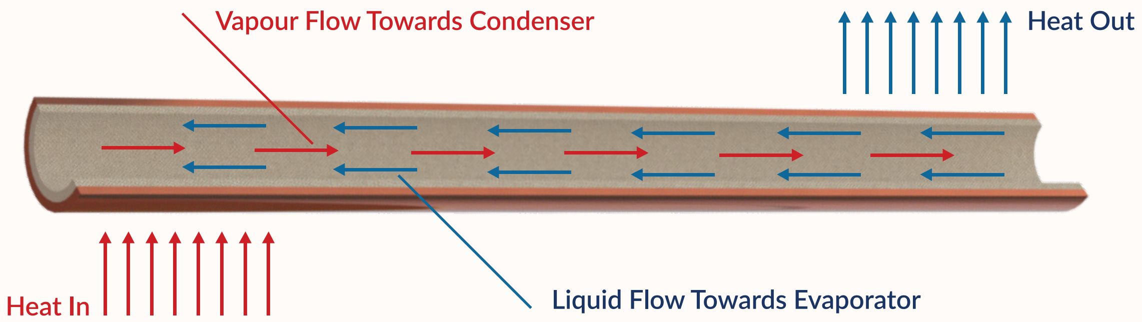
HEAT PIPES FOR ELECTRONICS THERMAL MANAGEMENT

Heat Pipes

Heat pipes possess the ability to transfer heat with minimum thermal resistance since they employ phase change phenomenon of a working fluid for their operation. This means that they can maintain minimum temperature difference across their length under operating conditions.



Components of a Heat Pipe

The simplest form of a heat pipe consists of three main components viz. a container, a capillary wick and a working fluid. The container forms the outer envelope of the heat pipe and is normally made of a high conductivity metallic tube such as Copper or Aluminium. Other materials may be used based on the outer environment. The working fluid is the media of heat transfer which is filled inside the heat pipe under vacuum. Capillary wick provides the pumping force necessary for the flow of condensed working fluid.

Working of a Heat Pipe

When heat is applied to the heat pipe at one end, the working fluid in the wick at this end evaporates, absorbing the heat. The vapours of the working fluid flow towards the colder portions of the heat pipe. The vapours condense in the colder portion of the heat pipe in the wick and the condensed liquid flows back to the hot portion of the heat pipe driven by the capillary force of the wick.

Important Properties of a Heat Pipe

Low Thermal Resistance

(High Equivalent Thermal Conductivity)

Provides ability to transport heat with minimum temperature drop across heat source and heat sink.

Isothermalisation

Ability to maintain equal temperature throughout the heat pipe geometry.

Heat Flux Transformation

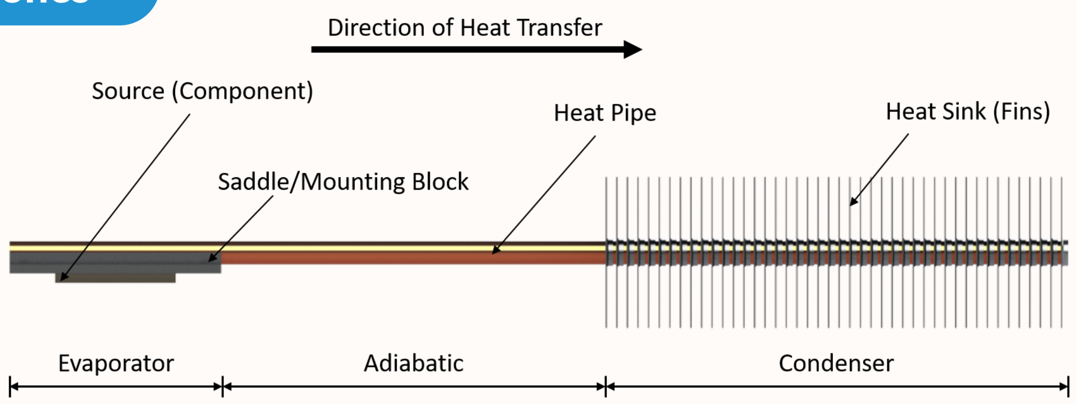
Ability to absorb heat from high heat flux sources and distribute the heat over a larger area making thermal management easier.

When to use a Heat Pipe?

There are two primary reasons why heat pipes are used in thermal management of electronic components.

For Heat Transport	For Heat Spreading
• Heat sink cannot be provided at the location of the components due to space constraints • Heat is required to be transported to a location where heat sink of sufficient area can be provided • Thermal resistance of heat transport is required to be very low to ensure the component temperature is as close as possible to the sink temperature • Heat pipes can transport the required heat with a minimum temperature drop as low as 3 °C	• Hot spots are generated in extruded or die-cast heat sinks due to high heat flux components, leading to failure of the heat sink. • Even though adequate surface area is provided on the heat sink to reject the heat to air, spreading of heat is important to efficiently use the heat sink. • Heat Pipes are embedded into such heat sinks to spread the heat across the heat sink by transporting heat from the hot spots to colder zones of the heat sink.

Heat Pipe Zones



As per the application, a heat pipe is normally divided in three zones:

Evaporator: This is the zone which is normally in contact with the components or the heat producing part. The heat pipe absorbs the heat from this zone.

Condenser: This is the zone which is normally in contact with the heat sink. The heat pipe rejects heat from this zone.

Adiabatic: This is the zone between the evaporator and condenser one. Depending on the application, an adiabatic zone may or may not be present in a heat pipe.

Please note that there is no physical distinction in these zones in a heat pipe and these zones are formed only on the basis of the application.

Also, heat pipes can have multiple evaporator and condenser zones, based on the application and these zones may not necessarily be located at the ends of the heat pipe.

Standard Circular Heat Pipes		
Diameter (mm)	Capacity (W-m)	*Minimum Length (mm)
5	3.12	75
6	4.00	50
	7.10	125
8	5.74	25
	10.63	75
10	7.44	25
	14.07	50
12	9.11	25
	17.43	50
15.88	22.17	25
	32.10	50
	36.78	50

To calculate the effective length and maximum heat transfer limit of the heat pipe, use the following formulae:

$$L_{eff} = \frac{L_{evaporator}}{2} + \frac{L_{condencer}}{2} + L_{adiabatic}$$

(refer earlier page for heat pipe zones)

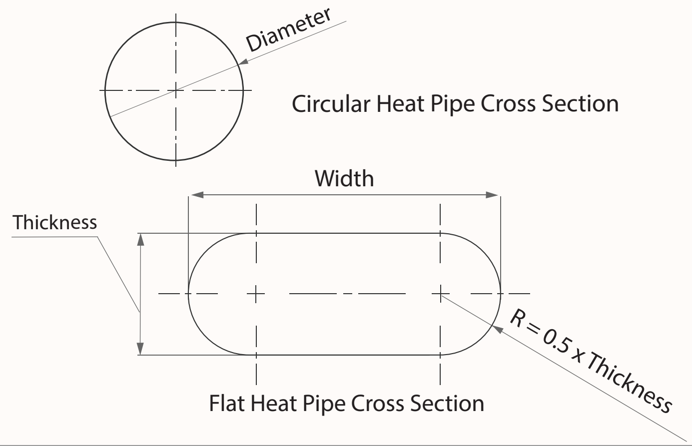
$$Q_{max} = \frac{Q_L}{L_{eff}}$$

In case of embedded heat pipes, since there is no adiabatic zone, the effective length can simply be considered as 50% of the total length

For every 90° bend of the heat pipe a 5% reduction in Qmax is to be considered

Please note that the values are given for horizontal or zero gravity orientation, for other orientations, please contact us

Standard Flat Heat Pipes			
Width (mm)	Thickness (mm)	Capacity (W-m)	*Minimum Length (mm)
6.1	3	3.11	100
5.9	3.5	3.15	75
5.6	4	3.16	75
7.7	3	4.01	100
7.4	3.5	4.06	75
7.1	4	4.07	75
7.1	4	6.93	200
6.9	4.5	4.08	75
6.9	4.5	7.12	150
6.6	5	4.08	75
6.6	5	7.18	150
10.9	3	5.82	75
10.6	3.5	5.87	75
10.3	4	5.89	75
10.3	4	10.54	175
10.0	4.5	5.89	75
10.0	4.5	10.77	125
9.7	5	5.9	75
9.7	5	10.83	100
9.4	5.5	5.9	75
9.4	5.5	10.86	100
9.1	6	5.9	75
9.1	6	10.87	75
8.9	6.5	5.9	75
8.9	6.5	10.87	75



*Minimum length is the length beyond which the given capacities are valid. If your requirement of length is below the minimum length, please get in touch with us.

We also manufacture heat pipes with customised heat transfer capacity.

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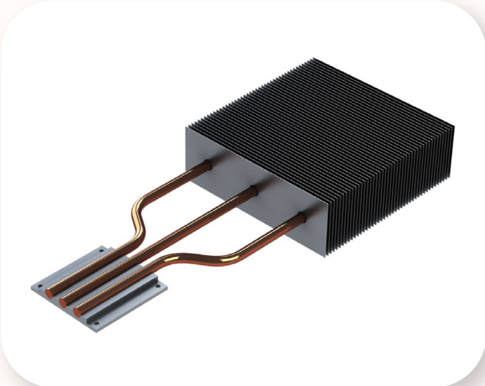
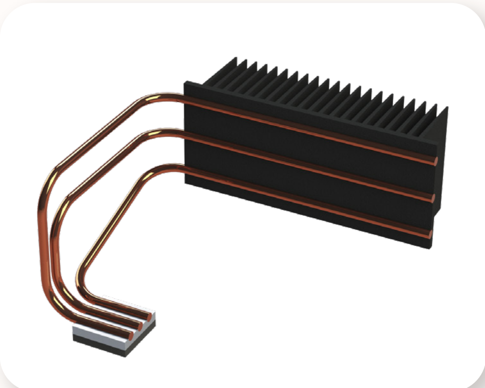
Types of Heat Pipe Assemblies

1. Heat Pipes with Stacked Sheet Metal Fins



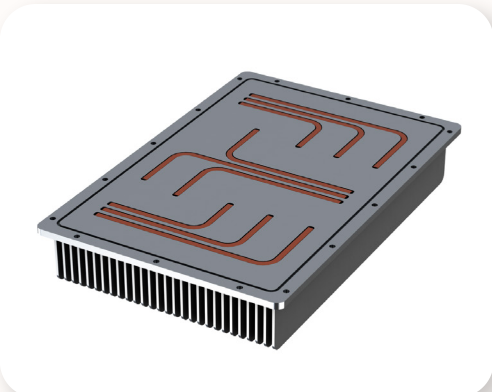
These types of assemblies are used to transport heat from the components to another location to manage the heat. Stacked sheet metal fins are commonly used with forced convection, since the fins can be closely spaced to reduce the weight as well as space occupied by the heat sink assembly. Copper, Aluminium or sometimes Stainless Steel is used as a fin material. Some initial investment in tooling is usually required to produce the fins of required shape and size.

2. Heat Pipes with Extruded or Die Cast Fins



These types of assemblies are also used to transport heat from the components to another location. Aluminium is used as the fin material in these assemblies. Such assemblies are commonly used where natural convection is employed as the cooling method since the fin spacing is optimally designed to suit natural convection and radiation heat transfer can be used to enhance the heat transfer by anodizing the fin and fin base. Also, standard fin extrusions or castings available in the market can be used to reduce tooling costs associated with the assembly.

3. Heat Pipe Embedded Heat Sinks



Such assemblies usually form the enclosure of electronic assemblies and employ mostly natural and sometimes forced convection cooling methods. Most common heat sink material in such heat sinks is Aluminium. Flat heat pipes are preferred in such heat sinks to keep the thickness of the heat sink base to a minimum as well as improving thermal contact. Heat pipes in such heat sinks are used to spread the heat across the heat sink to avoid hot spots.

Feel free to get in touch with us for your Thermal Management Requirements

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