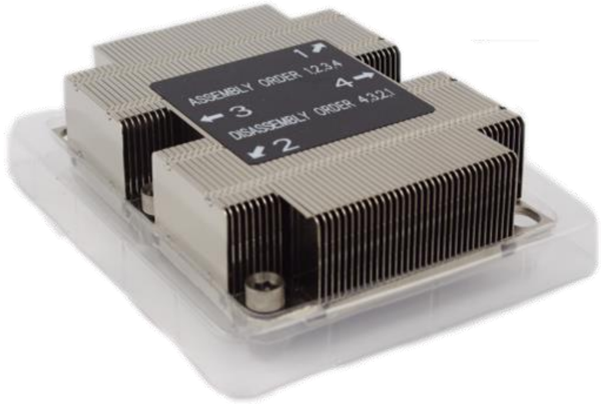
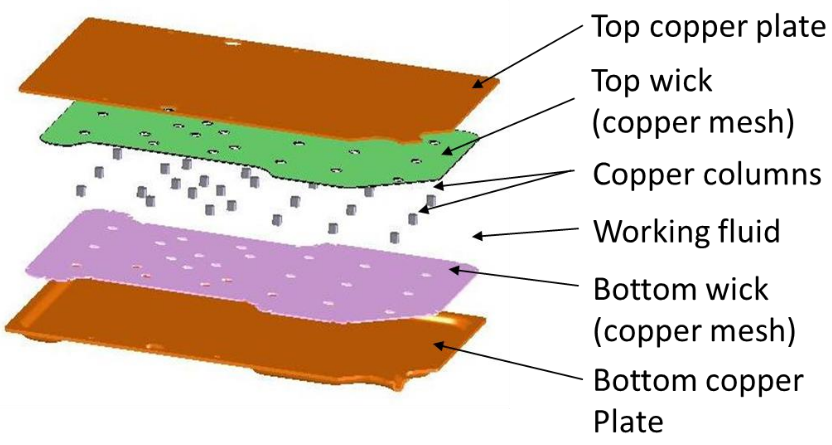
Vapor Chamber Introduction

Vapor Chambers are used to transport heat over a distance with very low thermal resistance. This is very helpful when small heat sources need to be dissipated over a larger area. Vapor chambers are a Fluid Phase Change application because they use a closed loop to transfer heat quickly through evaporation and condensation within the chamber. The particular aspect useful in designs is that vapor chambers transport heat in a plane, more effectively “spreading heat” compared to a heat pipe which transports heat over a distance in a straight line.



Vapor chambers, like heat pipes, do not actually dissipate the heat to the environment, but serve to move heat efficiently within a thermal system. A vapor chamber is made from copper plates (top and bottom) with an internal wick structure that is sealed around the perimeter with a small amount of water inside. As heat is applied to the chamber, the water will boil and turn to a gas, which then travels to the colder section of the vapor chamber, where heat is dissipated through an external heat exchanger, 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 the area of the heat source to all other areas of the vapor chamber.

There are a few types of wick structure that can be used within the vapor chamber, but most commercial chambers are classified as mesh or powder. In both cases, the powder or mess line the copper plate surfaces to allow water flow to/from all directions within the area of the vapor chamber. Often, when mesh is used as the wick structure, different sized meshes are used together to promote condensation or transport of liquid depending on the void size. Vapor chambers are best used in horizontal orientations. The effects of gravity may vary depending on application and orientation, but one must consider lower performance if used above 15° out of horizontal.



During the manufacturing process copper columns are used throughout the vapor chamber to support the plates that act as the lids and contain the liquid and vapor. The copper mesh is oriented within the chamber pressed against the copper plates. The plates are sealed around the perimeter via diffusion bonding. In some cases, soldering or welding are used, but diffusion bonding allows for the strongest and highest temperature compatible seal for the vapor chamber. The diffusion bonding process also allows the mesh to bond to the copper plates as well.

Why Use Vapor Chambers?

Key Features

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

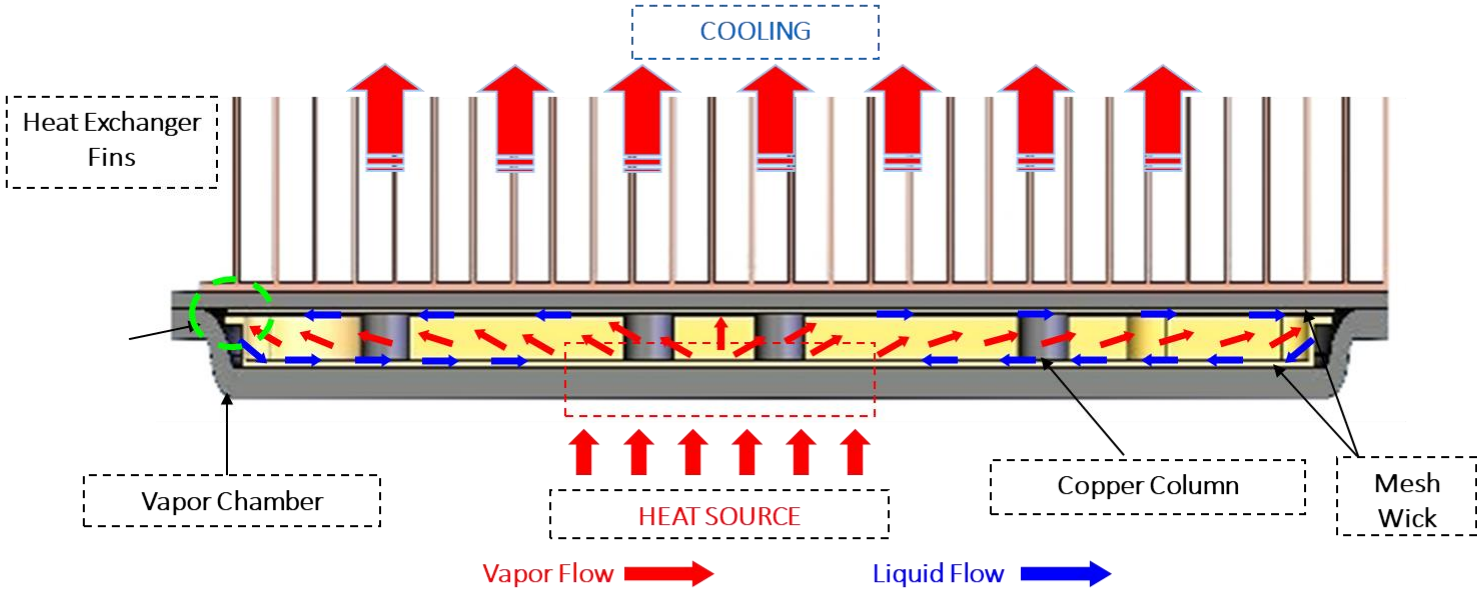
Vapor chambers are used in many harsh environments such as:

- Computers and Datacenters
- Telecommunications
- Aerospace
- Transportation

Vapor chambers 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 vapor chambers depending on thickness and area.

Many thermal systems benefit from the addition of vapor chambers, especially when heat sources are dense and the final heat exchanger is much larger and the heat from the source must be spread to a larger area effectively to efficiently use the 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 spread the heat to the heat exchanger with as little temperature change as possible. Vapor chambers excel at this and can transport large heat loads from small areas with very little temperature difference.

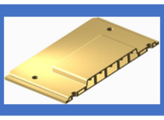
How Vapor Chambers Operate



Vapor Chamber Basics

- Comparison to Heat Pipes
- Transport
- General parameters

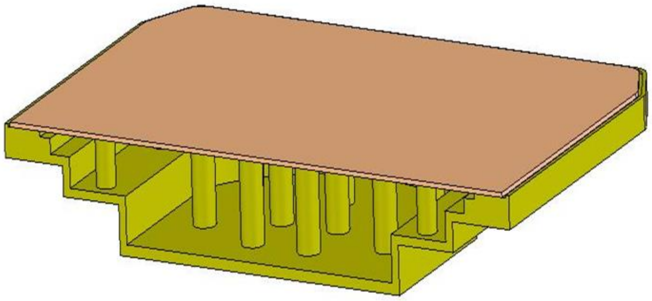
When considering the use of a vapor chamber in your application, it is important to consider the orientation with respect to gravity and overall heat load for the thermal system. The transport of vapor within the vapor chamber is responsible for the thermal conduction from one area to the other. A thicker vapor chamber can transport more vapor, translating into a larger heat carrying capacity. Although vapor chambers can have complex shapes and mounting features, they are not typically bent and integration can be more direct with the heat source than with heat pipes.

Vapor Chamber 		**Heat Pipe** 
2-Phase heat transfer	**Theory**	2-Phase heat transfer
2-D heat distribution. Spreading heat by a single vapor chamber. Suitable for large heat flux and high power.	**Application**	1-D heat distribution. Using one or more heat pipes to spread heat. Suitable for long distance between heat source and heat exchanger.
Complex shape in X and Y direction with pedestal.	**Shape**	Round, flattened or bent in any direction.
Mounted with through-holes in vapor chamber	**Fixtures**	Additional fixture plates needed to mount heat pipes.
Direct contact. Mounting pressure up to 90PSI.	**Heat Source Contact**	A base plate required to contact the heat source unless flattened/machined.
T=5mm >400W ;T=3mm >200W ; T=1mm >60W	**Qmax**	Ø5 >20W ; Ø6>40W; Ø8>60W
Vapor chamber has larger tooling cost so high volume applications can lower cost to ~2X heat pipe. However, solution may need only 1 vapor chamber compared to many heat pipes and fixture/base plates.	**Cost**	Lower cost for a single heat pipe, but may also need tooling cost for bending/flattening.

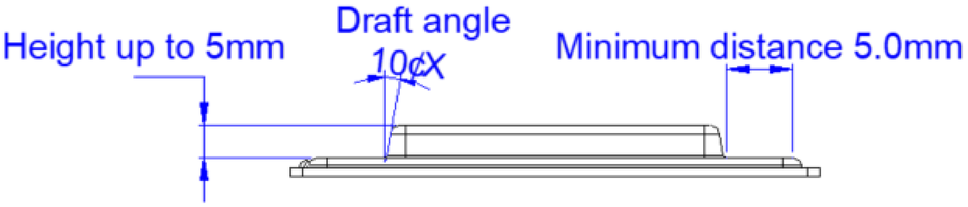
In many applications, the decision to use a vapor chamber is frequently compared to a thermal solution using heat pipes. In both cases, 2-phase transport is used as a vapor moves heat within the chamber or pipe and the liquid is condensed at the heat exchanger and transported back to the heat source. However, the main aspects of applications that differentiate vapor chambers from heat pipes are:

- High power density: when the heat source is small but heat generation is large, vapor chambers can more easily transport the heat to a larger area. A heat pipe solution would require multiple pipes, which may be difficult to integrate within the footprint of the heat source.
- High power: when the application must dissipate large wattage, a vapor chamber spreads the heat to a large area efficiently with similar temperatures of the chamber surface. This allows more efficient use of the final heat exchanger since hot spots are minimized. Heat pipes can also spread the heat, but unless many are ganged together, the hot spots may still persist.

Vapor Chamber Thermal Capacity

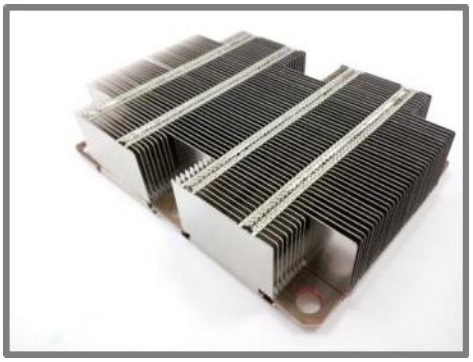


Much like heat pipes, the ultimate dimension in determining heat carrying capacity of a vapor chamber is the volume of the vapor space. This is determined by the thickness and area of the vapor chamber. For most applications, the thickness of the vapor chamber does not exceed 3mm, however pedestals and other surface features can be used to contact specific heat sources while leaving clearance for other board mounted objects. These pedestals can be extended 5mm from the vapor chamber lid plate. Mounting holes can also be integrated within the area of the vapor chamber for better integration with the heat source and locating the heat source a the center of the vapor chamber with good pressure application.

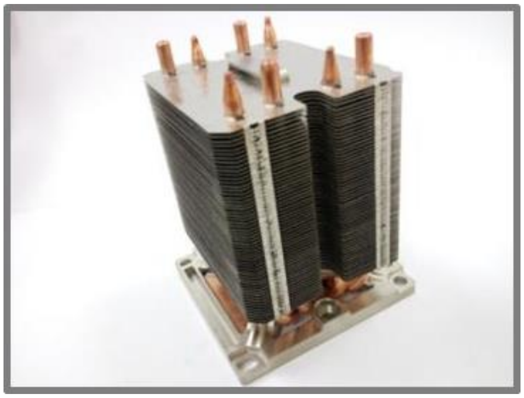


		Heat Carrying Capacity (Q-max) by Vapor Chamber Thickness							
		1.0mm	1.2mm	1.5mm	2.0mm	2.3mm	2.5mm	3.0mm	>3.0mm
Dimension (mm)	45*45	10W	15W	20W	25W	60W	80W	100W	>100W
	90*90	40W	50W	80W	100W	150W	180W	250W	>300W
	120*120	40W	50W	80W	100W	160W	200W	275W	>300W
	150*150	-	-	80W	100W	170W	220W	300W	>300W
	200*200	-	-	-	100W	175W	225W	>300W	>300W
	250*250	-	-	-	-	180W	240W	>300W	>300W
	300*300	-	-	-	-	-	-	-	>300W

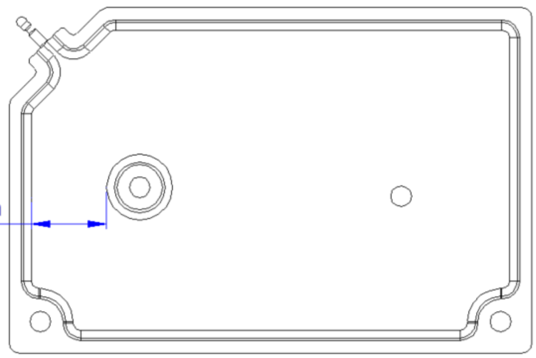
Note: Heat source = 30*30mm
This table is for reference. Q-max is related to heat source power density and effectiveness of final heat exchanger

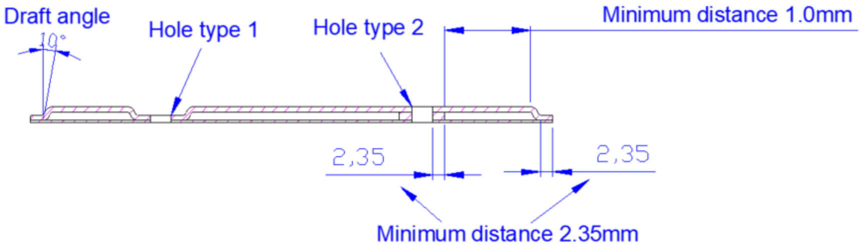


Vapor Chamber Assemblies



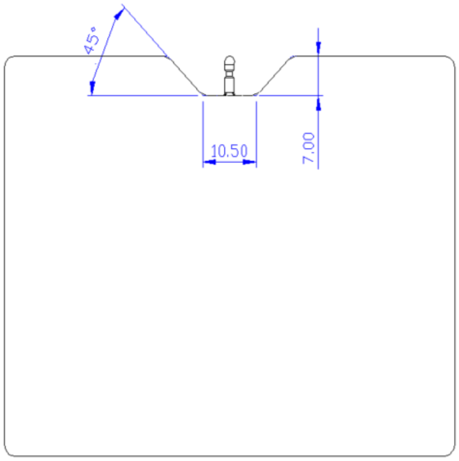
Interfacing vapor chambers with plates and heat exchangers is predominately about maximizing contact area. In most cases, the vapor chambers are soldered to heat exchanger fins for air cooled applications. The vapor chambers can also be soldered to liquid cold plates to take advantage of spreading the heat before final heat exchange with the liquid. In many cases, the vapor chambers are also integrated with heat pipes to take the heat that has spread in the plane of the vapor chamber and extend it in the vertical dimension to more efficiency interact with cooling fins. Integrating with the heat source is most commonly done with pressure, up to 90 psi, and the use of a thermal grease or other interface material to maximize surface area contact to the source.





2 types of filling ports (7mm maximum):

Retracted



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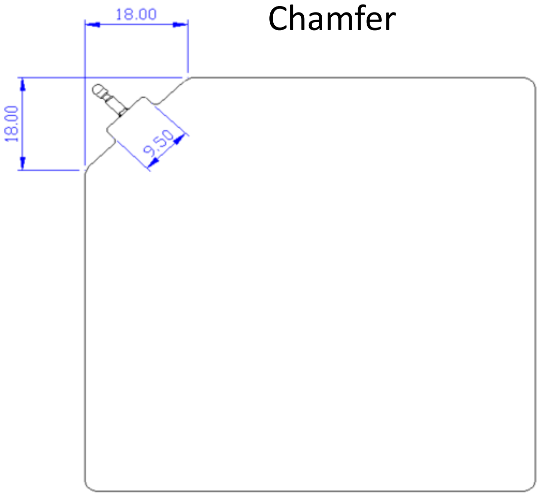

Wakefield Vette Standard Vapor Chambers

Wakefield-Vette offers individual vapor chambers through distribution. These most common offerings are a great option for testing, sampling, and validating your vapor chamber 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 #	Product Description	Thermal Resistance	length	width	thickness	qMax
VC-1131-8175-517	Standard Vapor Chamber 113.1mm x 81.75mm X 5.17mm	0.145	113.1	81.75	5.7	180W~
VC-90-90-3	Standard Vapor Chamber 90mm x 90mm x 3.00mm	0.143	90	90	3	150W~
VC-106-70-3	Standard Vapor Chamber 106mm x70mm x 3mm	0.150	106	70	3	150W~
VC-106-82-3	Standard Vapor Chamber 106mm x 82mm x 3mm	0.140	106	82	3	150W~

VC-1131-8175-517

Product Info Description

Dimension(mm) : L : 113mm / W : 81.8mm / T : 5.7mm

Operation Power : 180W~

Product Info Details

- Thermal Resistance : 0.145°C/W
- Operation Temp. : 40~130°C
- Platform : VGA

VC-90-90-3

Product Info Description

Dimension(mm) : L : 90mm / W : 90mm / T : 3mm

Operation Power : 150W~

Product Info Details

- Thermal Resistance : 0.143°C/W
- Operation Temp. : 40~140°C
- Platform : Intel 2011 Square

VC-106-70-3

Product Info Description

Dimension(mm) : L : 106mm / W : 70mm / T : 3mm

Operation Power : 150W~

Product Info Details

- Thermal Resistance : 0.150°C/W
- Operation Temp. : 40~140°C
- Platform : Intel 2011 Narrow

VC-106-82-3

Product Info Description

Dimension(mm) : L : 106mm / W : 82mm / T : 3mm

Operation Power : 150W~

Product Info Details

- Thermal Resistance : 0.140°C/W
- Operation Temp. : 40~140°C
- Platform : Intel 2011 Narrow