carnot principle, heating power: $P_h = P_C$ + Power input. You'll find the power input in the respective product specifications.
When a ΔT greater than the capacity of single stage systems is required, we supply assemblies with 2-stage TE modules. More or less any cooler can be cascaded on request.

Voltage

As the thermoelectric principle requires DC voltage, our TE assemblies are intended for DC operation only. All standard assemblies are designed for either 12 or 24 V DC operation. However, we also supply 48 V DC versions of larger assemblies and 5 V versions of the smallest assemblies.
Input voltage for the standard fans has to be within ±10% of nominal voltage and with max. 5% ripple for optimum functionality and service life. Do NOT use switched PWM voltage for the fans.
Input voltage for the TEMs can be reversed for heating, regulated down to 0 V DC and up to ±110% of nominal voltage. For switched PWM voltage, use a PWM frequency above 5 kHz to prevent service life reduction due to thermal cycling effects on the TE modules.

Fans

The fan is the only moving part in a thermoelectric assembly (Air systems). Consequently, there's an obvious correlation between the service life of the fan and the service life of the assembly. All standard fans are brushless with ball bearings.
Expected service life at 25°C is 50,000 hours (L10). We also provide fans with IP55 moisture protection, high performance fans with a service life of 100,000 hours (L10) or other fans suitable for your application. For more information, see page 17 or contact Supercool.

Temperature control

Supercool offers a broad range of controllers for a variety of applications.
Below are some aspects to consider when selecting a controller for your application:

- Required temperature accuracy and hysteresis
- Temperature range of your application
- Max. current requirements
- Is your application only for cooling or cooling/heating (reversible)
- Requirements regarding system efficiency (COP)
- Need for programming communication (RS232) or display of set values
- Need for alarm signal outputs, low voltage protection etc.

Please see page 14-15 for a description of available controllers.

In order to maximize the reliability and service life of your TE system, bear in mind the following:

- When regulating in ON/OFF mode make sure cycle time is 60 sec. or more
- If you use your own PWM-controller make sure the switching frequency is 5 kHz or more
- Do NOT use switched PWM voltage for the fans. Use separate true DC power input for fans.
- In critical applications, we recommend our EC-26 or PR-59 *(see page 14-15)* to minimize thermal stress.

Guidelines for installing your TE assembly

General:

- Minimize thermal losses and condensation by insulating all possible cold surfaces in your system (DA, DL, LA, LL).
- Secure good ventilation on the warm side (AA, DA, LA). Separate the inlet air from outlet air, if necessary by using air-ducts and hosing *(see page 17)*. If the warm side is built-in, make sure the inlet air comes from the outside.
- Be sure to use an external fuse with a rating of at least 150% of nominal current.

AA assemblies

- For non-insulated (electronic) cabinets, the warm air on the warm side must not heat up the cabinet, while cold air on the cold side should not blow directly onto the cabinet.
- Check that the enclosure is sealed and that there is a tight fit between assembly and cabinet.
- For insulated cabinets, make sure you have sufficient insulation and that there are no cold bridges.
- In a condensing environment, be sure to mount the cold side heat sink fins in a vertical position in order to drain the condensation.

DA/DL assemblies

- The cooled object is attached to the cold plate with 4-9 screws. Apply a thin layer of thermal conductive compound between surfaces.
- To ensure optimum performance, the flatness of the cooled object should be 0.05 mm/100 mm.
- When cooling a container or tank, use 3-5 mm of Al sheet (or equivalent) to ensure good thermal transfer. If you use a stainless steel tank, remember to mount an Al sheet with a larger surface area than the cold plate to improve thermal transfer.

LA/LL assemblies

- For superior performance even at lower liquid flow rates, or when a gas is cooled, turbulators are inserted into the liquid channels. Should your application call for a lower pressure drop, the turbulators can be removed.
- Recommended liquid flow on the warm side is 2 lit/min or more. Lower liquid flow rates lead to a slight reduction in cooling power.
- Recommended liquids are water with glycol or Fluorinert (3M).
- Remember to use a pump with the lowest thermal leakage and heat generation.
- Be sure to insulate the liquid heat sink and tubing to reduce thermal leakage.