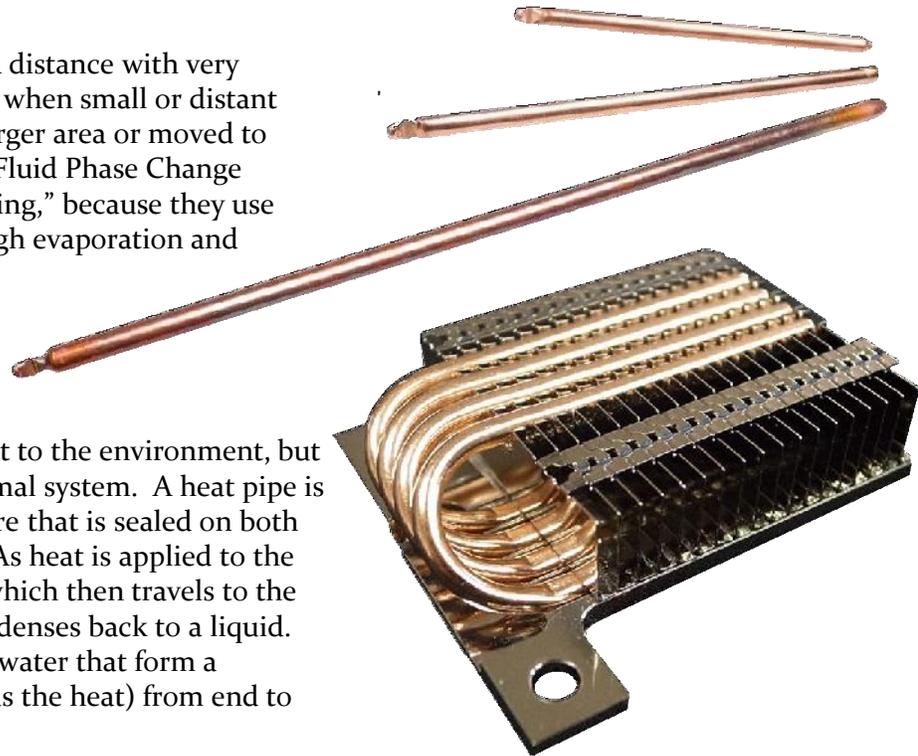
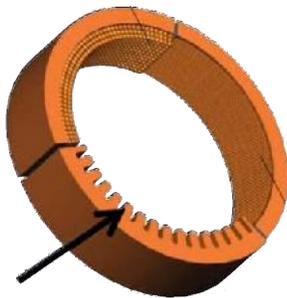


Heat pipes are used to transport heat over a distance with very low thermal resistance. This is very helpful when small or distant heat sources need to be dissipated over a larger area or moved to a remote heat exchanger. Heat pipes are a Fluid Phase Change application, often referred to as “re-circulating,” because they use a closed loop to transfer heat quickly through evaporation and condensation within the heat pipe.

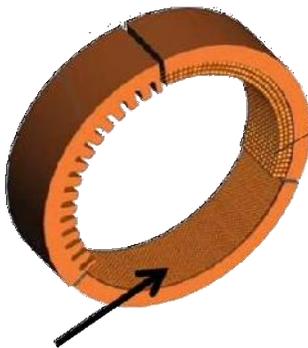


Heat pipes do not actually dissipate the heat to the environment, but serve to move heat efficiently within a thermal system. A heat pipe is a copper tube with an internal wick structure that is sealed on both ends with a small amount of water inside. As heat is applied to the pipe, the water will boil and turn to a gas, which then travels to the colder section of the heat pipe where it condenses back to a liquid. It is the evaporating and condensing of the water that form a pumping action to move the water (and thus the heat) from end to end of the pipe.

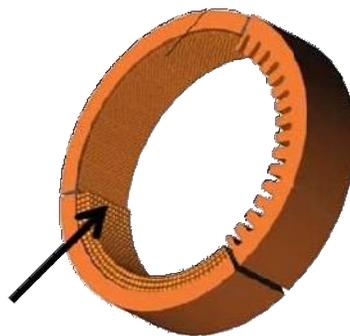


Grooved Heat Pipe

There are many types of wick structure that can be used within the heat pipe and they are generally classified into grooved, mesh, powder and hybrid. A grooved heat pipe is a copper tube with a series of shallow grooves around the internal perimeter of the heat pipe. While the water is a liquid, it travels in the grooves and while it is a vapor it travels in the open space of the pipe. Grooved pipes can be used in horizontal orientations, but are very limited in performance if used above 15° out of horizontal. A mesh heat pipe is a smooth wall copper tube with a woven copper mesh installed along the interior of the pipe. The mesh is designed to remain in contact with the walls of the pipe in areas where the pipe may be bent or flattened. Mesh pipes can be used in horizontal and orientations up to 30° out of horizontal. A powder wick heat pipe can also be known as a sintered heat pipe.



Mesh Heat Pipe



Powder Wick Heat Pipe

During the manufacturing process a mandrel is installed in the center of the pipe and copper powder is poured into the pipe around the mandrel. After the powder is sufficiently packed, the parts are placed into a sintering oven. Once at temperature, the copper powder will stick to the pipe and to itself, forming numerous internal pockets like a sponge. Because of the small pocket sizes, sintered pipes can efficiently move the water and can be used horizontally, vertically and all points in between including upside down. Wakefield-Vette primarily sells sintered, or powder, style heat pipes due to their higher performance and the best heat pipe for your application.



Key Features

- Material: Copper
- Wick Structure: Powder Sintered Copper
- Light Weight
- Versatile with high thermal performance

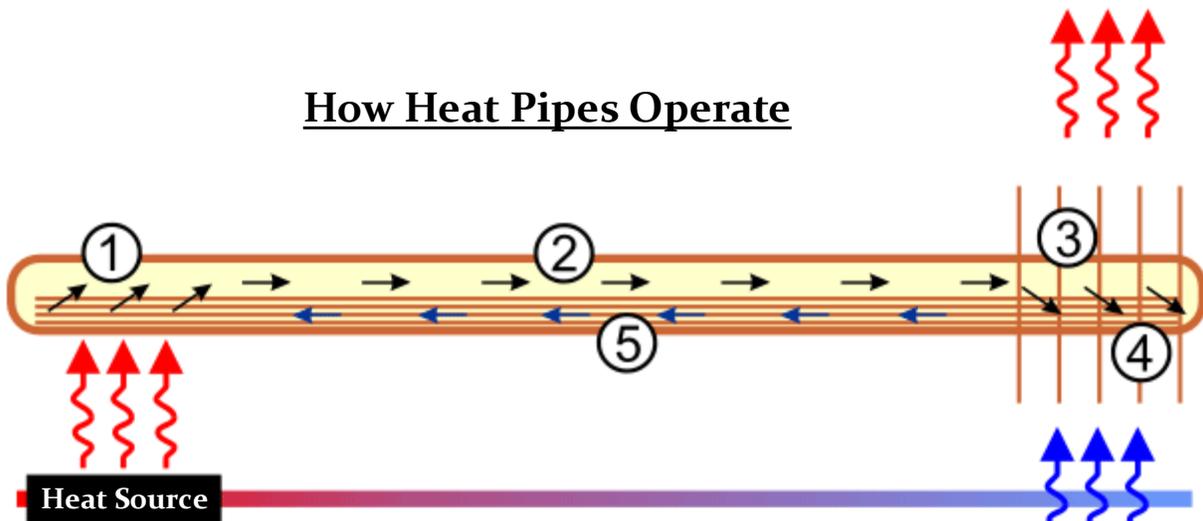
Heat pipes are used in many harsh environments such as:

- Telecommunications
- Aerospace
- Transportation
- Computers and Datacenters

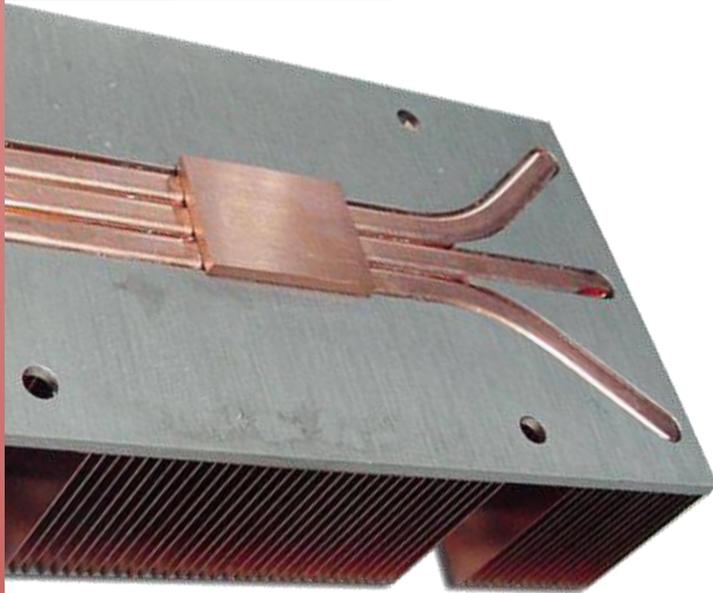
Heat pipes have proven to be robust and reliable over many years in these types of applications. The next section will give more technical detail on the performance of heat pipes depending on diameter, length, and angle of use.

Many thermal systems benefit from the addition of heat pipes, especially when heat sources are dense and/or remote to the final heat exchanger. Computer applications, such as processors, graphics cards and other chip-sets, have high thermally dissipated power in a small area. Fan heat sink combinations used in these applications can offer high-performance dissipation to the ambient, but much of the battle is to bring the heat to the heat exchanger with as little temperature change as possible. Heat pipes excel at this and can transport large heat loads from small areas with very little temperature difference.

How Heat Pipes Operate



1. Working fluid absorbs heat while evaporating to vapor
2. Vapor transfers along the cavity to the lower temperature area
3. Vapor condenses back to fluid, discharging heat
4. Fluid is absorbed by the sintered/powdered wick structure
5. Fluid returns to high temperature end via capillary force in the wick structure
6. Natural or forced convection air flow dissipates excess heat to ambient



Heat Pipe Basics

- Picking the correct pipe
- Transport
- General parameters
- Bending
- Flattening

When selecting the diameter and length of heat pipe it is important to consider the orientation with respect to gravity and overall heat load for the thermal system. The transport of vapor within the heat pipe is responsible for the thermal conduction from one end to the other. A larger diameter heat pipe can transport more vapor, translating into a larger heat carrying capacity. Also, the orientation of the pipe with respect to gravity plays a role in the thermal capacity of a heat pipe.

When selecting the diameter and length of heat pipe it is important to consider the orientation with respect to The thermal capacity is increased when the heat source is lower than the condenser (or ambient heat exchanger) because gravity assists the return of condensed water back to the heat source. The opposite is also true as the thermal capacity is reduced when the condensed water must move by capillary forces back to the heat source against gravity. This effect is exaggerated with longer heat pipes and testing has shown that the gravity effect can nearly the double the thermal capacity in the advantageous direction and cut the capacity in half in the deleterious direction from the heat pipe in the horizontal orientation. In the short heat pipe extreme (3"-4" length), this effect is nearly zero, so please consult with Wakefield-Vette engineers to find the right solution for your application.

Maximum Heat Transfer Table (Powder Type)

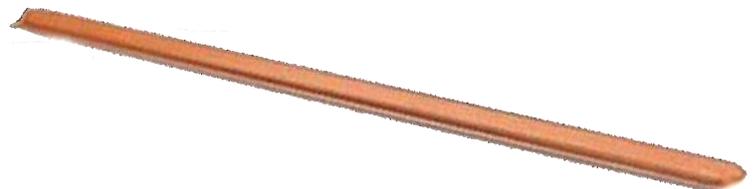
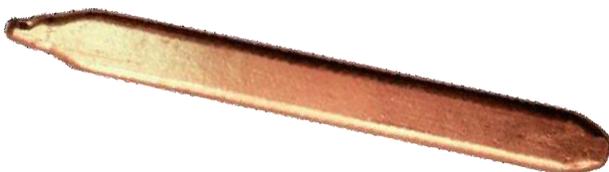
HEAT PIPE LENGTH = 150mm

Q _{max} / Type \ Diameter	Out Diameter $\Phi 3$ mm	Out Diameter $\Phi 4$ mm	Out Diameter $\Phi 5$ mm	Out Diameter $\Phi 6$ mm	Out Diameter $\Phi 8$ mm
Flatten $t=2.0$ mm	13.2 W	16.6 W	20.5 W		
Flatten $t=2.5$ mm	13.2 W	19.8 W	23.6 W		
Flatten $t=3.0$ mm	13.1 W	19.8 W	28.4 W	39.2 W	67.5 W
Round Pipe	13.2 W	19.8 W	30.1 W	48.1 W	74.2 W

Maximum Heat Transfer Table (Powder Type)

HEAT PIPE LENGTH = 250mm

Q _{max} / Type \ Diameter	Out Diameter $\Phi 3$ mm	Out Diameter $\Phi 4$ mm	Out Diameter $\Phi 5$ mm	Out Diameter $\Phi 6$ mm	Out Diameter $\Phi 8$ mm
Flatten $t=2.0$ mm	7.2 W	10.1 W	12.2 W		
Flatten $t=2.5$ mm	8.1 W	11.2 W	13.1 W		
Flatten $t=3.0$ mm	8.2 W	12.1 W	14.1 W	22.0 W	37.0 W
Round Pipe	9.0 W	12.3 W	15.6 W	29.3 W	45.0 W





Flattening is another aspect of heat pipes that effect their performance. Often it is necessary to flatten a heat pipe to fit into a desired shape or gap or to increase the contact area of the pipe with the heat. Since flattening reduces the effective cross-sectional area of the round pipe, the thermal capacity is reduced, just as if a smaller diameter pipe was being used. The larger diameter of the starting heat pipe, the larger reduction of thermal capacity is seen when flattening. Also, the larger diameter pipes cannot be flattened to the same ultimate dimension as the smaller pipes without disrupting heat flow altogether. This is also true for bending of pipes. The radius of bending is usually 3-5x the diameter of the heat pipe depending on the pipe diameter and the process of bending the pipe. The potential danger is to collapse the pipe, effectively cutting off vapor and thermal transport.

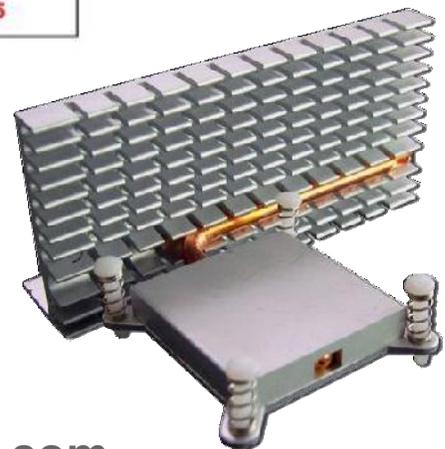
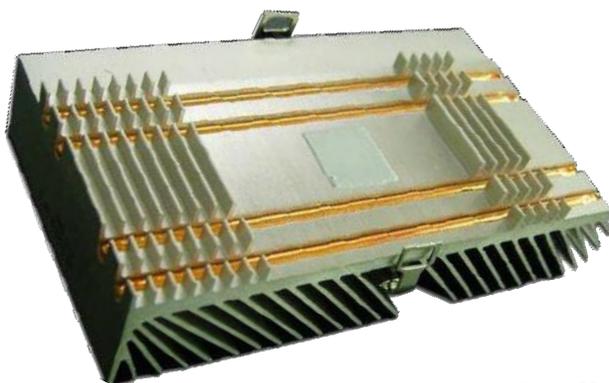
Size of Flattened Heat Pipes

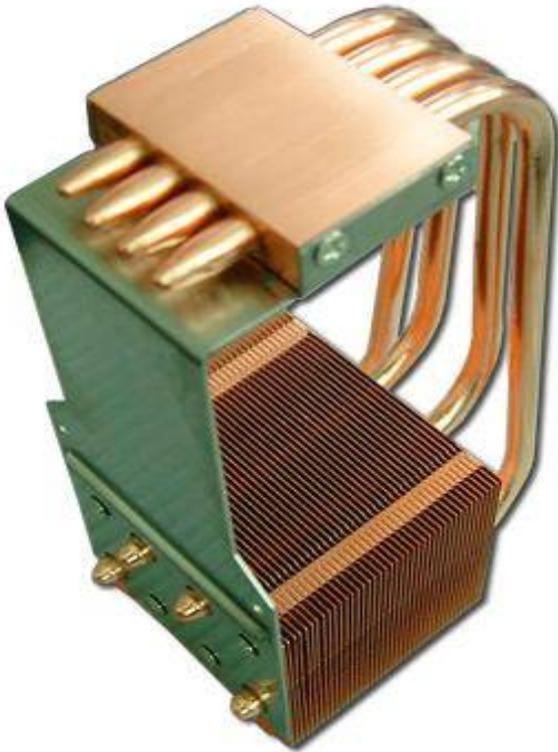
Diameter (mm)	Thickness (mm)	Width (mm)	Tolerance (mm)
4 mm	3	4.65	+/- 0.15
	2.5	5	+/- 0.15
	2	5.23	+/- 0.15
5 mm	3.5	5.97	+/- 0.15
	3	6.25	+/- 0.15
	2.5	6.55	+/- 0.15
	2	6.83	+/- 0.15
6 mm	4	7.3	+/- 0.15
	3.5	7.58	+/- 0.15
	3	7.84	+/- 0.15
	2.5	8.1	+/- 0.15
8 mm	6	9.35	+/- 0.15
	5	9.95	+/- 0.15
	4	10.5	+/- 0.15
	3	10.99	+/- 0.15

Bending radius for heat pipes of different diameters depending on the method of bending.

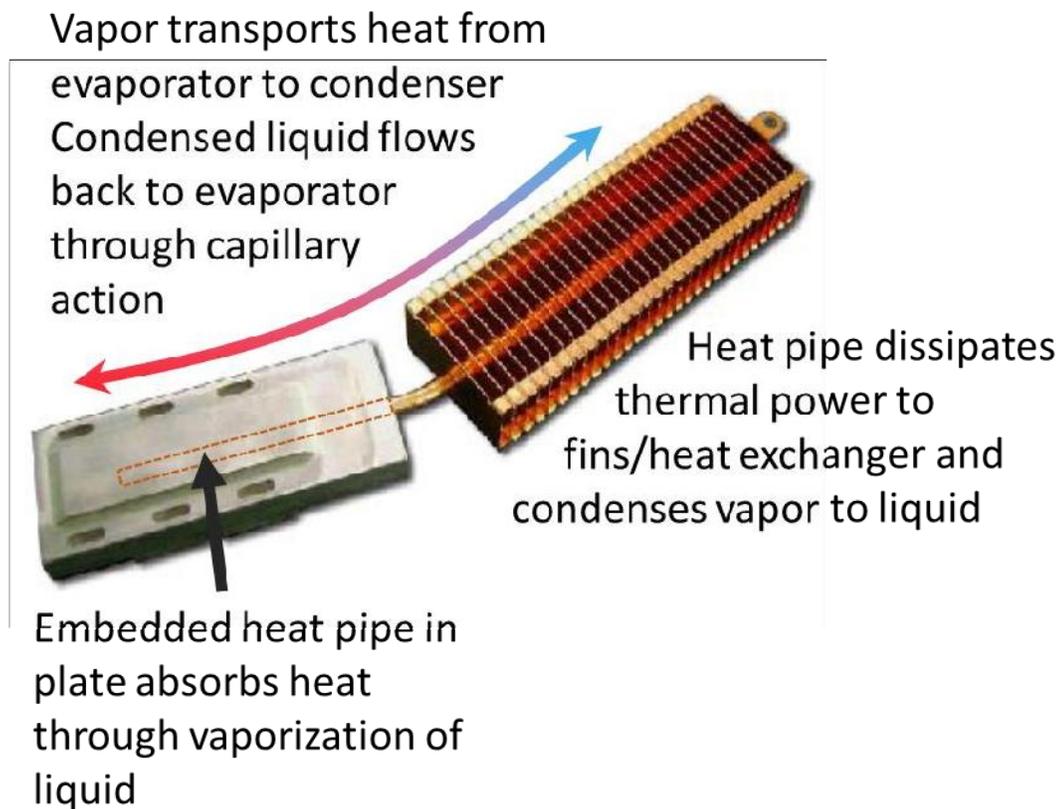
Bending

- By Hand:
 - 4mm: 4 x diameter
 - 6mm: 4 x diameter
 - 8mm: 5 x diameter
- Tooling:
 - 4mm: 3 x diameter
 - 6mm: 3 x diameter
 - 8mm: 4 x diameter





Interfacing heat pipes with plates and heat exchangers is predominately about maximizing contact area while adhering to the flattening and bending guidelines mentioned above. In most cases, the heat pipes are slotted into channels/grooves in the plate to maximize contact. The heat pipe can be secured into the groove using solder or thermal epoxy, which also augments the contact area of the heat pipe. The heat pipe can also be clamped between two plates with matching channels/grooves which are fastened together. In the clamped configuration, thermal grease can be used to increase the contact of the heat pipe to the plates to reduce the thermal resistance of the contact interface, just as the thermal epoxy and solder did in the prior example.



Wakefield Vette Standard Heat Pipes

Wakefield-Vette offers individual Heat Pipes through distribution. These most common offerings are a great option for testing, sampling, and validating your heat pipe solution into eventual production.

When building or testing your heat sink assembly please feel free to contact one of Wakefield Vette's authorized distributors to purchase. Always remember to contact us for free consultation on assembly design or parameter questions.

Wakefield Vette Part Number	Description
<u>121686</u>	Round Heat Pipe 4 x 70mm
<u>121687</u>	Round Heat Pipe 4 x 100mm
<u>121688</u>	Round Heat Pipe 4 x 150mm
<u>110578</u>	Round Heat Pipe 6 x 100mm
<u>110579</u>	Round Heat Pipe 6 x 150mm
<u>110580</u>	Round Heat Pipe 6 x 200mm
<u>110581</u>	Round Heat Pipe 6 x 250mm
<u>110582</u>	Round Heat Pipe 6 x 300mm
<u>121968</u>	Round Heat Pipe 8 x 100mm
<u>110583</u>	Round Heat Pipe 8 x 200mm
<u>110584</u>	Round Heat Pipe 8 x 250mm
<u>110585</u>	Round Heat Pipe 8 x 300mm
<u>121689</u>	Round Heat Pipe 10 x 100mm
<u>121690</u>	Round Heat Pipe 10 x 200mm
<u>121691</u>	Round Heat Pipe 10 x 250mm
<u>121692</u>	Round Heat Pipe 10 x 300mm
<u>121716</u>	Flat Heat Pipe 2.5 x 100mm
<u>121717</u>	Flat Heat Pipe 2.5 x 150mm
<u>121718</u>	Flat Heat Pipe 2.5 x 200mm
<u>121719</u>	Flat Heat Pipe 2.5 x 250mm
<u>121720</u>	Flat Heat Pipe 3 x 100 mm
<u>121721</u>	Flat Heat Pipe 3 x 150 mm
<u>121722</u>	Flat Heat Pipe 3 x 200 mm
<u>121723</u>	Flat Heat Pipe 3 x 250 mm
<u>121724</u>	Flat Heat Pipe 3 x 300 mm
<u>121725</u>	Flat Heat Pipe 4.5 x 100mm
<u>121726</u>	Flat Heat Pipe 4.5 x 150 mm
<u>121727</u>	Flat Heat Pipe 4.5 x 200 mm
<u>121728</u>	Flat Heat Pipe 4.5 x 250 mm
<u>121729</u>	Flat Heat Pipe 4.5 x 300 mm
<u>120231</u>	Ultra Thin 6MM DIA X 1.50MM
<u>120229</u>	Ultra Thin 5MM DIA X 1.00MM