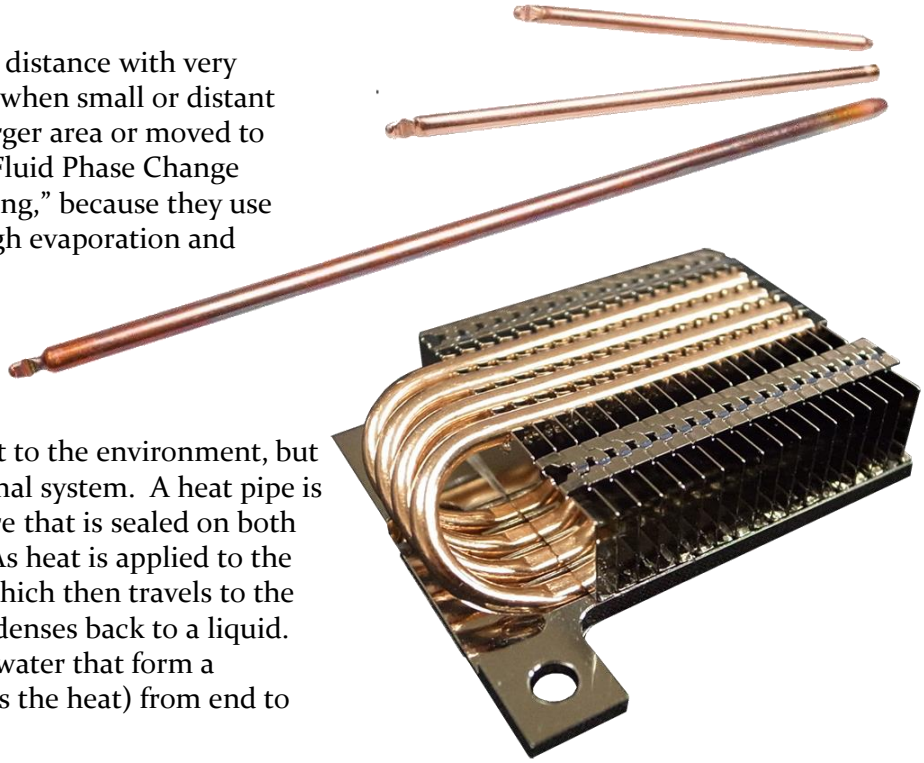
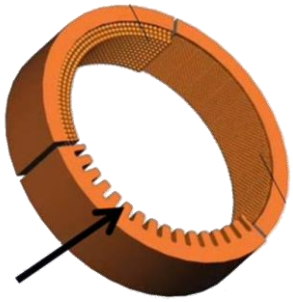
Heat Pipe Selection Guide

Heat Pipe Introduction



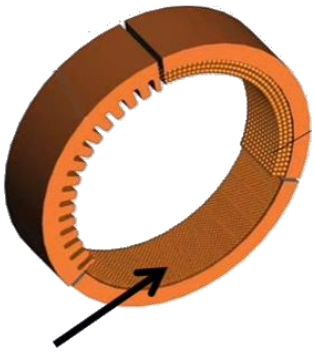
Heat pipes are used to transport heat over a distance with very low thermal resistance. This is very helpful when small or distant heat sources need to be dissipated over a larger area or moved to a remote heat exchanger. Heat pipes are a Fluid Phase Change application, often referred to as "re-circulating," 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.

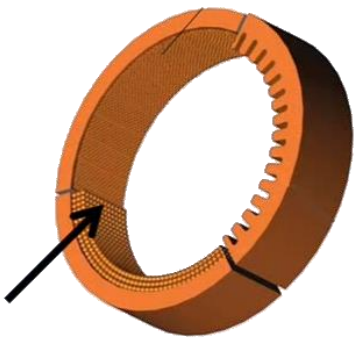


Grooved Heat Pipe

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.

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Why Use Heat Pipes?

Key Features

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

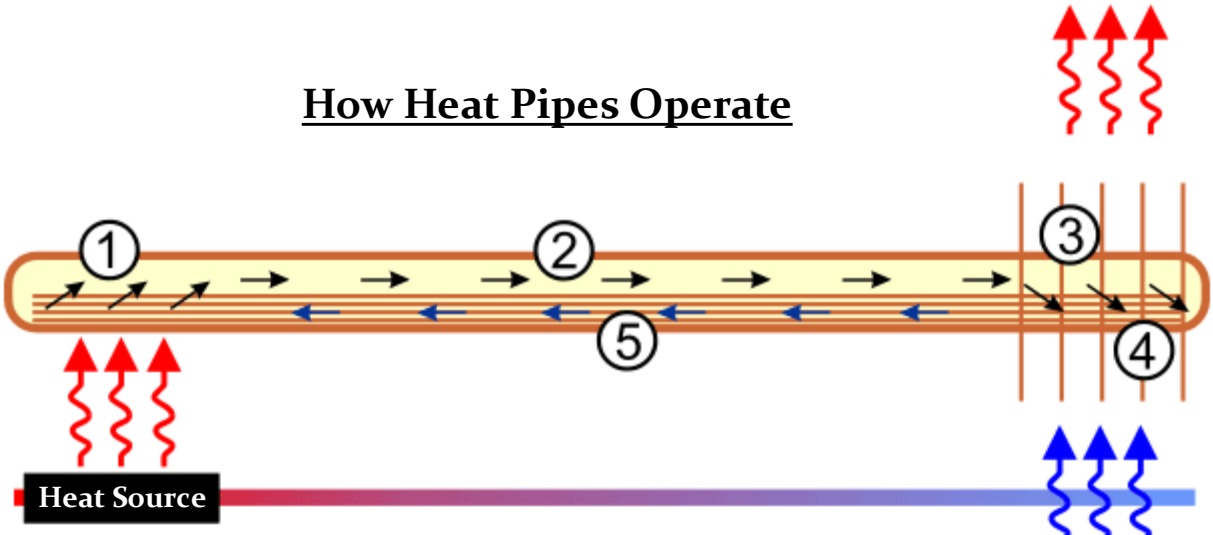
Heat pipes are used in many harsh environments such as:

- 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**

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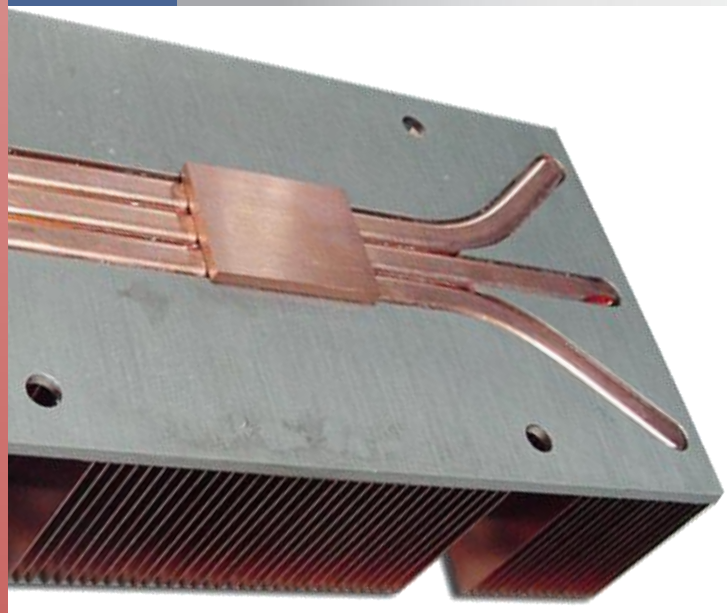
Heat Pipe Basics



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.

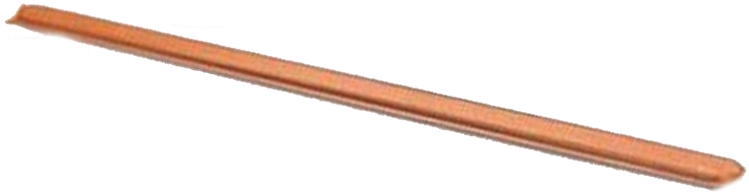
When selecting the diameter and length of heat pipe it is important to consider the orientation with respect to The thermal capacity is increased when the heat source is lower than the condenser (or ambient heat exchanger) because gravity assists the return of condensed water back to the heat source. 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

Qmax / Out Diameter / Type	Out Diameter Φ3 mm	Out Diameter Φ4 mm	Out Diameter Φ5 mm	Out Diameter Φ6 mm	Out Diameter Φ8 mm
Flatten t=2.0mm	13.2 W	16.6 W	20.5 W		
Flatten t=2.5mm	13.2 W	19.8 W	23.6 W	34.0 W	51.5 W
Flatten t=3.0mm	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

Qmax / Out Diameter / Type	Out Diameter Φ3 mm	Out Diameter Φ4 mm	Out Diameter Φ5 mm	Out Diameter Φ6 mm	Out Diameter Φ8 mm
Flatten t=2.0mm	7.2 W	10.1 W	12.2 W		
Flatten t=2.5mm	8.1 W	11.2 W	13.1 W	16.5 W	23.0 W
Flatten t=3.0mm	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



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Flattening Heat Pipes

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.

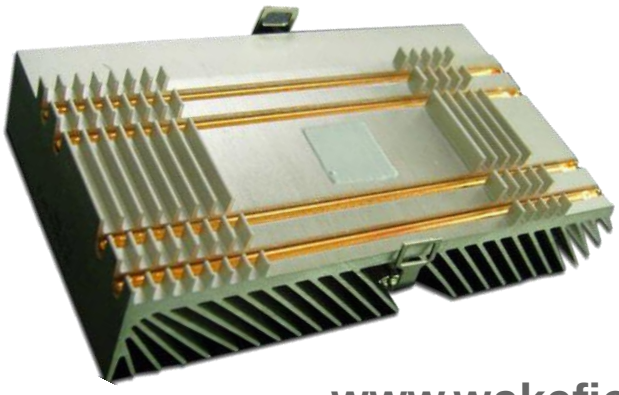
Size of Flattened Heat Pipes

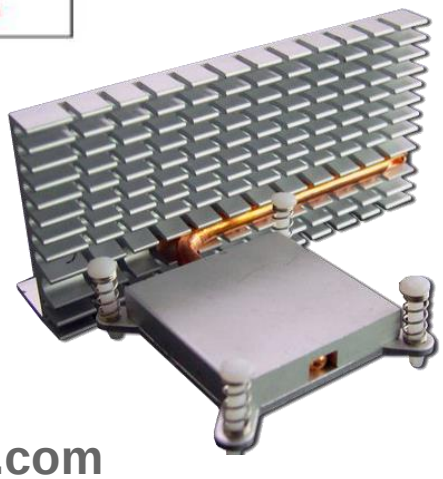
Diameter (mm)	Thickness (mm)	Width (mm)	Tolerance (mm)
4 mm	3	4.65	+/- 0.15
	2.5	5	+/- 0.15
	2	5.23	+/- 0.15
5 mm	3.5	5.97	+/- 0.15
	3	6.25	+/- 0.15
	2.5	6.55	+/- 0.15
	2	6.83	+/- 0.15
6 mm	4	7.3	+/- 0.15
	3.5	7.58	+/- 0.15
	3	7.84	+/- 0.15
	2.5	8.1	+/- 0.15
8 mm	6	9.35	+/- 0.15
	5	9.95	+/- 0.15
	4	10.5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

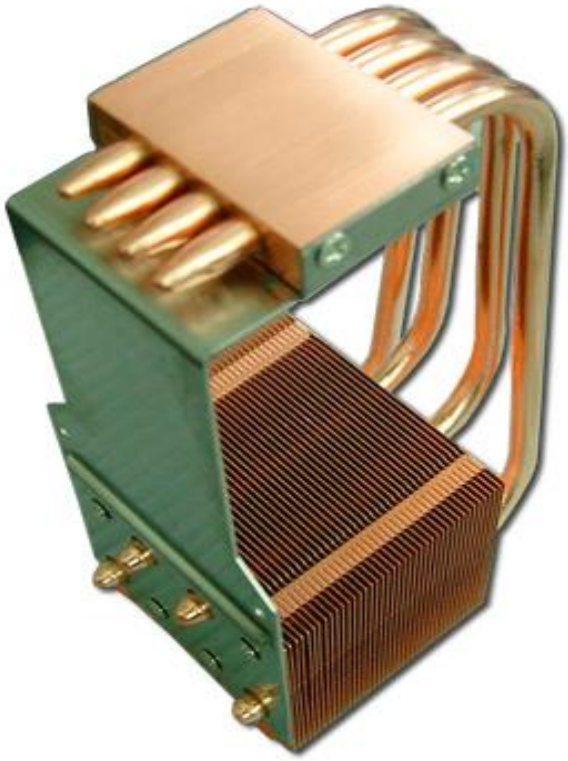
Bending radius for heat pipes of different diameters depending on the method of bending.

Bending

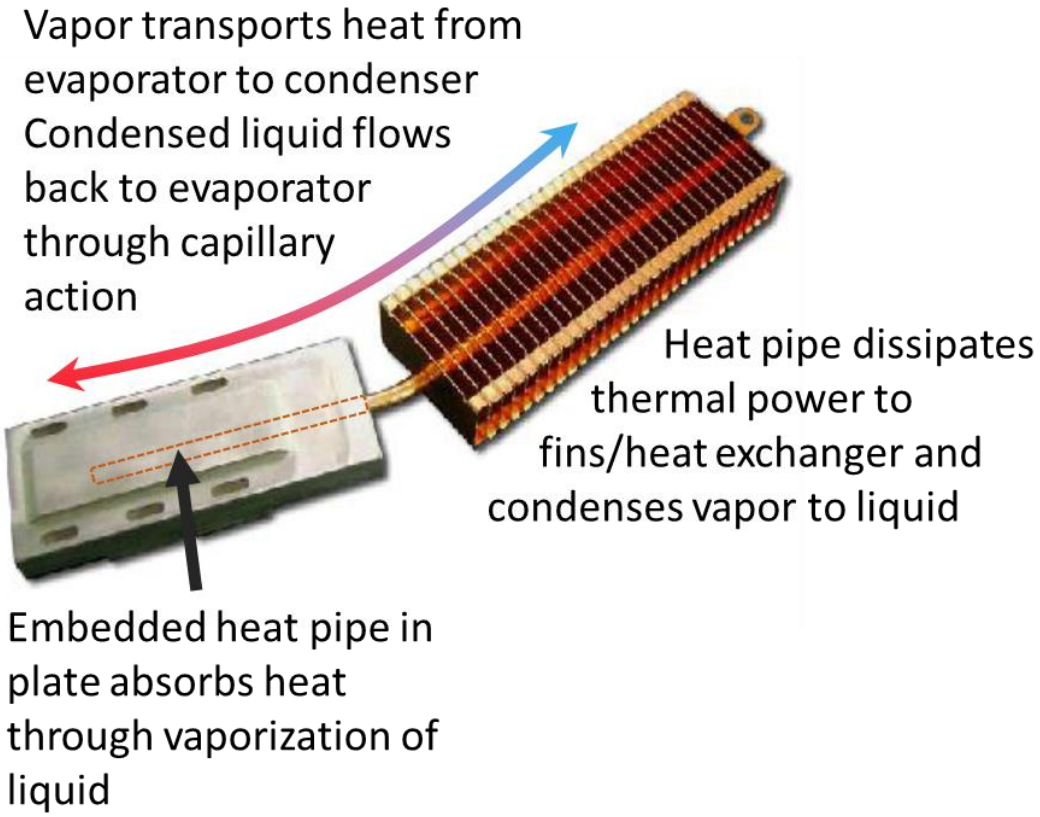
- By Hand:
  - 4mm: 4 x diameter
  - 6mm: 4 x diameter
  - 8mm: 5 x diameter
- Tooling:
  - 4mm: 3 x diameter
  - 6mm: 3 x diameter
  - 8mm: 4 x diameter







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.



Heat Pipe Selection Guide

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.

WKV PART NUMBER	DESCRIPTION	Type	Length (mm)	Diameter (mm)	qMax
124641	Heat Pipe Straight Sintered 3X70MM	Round	70	3	5W
124642	Heat Pipe Straight Sintered 3X100MM	Round	100	3	8W
124643	Heat Pipe Straight Sintered 3X150MM	Round	150	3	10W
124644	Heat Pipe Straight Sintered 3X200MM	Round	200	3	5W
121686_rev1	Straight Sintered 4mmx70mm	Round	70	4	7W
121687_rev1	Straight Sintered 4mmx100mm	Round	100	4	15W
121688_rev1	Straight Sintered 4mmx150mm	Round	150	4	10W
124646	Heat Pipe Straight Sintered 4X200MM	Round	200	4	10W
124647	Heat Pipe Straight Sintered 4X250MM	Round	250	4	8W
124645	Heat Pipe Straight Sintered 4X300MM	Round	300	4	5W
124650	Heat Pipe Straight Sintered 5X70MM	Round	70	5	20W
124651	Heat Pipe Straight Sintered 5X100MM	Round	100	5	32W
124652	Heat Pipe Straight Sintered 5X150MM	Round	150	5	35W
124653	Heat Pipe Straight Sintered 5X200MM	Round	200	5	30W
124654	Heat Pipe Straight Sintered 5X250MM	Round	250	5	25W
124648	Heat Pipe Straight Sintered 5X300MM	Round	300	5	15W
124649	Heat Pipe Straight Sintered 5X350MM	Round	350	5	10W
124657	Heat Pipe Straight Sintered 6X70MM	Round	70	6	35W
110578_rev1	Heat Pipe Straight Sintered 6x0.3x100mm	Round	100	6	35W
110579_rev1	Heat Pipe Straight Sintered 6x0.3x150mm	Round	150	6	60W
110580_rev1	Heat Pipe Straight Sintered 6x0.3x200mm	Round	200	6	50W
110581_rev1	Heat Pipe Straight Sintered 6x0.3x250mm	Round	250	6	40W
110582_rev1	Heat Pipe Straight Sintered 6x0.3x300mm	Round	300	6	40W
124655	Heat Pipe Straight Sintered 6X350MM	Round	350	6	25W
124656	Heat Pipe Straight Sintered 6X400MM	Round	400	6	18W
124682	Heat Pipe Straight Sintered 8X70MM	Round	70	8	45W
124662	Heat Pipe Straight Sintered 8X150MM	Round	150	8	70W
110583_rev1	Heat Pipe Straight Sintered 8x0.3x200mm	Round	200	8	50W
110584_rev1	Heat Pipe Straight Sintered 8x0.3x250mm	Round	250	8	40W
110585_rev1	Heat Pipe Straight Sintered 8x0.3x300mm	Round	300	8	55W
124658	Heat Pipe Straight Sintered 8X350MM	Round	350	8	35W
124659	Heat Pipe Straight Sintered 8X400MM	Round	400	8	25W
214660	Heat Pipe Straight Sintered 8X450MM	Round	450	8	20W
124661	Heat Pipe Straight Sintered 8X500MM	Round	500	8	15W
121689_rev1	Straight Sintered 10mmx100mm	Round	100	10	80W
124669	Heat Pipe Straight Sintered 10X150MM	Round	150	10	120W
121690_rev1	Straight Sintered 10mmx200mm	Round	200	10	70W
121691_rev1	Straight Sintered 10mmx250mm	Round	250	10	65W
121692_rev1	Straight Sintered 10mmx300mm	Round	300	10	50W
124663	Heat Pipe Straight Sintered 10X350MM	Round	350	10	60W
124664	Heat Pipe Straight Sintered 10X400MM	Round	400	10	52W
124665	Heat Pipe Straight Sintered 10X450MM	Round	450	10	45W
124666	Heat Pipe Straight Sintered 10X500MM	Round	500	10	40W
124667	Heat Pipe Straight Sintered 10X550MM	Round	550	10	35W
124668	Heat Pipe Straight Sintered 10X600MM	Round	600	10	25W
124670	Heat Pipe Straight Sintered 12x70MM	Round	70	12	50W
124671	Heat Pipe Straight Sintered 12x100MM	Round	100	12	130W
124672	Heat Pipe Straight Sintered 12x150MM	Round	150	12	150W
124673	Heat Pipe Straight Sintered 12x200MM	Round	200	12	130W
124674	Heat Pipe Straight Sintered 12x250MM	Round	250	12	115W
124675	Heat Pipe Straight Sintered 12x300MM	Round	300	12	100W
214676	Heat Pipe Straight Sintered 12x350MM	Round	350	12	75W
124677	Heat Pipe Straight Sintered 12x400MM	Round	400	12	65W
124678	Heat Pipe Straight Sintered 12x450MM	Round	450	12	55W
124679	Heat Pipe Straight Sintered 12x500MM	Round	500	12	50W
124680	Heat Pipe Straight Sintered 12x550MM	Round	550	12	42W
124681	Heat Pipe Straight Sintered 12x600MM	Round	600	12	30W
120229	Straight Ultra thin 5mm dia x 100mm length; Flattened thickness 1.0mmm	Flat	100	1	12W
120231	Straight Ultra thin 6mm dia x 100mm length; Flattened thickness 1.5mm	Flat	100	1.5	25W
121716_rev1	Flat Heat Pipe 2.5 X 100mm	Flat	100	2.5	35W
121717_rev1	Flat Heat Pipe 2.5 X 150mm	Flat	150	2.5	30W
121718_rev1	Flat Heat Pipe 2.5 X 200mm	Flat	200	2.5	25W
121719_rev1	Flat Heat Pipe 2.5 X 250mm	Flat	250	2.5	15W
121720_rev1	Flat Heat Pipe 3.0 X 100mm	Flat	100	3	45W
121721_rev1	Flat Heat Pipe 3.0 X 1500mm	Flat	150	3	40W
121722_rev1	Flat Heat Pipe 3.0 X 200mm	Flat	200	3	35W
121723_rev1	Flat Heat Pipe 3.0 X 250mm	Flat	250	3	30W
121724_rev1	Flat Heat Pipe 3.0 X 300mm	Flat	300	3	25W
121725_rev1	Flat Heat Pipe 4.5 X 100mm	Flat	100	4.5	55W
121726_rev1	Flat Heat Pipe 4.5 X 150mm	Flat	150	4.5	55W
121727_rev1	Flat Heat Pipe 4.5 X 200mm	Flat	200	4.5	50W
121728_rev1	Flat Heat Pipe 4.5 X 250mm	Flat	250	4.5	45W
121729_rev1	Flat Heat Pipe 4.5 X 300mm	Flat	300	4.5	40W

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