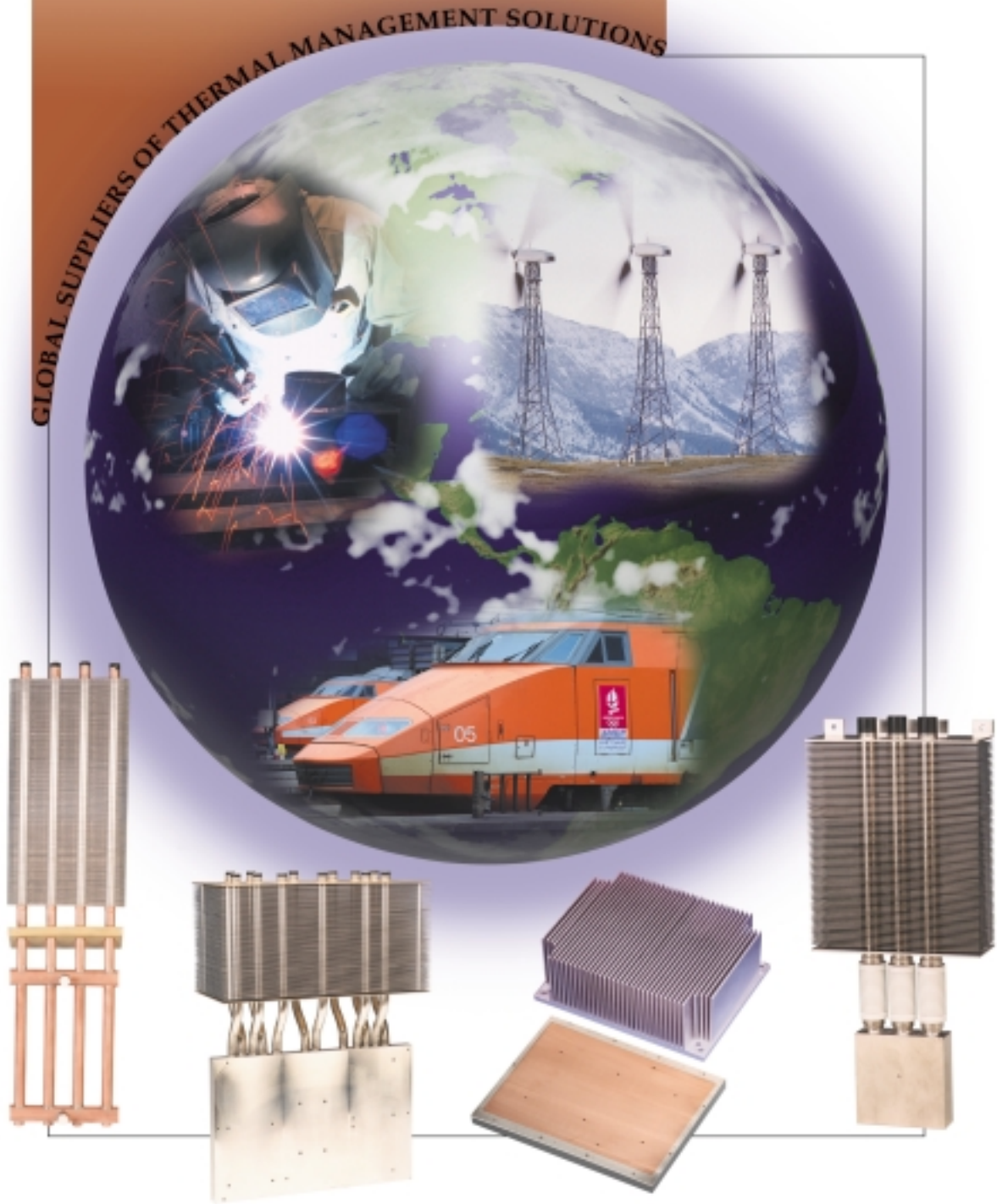
THERMACORE

Thermal Management Solutions

Power Semiconductor Cooling Solutions



Power Semiconductor Cooling Solutions

Controlling heat for today's power electronic products is a key factor in design optimization. Thermacore's two-phase heat transfer system is a highly effective solution for cooling variable speed drives in industrial, traction and high-speed train applications.

A heat pipe solution is efficient, cost effective, compact and maintenance free. Thermacore can design a heat pipe based system to fit your specific needs in any power application to dissipate from watts to kilowatts of heat.

Customized Thermal Solutions For Power Semiconductors

• INDUSTRIAL DRIVES

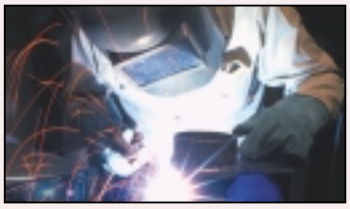
Power semiconductors have revolutionized the control of motors used in industrial applications. Previously, motor speed control was accomplished with gear reduction systems. Now using power semiconductors, the control of these motors can be achieved with the touch of a button. Typical industrial drive applications include petroleum and chemical plants, mining, metal fabrication, paper mills, cement operations, water/wastewater facilities and electric power generation.

• TRACTION

Most mass transit systems, such as subways, operate from electricity. Crude electricity supplied to the locomotive and rolling stock must be conditioned to provide propulsion, lighting and air conditioning. Power semiconductors are utilized to condition the electricity; the removal of heat as efficiently as possible is critical to their operation. Cooling systems must be reliable to meet vibration, climate extremes and shock conditions that are expected with long-term use of mass transit systems. Heat pipes meet this challenge operating on many transit systems around the globe from the tropics to the coldest regions of the world.

• UNINTERRUPTABLE POWER SUPPLY (UPS)

In today's precise manufacturing environments, power quality and reliability are extremely important. UPS systems provide a necessary power supply much like any other electronic system. When striving for high performance in a small package, the drawback often becomes heat. A highly efficient, cost-effective thermal control solution, such as heat pipes will allow engineers to take their UPS systems to the next level.



• WELDING

Power electronics fuel the welding equipment industry, and cooling of these electronics is critical for reliable and consistent welder performance. To ensure optimal production, it is important to have efficient, compact, cost-effective and maintenance-free operation. Heat sinks with heat pipes satisfy these criteria and are ideal for production line applications.

• WIND POWER

Generating electricity from wind is an environmentally friendly alternative. This type of raw power needs conditioning to reach the quality required by customers. Many wind farms are placed in remote locations of the world where maintenance-free operation is necessary. A heat pipe thermal solution has no moving parts to fail, reducing or eliminating maintenance requirements.

• ESCALATORS, ELEVATORS AND PEOPLE MOVERS

Power electronics are used extensively in the operation of escalators, elevators and people movers. A cooling system must be reliable, compact and maintenance free to ensure optimal performance. Heat pipe cooling satisfies those criteria efficiently and cost effectively.

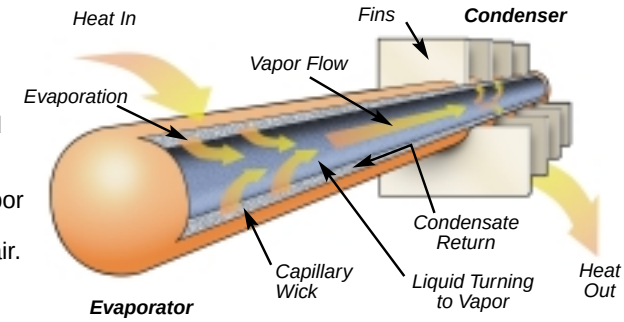
Power semiconductors, like Insulated Gate Bipolar Transistors (IGBTs), Silicon Controlled Rectifiers (SCRs) and Intelligent Power Modules (IPMs), need to be cooled properly for efficient and consistent performance. If not addressed with a reliable cooling system, internal damage can occur and create extended downtime of major power systems.

Theory of Operation

Typical power electronics that require cooling are IGBTs and “hockey puck” thyristors. Thermacore offers an extensive list of products to cool these types of components, each representing a progression in thermal performance enhancement.

Heat Pipe Cooling

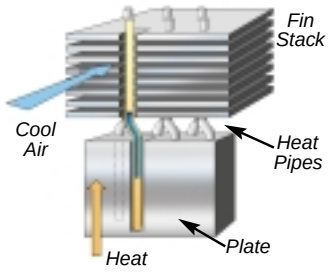
A heat pipe is a two-phase heat transfer device with an extremely high effective thermal conductivity. It can be cylindrical or planar, and the inner surface is lined with a capillary wicking material. The heat pipe is evacuated and back-filled with a small quantity of a working fluid such as water, acetone or methanol. Heat is absorbed in the evaporator region by vaporizing the working fluid. The vapor transports heat to the condenser region where the vapor condenses, releasing heat to the cooling media, such as air. The condensed working fluid is pumped back to the evaporator by capillary action or gravity.



Heat pipes have a lower total thermal resistance than solid conductors, enabling them to transfer heat more efficiently and evenly. They are totally passive heat transfer systems, having no moving parts to wear out and requiring no energy to operate. Heat pipes offer the design engineer low-cost packaging flexibility because they can be manufactured in a number of shapes and sizes. Their light weight and compact size also make them the ideal choice for space-constrained applications.

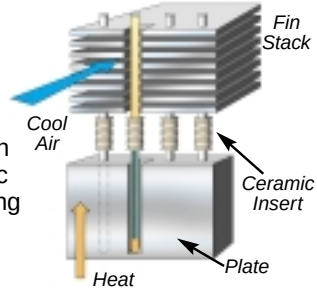
Therma-Charge™

Standard heat pipes are embedded in a metal plate under the power semiconductors and extended from the plate to a remote fin stack. Heat from the electronics is absorbed by the heat pipes and transported to the fins which are cooled by natural or forced convection.



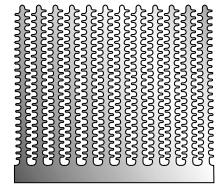
Isolated Therma-Charge™

Utilizing the same principals as the Therma-Charge™, another option involves making the unit electrically isolated. The center section of each heat pipe is replaced with a ceramic tube insert that is capable of blocking up to 9kV. To achieve electrical isolation, the unit uses a di-electric working fluid.



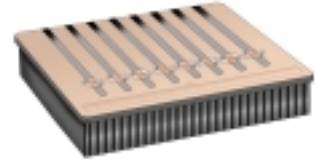
High-Performance Extruded Heat Sinks

High-performance extruded aluminum heat sinks are designed for power electronics cooling. The special extrusion process used achieves higher fin density, higher fin length to fin thickness ratios and enhanced fin surfaces. These attributes permit the heat sinks to outperform standard extruded heat sinks.



Embedded Heat Pipe

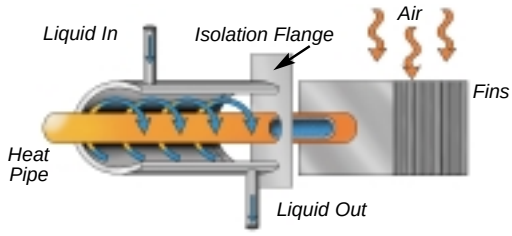
Embedding heat pipes into the heat sink is an effective cooling alternative to greatly enhance the performance of an existing heat sink with minimal design changes.



8 Embedded Heat Pipes Shown

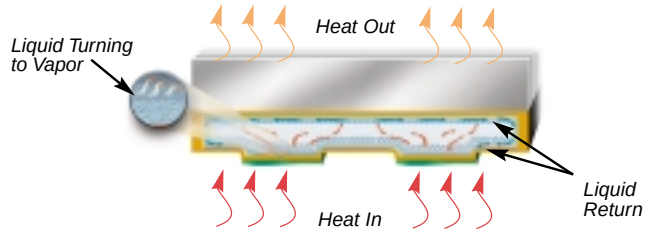
Liquid-to-Air

Hot air from inside a cabinet is forced over fins, conducting heat to the heat pipes. The heat pipes transport this heat to the cooling liquid being circulated over the heat pipe. The isolation flange provides necessary separation so cooling liquid cannot get inside the cabinet if there is a leak.



Therma-Base™

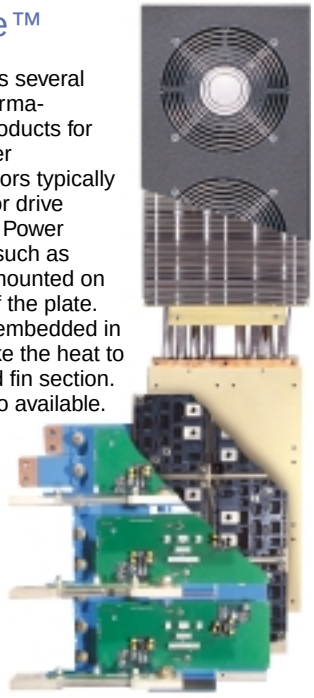
Another alternative for improving heat sink effectiveness is the use of a Therma-Base™, a plate style heat pipe that is applied to the base of a heat sink. Therma-Base™ is a hollow plate that allows the vapor to transport heat uniformly throughout the entire base plate surface of the heat sink. Therma-Base™ products can also be used as the base of IGBT modules.



Products For IGBT Cooling

Therma-Charge™

Thermacore manufactures several different Therma-Charge™ products for cooling power semiconductors typically used in motor drive assemblies. Power electronics, such as IGBTs, are mounted on both sides of the plate. Heat pipes, embedded in the plate, take the heat to an air-cooled fin section. Fans are also available.



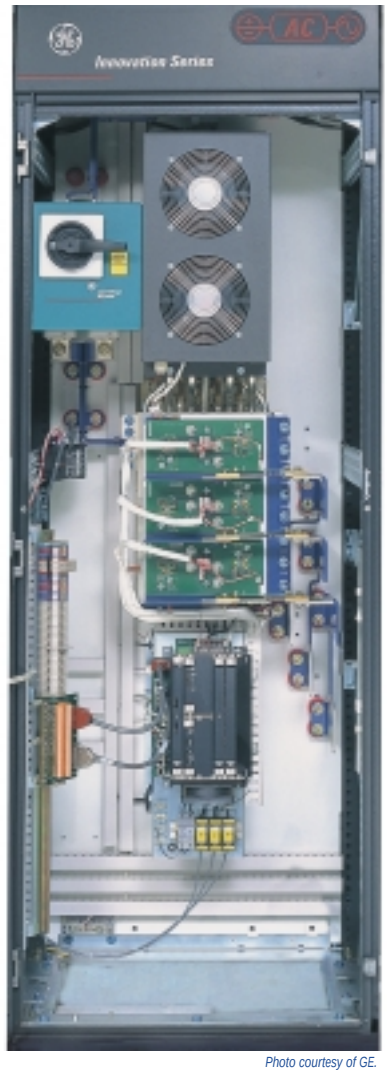
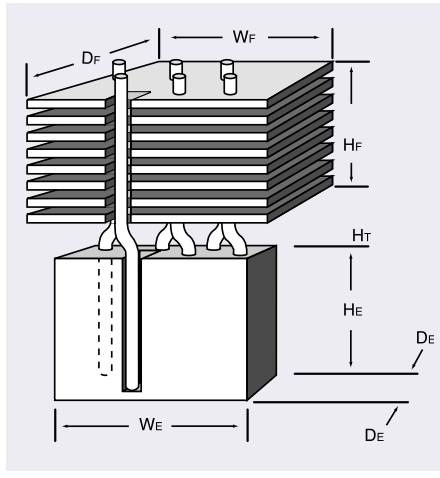
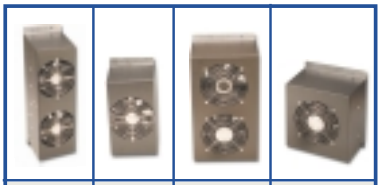


Photo courtesy of GE.





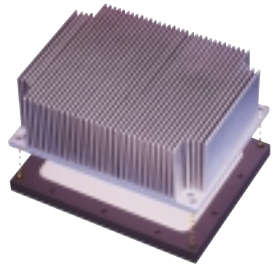
FAN PACK #1	FAN PACK #2	FAN PACK #3	FAN PACK #4

P/N*	Watts	HE Inches	HT Inches	HF Inches	WF Inches	WE Inches	DF Inches	DE Inches	Air Flow, CFM	Thermal Resist., ˚C/W	Fan Pack (optional)
771	3600	9.65	0	12.80	10.63	9.84	6.30	.79	275	0.017	--
835	6000	17.00	4.50	19.30	10.40	12.00	9.00	.98	600	0.006	3
1001**	8300	21.00	0	25.00	15.50	15.50	7.00	.98	1600	0.004	--
1030**	1300	4.42	0	12.00	19.54	21.50	2.00	.98	1000	0.024	--
1045**	2600	9.60	0	12.00	19.54	19.54	4.00	.98	1000	0.012	--
1084	2500	11.38	4.50	11.50	10.40	11.00	9.00	.98	300	0.012	4
1096	3750	11.38	0	19.30	10.40	11.00	9.00	.98	600	0.007	3
1105	3000	13.00	4.50	19.30	10.40	11.00	9.00	1.73	600	0.009	3
1113	1800	13.28	4.50	11.50	6.00	6.00	9.00	1.73	200	0.018	2
1119	1800	11.38	4.50	19.30	6.00	6.00	9.00	.98	360	0.015	1
1172	650	6.50	2.75	4.70	6.00	4.75	4.75	.75	60	0.062	119x119mm
1227	1300	11.39	4.50	11.50	6.00	6.00	9.00	1.73	200	0.027	1
1229	2650	11.75	4.50	19.30	6.00	6.00	9.00	1.71	360	0.018	1
1300	1800	7.09	0	8.62	18.90	19.40	5.90	1.00	600	0.006	--
1591	4000	10.47	4.50	19.30	10.40	10.03	9.00	1.00	600	0.009	3
1800	4000	15.50	4.50	19.30	10.40	11.00	9.00	1.73	600	0.009	3

* Request data sheet on the specific P/N. ** 90˚ angled unit.

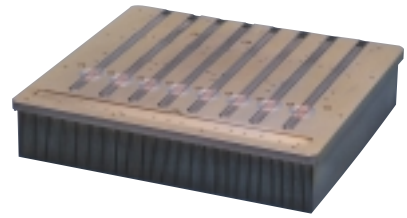
Therma-Base™

Therma-Base™ is a vapor spreader used as the base of a heat sink. A Therma-Base™ delivers higher performance heat transfer by alleviating spreading resistance, thereby lowering device temperatures. The Therma-Base™ has a greater capability to accept higher heat fluxes than a traditional aluminum or copper surface. It also will operate in any orientation, maximizing system packaging flexibility.

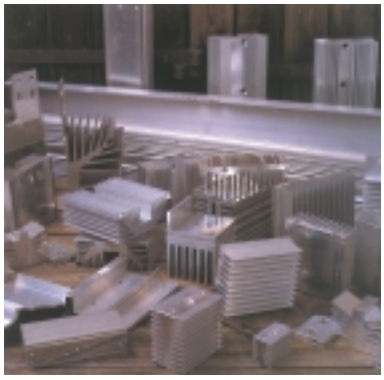


Embedded Heat Pipe/ Heat Sink

Embedded heat pipes extend the performance of an existing heat sink with minimal design changes, providing an effective alternative to other methods. For example, in the heat sink shown, heat pipes were embedded under each of eight power amplifier modules.



The heat pipes were 0.375" diameter flattened into grooves in the heat sink base with a thermal epoxy at the interface. This approach reduced the thermal resistance of the heat sink by 50%. Embedded heat pipes may provide the needed improvement in your existing heat sink. Contact Thermacore to help you determine if embedded heat pipes are right for your application.

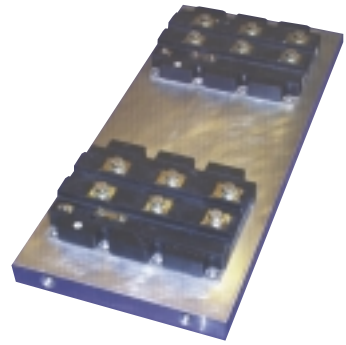


Extruded Heat Sinks

Thermacore International is the U.S. representative for the Webra brand extruded heat sinks. These heat sinks typically apply to cooling power electronics due to their unique design. Product literature is available upon request for these heat sinks.

Liquid-Cooled Plates

Thermacore and Webra manufacture water-cooled plates for cooling power semiconductors. In most applications, these water-cooled plates are designed specifically to the customer's requirements. There are, however, several designs that are available as shown in the table below. Specific information on each model is available upon request. Custom water-cooled assemblies are a specialty. Please contact us with your specifications.

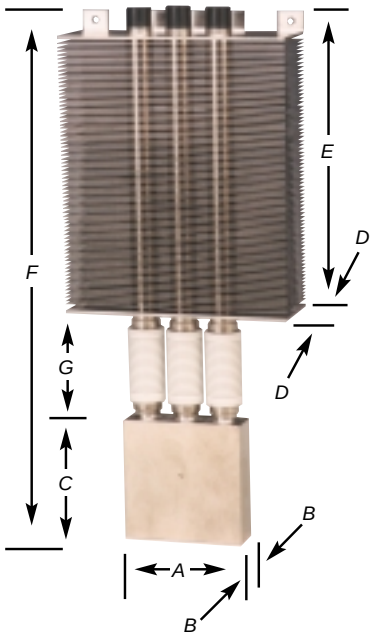


Model*	Component	Cooler Dimensions	Water Flow Rate	Pressure Drop	Rth
VK-560-222-23	2xIGBT	23x222x560mm	6-18 l/min.	0.3-1.6kPa	5 K/kW
VK-290-240-15	6xIGBT	15x240x290mm	6 l/min.	--	--
VK-400-280-19	2xIGBT	19x189x400mm	--	--	--
VK-495-150-34-103	--	34x150x495mm	1-13 l/min.	--	5 K/kW

*Request data sheet.

Products for Thyristor Cooling

Isolated Therma-Charge™



The Isolated Therma-Charge™ is designed for cooling thyristor modules. In most situations, several isolated units are used to cool several thyristors in a staggered arrangement. The entire assembly of isolated units and thyristors are then bolted together under high pressure to minimize thermal contact resistance.

Isolated Therma-Charge™ units are designed for electrical isolation. Without isolation, the heat sink would be at the same potential as the thyristors. To eliminate the safety issues, isolated units have ceramic insulators in the heat pipes that can insulate several thousand volts of electricity.

The Isolated Therma-Charge™ can be operated in gravity-aided positions as low as +5˚ orientation. Thermacore's isolated power cooler offers a thermal resistance as low as 0.06˚C/W with a power capacity as high as 700 watts. Different sizes and configurations of Isolated Therma-Charge™ units are possible and custom specifications are available. For further information on the isolated power cooler or other devices for thermal packaging, contact a Thermacore Applications Engineer.

Specifications:

Power .....700 Watts
Rise Above Ambient
Air Temperature.....45˚C
Thermal Resistance .....0.06˚C/W
Operating Temperature ....-25˚C to 100˚C
Voltage Standoff .....9000v (min.)
Heat Input Area.....65mm Dia. (nom.)
Projection of Heat
Pipes Beyond Fins .....1.0"
Storage Temperature .....-65˚C to 100˚C
Operating Position.....+5˚ to +90˚

Materials:

Heat Pipe Envelope .....Copper
Heat Pipe Working Fluid ..FC-72
Fins .....Copper or Aluminum

Parts No.	Power, Watts	a Inches	b Inches	c Inches	d Inches	e Inches	f Inches	g Inches	Air Flow, CFM	Thermal Resist. ˚C/W
413	700	3.54	1.18	3.54	2.36	8.11	15.7	3.22	300	0.06
426	700	3.54	1.02	3.54	1.97	9.57	17.44	3.54	300	0.06
703	700	3.54	1.18	3.54	1.97	9.88	17.44	3.22	300	0.06
906*	1400	4.75	1.00	10.50	1.75	13.00	24.25	0	165	0.03
907*	1400	4.75	1.00	7.50	1.75	13.00	21.25	0	165	0.03
New Prod.	1000	2.90	2.90	7.50	3.75	13.00	24.30	3.00	50	0.025

*Non-Isolated Unit

Liquid-Cooled Thyristor Plate

This cooled plate is designed for cooling thyristors up to 100mm in diameter and several thousand pounds clamping pressure. The total heat load to be dissipated can be as high as 3kW at a water flow rate of 3 l/min. Under these conditions, the thermal resistance for this plate is 8 K/kW. If your application requires increased thermal performance, Thermacore will apply its staff of thermal engineers to design a Liquid-Cooled Thyristor Plate to fit your requirements.

Air-Cooled Heatsinks

Three styles of heat sinks for top and bottom cooling of thyristor modules are available. The values listed in the table are for heat sinks measuring 180mm. They are available in lengths up to 300mm. In addition, special designs to meet specific customer needs are not a problem. Nickel plating or anodized surfaces are also available.

Type	Model	Dimensions	Airflow*	Pressure Drop*	Thermal Resistance*
Single	W-EKD-44	116x180x 45mm	Refer to datasheet	Refer to datasheet	Refer to datasheet
Double	W-GTL-75	151x180x 75mm	30-70 l/s	500-700 Pa	20-42 K/kW
Triple	W-GTK-105	151x180x 105mm	30-70 l/s	500-700 Pa	20-42 K/kW

Liquid-to-Air Heat Pipe Heat Exchanger

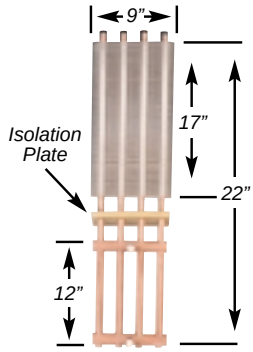
Specifications:

Power .....800 to 1200w

Air Flow 800cfm

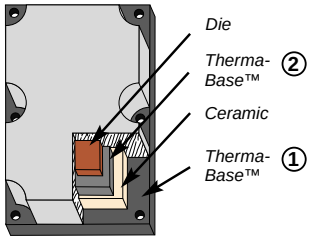
Coolant Flow .....3/4 - 1gpm

Thermal Res. ....0.02 ˚c/w



This unit keeps the cooling liquid away from critical components within the electronics cabinet. The hot air inside the cabinet is circulated through the fins. The fins conduct heat to the heat pipes, which in turn transport heat to the exterior of the cabinet. The cooling fluid removes heat from the heat pipe. Thermacore will custom design your liquid-to-air heat exchanger for your specific application.

Internal Cooling of Power Semiconductors



1) Replace the solid copper base of an IGBT with a high-performance Therma-Base™.
2) Insert a Therma-Base™ between the dies and the ceramic as shown in this illustration.

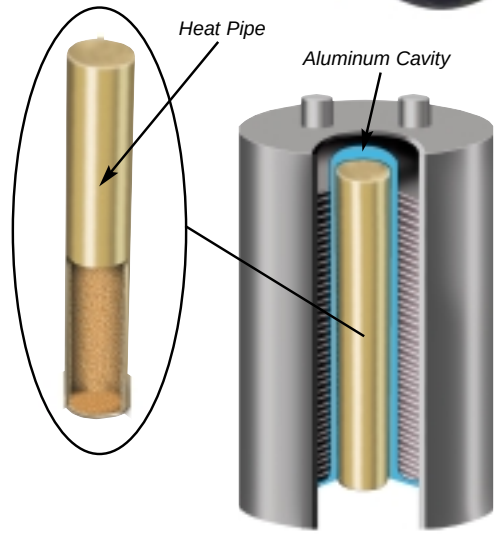
As the performance of power semiconductors increase, the method of their thermal control becomes the gating factor. The solution is to take advantage of the additive thermal performance with a Therma-Base™. There are two alternative methods (see adjacent) that can be applied to improve an IGBTs performance while also removing heat. Please contact Thermacore to explore the advantages of internal cooling of IGBTs.

Replace the existing copper base of an IGBT with a Therma-Base™ and improve its performance.

Heat Pipe Cooling of Capacitors*

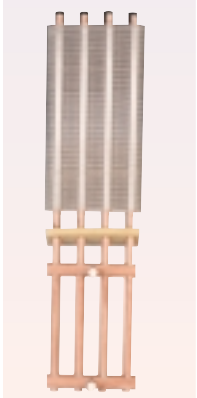
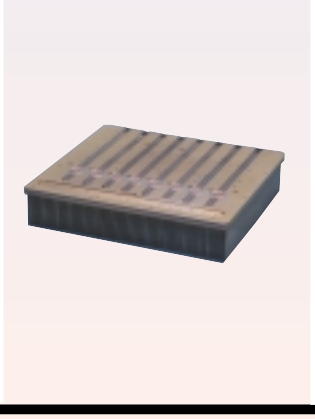
*Patent Pending

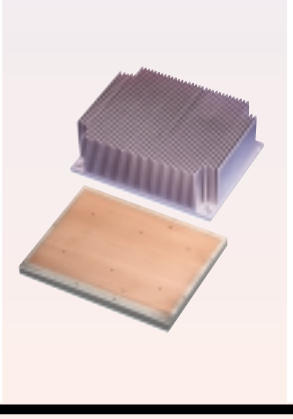
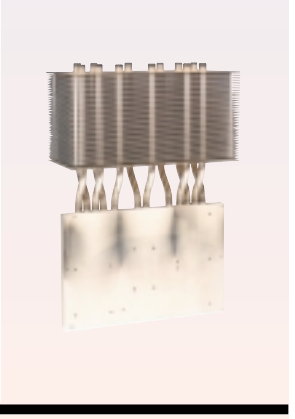
Thermacore has developed a method for cooling the internal portion of electrolytic capacitors. For compatibility reasons, the heat pipe cannot directly penetrate the capacitor. Instead the aluminum shell is pushed inward to form a finger-deep cavity to receive the heat pipe. The heat pipe transports the internal heat to the base of the capacitor where it can be dissipated. The aluminum shell of the capacitor will be sent to Thermacore for proper insertion of the heat pipe.



Global Leader in Heat Transfer Technology

Thermacore is a worldwide leader in the design and manufacture of thermal management solutions with over 30 years of experience. The company has 54 patents in the thermal design area and in excess of 600 combined man-years of thermal engineering expertise. With international manufacturing in the US, Mexico, Europe and Asia, Thermacore provides quality manufacturing to OEMs worldwide.

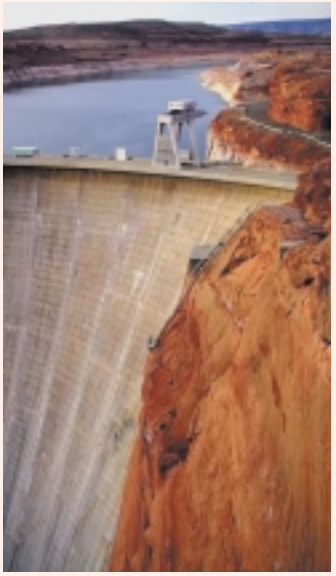



You'll Find Thermacore Products in Today's Critical Markets

- *Computers*
- *Communications*
- *Power Electronics*
- *Medical Equipment*
- *Consumer Electronics*
- *Automotive Electronics*
- *Test Equipment*
- *Instrumentation*





THERMACORE

A Subsidiary of Modine Manufacturing Company

MODINE

Thermacore, Inc.
780 Eden Road
Lancaster, PA 17604-3243 USA
Phone: (717)569-6551
Fax: (717)569-8424
Internet: www.thermacore.com
E-mail: info@thermacore.com

Thermacore Europe Ltd.
12 Wansbeck Business Park
Ashington
Northumberland, UK NE63 8QW
Phone: +44-1670-859-500
Fax: +44-1670-859-529
Internet: www.thermacore-europe.com
E-mail: info@thermacore-europe.com

Thermacore Taiwan Inc.
No.1, Sec.2
Yang Hu Road
326 Yang Mei
Tao Yuan County, Taiwan R.O.C.
Phone: +886-3-288-9050
Fax: +886-3-288-9052
E-mail: info@thermacore.com.tw

Thermacore Korea Ltd.
3Ra-205 Shiwa Industrial Complex
1273-4 Chungwang-dong, Shihung City
Kyunggi-Do, Korea
Phone: +82-31-433-9156
Fax: +82-31-433-2967
E-mail: thermko@chollian.net