CRS ENGINEERING

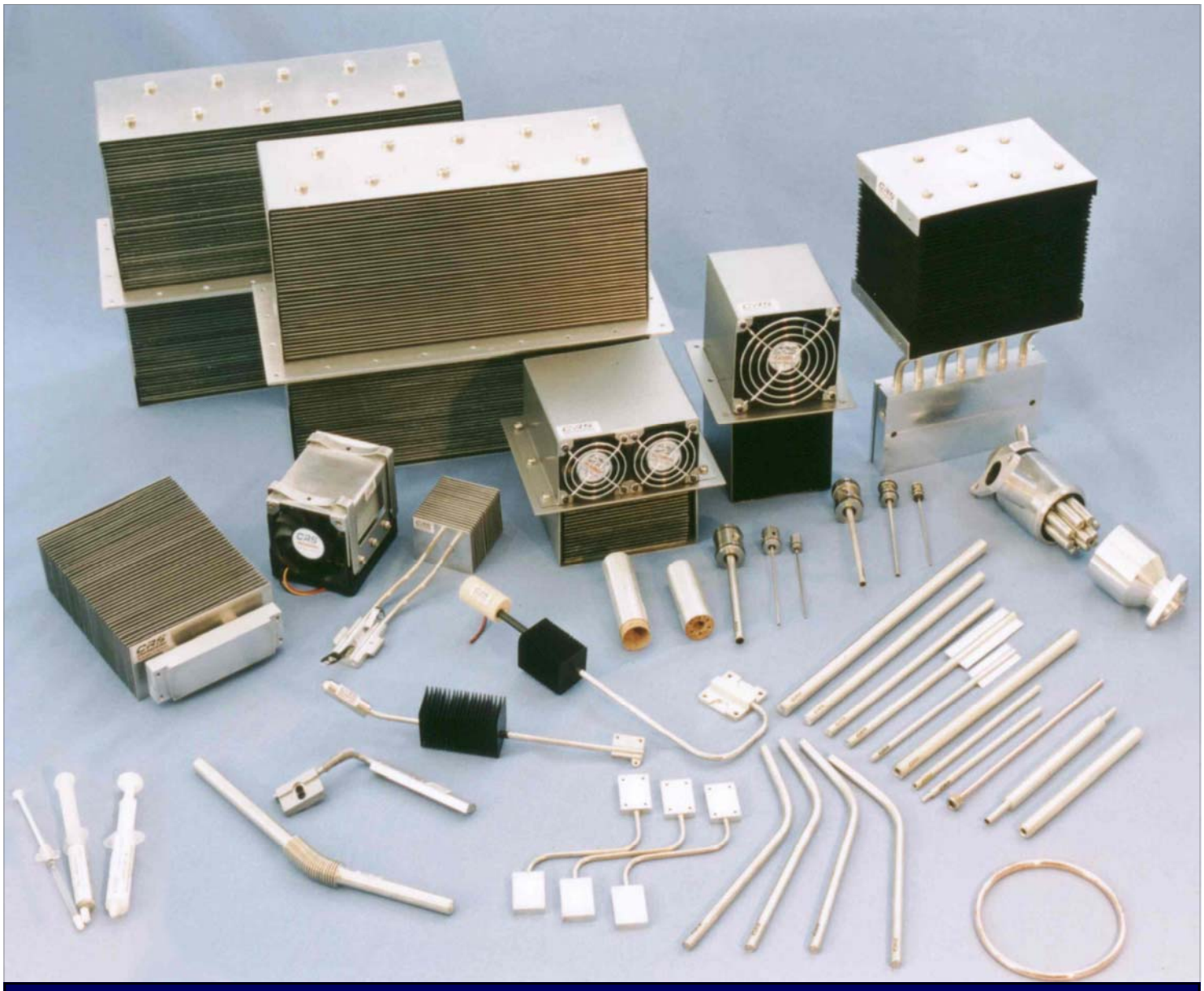
Heat-pipes & Thermal Management Systems

High Performance Thermal Solutions

Heat-pipes & Engineering Systems

For Power Electronics

A4 /V26



Stay Cool !

CRS ENGINEERING

Heat-pipes & Thermal Management Systems

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Welcome to CRS Engineering!....

Thank you for your interest in our Heat-pipe products and services in providing thermal solutions.

Most of our work is directly involved with customer specific applications, as such, the following pages are intended only as an insight into the products and services which our company can offer. We hope to inspire you with many new ideas together with our ability to resolve your particular thermal issues.

CRS Engineering has a wide experience in the field of thermal management and recognises the challenging and complex thermal demands facing today's development and application engineers.

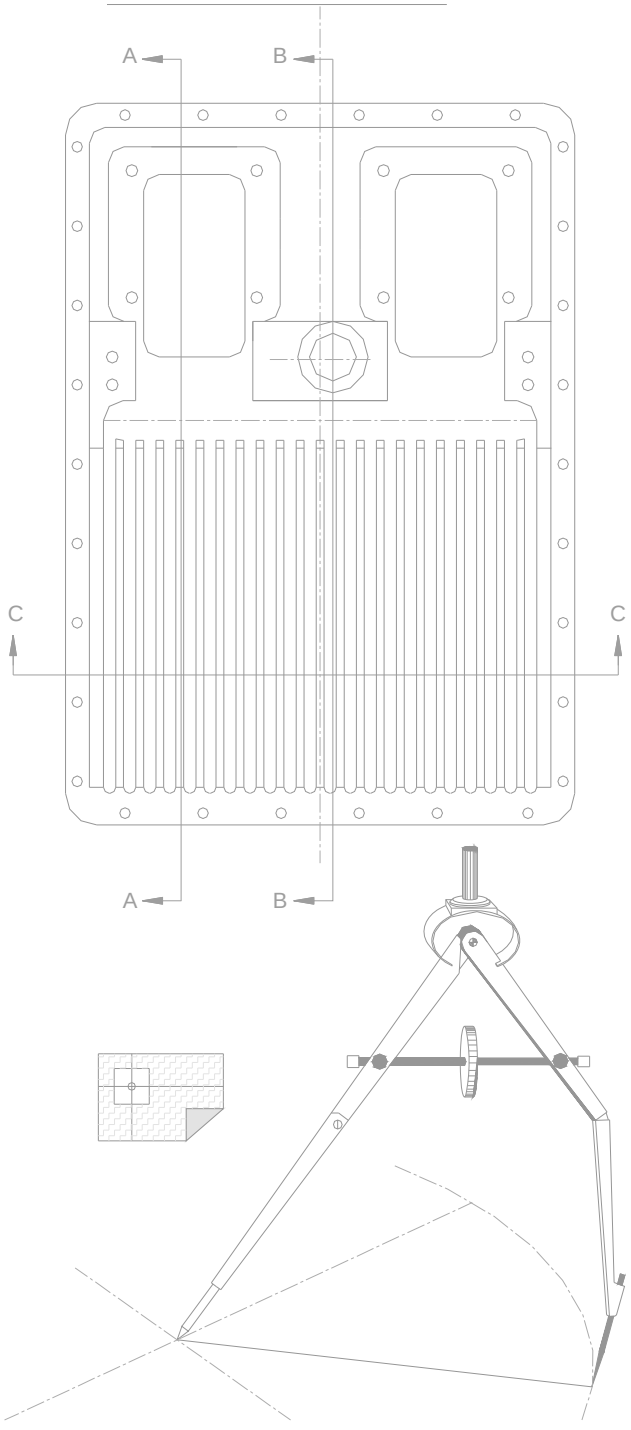
We are confident that our early involvement will benefit you immediately by determining the best approach in finding the most appropriate solution to satisfy your thermal requirements, and would be pleased to invite you for a free initial consultation with us so that a first stage appraisal of your application can made as soon as possible.

CRS Engineering provides:-

- ✓***Consultancy & Design.***
- ✓***Standard & Custom built Heat-pipes***
- ✓***Research & Development***
- ✓***CAD Thermal Analysis and Drawing***
- ✓***Thermal Performance Testing***
- ✓***Prototyping and Pre-series Production***
- ✓***Series Manufacture.***

DETAIL OF HEAT-PIPE CHILL PLATE

TOP SIDE PLAN VIEW



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Item-9G	QTY-100	Title/Name, designation, material, dimension etc			Article No./Reference
Designed by ENGINEERING	Checked by C.R.SIMPSON	Approved by - date 14-03-03	Filename XYZ-0004B	Date 10-03-03	Scale 1:1
CRS-ENGINEERING		THERMAL-SOLUTION			
		DIMENSIONS-3		Edition 1	Sheet 4/5

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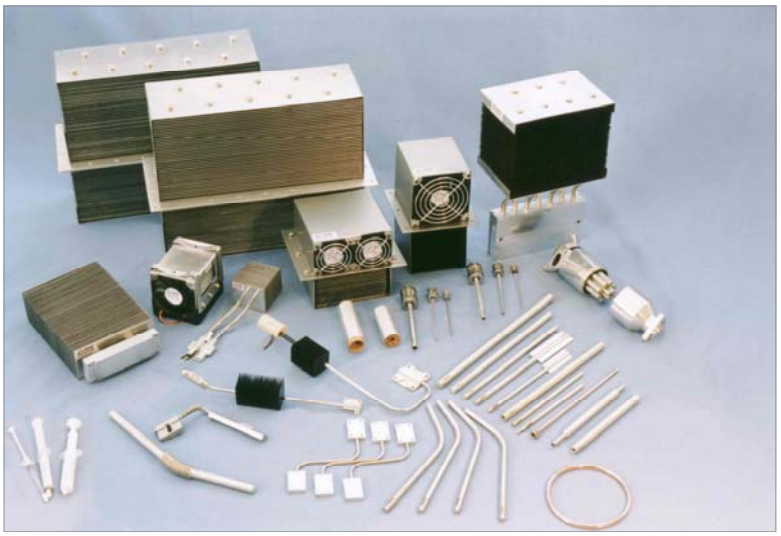
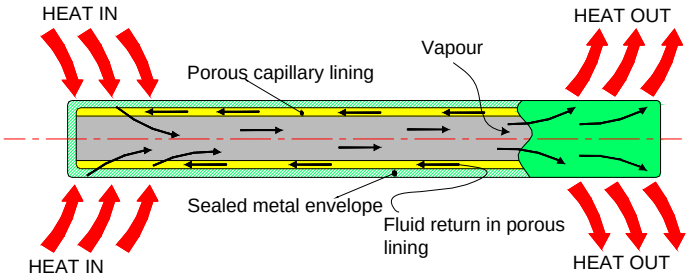
Heat-pipes & Thermal Management Systems

What is a Heat-pipe ?

In their simplest forms heat-pipes are usually sealed tubes containing a working fluid and its vapour together with a capillary wick lining system. A heat-pipe can be thought of as a super heat conductor, the application of heat at any point causes a liquid-vapour phase change inside the heat-pipe which enables large amounts of energy to be transmitted in the vapour phase with only a minimal temperature gradient. In terms of thermal conductivity a heat-pipe can exhibit a performance which exceeds that of an equivalent sized component made from pure copper by over 1000 times. Typically heat-pipes are produced in rod form with a circular cross section and may have diameters ranging from 2 mm to over 50 mm. Alternatively flattened sections heat-pipes are also available. Lengths can vary from only a few centimetres to several metres in length.



How does a Heat-pipe work ?



The diagram opposite shows a sectioned heat-pipe metallic enclosure with the capillary action porous lining. Operating on the principle of latent heat of vaporisation a heat-pipe utilises a working fluid operating in an otherwise completely evacuated and sealed enclosure. In effect the fluid exists within the vessel as a saturated vapour. When heat is applied to any point along the external surface, the fluid inside the heat-pipe evaporates and then condenses again at any other point which is at a fractionally lower temperature. In doing so, the latent heat capacity of the working fluid is utilised to effect a very efficient energy transfer. The passive operation of heat-pipes requires no external motive power except that of the applied temperature differential "ΔT" of the thermal loading. Having no moving parts, they are silent in operation and extremely reliable. Heat-pipes produced by CRS Engineering are manufactured to exacting standards for superb conductive performance properties.Integrated heat-pipe assemblies incorporating cooling fins, thermal input and heat sink pads are built as modular units which have minimal thermal system resistance and are convenient to install.

- ✓ ***Extremely High Thermal Conduction.***
- ✓ ***Fast Response to Thermal Loading.***
- ✓ ***Silent Operation.***
- ✓ ***Highly Reliable.***
- ✓ ***No Moving Parts.***

CRS Standard Range Heat-pipes:

Diameter (+ 0.0 / -0.1mm)	Length (+ 0.0 / -0.5 mm)											
	50	60	70	80	100	125	150	175	200	250	300	350
2.0	★	★	★	★	★	★						
2.5	★	★	★	★	★	★						
3.0	★	★	★	★	★	★	★	★				
4.0	★	★	★	★	★	★	★	★	★			
5.0	★	★	★	★	★	★	★	★	★			
6.0		★	★	★	★	★	★	★	★	★		
8.0					★	★	★	★	★	★		
10.0							★	★	★	★	★	★
12.0							★	★	★	★	★	★

CRS ST and HT Standard Range Heat-pipes are available in the above tabled metric sizes :

Description:

CRS standard range heat-pipes: Material: high purity copper. (electroless tin plated finish)

Temperature Range:

Low Temperature -	CRS-5000 LT series -20° C to +150° C
Standard Temperature Range -	CRS-5000 ST series +5° C to +170° C
High Temperature -	CRS-5000 HT series +5° C to +270° C
Extra High Temperature -	Available at over 300° C on request.

Special Sizes: Heat-pipes of any of the above listed diameters can be manufactured to special lengths from 20 mm to over 3 metres. Non standard range diameters including inch sizes can also be supplied on request.

Types: More than 50% of heat-pipes manufactured by CRS Engineering are customer specific. These include: flexible, flattened section, annular section, with integrated heat sinks, input pads and finned assemblies to facilitate attachment and cooling of heat generating devices.

Special Materials: Heat-pipes can be supplied with plain copper surface finish, or plated with tin, nickel, brass, silver, chromium or gold. Stainless steel heat-pipes can also be manufactured to special order.

Order Instructions: It is recommended that you consult CRS Engineering with any new application requirements before ordering. For CRS standard range heat-pipes, state required diameter, length and temperature suffix.

Ordering Example: 3 pcs - CRS-5000-10x250-ST.

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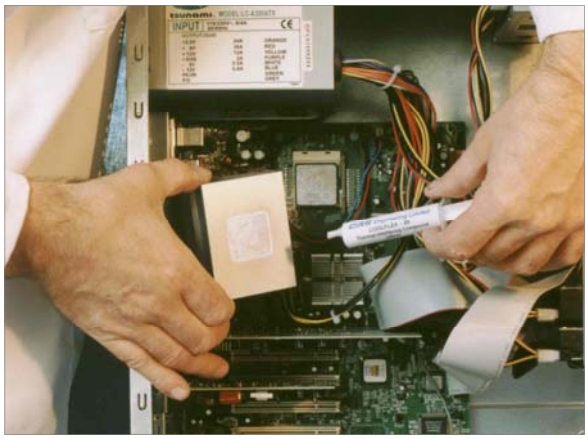
Heat-pipes for Super Thermal Conductivity

Installation of Heat-pipes:

Thermal Interfacing



In all applications where heat is transferred, there are thermal resistances to overcome. The greatest thermal resistances in thermal systems are normally found at interfaces between component parts. To minimise these, it is preferable to eliminate any unnecessary thermal joints wherever possible. All remaining thermal joints need then to be optimised for good heat conduction. For jointing surfaces to have a good thermal interface they need to have intimate contact with each other. This requires that each surface has a fine finish, and is flat or co-planer to the adjoining surface. Good thermal interfacing can be difficult to achieve, uneven surfaces and necessary fitting tolerances often result in relatively poor contact. In some instances this can even result in having only several points of contact despite having a large surface contact area available. Generally it is necessary to use a suitable interfacing material to compensate for surface discrepancies of roughness and undulation. Wherever possible, close fitting, solder brazed interfaces provide the most satisfactory solution.

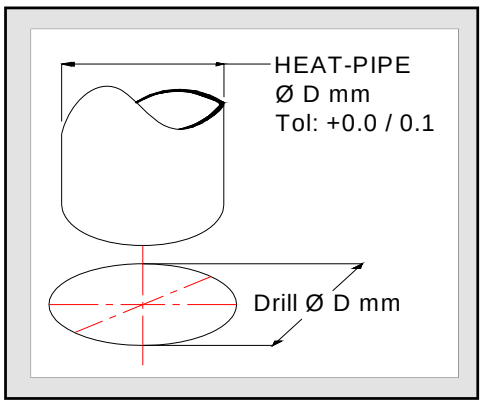
Thermal Interface Compounds

Where soldering of joints is not an option CRS Engineering offers two types of installation compounds:

Coolflex 90 a non setting high thermally conductive paste. (available in a 10 cc syringe).

Coolbond 85 a two-part high thermally conductive epoxy adhesive. (available in a 5 cc syringe with a separate phial of accelerator)

Fitting of heat-pipes into drilled holes



Installation of tubular heat-pipes into drilled components can offer a simple and convenient method of assembly. The drilling size for the heat-pipe should allow a radial gap of between +0.05 mm and +0.12 mm (+0.002 / +0.005") around the heat-pipe.

Standard range CRS heat-pipes are produced with a diametrical tolerance of +0.0 / -0.1mm. so that they will easily fit into holes drilled to the nominal diametrical size. (Note: drilled holes are invariably marginally oversize depending upon the concentricity of the individual drill bit used, it is advisable therefor to first drill the hole location with a smaller diameter drill bit.

Important note: Soldering of heat-pipes should not be attempted without prior consultation with CRS Engineering. Accurate temperature control equipment is necessary and with out this damage or serious personal injury can occur.
CRS Engineering can provide this service manufacture and assembly.

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Heat-pipes for Super Thermal Conductivity

Basic Considerations & Design

When deciding upon an appropriate solution for a thermal application it is necessary to determine as close as possible the thermal performance requirements of the system in terms of W/°C. CRS Engineering will be pleased to give an initial stage appraisal of your application without obligation. To assist us with your requirements, please read the following information check list and try to answer as many of the questions as possible.

Imformation Check List

1. - What is the maximum amount of heat energy which needs to be transferred or dissipated in watts?
2. - What is the maximum allowable temperature of the component to be cooled in °C?
3. - How is the system to be cooled, i.e. forced air cooled, naturally convected, water cooled etc.
4. - What is the maximum and minimum ambient temperature of the cooling medium?

Need to use Heat-Pipes?

5. - What is the intended operational position of the heat-pipe ; horizontal, vertical or inclined?
6. - Will the heat-pipes be required to be straight or bent to some particular form?
7. - Are there any fixtures to the heat-pipe required, i.e. input and / or output mounting blocks, direct attatchmen fin packages water cooling jackets, thermocouples, mounting flanges, fans, blowers etc?
8. - Any other special features for consideration, i.e. special materials of construction, zero gravity or high acceleration etc?

Additional Information?

9. - Can a sketch or drawing of the intended arrangement be provided or possibly a photograph of the equipment or set up?
10. - Any other information which may be of assistance?

The following tables provide design engineers with as much information as is possible here for the CRS Engineering standard range heat-pipes. Table 1 needs to be read in conjunction with Table 2 and Table 3, for overall power transmission capabilities. The maximum power transmission ratings stated in table 1 are for CRS ST series and HT series heat-pipes operating in a horizontal position, i.e. virtual zero gravitational influence.

The temperature ranges given of +20° C to +120° C are mean operating temperatures taken at a mid-measurement point between the heat input and heat output sections of the heat-pipe.

Table 1.

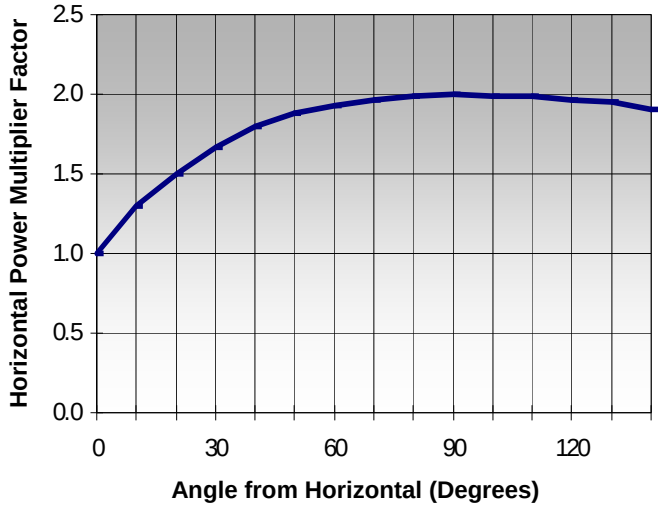
CRS- 5000 Series	Maximum Power Handling Capability (Watts)				
	@ +20° C	@ +40° C	@ +60° C	@ +80° C	@ +120° C
2.0	9.0	11.0	12.0	13.0	14.0
2.5	12.5	16.0	17.5	19.5	21.5
3.0	16.0	23.5	24.5	26.5	29.0
4.0	22.0	27.5	30.5	32.0	37.0
5.0	50.0	58.0	63.0	65.0	68.0
6.0	72.0	86.0	93.0	98.0	108.0
8.0	90.0	108.0	115.0	122.0	134.0
10.0	112.0	134.0	143.0	152.0	169.0
12.0	148.0	178.0	186.0	197.0	218.0

Effects of Gravity upon Capillary Action

The function of a heat-pipe is reliant upon an effective capillary action system to return the working fluid from the condenser section (Cd) where cooling is applied, to the evaporator section (Ev) where heat input to the heat-pipe is applied. This function is served by the porous lining wick structure or "wicking system" which is built into the heat-pipe. Gravity has an important influence on the thermal performance. As can be seen in Table 2 gravity can be used to advantage to increase the thermal transmission capability to up to twice that of the maximum horizontal position rated value shown in Table 1. (i.e. provided that the Ev section is below the Cd section). In this orientation, gravity assists the return of the return working fluid.

Table 2.

Gravity Assisted Transmission (Cd. Section above Ev. Section)



Opposing Effects of Gravity ....

In the opposing mode, i.e. with Ev section high, and driving heat downwards, the heat-pipe function is totally dependent upon capillary action to return the working fluid to the evaporator against gravitational restraint. Table 3 shows the effects of this which is to repress the heat-pipe performance capability. In this situation the capillary pumping capability must adequately exceed the static head difference between the Cd and Ev sections.

For particular applications where orientational constraints require heat-pipes to operate in this mode, CRS Engineering produces heat-pipes with special anti-gravity wicking systems. These SSX series heat-pipes use wick structures that develop an increased capillary pumping action over that of the standard series. SSX series typically have an increased diametrical size for a given value of power handling capability.

Table 3.

Gravity Suppressed Transmission (Ev. Section above Cd. Section)

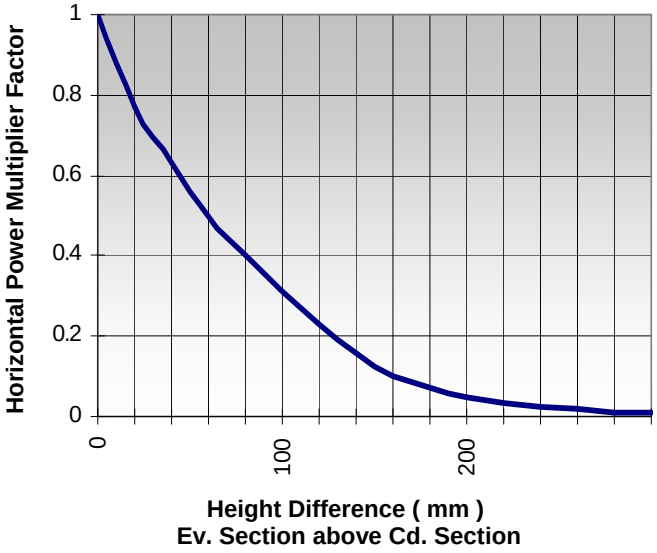


Photo showing sectioned anti-gravity heat-pipes.
(the wick structures can be of a sintered metallic lining or of a multi layer woven metallic lining depending upon application needs).

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Heat-pipes for Super Thermal Conductivity

Heat-pipe Types:

Tubular Heat-pipes

These are the simplest and most popular type of heat-pipes and are used in most common applications to transfer heat energy from one place to another. They can also be used as heat spreaders to isothermalise components where a uniform temperature is desired. Although heat-pipes are predominantly used in cooling applications, they can also be used very effectively in heating applications. This can negate the necessity of having multiple electrical heating elements, and greatly simplifies cabling and design.

Annular Heat-pipes

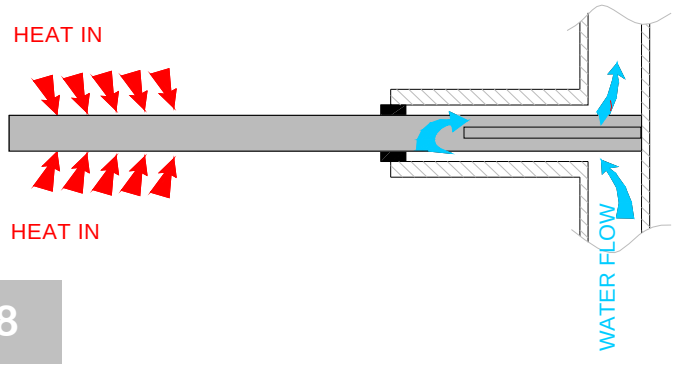
These heat-pipes have an open axial concentric bore. They are used in a variety of situations where heat transfer is provided together with space for mechanical access, examples are:-

- as a flow channel for gas or liquid,
- for cabling or thermocouple access,
- as a location guide for a push rod mechanism.

Larger diameter heat-pipe rollers are also made similarly with open an central bore for use as rotary thermal spreaders and having internal air cooling.

Baffled Heat-pipes

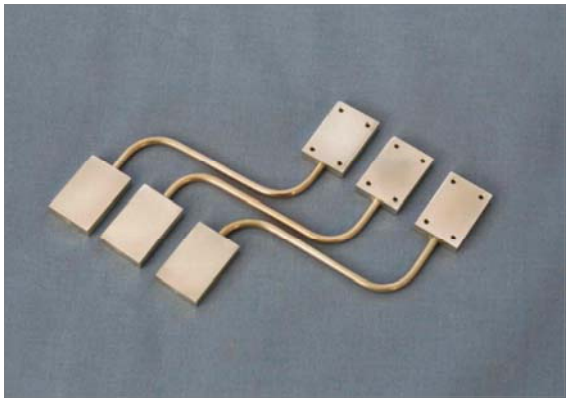
Heat-pipes which are fitted with baffle plates are used in water cooled applications. The heat-pipes are installed into sealed manifolds and transfer heat from the heat source to the cooling water. The attached axial baffle plates are used to direct water along the heat-pipe cooling length in the flow channel.



Customer Specific Applications....

Bent Tubular Heat-pipes

A common application requirement is for heat-pipes to be bent to fit some route in a particular installation, possibly involving complex 3-D architecture. By using special internal wick structures CRS Engineering is able to produce heat-pipes in softened condition which can be formed to shape upon installation. Where exact bending is required or where tight bending radii are involved, it is essential to carry this out during manufacture.

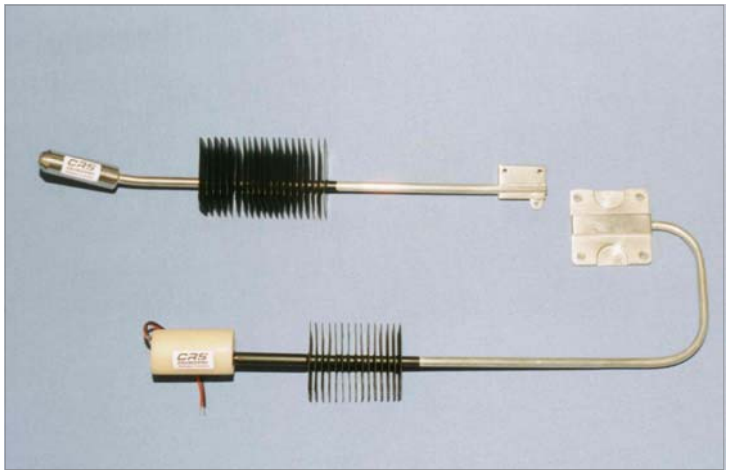


Flexible Tubular Heat-pipes

A limited degree of flexibility is possible with most standard range heat-pipes, as a function of their length and diameter. Often this degree of flexibility may be sufficient to accommodate small dimensional discrepancies and tolerances encountered during assembly and installation with other components. Truly flexible heat-pipes incorporate an intermediate convoluted bellows section providing excellent flexibility and anti-vibration characteristics.

Variable Conductance Heat-pipes

VCHP heat-pipes provide a convenient means of automatic temperature control. By regulation of the heat-pipe thermal conductivity it is possible to maintain the evaporator section at near constant temperature with around only 5° C fluctuation. VCHP's are specifically pre-set to operated over a specific range of variable ambient temperatures with variable heat load inputs. Where very precise control is required they can be integrated with electronic control to achieve temperature stabilization of better than 1°C with only minimal power comsuption required by the controlling circuit.



Diode Heat-pipes have a high thermal conduction in one direction and a low thermal condution in the opposite direction. They are used in applications where it is possible for heat sink temperatures to exceed the heat-pipe evaporator temperature, e.g. in aerospace applications due to solar radiation. Usually an array of diode heat-pipes are used together to dissipate heat to a number of heat sinks to maintain heat dissipation.

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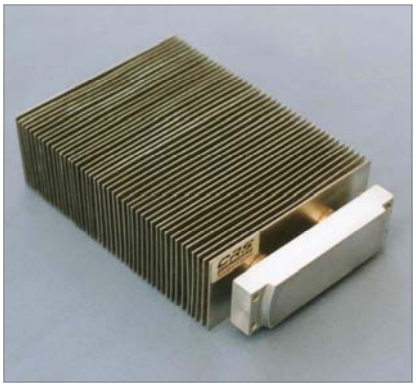
Heat-pipes for Super Thermal Conductivity

Customer Specific Applications....

High Performance Heat-pipe Heat Sinks

Integral heat-pipe heat sinks built into cooling fin assemblies provide one of the most effective means of efficient cooling of power electronics components. The forced air cooled assembly shown opposite, was designed and produced in series by CRS Engineering.

Performance: Rth = 0.09°C/W. (i.e. with 100 W heat dissipation the input heat block temperature is only 9°C higher than the ambient cooling air temperature!).

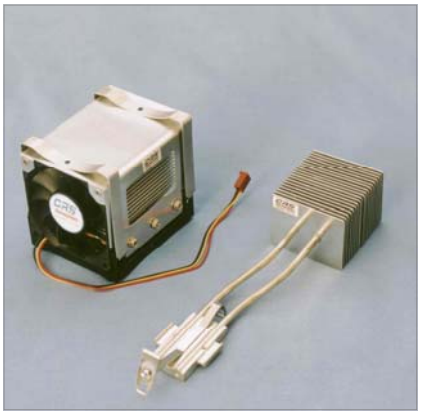


High Performance (Water Cooled) Heat-pipe Heat Exchanger

The cluster array of heat-pipes shown here is used in a high temperature gas flow manifold where over 5 kW of heat energy is transferred to cooling water. *(the gas on temperature exceeds 700°C!)* Heat-pipe systems may be used to great advantage providing lighter and more compact assemblies than is possible with the conventional systems which they replace.

Heat-pipe Processor Coolers

Processor cooling is an increasingly demanding challenge. Here heat-pipe cooling provides an optimal solution, allowing heat to be collected at source and dissipated at some convenient location. Directly attached finning to heat-pipes is very effectively utilised as the heat-pipes very evenly distribute the heat flux to each fin so gaining much higher fin bank efficiencies than is possible with conventional finned heat sinks. A performance of 0.35°C/W is typical with 70 W dissipation and 0.09°C/W is also possible provided that sufficient space exists for the necessary fin bank volume.



Enclosure Coolers

Heat-pipe Enclosure Coolers offer a compact and convenient method of cooling IP 54 enclosures.

An internal fin bank is connected to an external fin bank using heat-pipes. A central dividing plate forms an integral sealed part of the assembly and installation requires only a suitable rectangular cut-out and fixing holes to be made in the enclosure. The units are hermetically sealed to the enclosure via the central dividing plate. Typically, small units will handle 200W to 2 kW and maintain the internal ambient air at less than 50°C. Heat-pipe Enclosure Coolers are supplied to order complete with cooling fans to customer specification.

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Heat-pipes for Super Thermal Conductivity

Customer Specific Applications....

Heat-pipe IGBT Coolers

These modular heat-pipe units offer one of the most practical options for providing lightweight, high performance cooling of power semi-conductors. Typically they are used in traction applications to cool drive controllers. Simply to install the units normally require no maintenance other than occasional cleaning.

Power Rating: Typically designed to handle around 2 kW to 3 kW per module with forced air cooling.

Rugged Enclosure Coolers

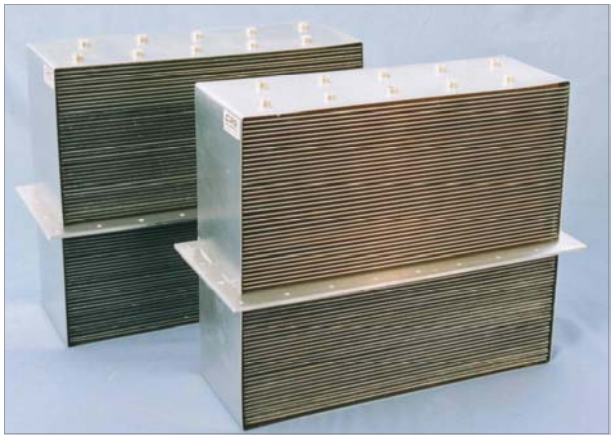
Heat-pipe Ruggedised Enclosure Coolers provide the latest technical innovation in the development of robust enclosure cooling. These rugged enclosures are used in situations where sensitive, vitally important power electronic components are required to operate in some of the most demanding environmental conditions. The enclosure type shown here is fully tested to comply to military specification and is used to house crutial IT systems.

Hermetically sealed, these enclosures are both gas tight and water resistant. Specially developed internal mountings protect the electronics operating system inside from shock and vibration. CRS flexible heat-pipes are attached to the internal electronics package and provide the high thermally conductive link required to transport the internally generated heat from source to the external heat sink casing. Axial fans provide cooling air flow where installation space maybe seriously confined. Applications include in-flight entertainment systems, military helicopters, fighting vehicles, ships and submersibles.

Heat-pipe Heat Exchangers

Large scale heat-pipe heat exchangers are configured individually by CRS to specification. Fin volume together with internal and external mass flow rates are designed precisely to suit specific thermal requirements. Differential volumetric air flow rates are managed by optimal sizing of ducts. Compact and modular in design, heat-pipe heat exchangers can realise up to 70% energy reclaim.

Power Rating from 2 kW to 80 kW
(Max Mean Operational Temperature +250°C).



CRS Engineering Company Profile....

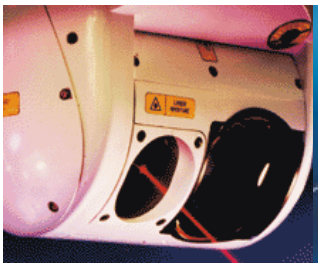
Founded in 1999, CRS Engineering is a dynamic, privately owned limited company specializing in the design and manufacture of heat-pipe systems. Receiving the Tyneside & Northumberland Business Awards Technology Award in 2005 CRS is also acknowledged internationally for providing customer specific thermal solutions through innovative design and development.

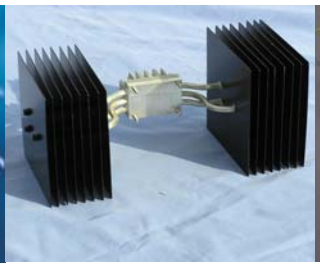
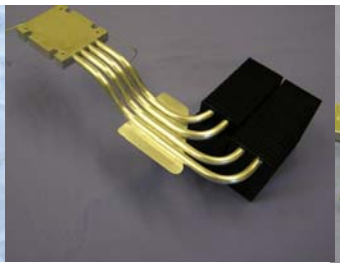
CRS Engineering concentrates its efforts at the leading edge of thermal technologies. Investing in research and development together with an active involvement in customer applications has enabled CRS Engineering to make cutting edge advances in heat-pipe technology and to further elevate performance capabilities of specific thermal systems.

In response to customers requirements for components of optimal quality, performance and reliability, CRS Engineering sets exacting standards. All heat-pipes and integrated thermal systems are produced in house and undergo in-process checks throughout manufacture. All manufactured components are individually inspected and performance tested prior to despatch.

CRS Engineering has experience in a wide range of confidential technical development projects, including classified military defence work. An expanding client base ranges from companies involved in textiles, plastics, electronics, as well as in medical, aerospace and defence industries.

CRS Engineering provides customers with a complete thermal solutions service from application analysis, conceptual development and prototyping.

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