# Thermal management solutions with heat pipes

Andrea Sce

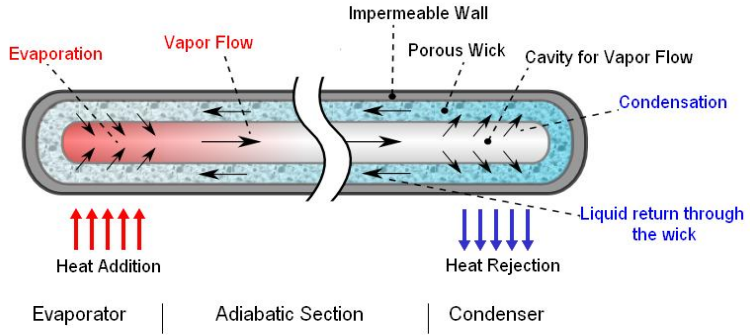
AAVID THERMALLOY

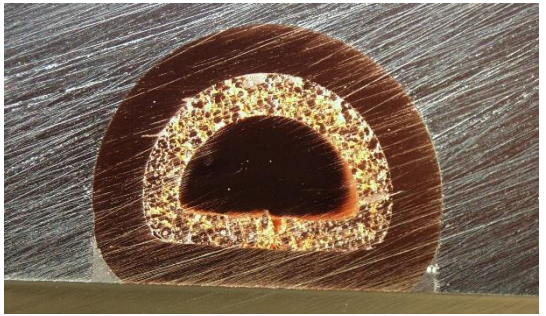
# Corporate Overview

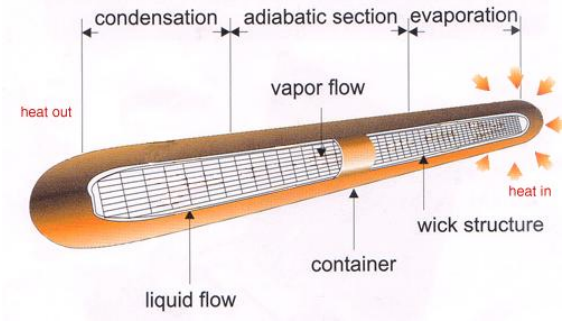
- World's Leader in Thermal Management Solutions
- Product Manufacturing – Engineering Services – Technology Development
- 3000+ Global Employees including 300+ engineers
- 111000 $m^2$ of manufacturing space
- ISO 9001:2008

# Aavid Locations and “Family”

# Heat Pipes Working Mechanism



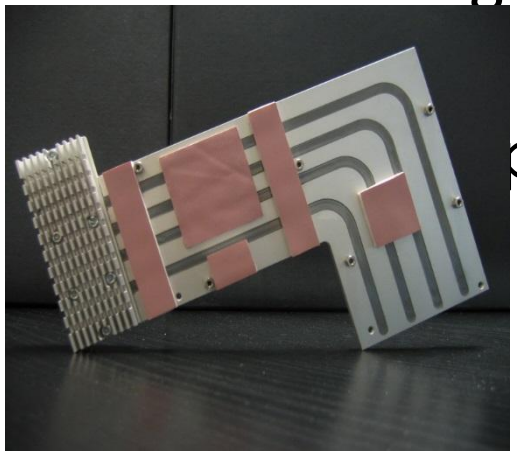



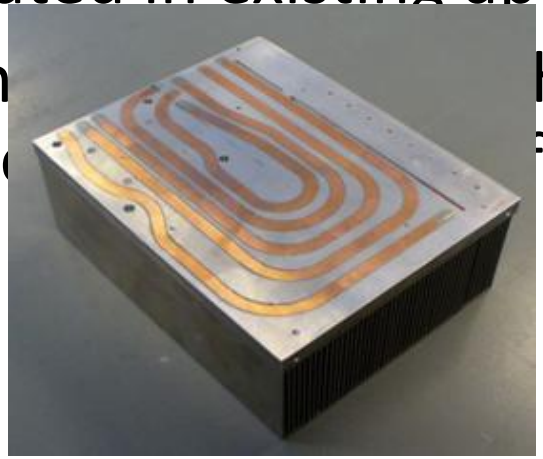



- Heat pipes are basically thermal energy transporters
- They move heat from a warm location to a cold location

# Why to Use Heat Pipes?

- Overcome limitation of air cooling solutions
- Can be integrated in existing applications





# Heat Pipes Power Capacity

- Mainly related to diameter
- Reduced by flattening or bending
- Affected by orientation
- HP efficiency is decreasing with length
  - Maximum, minimum

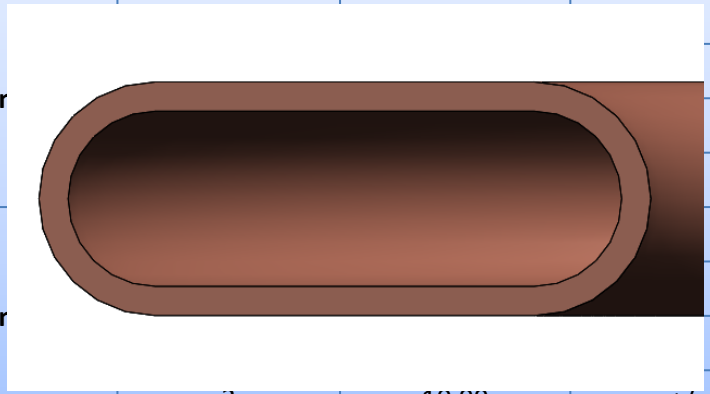
| Diameter (mm) | Maximum Power (W)* |
|---|---|
| 3 | 12 |
| 4 | 25 |
| 5 | 30 |
| 6 | 60 |
| 8 | 100 |
| 9.5 | 120 |

*** L = 150 mm, vertical orientation against gravity**

# Flattening

- In case of geometrical constraints
  - Base thickness
- Power capacity is reduced
- Values given at 150 mm, vertical orientation against gravity

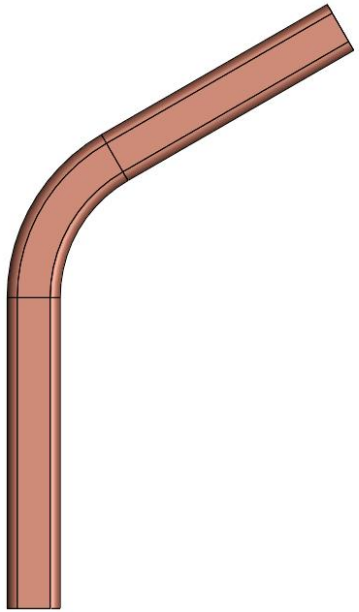
| | Ø 4 mm | Ø 5 mm | Ø 6 mm | Ø 8 mm |
|---|---|---|---|---|
| Diameter (mm) | Thickness (mm) | Width (mm) | Tolerance (mm) | |
| Ø 5 r | | | | 0.15 |
| | | | | 0.15 |
| | | | | 0.15 |
| | | | | 0.15 |
| Ø 8 r | | | | 0.15 |
| | | | | 0.15 |
| | 3 | 10.99 | +/- | 0.15 |
| Round Pipe | 25 W | 30 W | 60 W | 100 W |



# Bending

- In case of geometrical constraints
  - Obstacles, lay-out of application
- Power capacity is reduced
  - Consider a reduction of 5-10% for every bend

| | |
|---|---|
| Ø 4 mm | |
| Ø 5 mm | |
| Ø 6 mm | |
| Ø 6.35 mm | |
| Ø 8 mm | |
| Ø 9.6 mm | |

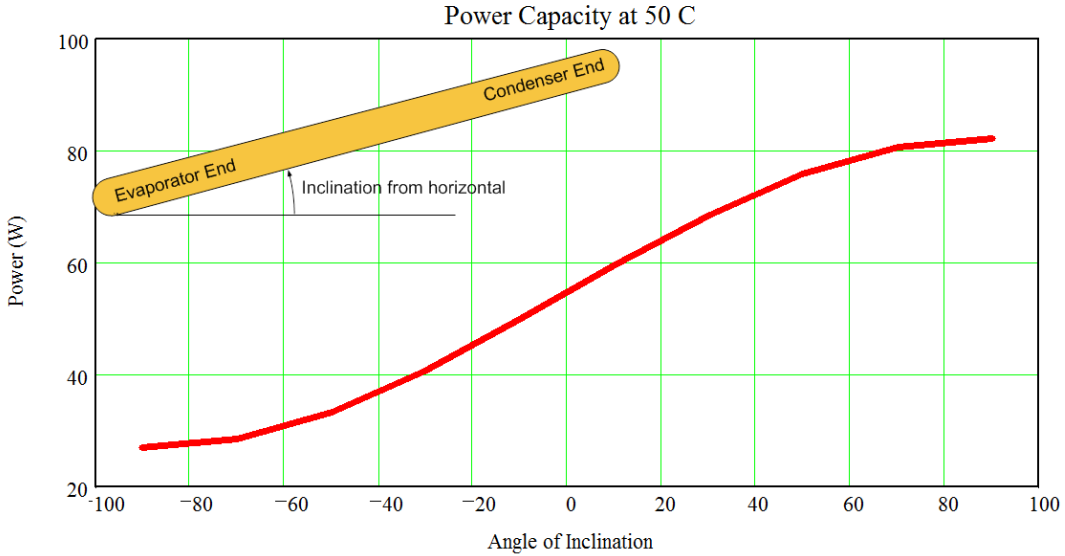


ggested
ending
Angle

> 120°

# Orientation

- In an ideal World vapor should go up and liquid down…
- In reality…




Estimated for $\Phi$ 6mm, 150 mm long straight sintered heat pipe at 50 $^{o}$C

# Heat Pipes Selection

- Based on boundary and operating conditions

Table 1. Typical Operating Characteristics of Heat Pipes

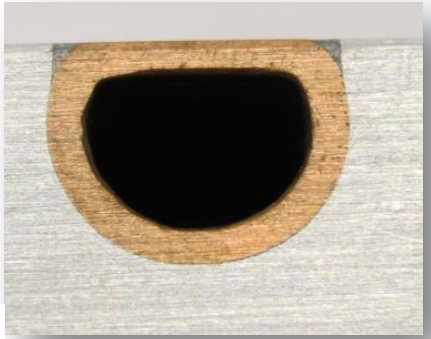
| Temperature Range (°C) | Working Fluid | Vessel Material | Measured axial[8] heat flux ($kW/cm^2$) | Measured surface[8] heat flux ($W/cm^2$) |
|---|---|---|---|---|
| -200 to -80 | Liquid Nitrogen | Stainless Steel | 0.067 @ -163°C | 1.01 @ -163°C |
| -70 to +60 | Liquid Ammonia | Nickel, Aluminum, Stainless Steel | 0.295 | 2.95 |
| -45 to +120 | Methanol | Copper, Nickel, Stainless Steel | 0.45 @ 100°C[X] | 75.5 @ 100°C |
| +5 to +230 | Water | Copper, Nickel | 0.67 @ 200°C | 146@ 170°C |

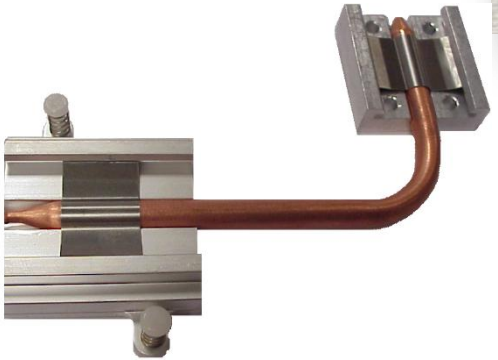
# Design Considerations

- Heat pipes to address
  - Power capacity
  - Heat flux capacity
- Heat flux limitations
  - Working fluids
  - Wicks
  - Constructions materials
  - Assembly practices and controls
- Practical heat flux limits
  - 100 to 120 W/cm$^2$ for sintered copper-water

# Design Considerations

- Life and Reliability
  - Boundary conditions (freezing)
  - Load sharing and redundancy
  - Dry-out phenomena
  - Mechanical robustness of the design
- Hi-Contact Technology
  - Maximize contact area
  - Leaves minimal material
- Joining technologies
  - Soldering process
  - Epoxy resin
  - Thermal grease

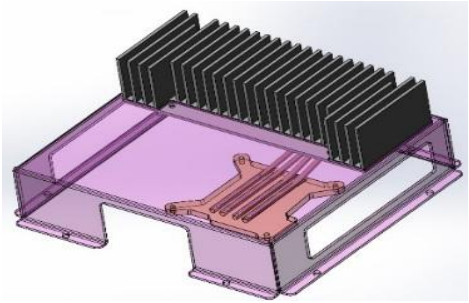




# Case Studies

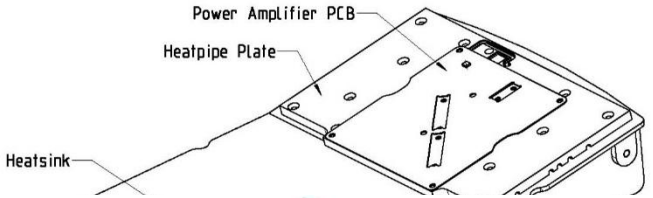
# Control Monitor Cooling

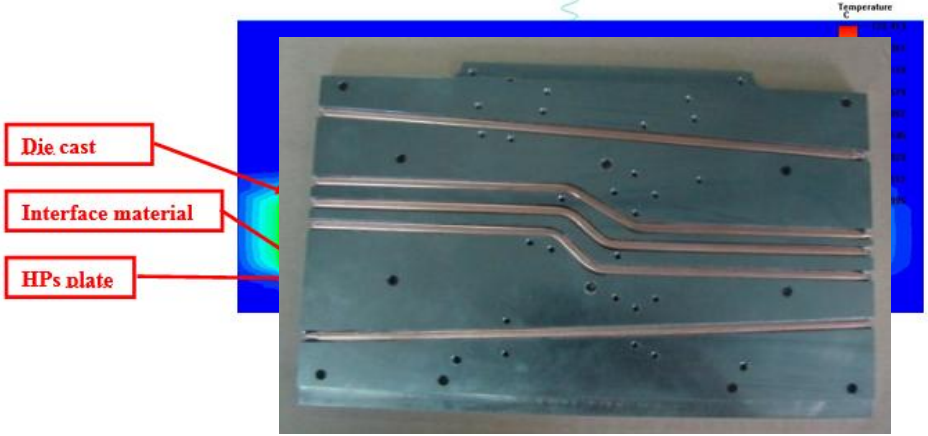
- Industrial application
- HPs to move heat outside of the box
- Two options
  - Passive solution (P = 35 W, $R_{th}$ = 0,8 °C/W)
  - Active solution (P = 45 W, $R_{th}$ = 0,6 °C/W)
- Soldering technology
- Full aluminum construction
- Prototypes validated



# Spreading Heat in a RRH

- Remote Radio Head
- HPs to spread heat
  - Very concentrated power losses
  - On existing die-casted solution
- Passive solution
  - P = 170 W, Rth = 0,4 °C/W
- Soldering technology
- Full aluminum construction
- Prototypes validated



# Aavid Expertise

- HPs are flexible
- HPs systems to be designed with a correct approach
  - Prevent dry-out phenomena
  - Define all the characteristics of the system
    - Joining technologies
    - Number and diameter of the HPs
    - HP model
- Design Centres are able to fully develop a new product for you
  - Thermal design
  - Mechanical design
  - Validation test

AAVID THERMALLOY

# Thanks for your attention!
# Questions are welcome!

Andrea Sce
sce.a@aavid.com
+39 051 764079