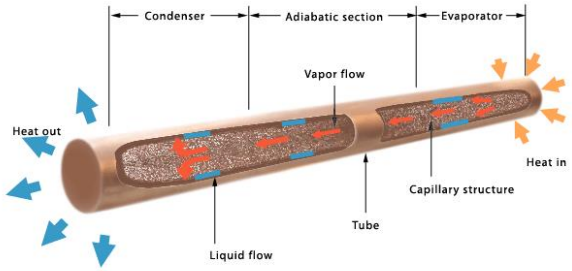
Heat Pipe Basics

Developed in the 1960's, heat pipes are becoming more and more prevalent in today's cooling systems.

Many engineers that have worked with thermal management are familiar with the basic concept: heat pipes transfer heat from the source to a location where it can be safely or more easily dissipated.

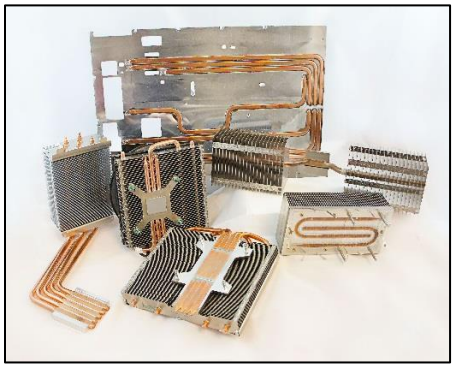
All heat pipes work with the same basic cycle:

1. Heat is absorbed from the device at one point on the heat pipe
2. The absorbed heat evaporates local liquid into a vapor
3. That vapor travels to a cooler region of the pipe
4. The vapor then cools and condenses back into liquid
5. The liquid travels back down the wick to the heat source through capillary action



As there are no moving parts, this cycle can repeat indefinitely. Additionally, because of the latent heat of vaporization, fluid can absorb and carry more energy or heat during phase change from liquid to a vapor. This provides a much higher effective conductivity than the metals typically used for heat sinks or single phase cooling.

Sounds simple. However, heat pipes still remain a commonly misunderstood technology.



Aavid has been on the cutting edge of heat pipe technology for over 20 years and as the industry leader is responsible for many of the most advanced integrated heat pipe assemblies in use today. We have developed heat pipe solutions for a wide range of devices across all industries, from small consumer electronics to aerospace applications.

As we continue to develop innovative cooling solutions utilizing this technology, we've come across a number of widespread industry myths about heat pipes. It is time they were dispelled.

The 7 Most Common Heat Pipe Myths

Myth #1: If heat pipes break, they will get liquid on my electronics.

Fact: Heat pipes rarely, if ever, break. And if they do, the small amount of liquid held in the pipe would be fully saturated into the wick and extremely unlikely to drip or damage your electronics.

Heat Pipes are inherently robust and are a purely passive system that does not wear down over time as active systems often do. A well-engineered heat pipe would require cutting or a copious amount of repeated bending to break. This is one of the reasons why heat pipes are used in industries such as aerospace and defense, where high reliability and long lifetimes are required.

Through decades of refining manufacturing techniques and engineering specifications, Aavid has developed consistently robust, high quality heat pipes. To prove out their design, seal, and welding, Aavid heat pipes are tested in thermal labs utilizing high temperature testing in accelerated life tests.

If the seal of a heat pipe were to be broken, the miniscule amount of liquid actually within the pipe would be fully saturated into the wick so that no fluid would drip out. The wick would keep any liquid within the heat pipe with capillary forces. Furthermore, heat pipes are charged with a vacuum while being filled. This process ensures that a certain amount of the fluid contained in the pipe is always in vapor form and therefore will not drip.

Myth #2: Heat pipes are heavy.

Fact: Heat pipes can remove more weight than they add to an assembly.

Aavid engineers often integrate heat pipes into custom cooling solutions in order to decrease the weight or volume of the overall solution. Although most often made of copper, heat pipes are hollow and can decrease the weight of your solution while improving thermals in a variety of ways. In many assemblies, heat pipes are used to transfer heat to a cooler, more open area of the device, where a fan can be added to decrease the size and weight of your cooling solution.

Above: Embedded heat pipes to enable a much smaller heat sink.

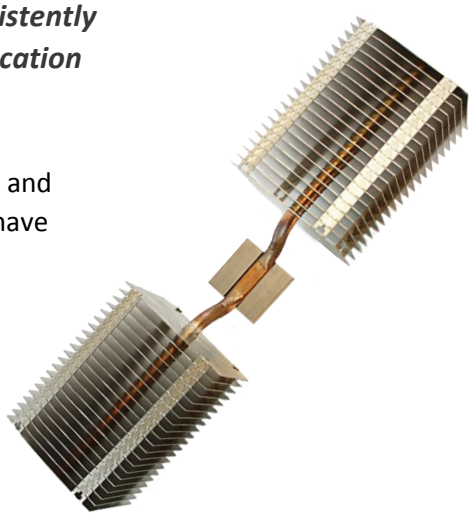
Another common example is replacing a traditional copper spreader with an aluminum heat sink base that has embedded heat pipes. These heat pipes can be arranged to target spreading to specific locations while reducing the amount of copper needed and therefore reducing the overall weight and cost of your solution.

Myth #3: Heat Pipes only work with the evaporator and condenser on the ends.

Fact: Heat pipes function along the entire length of the pipe and will consistently transfer heat from warmer regions to cooler regions regardless of their location along the pipe.

Heat pipes contain a wicking structure throughout the pipe so they can evaporate and condense as needed along the full length of the pipe. Because of this, heat pipes have unique design flexibility that enables more innovative and cost efficient solutions.

As mentioned previously, many applications that go through Aavid design centers utilize heat pipes to spread heat rather than transfer it. When heat pipes are embedded in the base of the heat sink, the heat condenses along the entire length of the heat pipe rather than a set region. This allows engineers to use smaller volume or less complex cooling systems for high power density devices. An example of this would be to integrate heat pipes into an air cooled system in order to mitigate a need for a liquid system when cooling high power IGBTs.



Above: Example of a heat pipe being used with the heat source at the center and the evaporators at either end.

Myth #4: Heat pipes only spread heat in a straight line. If I want to spread heat along the whole base, I need a vapor chamber.

Fact: Heat pipes can be bent and used in a manner similar to a vapor chamber but with more structural integrity.

Although a heat pipe only moves heat along its axis, this axis can be bent or used with multiple heat pipes to act effectively as a planar spreading mechanism similar to a vapor chamber. Aavid engineers accomplish this through years of experience designing and modeling heat pipe bends and arrays that effectively translate heat pipes from a one dimensional heat transfer unit into a two dimensional heat spreader.

Above: Example of heat pipe spreaders within a heat sink base to mimic a vapor chamber

While they can be designed to mimic the function and performance of a vapor chamber, heat pipes are less expensive and offer increased structural integrity. When embedded correctly, heat pipes can accommodate a significant amount of mounting force in applications where vapor chambers proved too delicate.

Myth #5: It has to be very hot for heat pipes to work.

Fact: Manufacturing techniques enable heat pipes to function even with small temperature rises.

Because heat pipes are charged with a vacuum prior to sealing, the fluid exists as both a liquid and a vapor at its saturation point. This is similar in principle to boiling a liquid at higher elevations with lower pressures. It takes much less heat for the molecules to be energized enough to change phase from a liquid to a vapor. Therefore the temperature of the heat source does not need to reach the standard room temperature boiling point to cause the liquid to vapor phase change. In fact, only a few degrees difference is needed between the "hot" and "cold" areas of a heat pipe for it to function. This is one of the key benefits of utilizing heat pipes and keeps the thermal resistance of your solution minimized.

Myth #6: Heat pipes cannot be used in freezing conditions.

Fact: How a heat pipe operates in environmental conditions is dependent on materials and design. Heat pipes can be developed to function in extremely rugged conditions such as freezing environments.

Although copper and water is the most popular combination, other materials can be used based on specialized requirements. Liquids such as ammonia, methanol, and acetone can all be combined with compatible metals to develop heat pipes that can function in temperatures well below -60°C.

Even with copper and water, the solution can be designed to mitigate environmental conditions. By utilizing the proper thermal technologies and techniques, thermal solutions with integrated heat pipes can even enable device functionality such as cold start for applications such as outdoor telecom, industrial, and military. With the correct design parameters, heat pipes can also withstand a large number of repeated freeze/thaw cycles without any bursting or failures.

Just for show….. they wouldn't actually work like this.

Myth #7: Heat pipes are expensive.

Fact: Heat pipes can actually save you money.

Copper's ductility enables heat pipes to be economically fabricated, reliably sealed, and easily bent and pressed into specific geometries. Through refined manufacturing techniques and design considerations, Aavid is able to offer extremely cost-effective copper/water high performance heat pipes.

Myth #7 (cont.)

Furthermore, utilizing heat pipes to enable smaller volume solutions and replace heavier, more expensive materials. An aluminum/embedded copper heat pipe base can be more thermally efficient as a solid copper base for spreading heat at a fraction of the cost. It can be noted, however, that heat pipes can start getting more expensive when unusual materials or working fluids are required for your application requirements.

While heat pipes are cost efficient, the actual cost of an integrated heat pipe solution is dependent on the type of technology they are combined with. A heat pipe itself is not a solution and needs a method of dissipating heat like a heat sink. That being said, using heat pipes allows for more design flexibility and more options for your cooling technology and how you can use it.

Ready to Experiment?

Aavid offers Heat Pipe Explorations & Discovery Kits that allow individuals or teams to see how heat pipes work and can be used with their thermal management solution. Watch the Introduction Video.

HEAT PIPE EXPLORATION KIT
For larger groups
90 heat pipes diameter 4 - 8 mm
30 Condenser Caps and plates
30 Evaporator Caps and plates
200 M3 Screws
1.1 Oz. Thermal Grease
Shop Now

HEAT PIPE DISCOVERY KIT
For smaller groups
30 heat pipes diameter 4 - 6 mm
8 Condenser Caps and plates
8 Evaporator Caps and plates
100 M3 Screws
1.1 oz. Thermal Grease
Shop Now

To learn more about how heat pipes can enable improved cooling for your design visit
www.aavid.com or download the Aavid Heat Pipe Brochure

For a free consultation with one of our design engineers regarding your thermal needs
Call 1.855.322.2843 or fill out our Design Help Online Form.

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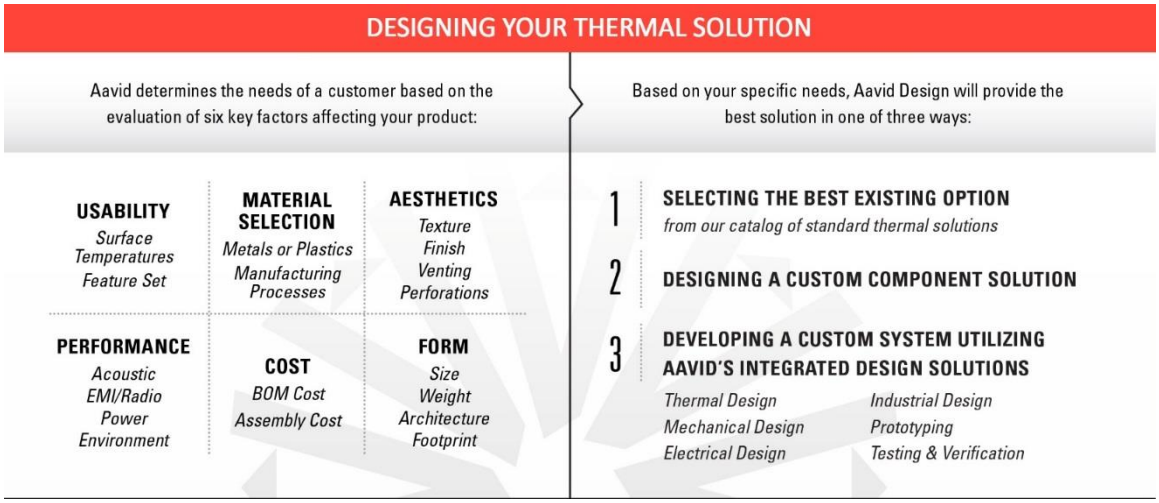

About Aavid

Founded in 1964 as Aavid Engineering, Aavid Thermalloy is the oldest and largest design engineering and manufacturing corporation focused on thermal management solutions in the world. For over 50 years we have consistently brought the most innovative new cooling solutions to market while also improving the efficiency and availability of conventional cooling technologies. In doing so, we have developed the widest array of cooling products and services in the industry. Aavid provides thermal solutions across all industries and for any application on a global level. Decades of experience and expertise combined with an unwavering dedication to unique problem solving allows us to meet any requirements and resolve any thermal challenges.

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