II-VI:

GUIDE TO WORKING WITH

THERMOELECTRIC MATERIALS

II-VI MARLOW

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PART ONE

How Efficient is a Thermoelectric Cooler?

Efficiency relates to the amount of energy produced from a machine versus how much energy one puts into it. In heat pumping applications, this term is rarely used because the energy-in is very different from the service provided. We supply electrical energy to a TEC, but the result is heat pumping.

For thermoelectric modules, it is standard to use “coefficient of performance”, not efficiency. The coefficient of performance (COP) is the amount of heat pumping divided by the amount of supplied electrical power. In other words, COP tells you how many units of heat pumping you will get for each unit of electrical power you supply.

It is possible, in certain situations, to pump more watts of heat than the watts of electrical power input. COP depends on the application, heat pumped, and temperature differential required. Typically, the coefficient of performance, heat pumped then divided by input power, is between 0.4 and 0.7 for single stage applications. However, higher COPs can be achieved with optimized, custom thermoelectric modules.

What is a Thermoelectric System Over a Compressor?

Thermoelectric coolers are solid-state heat pumps, which have no moving parts and do not require the use of harmful CFCs. Therefore, they are inherently reliable and require little or no maintenance. They are ideal for cooling applications that may be sensitive to mechanical vibration.

Their compact size makes them well suited for applications with space or weight limitations, such as portable or airborne equipment. The ability to use thermoelectric modules to heat or cool suits applications requiring temperature stabilization of a device over a wide ambient temperature range such as laser diodes.

PART THREE

What is the Best Way to Power and Control a TEC?

Thermoelectric coolers require smooth DC current for optimum operation. A ripple factor of less than 10% will result in less than 1% degradation in ΔT.

Voltage or current limiting should be used in order to ensure that Imax for the thermoelectric module is not exceeded. A bipolar power supply is required for those applications requiring both heating and cooling. Pulse width modulation may be used at frequencies above 1 kHz. A linear proportional, PI or PID control can also be used.

II-VI Marlow does not recommend an ON/OFF control. While this is the simplest control technique, temperature cycling within the thermoelectric module as power is cycled from full ON to full OFF may result in premature failure.

PART FOUR

How Big Can You Make a Thermoelectric Cooler in Length and Width? What Limits the Size?

About 50 mm in length by 50 mm in width is the typical upper size limit for TECs.

One side of the TEC contracts as it cools and the other side expands as it heats. This stresses the elements and solder joints. Since thermal expansion occurs on an inch per inch basis, the larger the cooler gets, the greater the stress becomes on the elements around the perimeter of the cooler.

In cases where the required heat pumping capacity exceeds that which could be provided by one TEC, additional TECs can be used side-by-side. In special cases, II-VI Marlow Industries will manufacture TECs up to 60mm x 60mm.

PART FIVE

What Simple Test Can I Use to Verify My TEC is Working Correctly?

Measuring electrical resistance is a good way to check the health of a TEC.

II-VI Marlow recommends taking an AC resistance measurement using a digital impedance meter or LCR. Using a standard ohmmeter with a DC input signal will not yield accurate readings, because DC voltage applied across the TEC will generate a temperature change and variations in resistance readings. Nominal AC resistance specifications for II-VI Marlow coolers are available upon request.

PART SIX

What do the TEG Parameter Mean?

Thermal resistance of a TEG represents the degree to which a temperature drop will occur across the device when heat flows through it.

When designing a thermal TEG system, this thermal resistance will often be used to select a TEG that thermally "matches" the heat sinks used in the application. VOC, or open circuit voltage, is the maximum voltage the TEG will ever produce. It is important to remember that the TEG voltage during operation will be considerably lower than this value; usually around ½ of VOC.

Efficiency is the ratio of electrical power produced by the TEG to the heat that flows through the TEG.

PART SEVEN

What do the Thermoelectric Parameters Imax, Vmax, dTmax, and Qmax mean?

As current flows through any material, heat is generated.

This principle also applies to thermoelectric material. At a certain point, the heat generated can internally offsets the thermoelectric module's ability to pump heat.

Each thermoelectric module has a heat-pumping limitation. This limit is referred to as Qmax.

The current associated with Qmax is referred to as Imax. The corresponding voltage across the coolers is referred to as Vmax.

If a TEC is completely insulated and isolated from the environment and running at Imax, it will produce its maximum temperature difference, dTmax. At this point, it will also be pumping no heat whatsoever.

As heat is applied to the cold side of the TEC, the temperature differential is suppressed. Effectively, one trades temperature differential for heat pumping. As such, if the temperature differential is 0, the corresponding heat load is Qmax.

The coefficient of performance (COP) is defined as the amount of heat pumping one gets for each unit of electrical power supplied.

PART EIGHT

What Does the Meaning of Nomenclatures -01, -02, -03, and AC, BC, AB, AN Mean?

-01 means both sides of the TEC are metallized, -02 means the bottom (hot) side is metallized and -03 means neither side is metallized (bare ceramic on both sides).

AC means Alumina ceramics. BC means Beryllia ceramics. AB means there is a mix of Alumina and Beryllia on top or bottom ceramics (or within the stages of a multi-stage thermoelectric cooler). AN means Alumina Nitride.