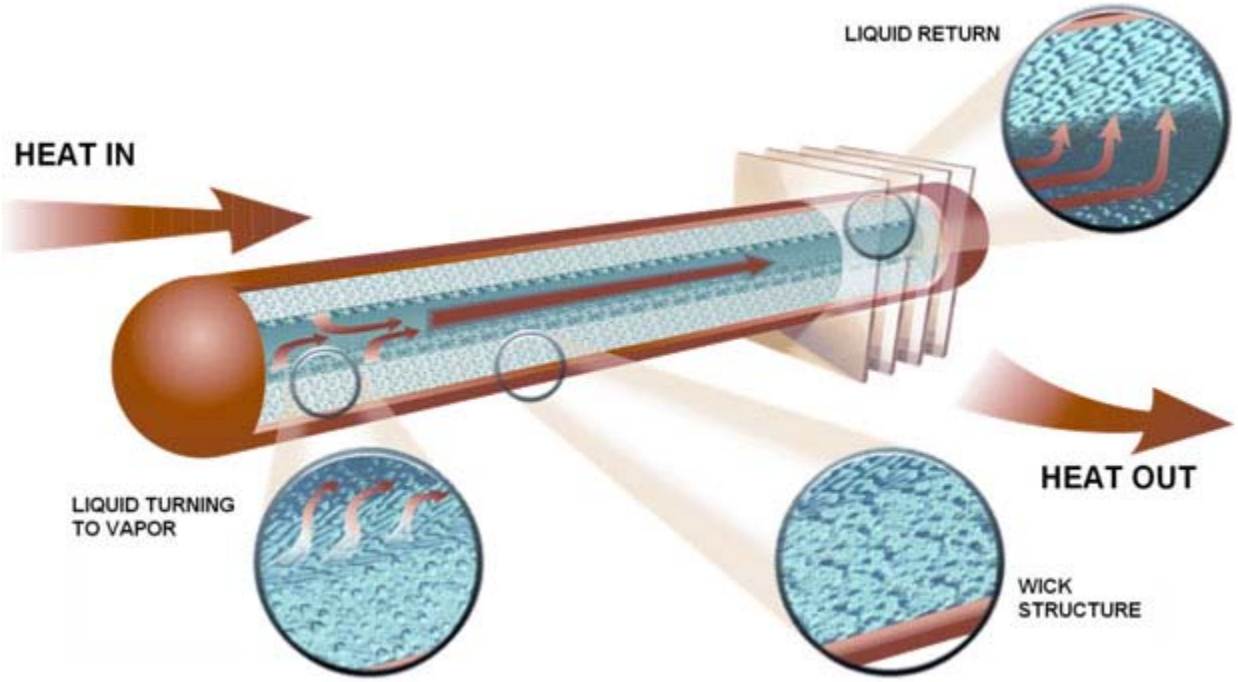
COMMON QUESTIONS ABOUT HEAT PIPES



What is a heat pipe?

A heat pipe is a heat transfer device with an extremely high effective thermal conductivity. Heat pipes are evacuated vessels, typically circular in cross sections, which are back-filled with a small quantity of a working fluid. They are totally passive and are used to transfer heat from a heat source to a heat sink with minimal temperature gradients, or to isothermalize surfaces.

How do they work?

Heat pipes transfer heat by the evaporation and condensation of a working fluid. As stated above, a heat pipe is a vacuum tight vessel which is evacuated and partially back-filled with a working fluid. As heat is input at the evaporator, fluid is vaporized, creating a pressure gradient in the pipe. This pressure gradient forces the vapor to flow along the pipe to the cooler section where it condenses, giving up its latent heat of vaporization. The working fluid is then returned to the evaporator by capillary forces developed in the porous wick structure or by gravity.

Do heat pipes work against gravity?

Yes, a heat pipe is said to be operating against gravity when the evaporator is located above the condenser. In this orientation, the working fluid must be pumped against gravity back to the evaporator. All heat pipes have wick structures that pump the working fluid back to the evaporator using the capillary pressure developed in the porous wick. The finer the pore radius of a wick structure, the higher against gravity the heat pipe can operate. A thermosyphon is similar to a heat pipe, but has no wick structure and will only operate gravity aided.

What fluids are used in heat pipes?

Heat pipe working fluids range from Helium and Nitrogen for cryogenic temperatures, to liquid metals like Sodium and Potassium for high temperature applications. Some of the more common heat pipe fluids used for electronics cooling applications are ammonia, water, acetone, and methanol. Thermacore has experience designing, developing, and manufacturing heat pipes with over 22 different working fluids for a variety of applications from cryogenic (-250°C) to high temperature (>1000°C)

Phone: 717-569-6551 *780 Eden Road, Lancaster, PA 17601-4794 USA* *FAX: 717-569-4797*
info@thermacore.com *www.thermacore.com* *717-569-8424*

Why does a water heat pipe work below 100ºC?

Water at atmospheric pressure boils at 100ºC. Inside a heat pipe, the working fluid (water) is not at atmospheric pressure. The internal pressure of the heat pipe is the saturation pressure of the fluid at the corresponding fluid temperature. As such, the fluid in a heat pipe will boil at any temperature above its freezing point. Therefore, at room temperature (20ºC), a water heat pipe is under partial vacuum, and the heat pipe will boil as soon as heat is input.

What are heat pipes used for?

Heat pipes are used for a wide variety of applications covering the complete spectrum of heat transfer applications. Heat pipes are ideal for any application where heat must be transferred with a minimum thermal gradient either to increase the size of heat sink, to relocate the sink to a remote location, or where isothermal surfaces are required. Typical applications include electronics cooling, isothermal furnace liners, and heat transfer for space applications.

What is the thermal conductivity of a heat pipe?

Heat pipes do not have a set thermal conductivity like solid materials due to the two phase heat transfer. Instead, the effective thermal conductivity improves with length. For example, a 4 inch long heat pipe carrying 100 watts will have close to the same thermal gradient as a 12 inch long pipe carrying the same power. Thus the 12 inch pipe would have a higher effective thermal conductivity. Unlike solid materials, a heat pipe's effective thermal conductivity will also change with the amount of power being transferred and with the evaporator and condenser sizes. For a well designed heat pipe, effective thermal conductivities can range from 10 to 10,000 times the effective thermal conductivity of copper depending on the length of the heat pipe.

Are heat pipes reliable?

Since heat pipes have no moving parts, they are extremely reliable. This is the main reason they are used extensively in space applications where maintenance is not available. The main cause of heat pipe failures is gas generation in the heat pipe. This problem is totally eliminated by proper cleaning and assembly procedures.

Are they expensive?

Compared to less effective methods of heat transfer such as aluminum extrusions and cast heat sinks, heat pipes can be expensive, especially in small quantities. In applications where cooling requirements can be met by simple conductive heat sinks, heat pipes are not recommended. In more demanding applications, however, the cost of heat pipes is competitive with other alternatives. The cost of heat pipes is also partially offset by the improvement in system reliability and the increased life of cooler running electronics. In high quantity applications, the cost of heat pipes drops significantly and often provides the most economical solution to many cooling applications.

Do water heat pipes freeze?

Yes, heat pipe working fluids including water maintain the normal freezing point. Properly designed heat pipes, however, will not be damaged by the freezing and thawing of the working fluid. Heat pipes will not operate until the temperature rises above the freezing temperature of the fluid.

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