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# New Technology Overview

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# Company Overview

- Pioneer Thermal was founded in 2003 with a 15000 square meter facility
- ISO9001:2015 , ISO14001:2015 and IATF16949 certified factory
- Total 350-400 employees in factory ( Production 73%, Quality 6%, R&D 11%, other 10%)
- In-house manufacturing: punching & tooling, CNC machining, saw cut and cross-cut, skiving, soldering, on-line thermal testing, friction stir-welding, Brazing & simple surface treatment
- Founded by engineers. Focused on high efficiency & quality control

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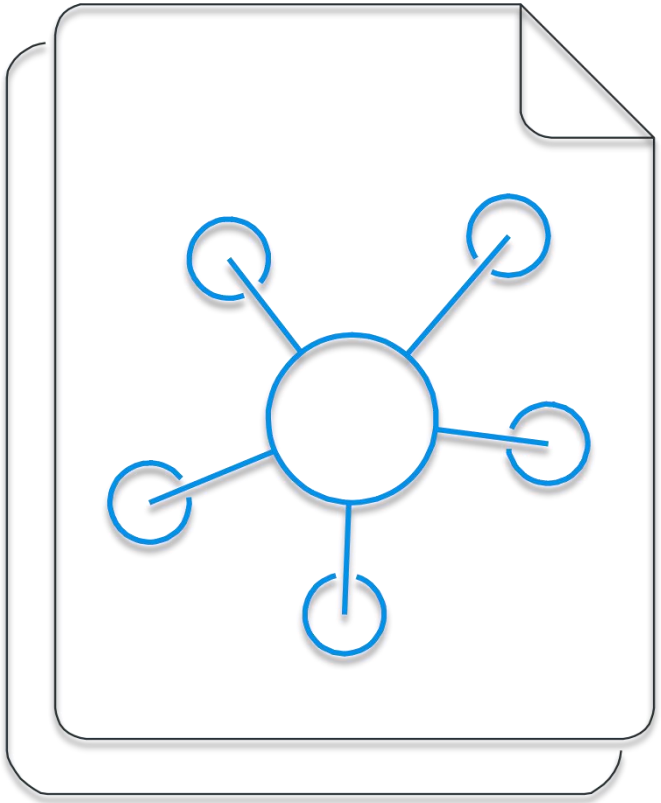

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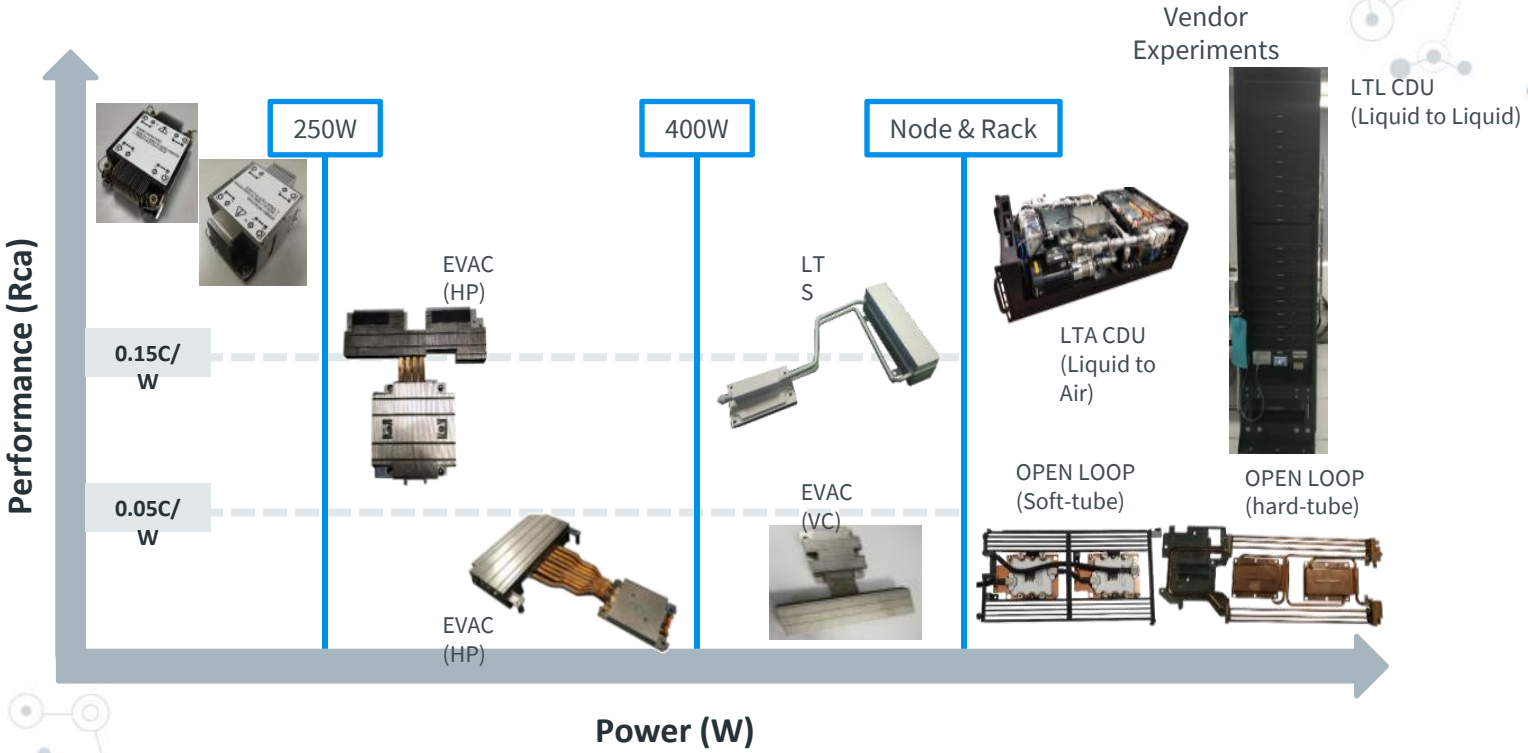
# Thermal Design Technical Roadmap



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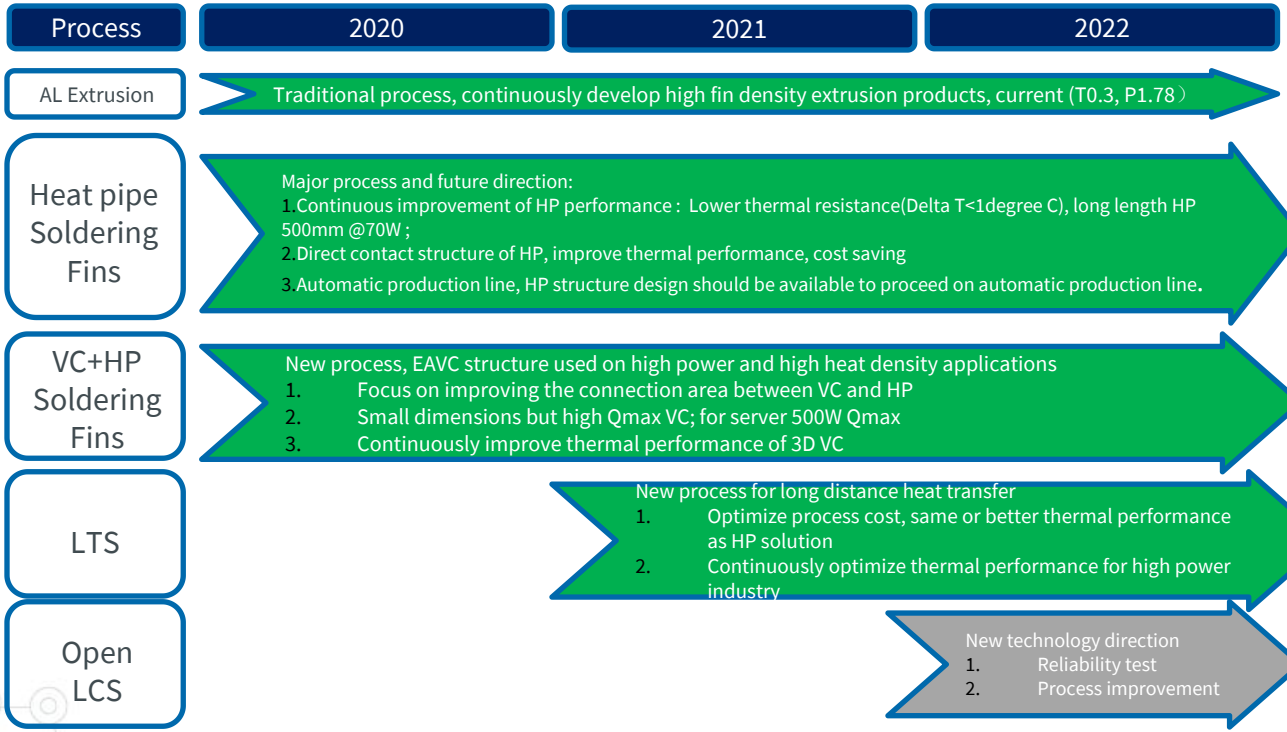
# CPU Thermal Solutions Analysis



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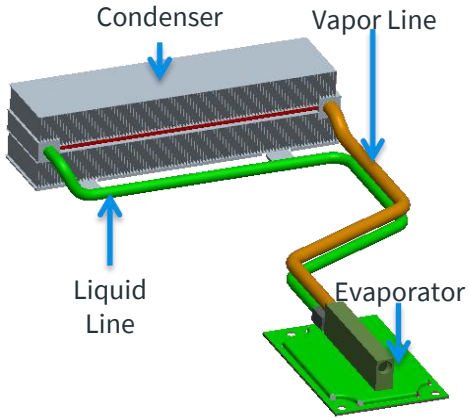
# High Power Thermal Solution-Thermosyphon

## Introduction:

The thermosyphon has a remote condenser area that is connected to the evaporator for the heat source (CPU/ASIC…etc.) via one cool channel (Liquid Line)and one warm channel (Vapor Line) that produce a natural convection path.




The key features of thermosyphon are,

1) Phase-Change heat transfer
2) High power (Over 500W, thermal performance depends on condenser size)
3) Long-distance heat transfer (Over 500mm)
4) Flexible Layout

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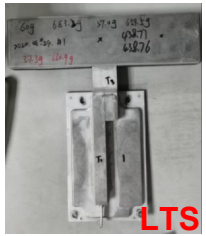
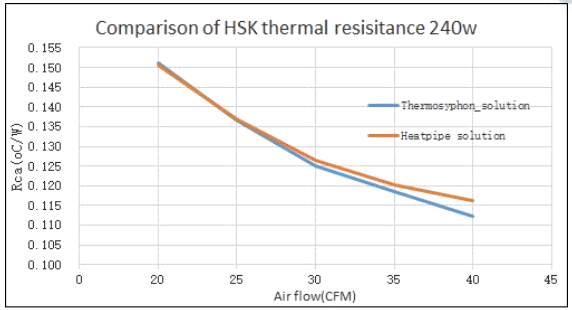
# High Power Thermal Solution-Thermosyphon (Comparison Testing)

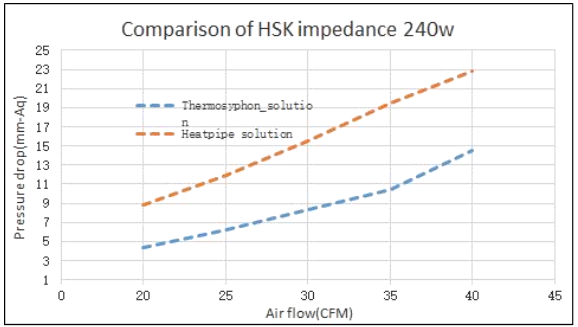



-Heat Sink Dim.: 182L * 187W * 30H
-Surface Area: 169,000 mm^2


-Heat Sink Dim.: 178.6L* 172.4W * 30H
-Surface Area: 284,000 mm^2

| Sample | Air Flow (CFM) | Power (Watt) | Tc (°C) | Ambient (°C) | Rca (°C/W) | dP (mm-Aq) |
|---|---|---|---|---|---|---|
| LTS (1U) | 20 | 240.7 | 59.3 | 22.9 | 0.151 | 4.39 |
| | 25 | 240.7 | 56.1 | 23.2 | 0.137 | 6.18 |
| | 30 | 240.7 | 53.8 | 23.7 | 0.125 | 8.32 |
| | 35 | 240.7 | 52.4 | 23.9 | 0.118 | 10.48 |
| | 40 | 240.7 | 51.2 | 24.2 | 0.112 | 14.5 |
| EVAC (1U) | 20 | 238.9 | 61.7 | 25.7 | 0.151 | 8.81 |
| | 25 | 238.9 | 58.6 | 25.9 | 0.137 | 11.9 |
| | 30 | 238.9 | 56.4 | 26.2 | 0.126 | 15.5 |
| | 35 | 238.9 | 54.9 | 26.2 | 0.120 | 19.5 |
| | 40 | 238.9 | 53.4 | 25.6 | 0.116 | 22.8 |



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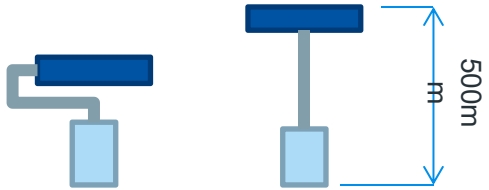
# High Power Thermal Solution-Thermosyphon

**Why and when to choose LTS:**

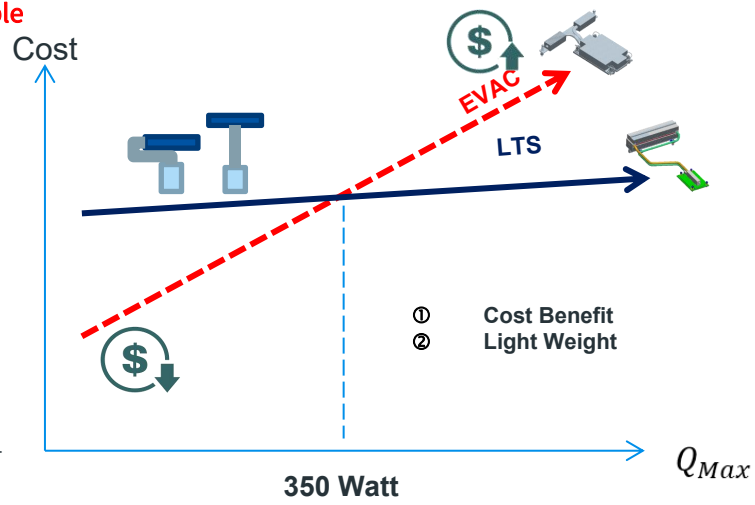
1) The thermal performance between EVAC and LTS is very close under the same power, but LTS has the advantages of **Flexible Mechanisms** and **Long-Distance** heat transfer.




Flexible layout of LTS

Long-Distance Heat Transfer of LTS

2) Over 350 watts, LTS keeps its advantages while having more competitive cost and weight than EVAC.
3) Under 300-350 watts, LTS has Flexible Mechanism and Long-Distance Heat Transfer only.



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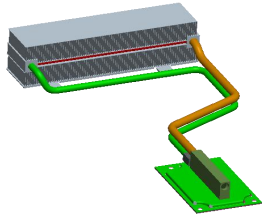
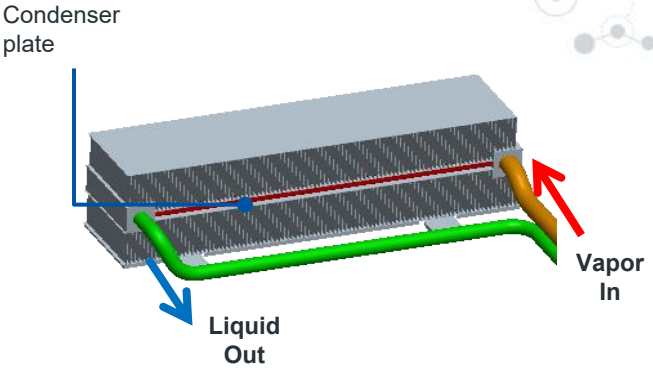
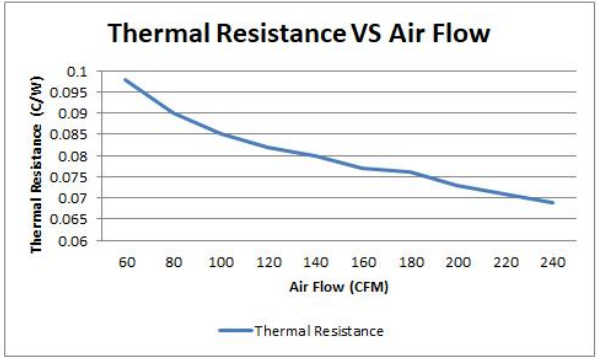
# High Power Thermal Solution-Thermosyphon



- Input power: **475**W
- Heater: SP3 Heater
- TIM: 7783D
- Tooling sample




| CFM | Tcase | Evaporator outlet temp. | Radiator inlet temp. | Ambient | $R_{ca}$ | $R_{evaporator}$ | $R_{condenser}$ |
|---|---|---|---|---|---|---|---|
| 59.1 | 71.8 | 56.8 | 54.6 | 25.2 | 0.098 | 0.032 | 0.062 |
| 78.5 | 67.1 | 50.9 | 49.0 | 24.2 | 0.090 | 0.034 | 0.052 |
| 100.5 | 65.6 | 48.8 | 46.8 | 25.0 | 0.085 | 0.035 | 0.046 |
| 119.6 | 65 | 47.7 | 45.8 | 26 | 0.082 | 0.036 | 0.042 |
| 139.2 | 63.6 | 46 | 44.1 | 25.8 | 0.080 | 0.037 | 0.039 |
| 158.3 | 62.2 | 44.6 | 42.8 | 25.8 | 0.077 | 0.037 | 0.036 |
| 178.6 | 60.3 | 42.2 | 40.7 | 24.3 | 0.076 | 0.038 | 0.035 |
| 199 | 60.6 | 42.4 | 41.1 | 26.0 | 0.073 | 0.038 | 0.032 |
| 218.1 | 58.1 | 40.1 | 38.9 | 24.2 | 0.071 | 0.038 | 0.031 |
| 237.3 | 58.7 | 40.7 | 39.5 | 25.9 | 0.069 | 0.038 | 0.029 |



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# High Power Thermal Solution-VC + Heat Pipe

## Why and when to choose VC + Heat Pipe:

**Challenge**

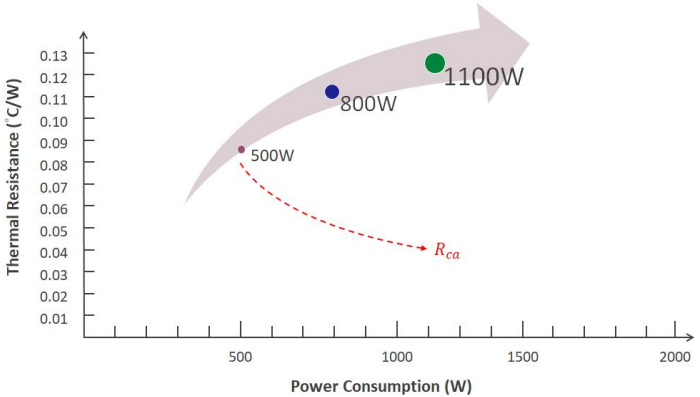
- High Power : > 1000W
- High Performance : < 0.04 ˚C/W
- Mechanical restriction : KOZ
- Heat sources : single or multiple

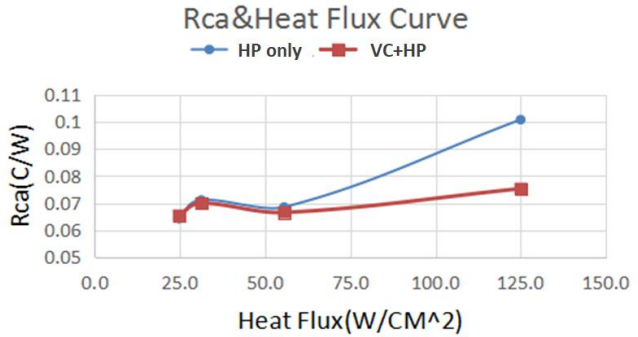
**Heat Pipe only solution**:

- $Q_{Max}$is enough but NOT for $R_{th}$.
- HP QTY is limited by mechanical restrictions.
- Copper block temp. spreading is worse than VC.

**VC+HP solution**:

- $Q_{Max}$is enough and with better $R_{th}$.
- VC brings effort while ***Heat Flux*** increasing.



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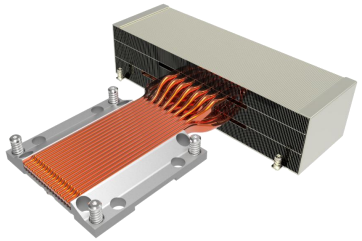
# High Power Thermal Solution-VC + Heat Pipe

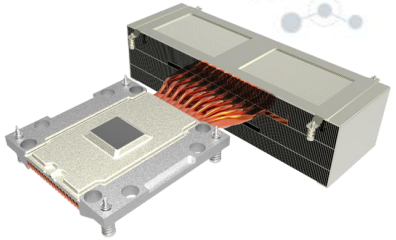
Size：322.3 × 366.195 × 85.04 mm

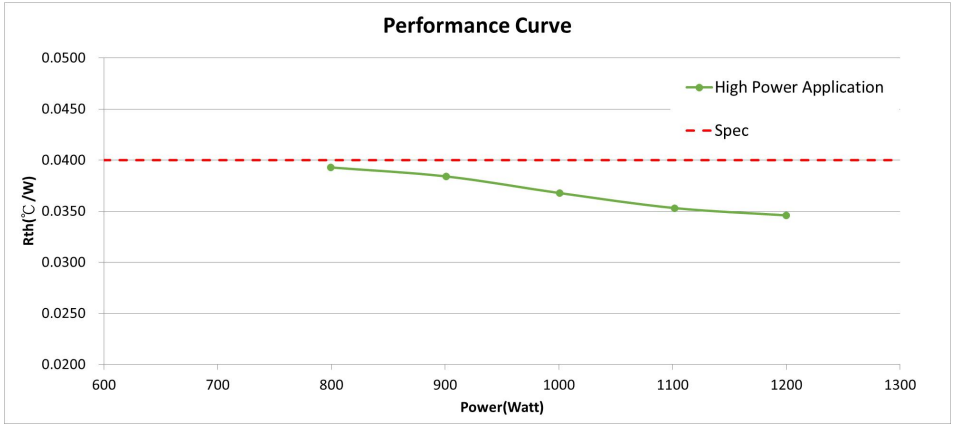
Material：

- 3 Layers × AL Fin 1100 0.3t Pitch 1.99mm
- 17 × D10 Heat Pipe (Groove + Powder)
- 1 ×Cu Base Bracket
- 1 × Vapor Chamber
- 2 × C-Type Fin Bracket
- 4 × Screw Assembly - ASIC
- 4 × Screw & Spring - Condenser
- 1 × SK7 Bracket
- 1 × Sponge

Thermal Target : 0.04 ˚C/W @1100W, 240CFM

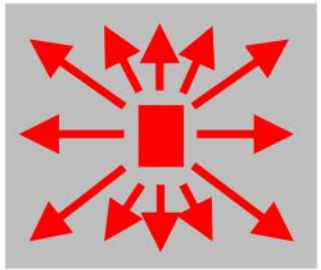




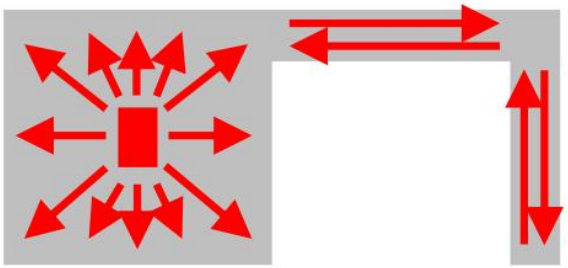


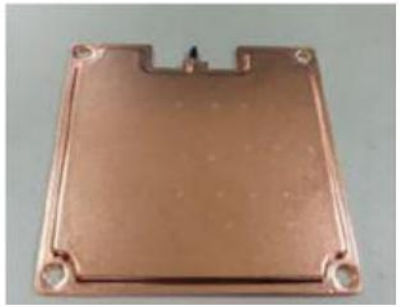
# High Power Thermal Solution-3D VC

**Vapor Chamber :**
**2D heat conduction (VC)**



**3D Vapor Chamber :**
**3D heat conduction (3DVC)**





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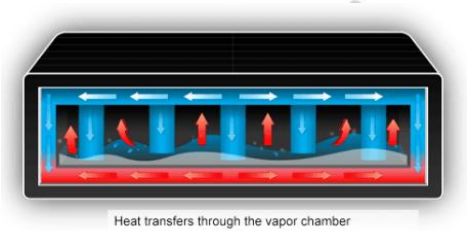
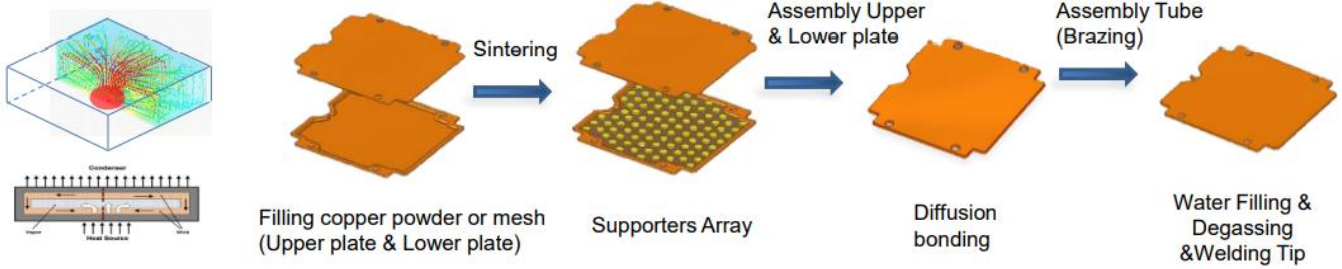
# Vapor Chamber Technology

## Vapor Chamber Design Process




### Size and Shape

Max Size: 300x300mm

### Thickness

Conventional: 2.5—6mm

### Through hole

Depends on location

### Flatness

Contact area 0.05 - 0.1mm
45x45mm

### Thermal Conductivity

Around 3000W/mK

### Max Loading Force

Force 10Kgf
Area 90 x 90mm
Deformation <0.3mm

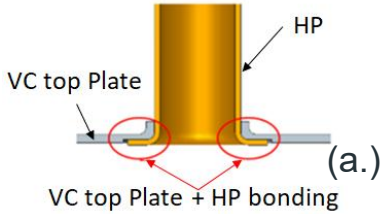
# High Power Thermal Solution-3D VC

## ■ *Condenser*

➢ *Joint Continuity* :

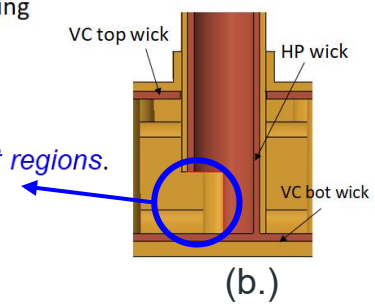
a. Wick structures connection

- *VC_top joint HP_bot by fixture.*




b. Direct contact VC base connection

- *Shorten liquid path back to evaporator .*
- *Make vapor easily get into the HP by cutting some of HP_bot regions.*




➢ *HP Improvement :*

a. Use **powder** wick structure

- *Anti-gravity effect*
- *Mfg. difficulty relatively low*

b. Use **groove** wick structure

- *With gravity effect condition*
- $R_{ca}$ *performs better*

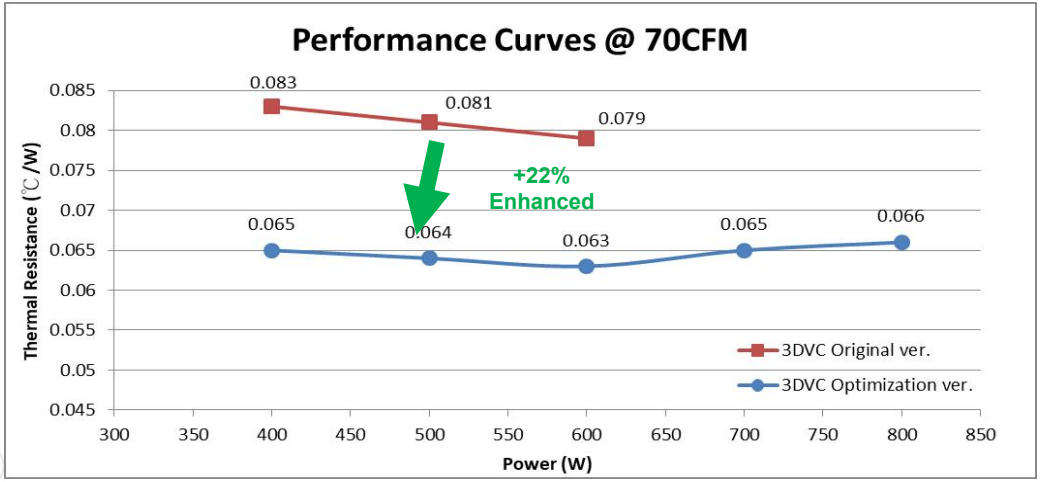
# High Power Thermal Solution-3D VC (Optimizing Sharing)

Size：L130 * W68 * H110.2 mm

Thermal Performance：

- 0.066 ℃/W @ 70CFM under 800W

Dummy heater Size：L36 * W25 mm




* NOTE : Improved by at least 22% after optimization

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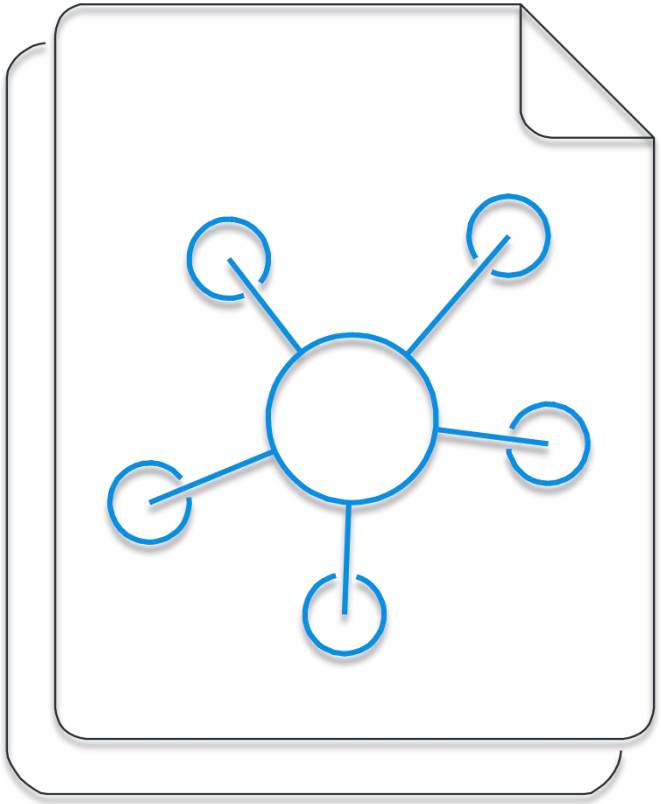

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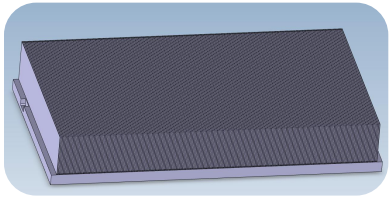
## ➢ New High Contact Technology

From each iteration of High power products, the heat loss of customers is basically maintained at the level of 10,000 watts, which heat sinks are designed smaller in size yet have higher requirements for performance at the same time.

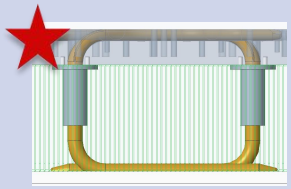
With such a high heat flow density, we need to solve the current problem for our customers through a more optimized heat transfer path.

The following is analyzed in several different heat dissipation solutions:



- **Early on heat dissipation requirements:**
  -Profile (LxWxH): 700x390x113.1mm
  - Heat dissipation： 11684.4 W
  - Flow volume： 2300m3/h
  - ΔT ≤65℃

- **Current Heat dissipation requirements:** -Profile (LxWxH): 497x350x101.5mm
  - Heat dissipation： 11754 W
  - Flow volume： 900m3/h
  - ΔT ≤65℃

| TYPE | Advantage | Disadvantage |
|---|---|---|
|  | -Simple process, Without Heat pipe. | -- high power IGBT can not meet the thermal design requirements,Poor performance. |
|  | -The heat pipe can be directly formed into a "U" shape as a single unit.<br>Easy to install and soldering. | -Heat loss relies entirely on heat pipes to transfer heat to the blades<br>-Sufficient heat pipes are required<br>-High heat pipe Q-max requirement<br>-When the heat pipe fails, the risk of thermal runaway is high and the IGBT may burn up in a short time. |
|  | - The heat pipe touches the IGBT directly to transfer the heat to the top of the stacked fins (the coolest end)at the fastest speed to reduce the heat sink's thermal resistance;<br><br>-Ensure the heat pipe bend section of the fins loss of heat dissipation area;<br>-When the heat pipe fails, the same heat dissipation area is still available to support the function of heat dissipation for the product; | --Additional guide bushings are needed when the base plate is too thin. |

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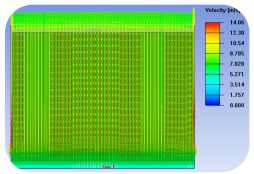
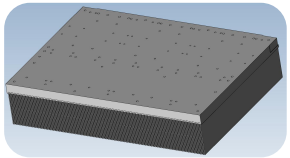
➢ New High Contact Technology---Thermal Simulation Analysis

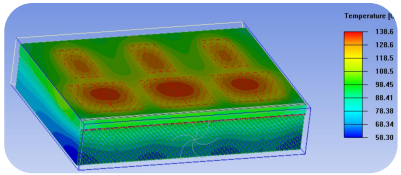
01

Common Skived fin heatsink



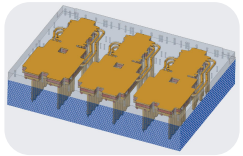
ΔT=98.6℃

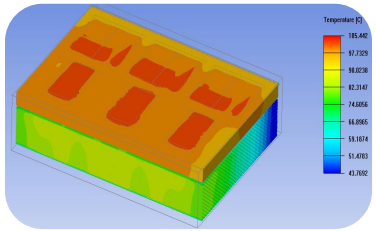




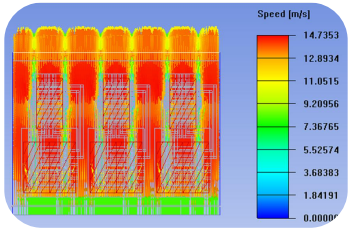
02

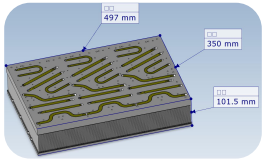
Adding“U”shape Heat pipe+stamping Fin structure



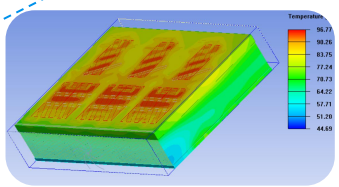


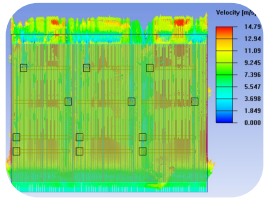
ΔT=65.44℃




03





PT New design solution
（See the next slide）

ΔT=56.77℃

Compare：Through simulation analysis, only solution 03 can meet the performance requirements of the customer, so we customize the product design solution 03 above for the customer.

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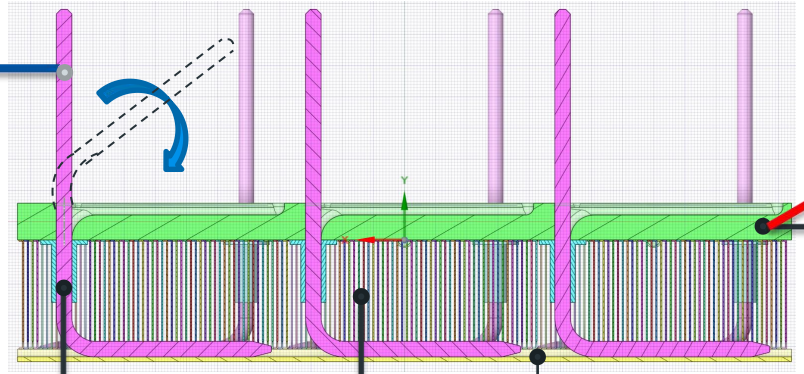
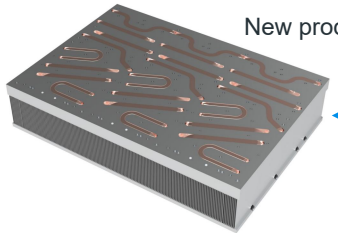
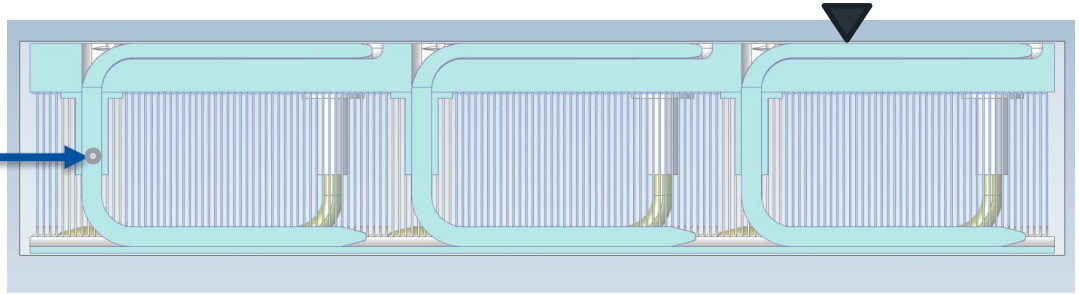
- New High Contact Technology- Features of the design




This is a process innovation of PT, which will be subsequently applied to many high-performance heat sinks, and we will also apply for patents after the verification.




Heat source contact the base plate directly



The "L" shaped heat pipe is bent and flattened to a lying "U" shape directly during assembly and welding; finally it is pressed and rolled into a plane in direct contact with the heat source, which will be more direct to take the heat away.

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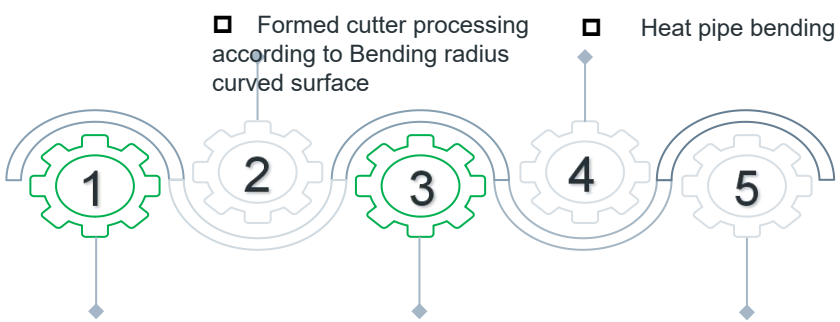
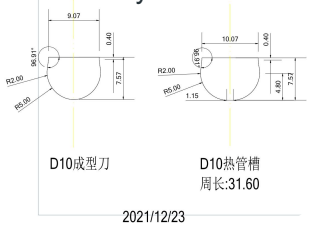
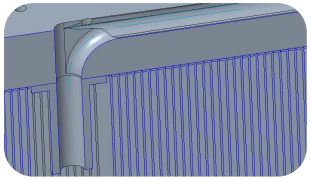
➢ New High Contact Technology- Manufacturing Feasibility

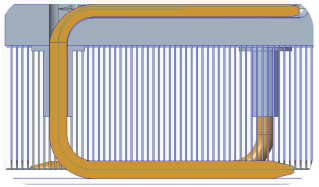
Ensure the accuracy of dimensional accuracy of B&R process implemented by base

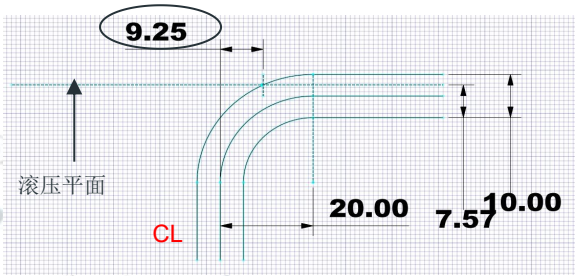



- Aluminum plate drilling 10.1 over-hole
- D10-Heatpipe grooves CNC machining
- Formed cutter processing according to Bending radius curved surface
- Heat pipe bending
- Heat pipe press-fit







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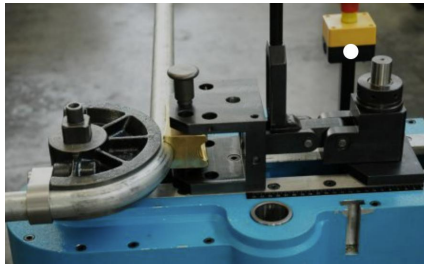
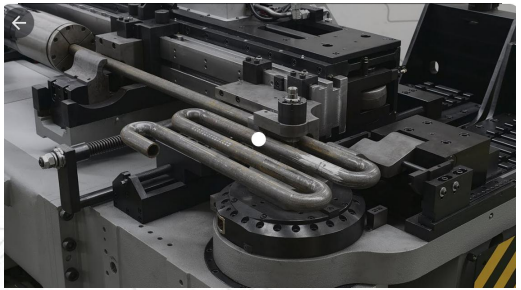
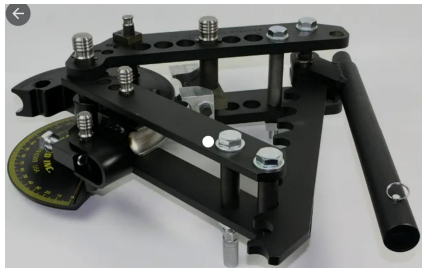
- New High Contact Technology- Basic method for bending pipe fittings





## Different ways of pipe bending

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- New High Contact Technology- Difficulties of manufacturing processes

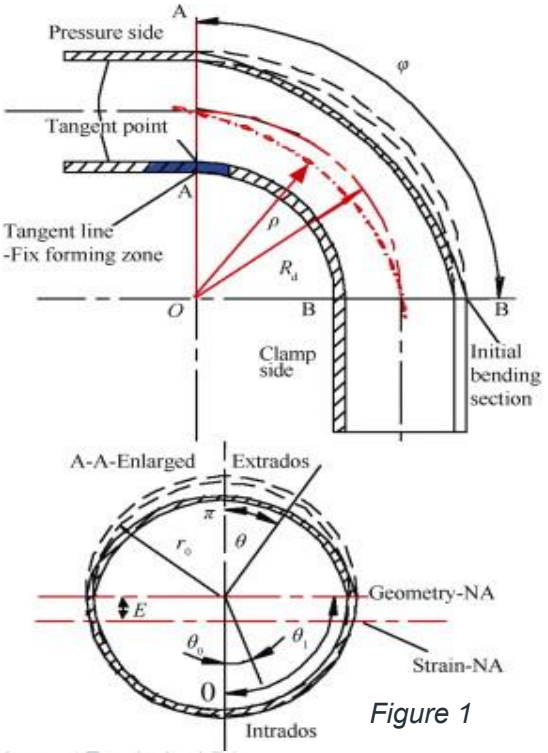


*Figure 1*

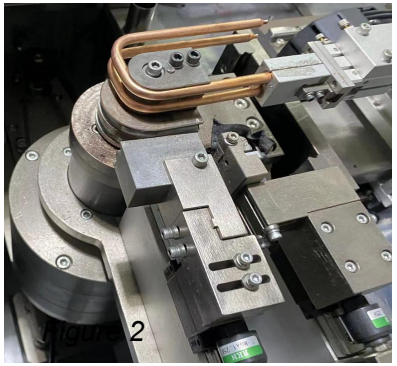

*Figure 2*

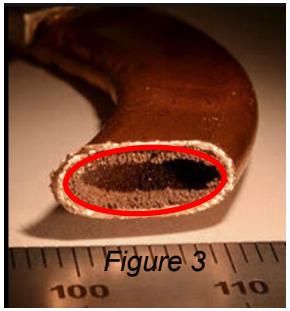


*Figure 3*

Sinter powder

verify the effect of bending on the adhesion of sinter powder

**Introduction of heat pipe bending process**

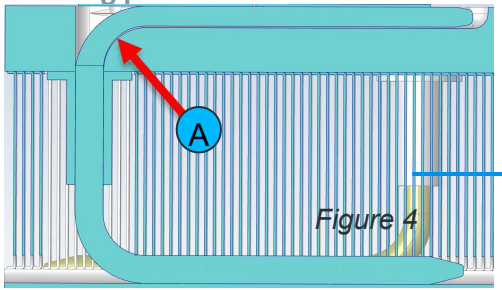


*Figure 4*

Figure 4 shows the forming effect of the bending section at A

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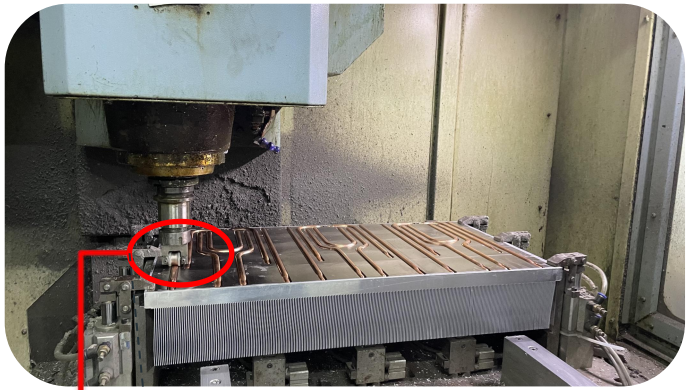
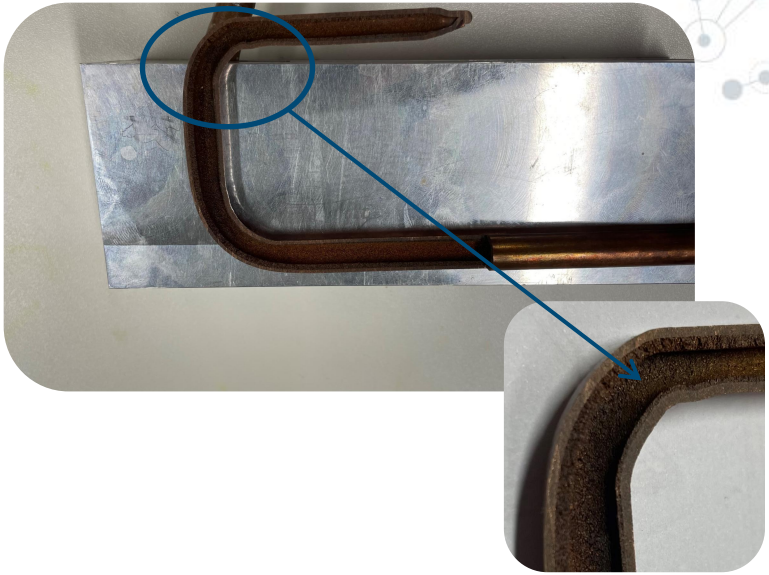
- New High Contact Technology- The Manufacturing Plan and Process



The product is manufactured by CNC ,which has high stability.

The heat pipe is bent and flattened into the corresponding groove shape by CNC rollers



It can be seen that after bending, the sinter powder inside the heat pipe does not fall off.

which as far as possible to avoid the problem of heat pipe performance decay caused by capillary damage

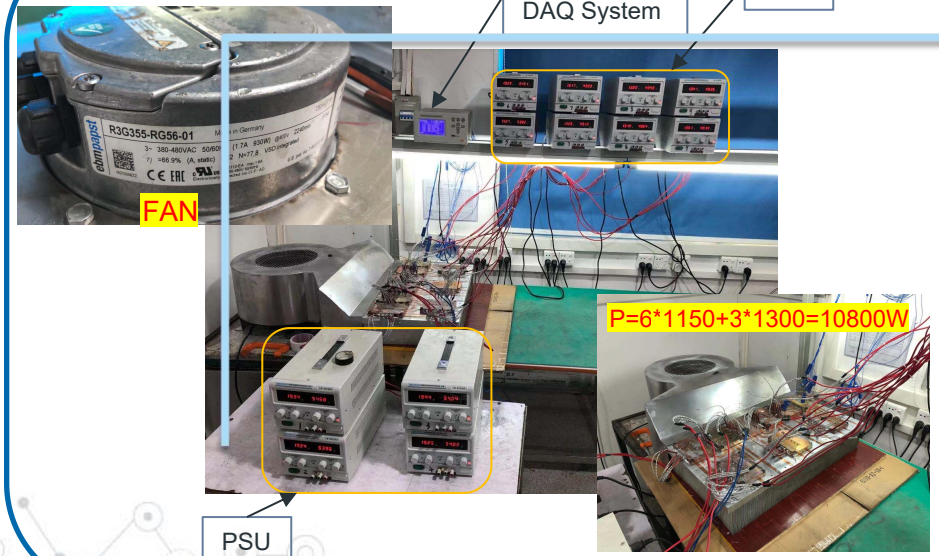
PT HEATSINK

- New High Contact Technology- Thermal Testing

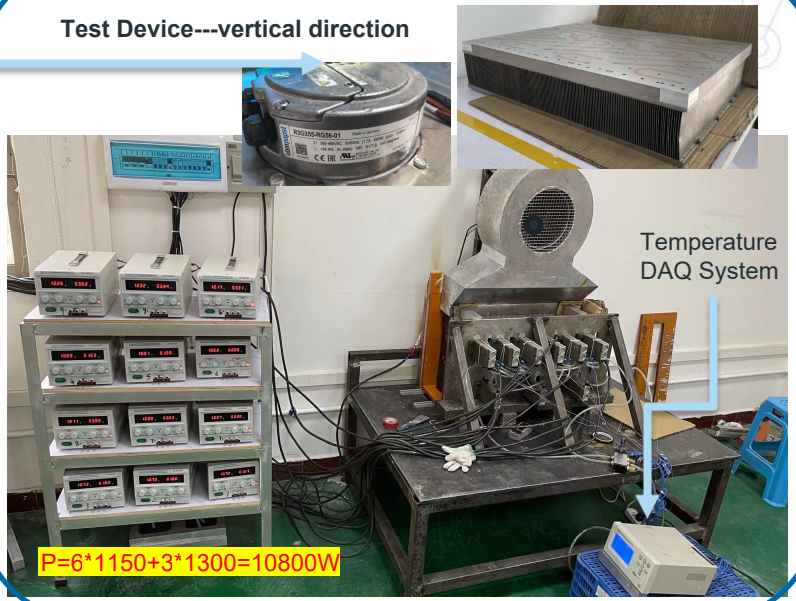
When the prototypes are ready, we will test their thermal efficiency.
Preliminary test results are expected to be released in ***August 2022.***

- Thermal performance test is refered to the test method we used on previous products

**Test Device---horizontal direction**




**Test Device---vertical direction**



PT HEATSINK

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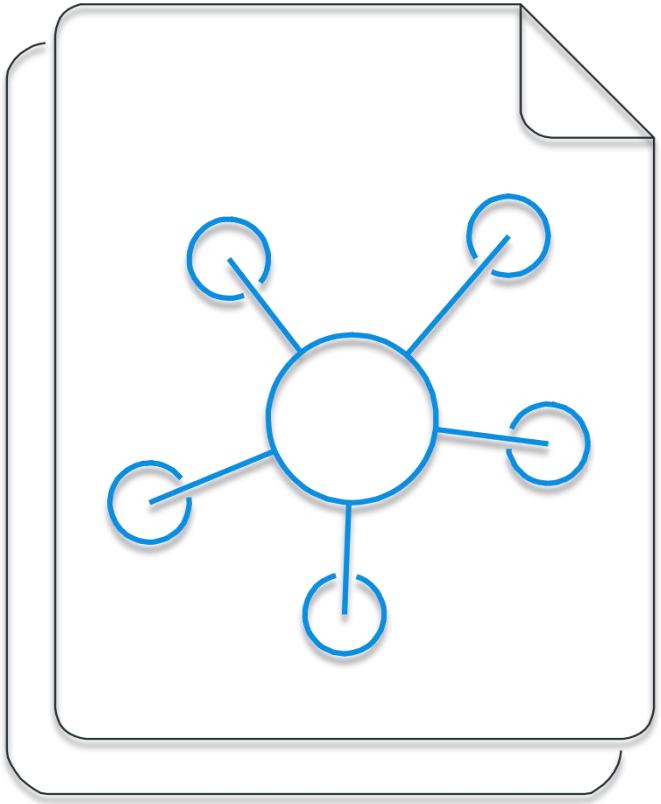

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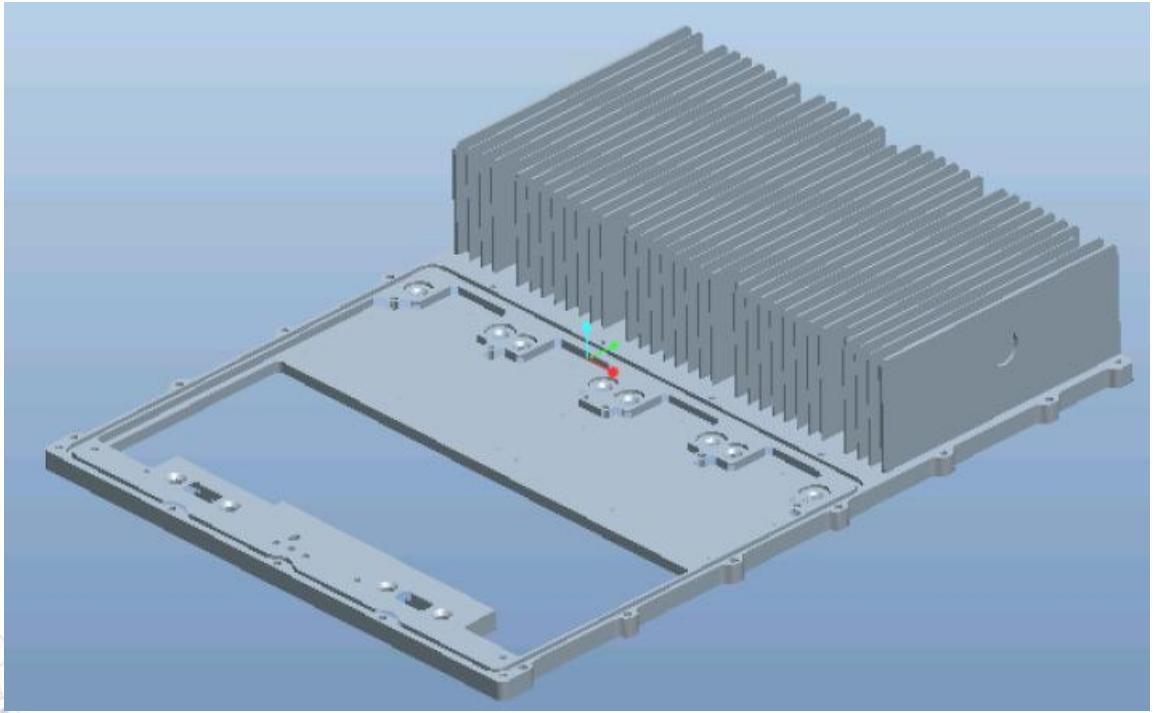
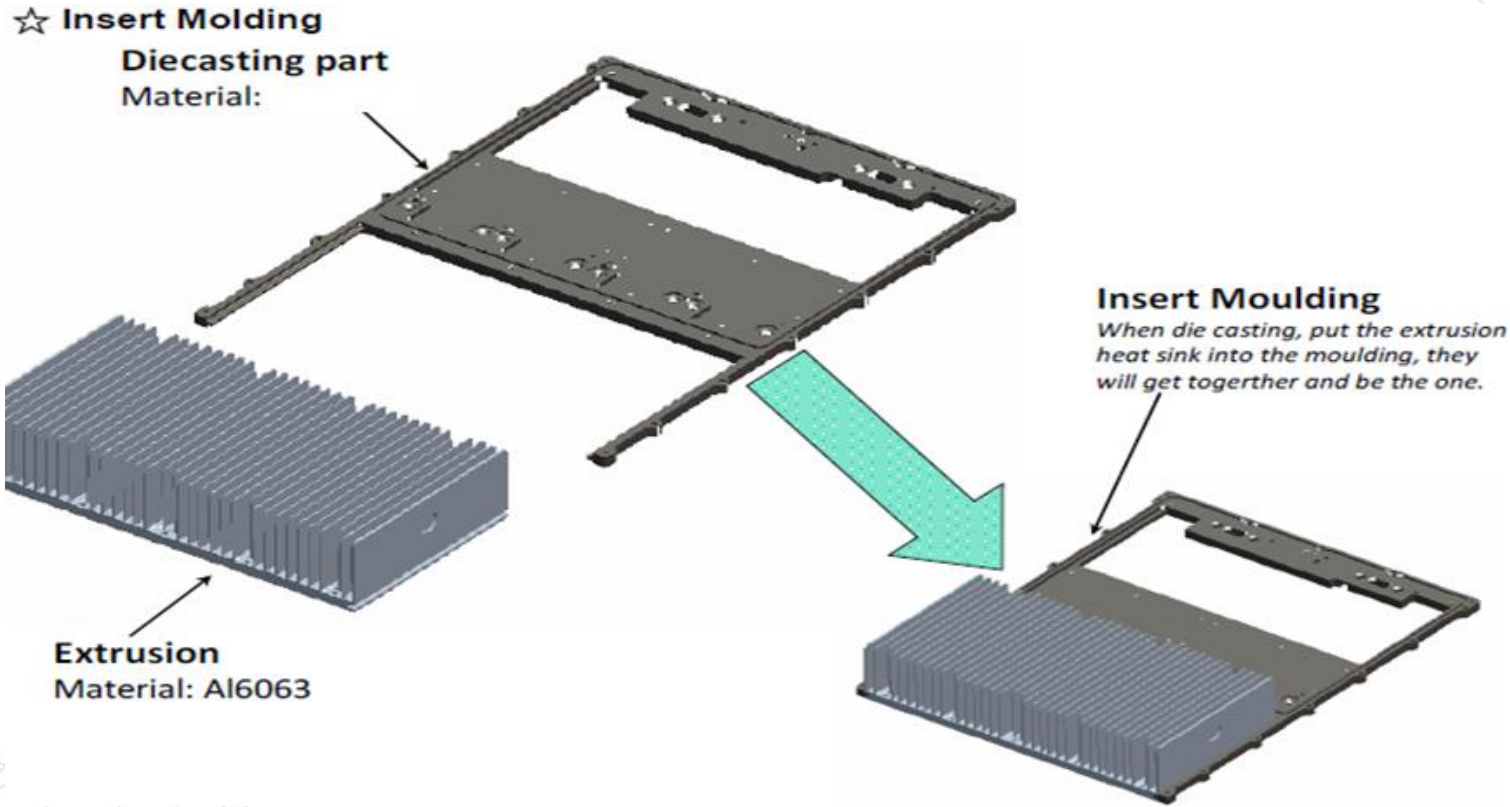
- Insert Molding--Purpose
  - Reduce usage of Al extrusion material
  - Reduce the cost of machining
  - Increasing thermal performance



- Insert Molding--Process solution



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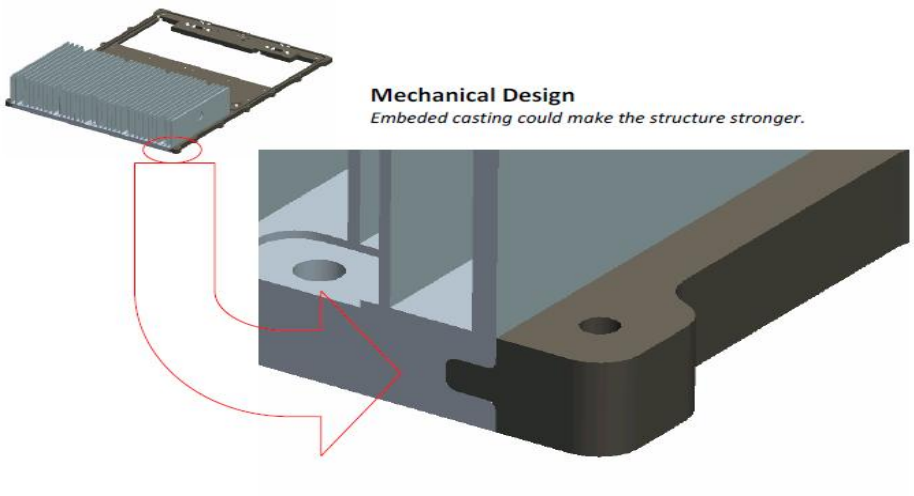
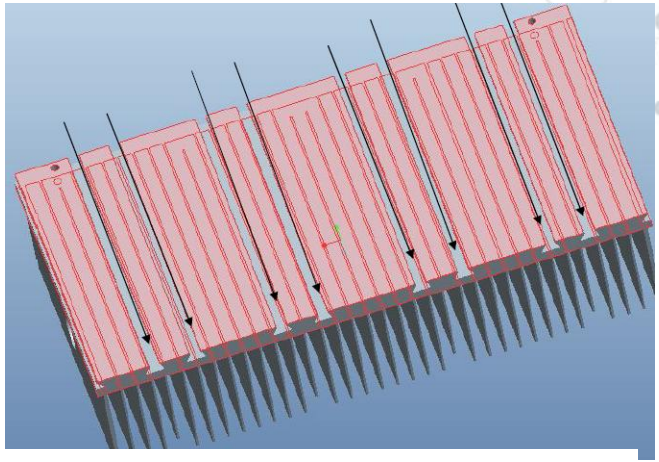
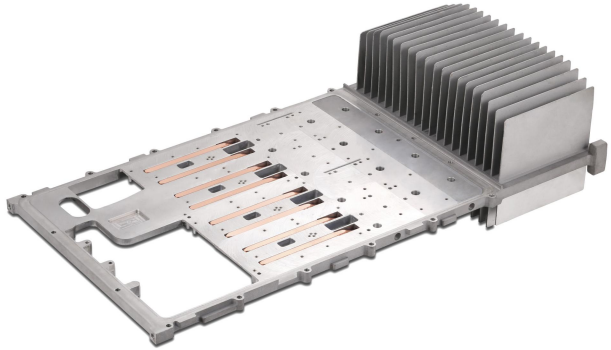
- Insert Molding--Mechanical Design



- Application
  - Extrusion Heatsink
  - RRU Diecasting Heatsink



PT HEATSINK

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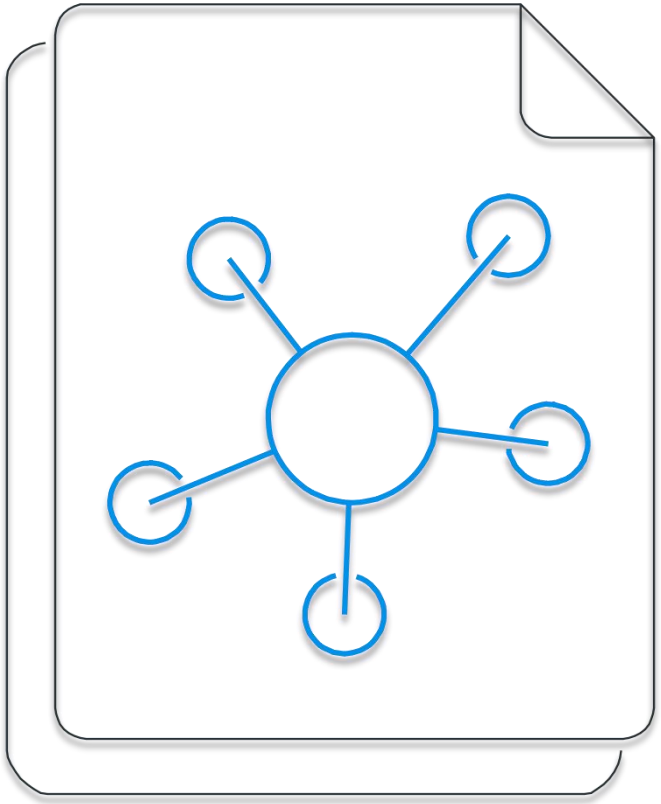
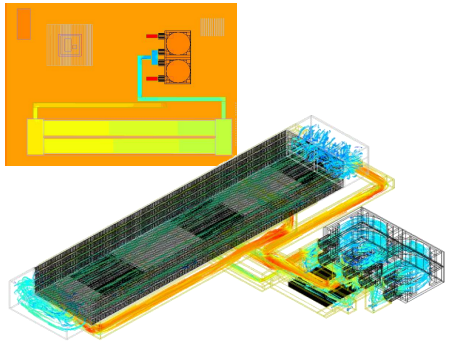
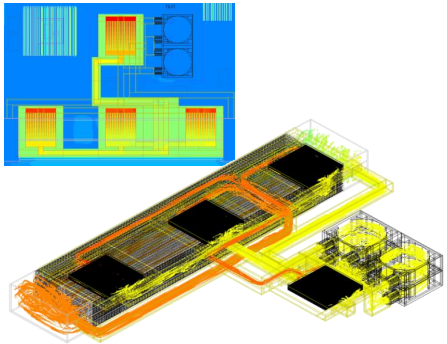


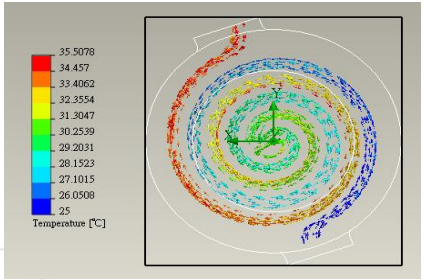
# Cold Plate Solutions - Numerical Analysis Tool

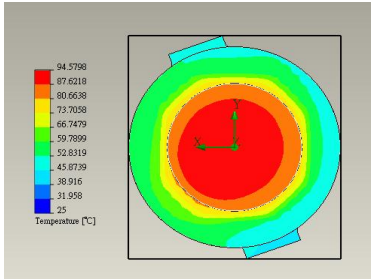
## Flotherm

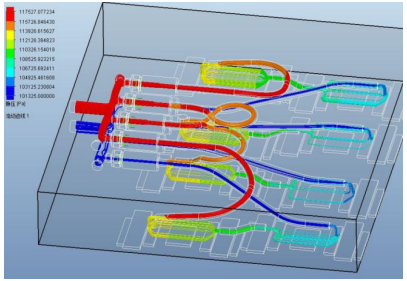




## EFD

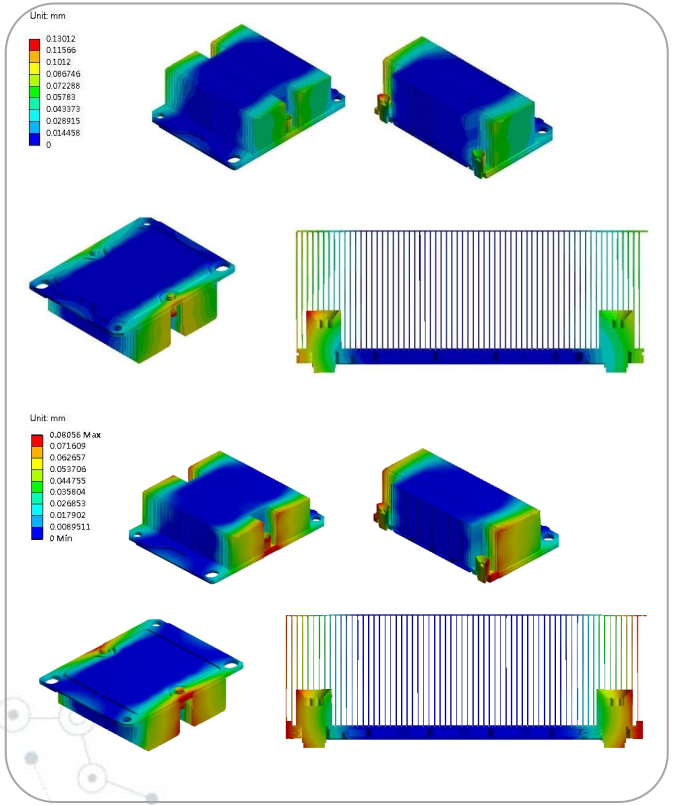


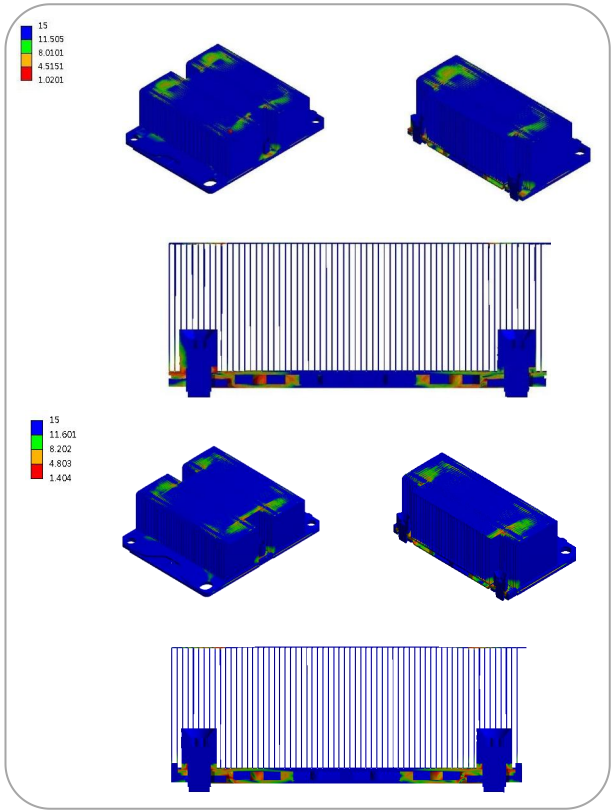



PT HEATSINK

# Cold Plate Solutions - Numerical Analysis Tool



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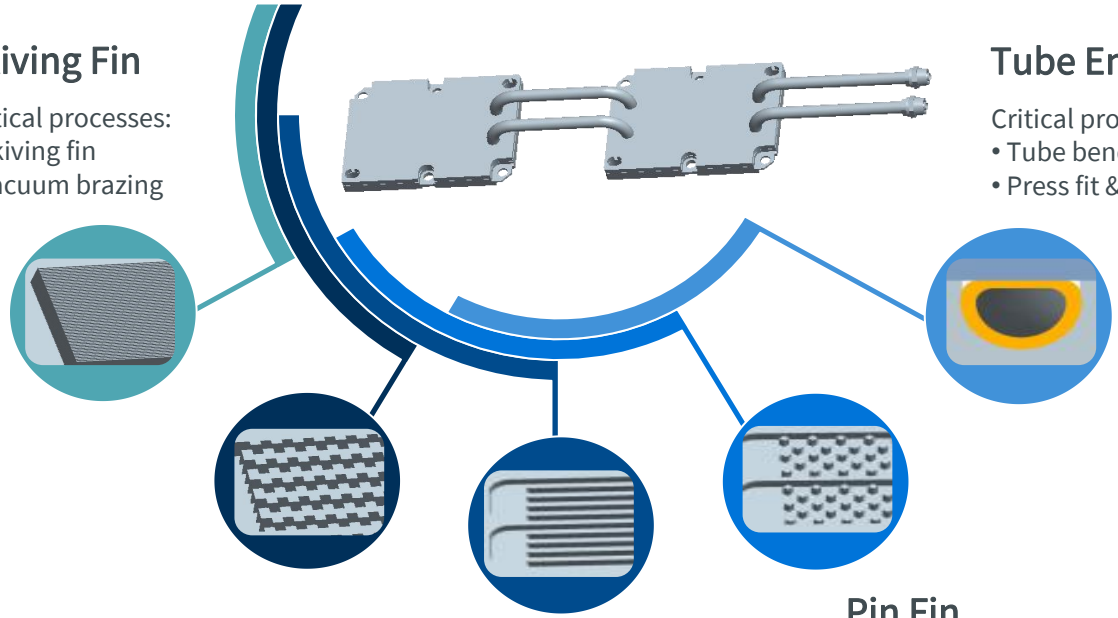
# Cold Plate Solutions - Channel Design Types



## Skiving Fin

Critical processes:
- Skiving fin
- Vacuum brazing

## Tube Embedded

Critical processes:
- Tube bending
- Press fit & fly cut

## Channel w/ Turbulator

Critical processes:
- Turbulator: Stamping
- Vacuum brazing

## CNC

Critical processes:
- CNC machining
- Vacuum brazing

## Pin Fin

Critical processes:
- CNC machining or casting
- Vacuum brazing

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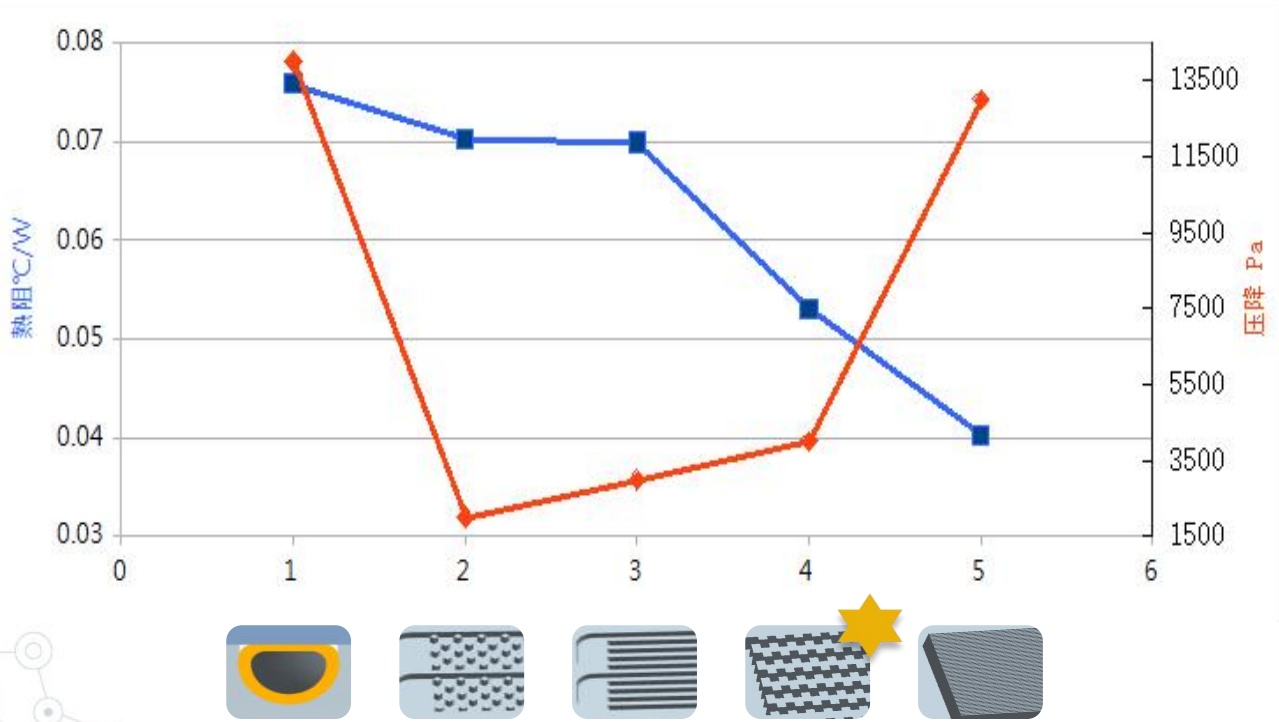
# Cold Plate Solutions - Channel Design Studies



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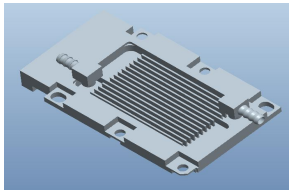
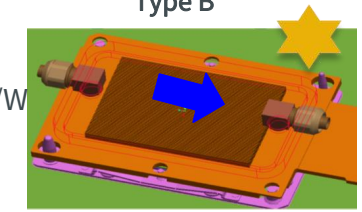
# Cold Plate Solutions - Design Solutions

Type A

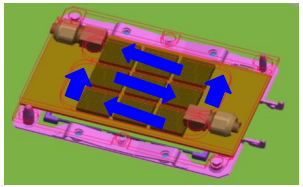


R=0.089°C/W
Dp:1.9Kpa
@1LPM

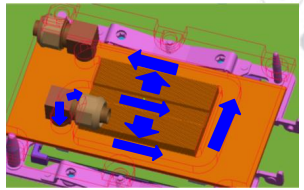
Type B

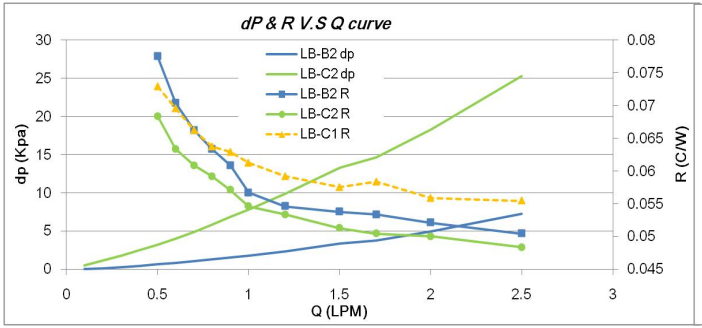


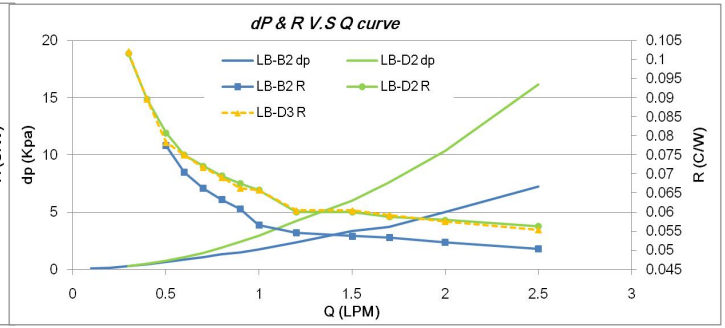
Type C



Type D






| 1LPM | R(°C/W) | dP (Kpa) |
|---|---|---|
| Type B | 0.0567 | 1.754 |
| Type C | 0.0546 | 7.78 |
| Type D | 0.0658 | 2.944 |

Note:
Type B is the optimal choice in terms of flow impedance and thermal performance.

EX:
For 300W x 4 series scenario: If Type B R = 0.0567°C/W @1LPM, W_in 45 °C, means the 4th CPU T_case will be 75°C

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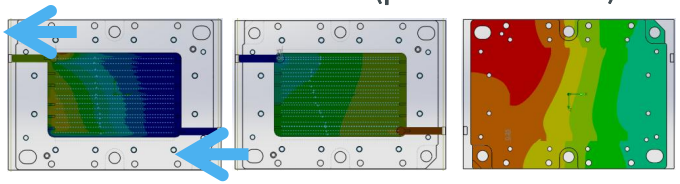
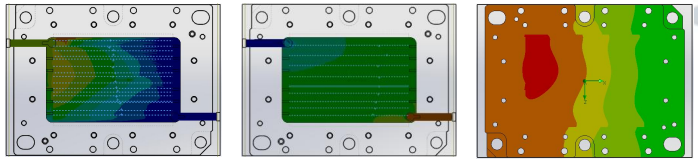
# Cold Plate Solutions - Design Solutions

**Skived fins: 0.25x0.25mm (pitch x thickness)**



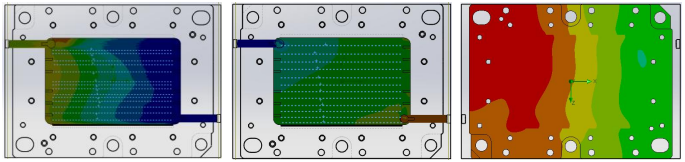
T-out: 29.5C dP: 5615Pa T-surface:31.27C T-in: 25C

**Skived fins: 0.5x0.5mm**



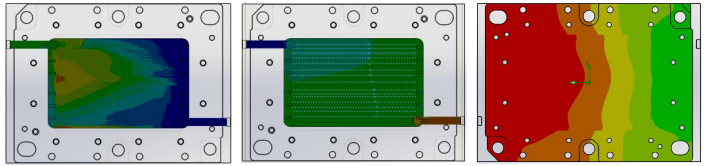
T-out: 28.8C dP: 4949Pa T-surface:31.51C T-in: 25C

**Skived fins: 0.35x0.35mm**



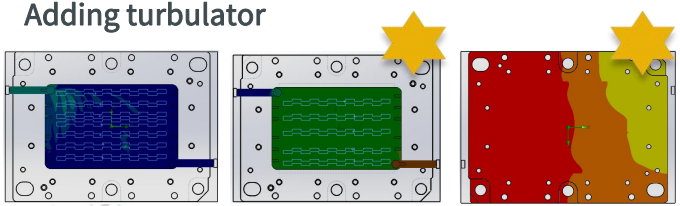
T-out: 28.76C dP: 5400Pa T-surface:30.81C T-in: 25C

**Skived fins: 0.7x0.7mm**



T-out: 29C dP: 4963Pa T-surface:33C T-in: 25C

**Adding turbulator**



T-out: 28.86C dP: 4755Pa T-surface:36.39C T-in: 25C

Generate turbulence and swirling flow w/
- Minimum ΔP increment
- More uniform temp. distribution

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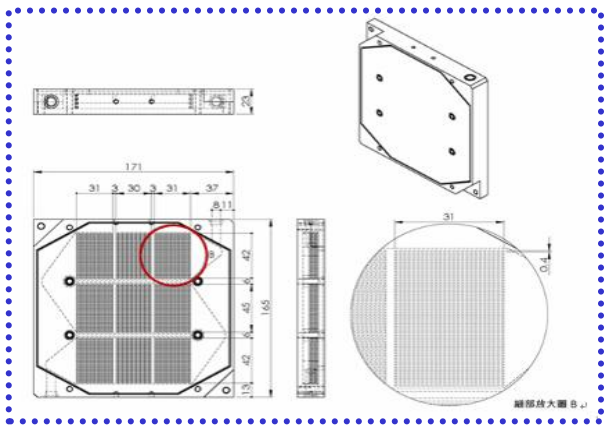
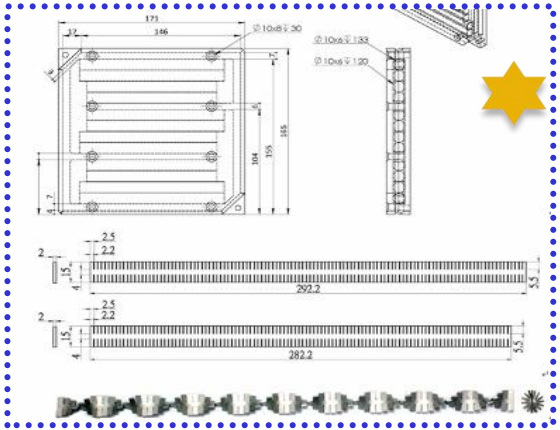
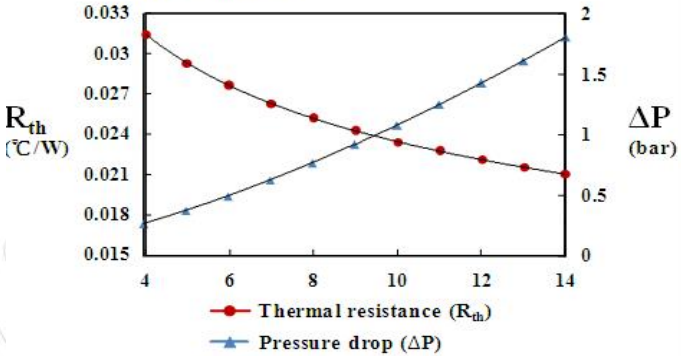
# Cold Plate Solutions - Adding Turbulators Example

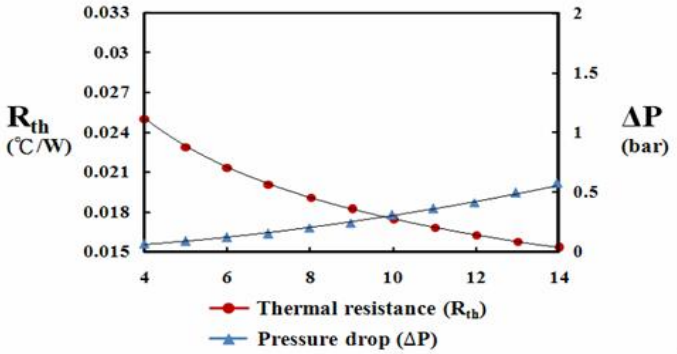


(a) Fin channel

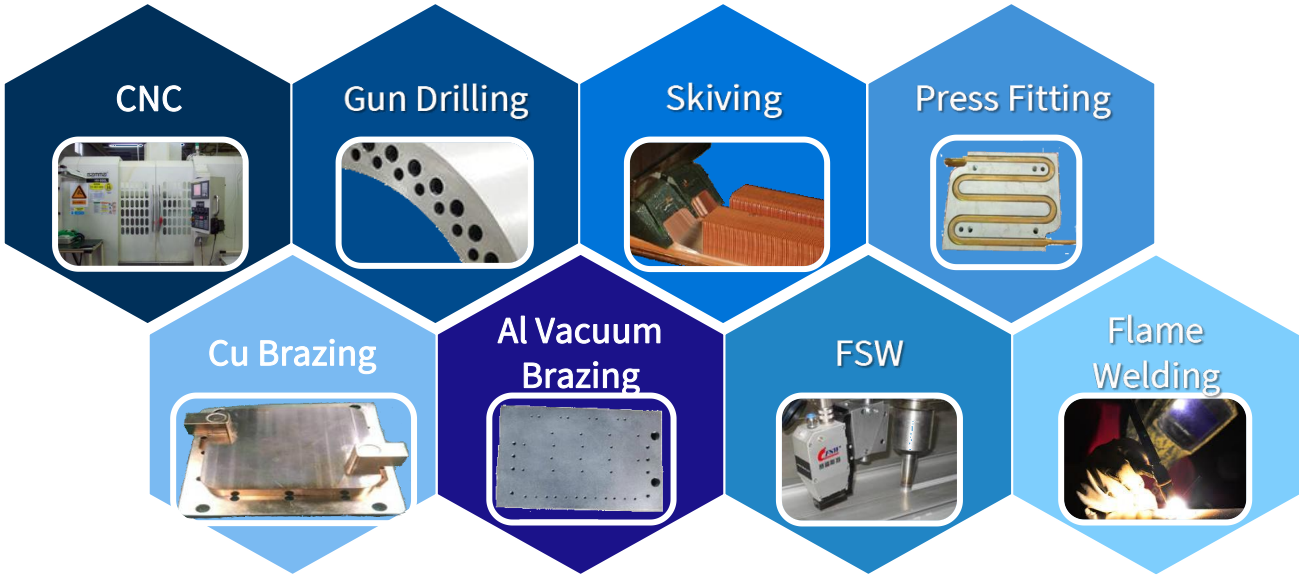


(b) Spiky twisted tape channel



# Cold Plate Solutions - Key Cold Plate Mfg. Processes

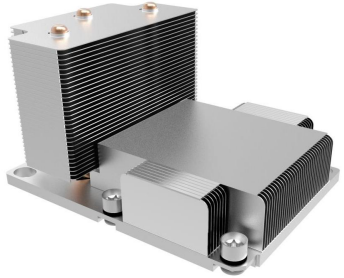



*To weld connectors & tubes

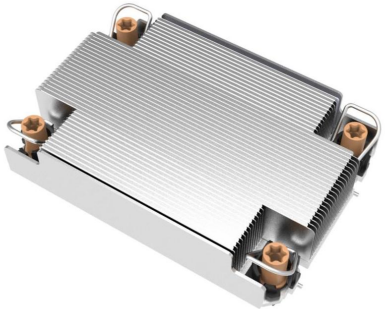
# Server Industry Products

Intel purley 1U

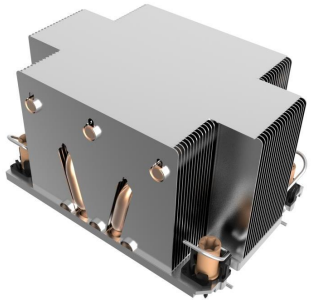
Intel purley 2U



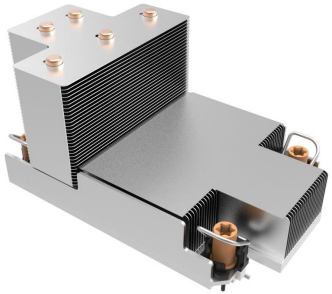
Intel purley 2U



Intel whitley 1U

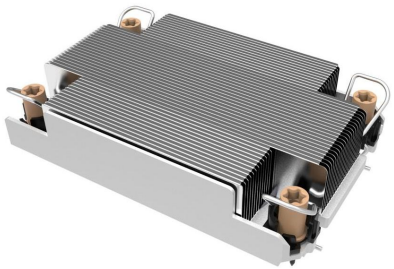


Intel whitley 2U

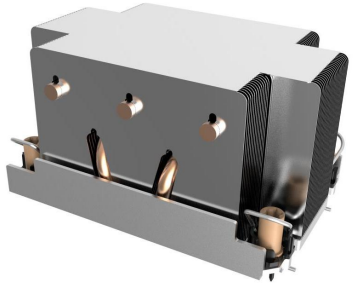


Intel whitley 2U

# Server Industry Products

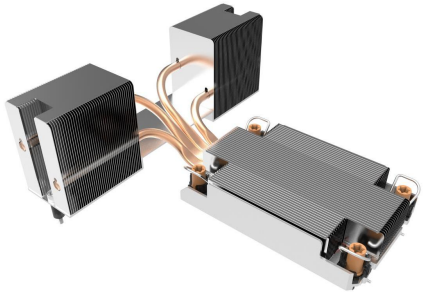


Intel EGS 1U

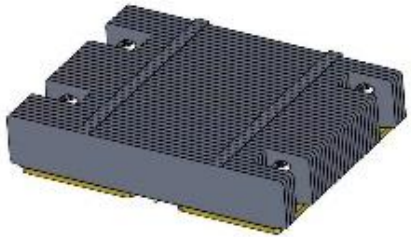


Intel EGS 2U(270W)

Intel EGS 2U（300W)



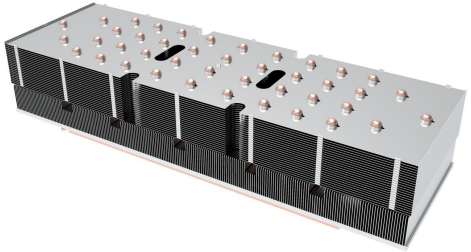
Intel EGS 2U（350W)



AMD SP3 1U (38Fins)

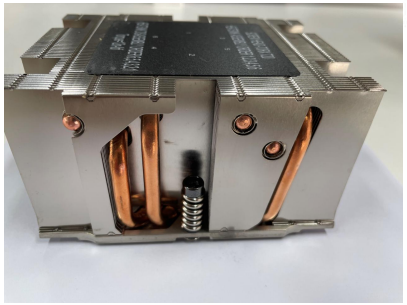
AMD SP3 1U (63Fins)

# Server Industry Products



3D VC

AMD SP3 2U



AMD SP5 2U

VC+HP soldering

VC soldering

Heat pipe soldering

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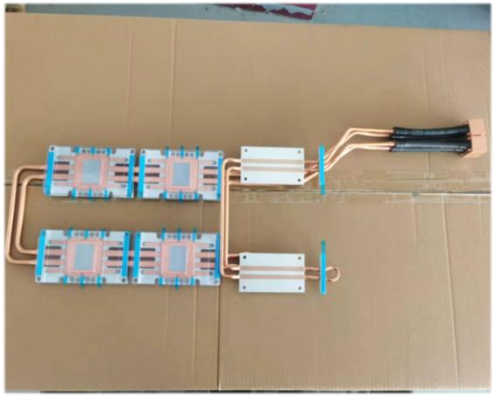
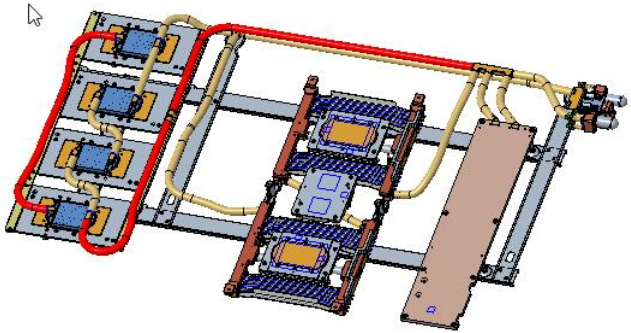
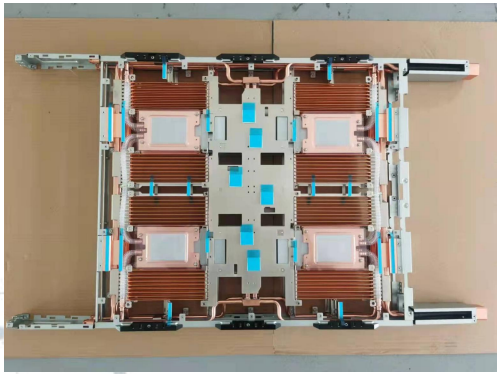
# Server Industry Products







# Verification Tools – (Performance Checks)

Wind Tunnel

On-Line Thermal Tester


HP Qmax Tester

HP Delta T Tester

# Verification Tools – (Dimensions)

CMM


Projector

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# Verification Tools – (Reliability)

Thermal Shock

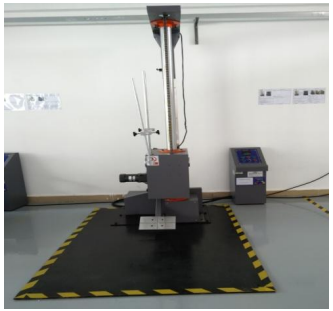

High Temperature Aging Chamber

Salt Spray Tester

Pressure Tester


Clip Force Tester


Drop Tester



# Verification Tools – (Reliability)

Helium Leakage Tester


Liquid Pressure Tester

Flow Resistance Tester

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Ready to start your next project?
Have questions?
Want to schedule a meeting?

Feel free to reach out to our team at:
henry.hu@ptheatsink.com