



## APPLICATION NOTE AN-016

### Operating TECs to $-40^{\circ}\text{C}$ and Below

April 5, 2019, Rev A

#### TEC Pumping Capacity

A TEC's thermal pumping capacity significantly degrades as temperatures drop.

Using a CP14,127,06 as an example:

- Pumps a maximum of 52 watts at  $25^{\circ}\text{C}$ ,  $I_{\text{max}}$  at 6.81 Amps,  $V_{\text{max}}$  15.3 Volts
- Pumps a maximum of 45 Watts at  $0^{\circ}\text{C}$ ,  $I_{\text{max}}$  6.82 Amps,  $V_{\text{max}}$  13.5 Volts
- Pump a maximum of 12 watts at  $-80^{\circ}\text{C}$ ,  $I_{\text{max}}$  at 6.08 Amps,  $V_{\text{max}}$  at 7.2 Volts

The max current stays fairly consistent but  $V_{\text{max}}$  drops due to internal resistance. Max current begins to drop at about  $-60^{\circ}\text{C}$ . The delta-T shrinks from  $65^{\circ}\text{C}$  to about  $8^{\circ}\text{C}$  at  $-80^{\circ}\text{C}$ . Once you get below  $-40^{\circ}\text{C}$ , it only really operates in a vacuum or really dry air/nitrogen.

#### Coolant

Operating to  $-40^{\circ}\text{C}$  and below is going to take sub-zero coolant. Lowering the coolant temperature will lower the power needed to cool the TEC, as the delta-T is smaller. Check the wetted materials list of the mount (and the rest of your system) for compatibility with various coolants.

#### Seals and Expansion/Contraction

To get to very low temperatures, you'll likely need to operate with a liquid well below freezing. At lower temperatures, leaks are a concern, as the o-ring seal will begin to harden as the temperature drops, and machining imperfections in the groove the o-ring sits in that would normally be sealed by a more pliable o-ring may start leaking. Operating with lower water pressure will help. The EPDM O-ring used in the mount will be at its limit should the water block reach  $-50^{\circ}\text{C}$ , where the O-ring is installed.

Another concern is the differential thermal expansion between the stainless-steel screws and the aluminum blocks they hold together. The contraction of the aluminum may loosen the compressive force the screws apply to keep the water block sealed. Not likely a big issue, but a consideration, especially if leaks do form at lower temperatures.

## **Wetted Materials**

Review the mount manual for a list of wetted materials. The 274, for example, should be fine with an ethylene glycol, but other coolants may have interactions. This can cause corrosion leading to potential damage to the mount or system. Your chiller and/or coolant manufacturer should be able to assist in evaluating options.

## **Temperature Sensor**

An RTD is recommended due to its relatively linear operating range. Most Arroyo Instruments mounts have the option for an RTD sensor. The BetaTHERM 10K sensor typically used in most Arroyo mounts can only operate down to about -44°C when used in the 10uA Thermistor sensor mode.

## **Multi-Stage TECs**

Multi-stage TECs are an option to increase the delta-T with higher temperature coolant, or even air-cooled heat sinks. The biggest drawback of multi-stage TECs is thermal capacity... the additional stages significantly reduce the thermal capacity of the system. If you are working with high power devices, a multi-stage solution could be problematic.