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“Liquid Cooling – Practical Guidelines to Design & Manufacture”

Mark Pelillo, *Director of Engineering*

Mark Pelillo is the Director of Engineering at Wakefield-Vette. Mark has been in the electronics cooling design industry for over 25 years and has been a pivotal part in introducing new technologies to the marketplace. Mark earned his engineering degree at Clarkson University. Mark has been with Wakefield-Vette since 2005, where he leads the engineering team. This team supports existing customer challenges, while researching and introducing new technologies to market. Mark’s vast experience not only with design but in manufacturing, allows Wakefield-Vette’s customers to improve their thermal performance while simplifying the manufacturing steps to meet specifications.

Wakefield-Vette & Richardson RFPD

- Wakefield-Vette has been in continuous operations since 1952, providing thermal solutions across multiple industries, from international Fortune 50 companies to small and medium sized businesses. These industries include Power Conversion, Information Technology, Renewable Energy, Telecommunications, Transportation, Aerospace/Defense, LED Lighting, Factory Automation, Consumer, and Medical.
- Richardson RFPD, an Arrow Company, is a specialized electronic component distributor providing design engineers with deep technical expertise and localized global design support for the latest new products from the world's leading suppliers of RF, Wireless, Energy and Power Technologies.
- Richardson RFPD, is Wakefield-Vette’s largest distribution channel partner.

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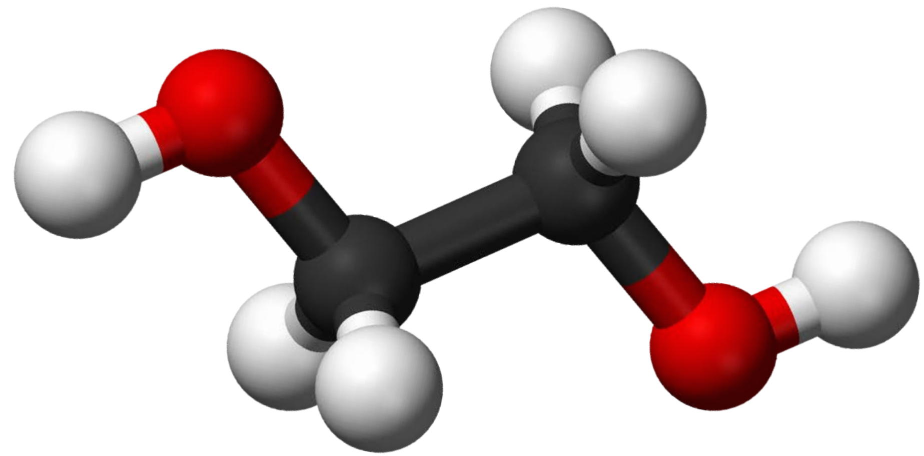
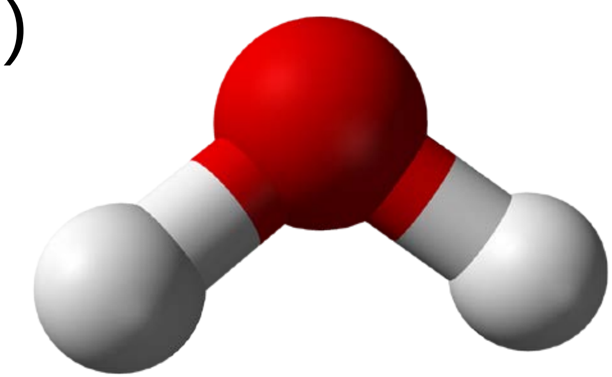
What is Liquid Cooling?

- Liquid cooling is a natural evolution beyond air cooling where either due to thermal requirements or footprint requirements, the desired performance can no longer be economically met by air cooling.
- Liquid technology is typically selected based on two requirements;
  - Normalized Thermal Resistance (ìC/W)
    - Average Plate temperature minus incoming fluid temperature/total thermal power.
  - Pressure Drop (PSI)

How to Achieve Liquid Cooling

- Tube/Channel
  - Copper
  - Aluminum
  - Stainless Steel
- Fluid
  - Water/Glycol (Most Common)
  - Fuel
  - Oil
  - Refrigerant





Water & Glycol Combined

Min. Requirement for Good Quality Water *

Mineral	Limit
Calcium	< 50 ppm
Magnesium	< 50 ppm
Total Hardness	< 100 ppm (5 grains)
Chloride	< 80 ppm (suggested < 25 ppm)
Sulfate	< 25 ppm

*Source: Dow Thermal Fluids

Rolled Tube

180 Series

Characteristics:

- Base material: Al Extrusion
- C122 K-type Copper tube or Stainless Steel
- Tube and base bonded by highly conductive epoxy
- Flow path depending on the location of heat sources
- Design limit: Extrusion Profile
- Common tube types: 3/8”

Standards Available

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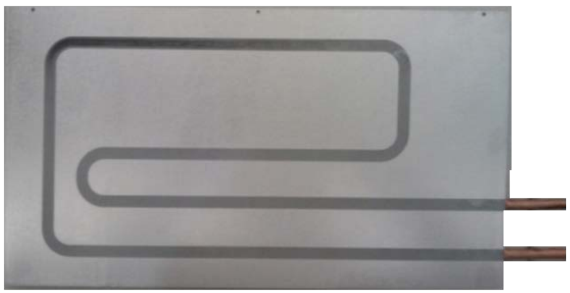
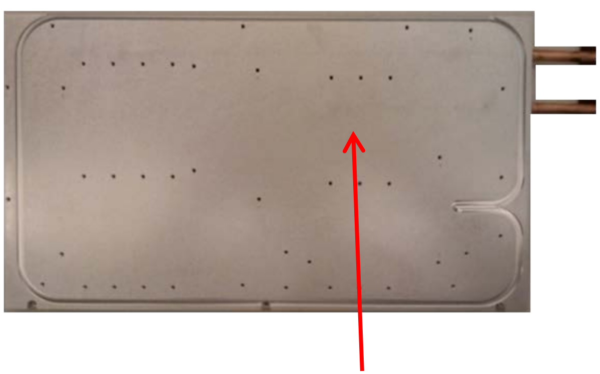
Full Buried

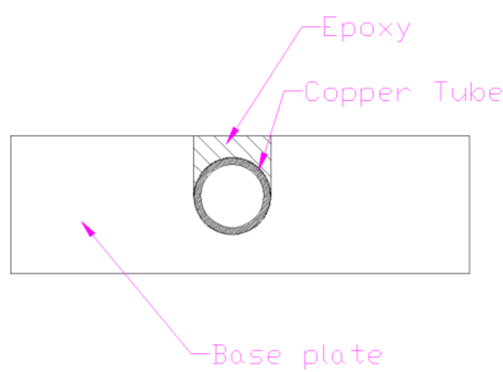


Characteristics:

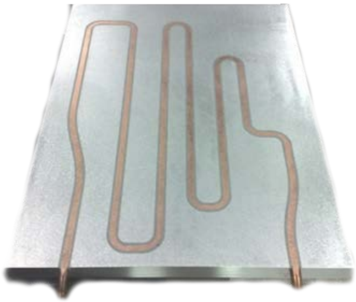
- Base material: Al or Cu
- Copper or Stainless Steel
- Tube and base bonded by highly conductive epoxy
- Flow path depending on the location of heat sources
- Design limit: bending radius
- Common tube types: 1/4”, 3/8”, 1/2”
- Base thickness depending on the tube type

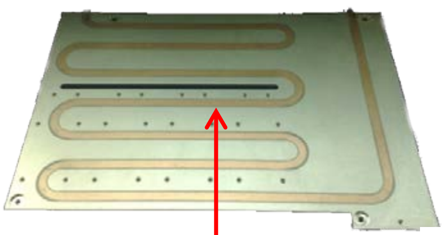


Contact surface



Exposed Tube

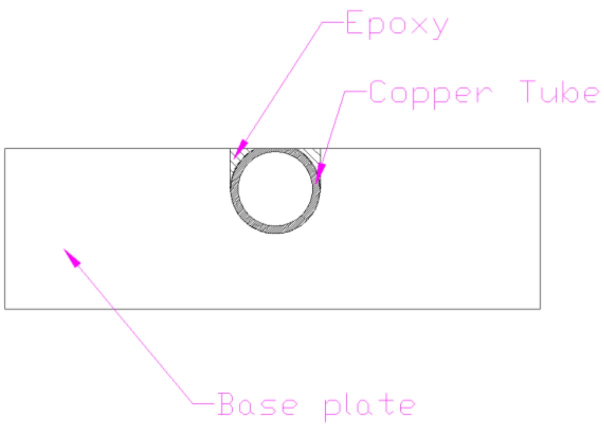




Contact surface

Characteristics:

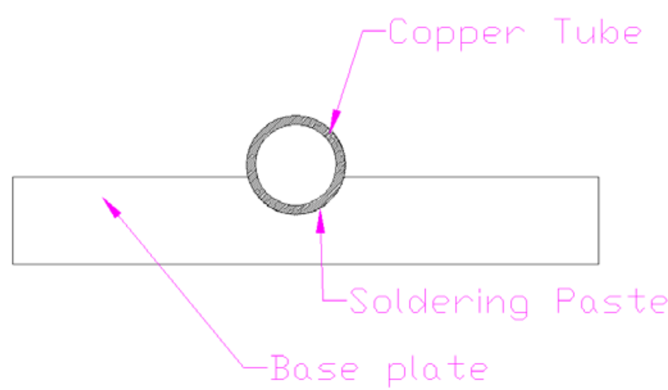
- Base material: Al or Cu
- C12200 K-type copper tube
- Tube and base bonded by highly conductive epoxy
- Flow path depending on the location of heat sources
- Design limit: bending radius
- Common tube types: 3/8”, 1/2”, 5/8”
- Base thickness depending on the tube type



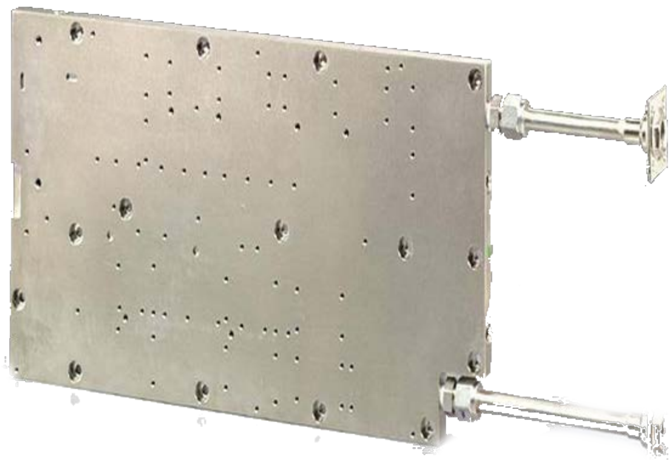
Half Buried

Characteristics:

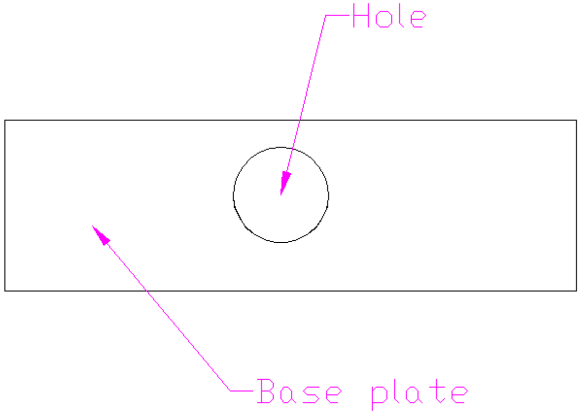
- Base material: Al (Nickel plated) or Cu
- C12200 Copper tube
- Tube and base bonded by Soldering Paste
- Flow path depending on the location of heat sources
- Design limit: bending radius
- Common tube types: 1/4”, 3/8”, 1/2”



Deep Drilled



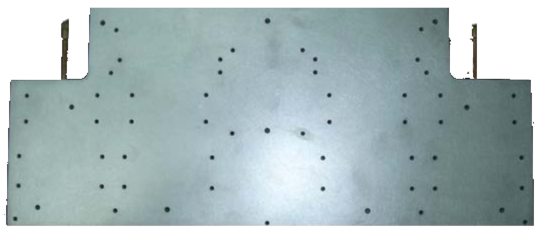
Characteristics:
• Base material: Al or Cu
• No copper tube inside
• Easy layout without much design limit
• Adapters or copper tubes are soldered on the drilled assembly

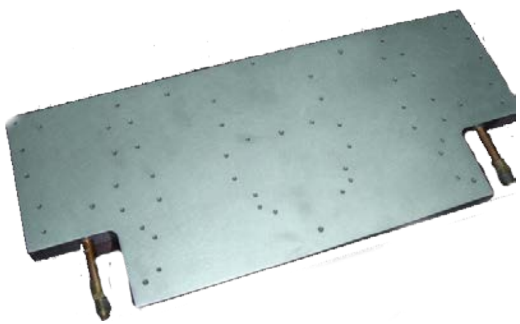


Manifold

Characteristics:
• Counterflow tube configuration
• Sandwich-style coldplate construction
• 7600W @ 3 GPM
• Parallel flow provides lower pressure drop and helps to balance plate temperatures

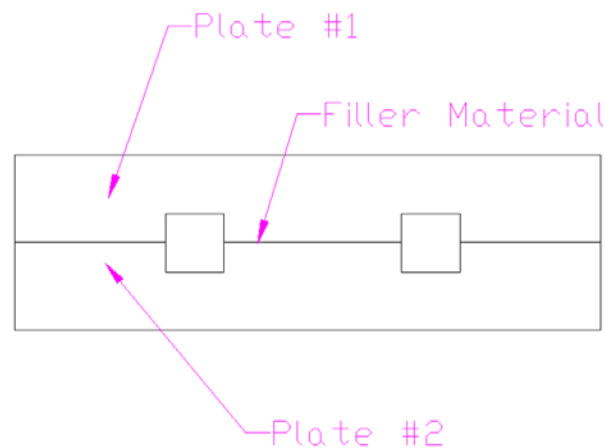
Two Piece Brazed



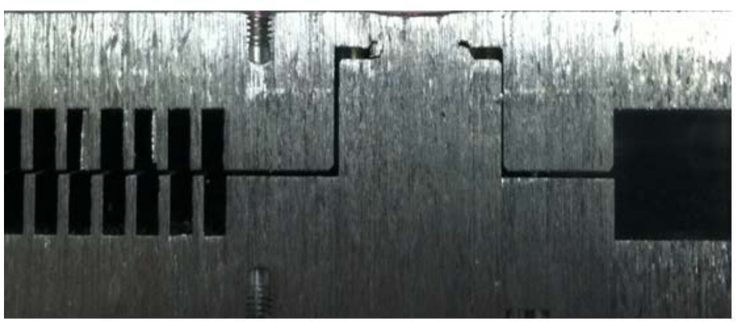


Characteristics:

- Base material: Al or Cu
- No copper tube inside
- Plates are bonded by brazing
- Easy layout without much design limit
- Adapters or copper tubes are soldered on the brazed assembly



Two Piece Welded



• Welded construction requires combination of perimeter and column joints to seal flow passages and prevent “oil can” effect. An “Oil Can” effect occurs when two pieces are perimeter welded and can deform due to internal fluid pressure.

•This deformation can cause leakage in some cases. In the example shown here, you can have poor fluid distribution because it could possibly bypass the fins.

Liquid Cooling Summary

	Material			Characteristic & Rating			
Style	**Base Material**	**Tube Material**	**Bonding Material**	**Cost**	**Performance**	**Design Flexibility**	**Key Attribute**
Rolled Tube	Al	Cu/SS	Epoxy	1	1	1	Cost effective single sided cooling
Full Buried	Al or Cu	Cu	Epoxy	1	2	3	Liquid flow contained in a continuous tube
Exposed Tube	Al or Cu	Cu	Epoxy	2	3	3	Continuous tube with direct device mounting
Half Buried	Cu	Cu	Soldering Paste	2	4	2	Efficient but inexpensive construction
Two Piece Brazed	Al or Cu	None	Solder	5	5	5	Allows for unlimited and divided flow paths
Two Piece Gasket	Al or Cu	None	Gasket	3	4	5	Unlimited flow path without braze cost
Two Piece Welded	AL	None	Weld Alloy	3	5	4	Allows for unlimited and divided flow paths
Sandwich Design	Al or Cu	Cu	Epoxy	3	2	2	Allows for double sided equal cooling
Deep Drilled	Al or Cu	None	None	3	3	3	Reliably balanced construction

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