# Low Profile Heat Sink Cooling Technologies for Next Generation CPU Thermal Designs

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# Overview

- Introduction
- Performance of Optimized All-Metallic Heat Sink Design
- Embedded Heat Pipe Heat Sink
- Vapor Chamber Heat Sink
- Oscillating Heat Pipe Heat Sink
- Thermal Performance Results
- Summary

# Introduction

- Critical Design Criteria

  Power : 150 watts

  Sink-Air Thermal Resistance: 0.18 C/W

  Pressure Loss & Flowrate : 0.17” H2O, 35 cfm

  Heat Input Area: 16 mm x 16 mm

  Frontal Area : 50 mm tall x 114 mm wide  (vertical board)

  Allowable Mass: 680 grams

- All-Metallic Heat Sink Design?

# All-Mettalic Heat Sink Performance

- Optimized Metal Heat Sink Design

  Copper Base with Idealized attached Aluminum Fins
  Base Dimensions: 4 mm thick x 100 mm flow length
  Fin design: Plane, Continuos
  0.28 mm thick x 46 mm tall x 70 fins

- Sink-Air Resistance Requirement: 0.18 C/W
- Thermal Resistance for Metal H/S: 0.26 C/W

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- Coolable Power would be reduced by 23 watts

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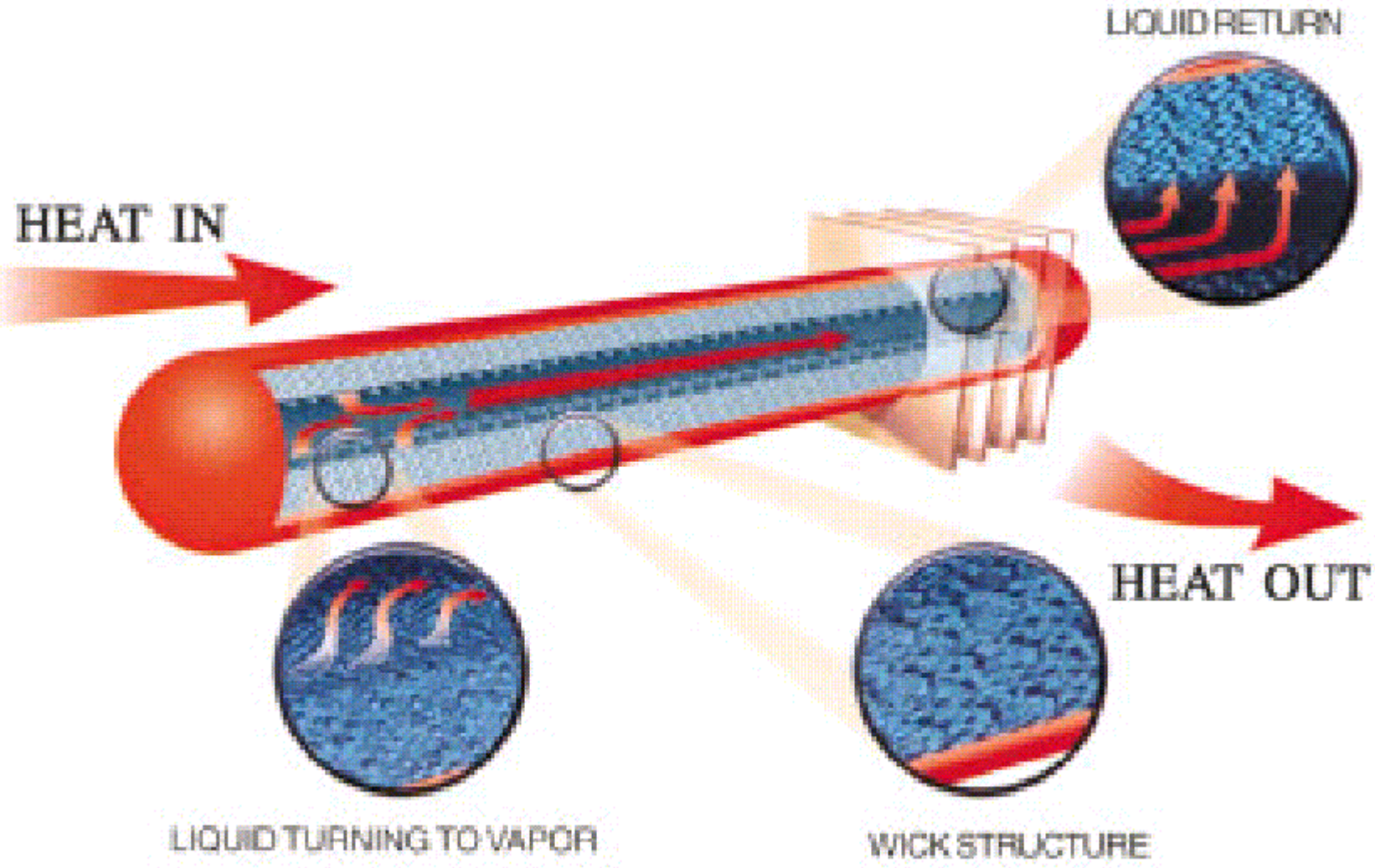
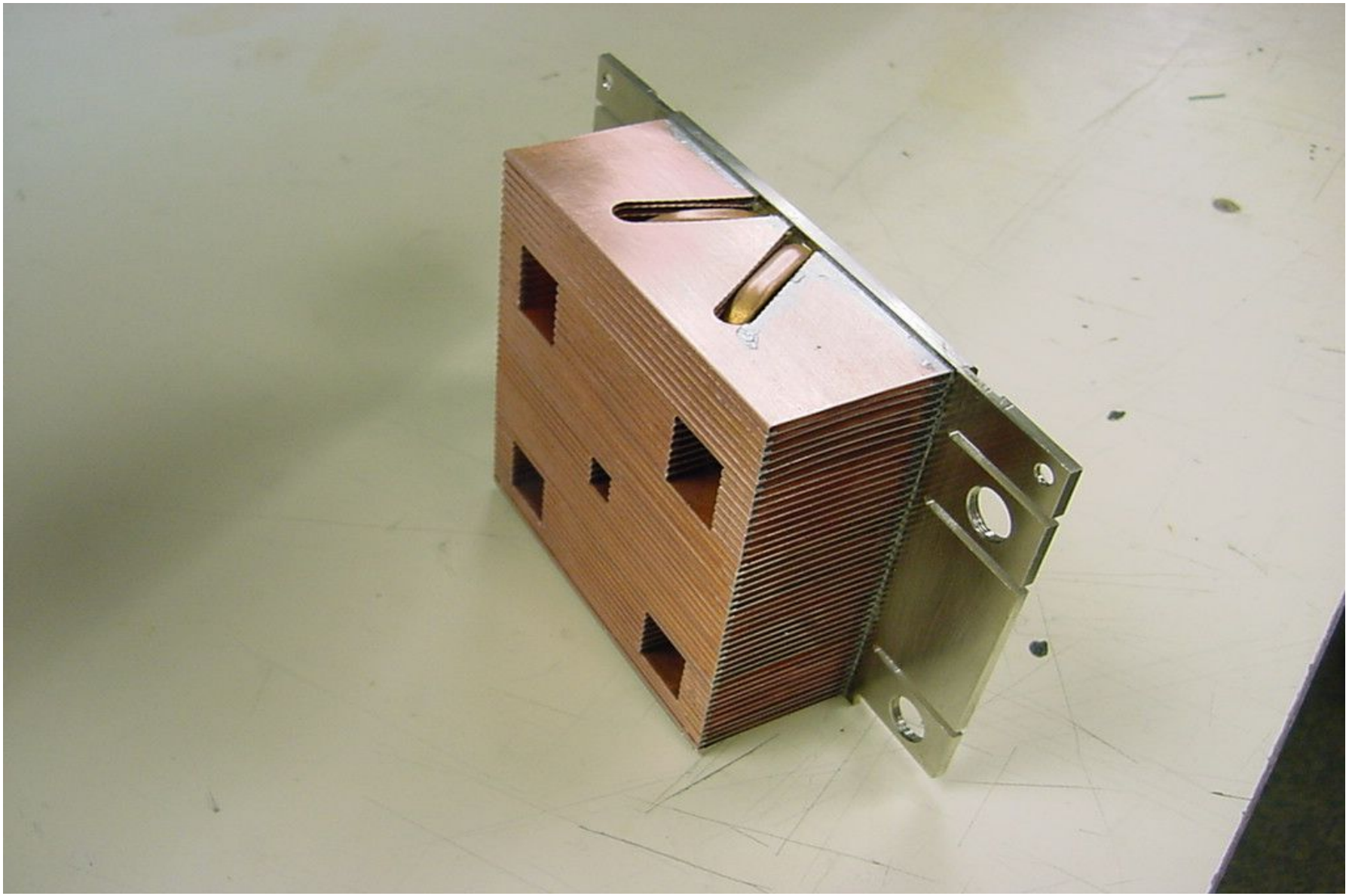
- CPU Speed would be Reduced by 15%

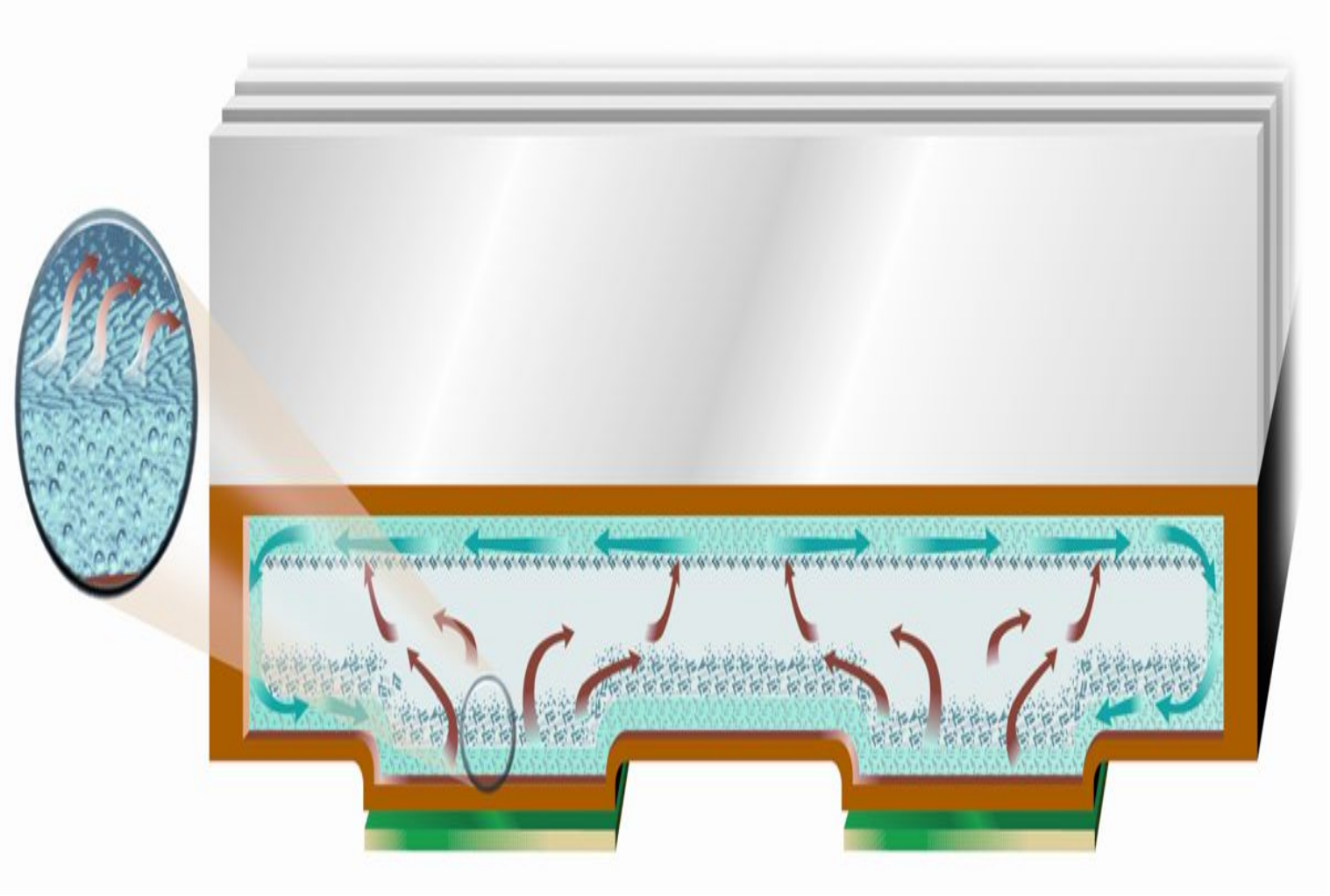
# “One-Dimensional” Heat Pipe



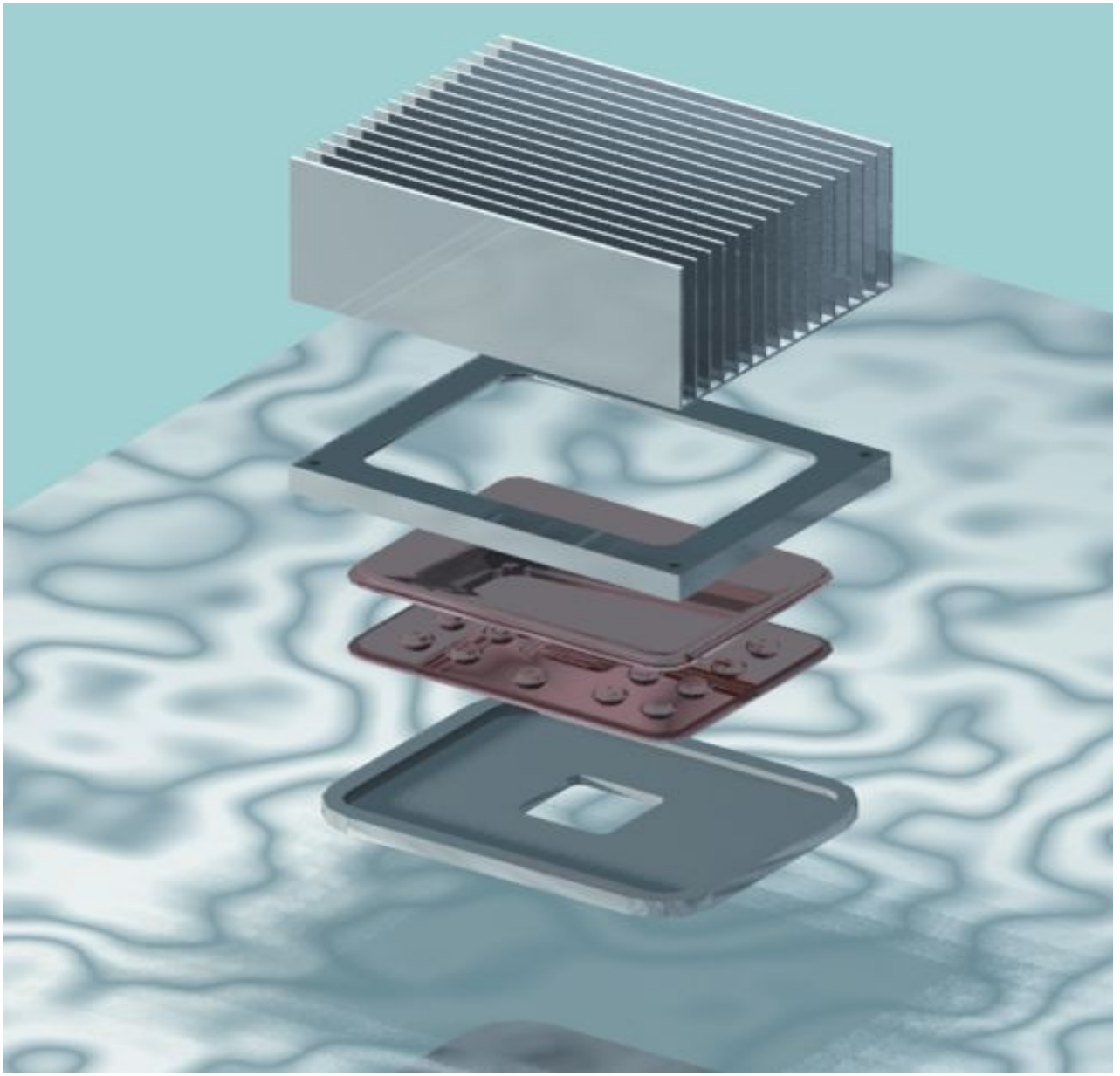
# Embedded Heat Pipe Prototype - Aavid Thermalloy



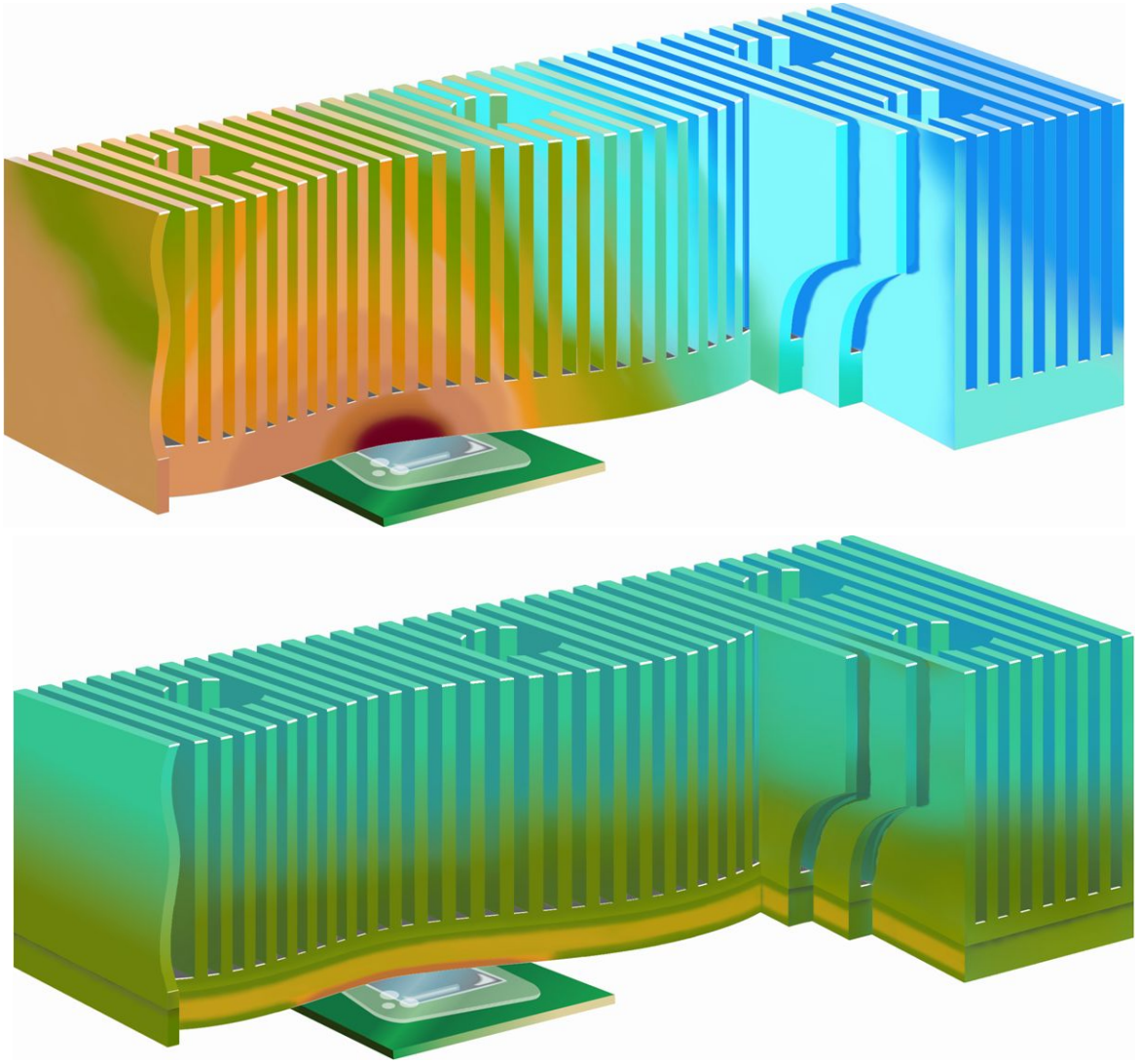
# 3-Dimensional Heat Pipe Base - Vapor Chamber



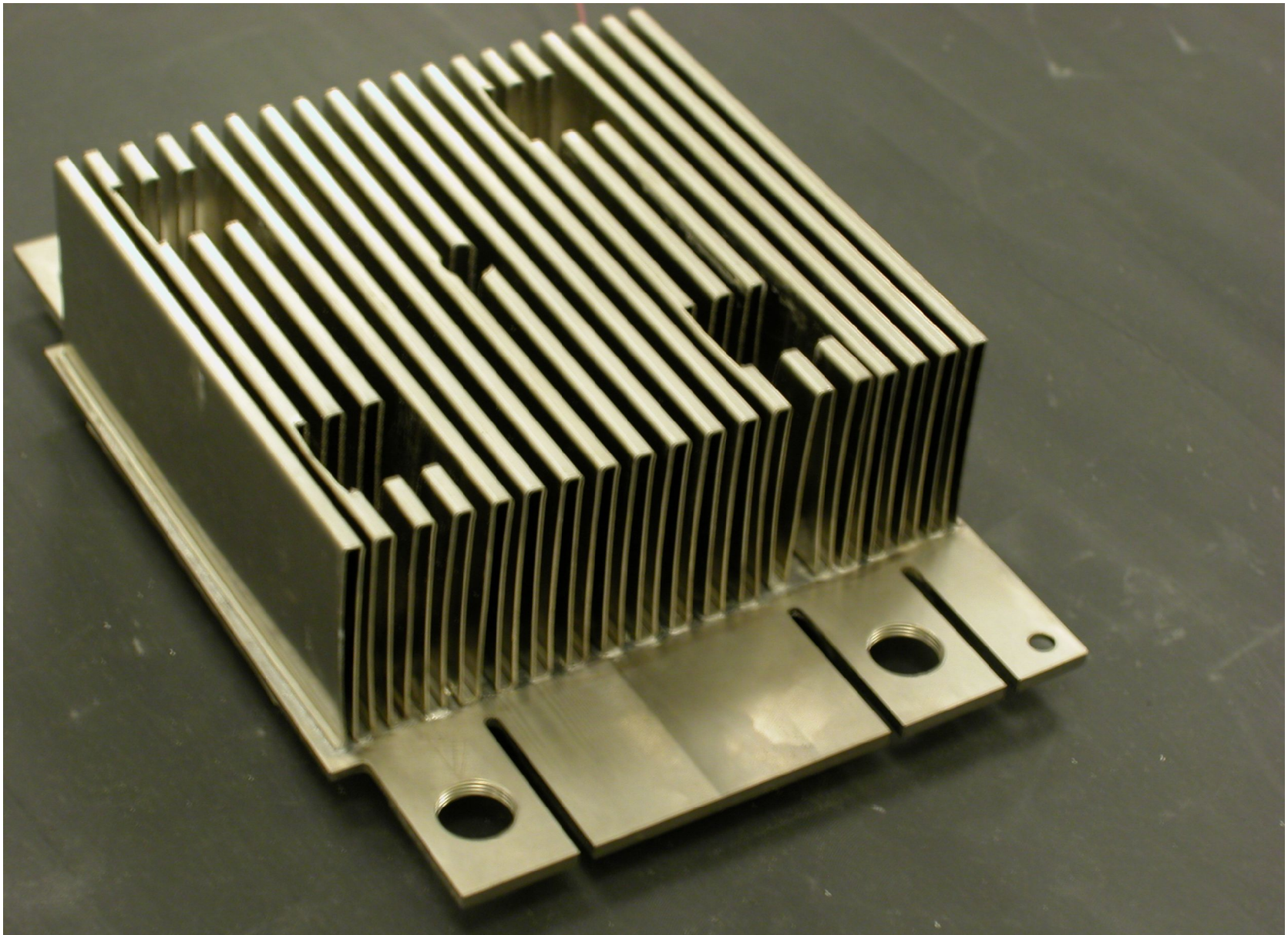
# Exploded View of Vapor Chamber



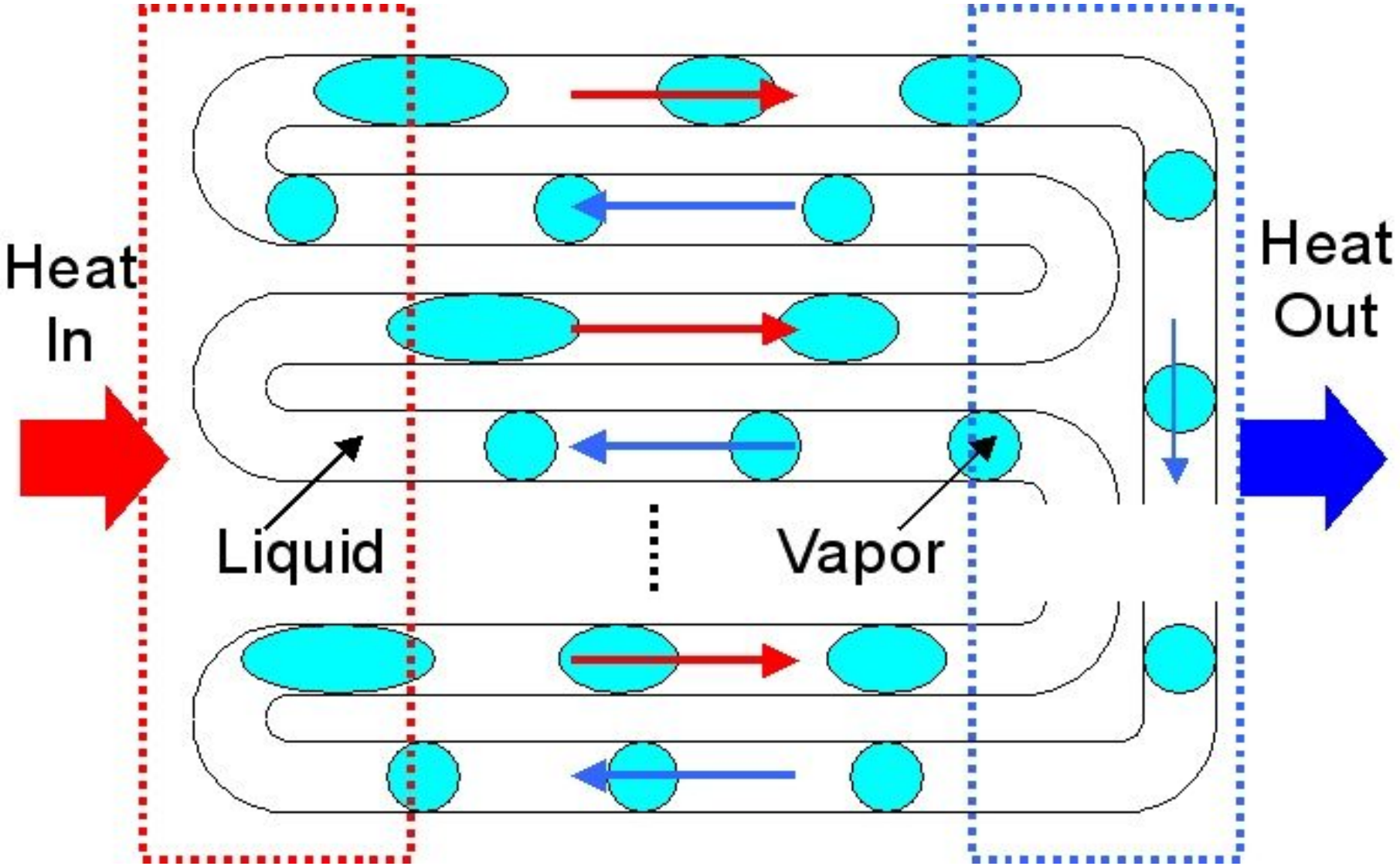
# Comparison of Vapor Chamber Base and Aluminum Base Thermal Profiles



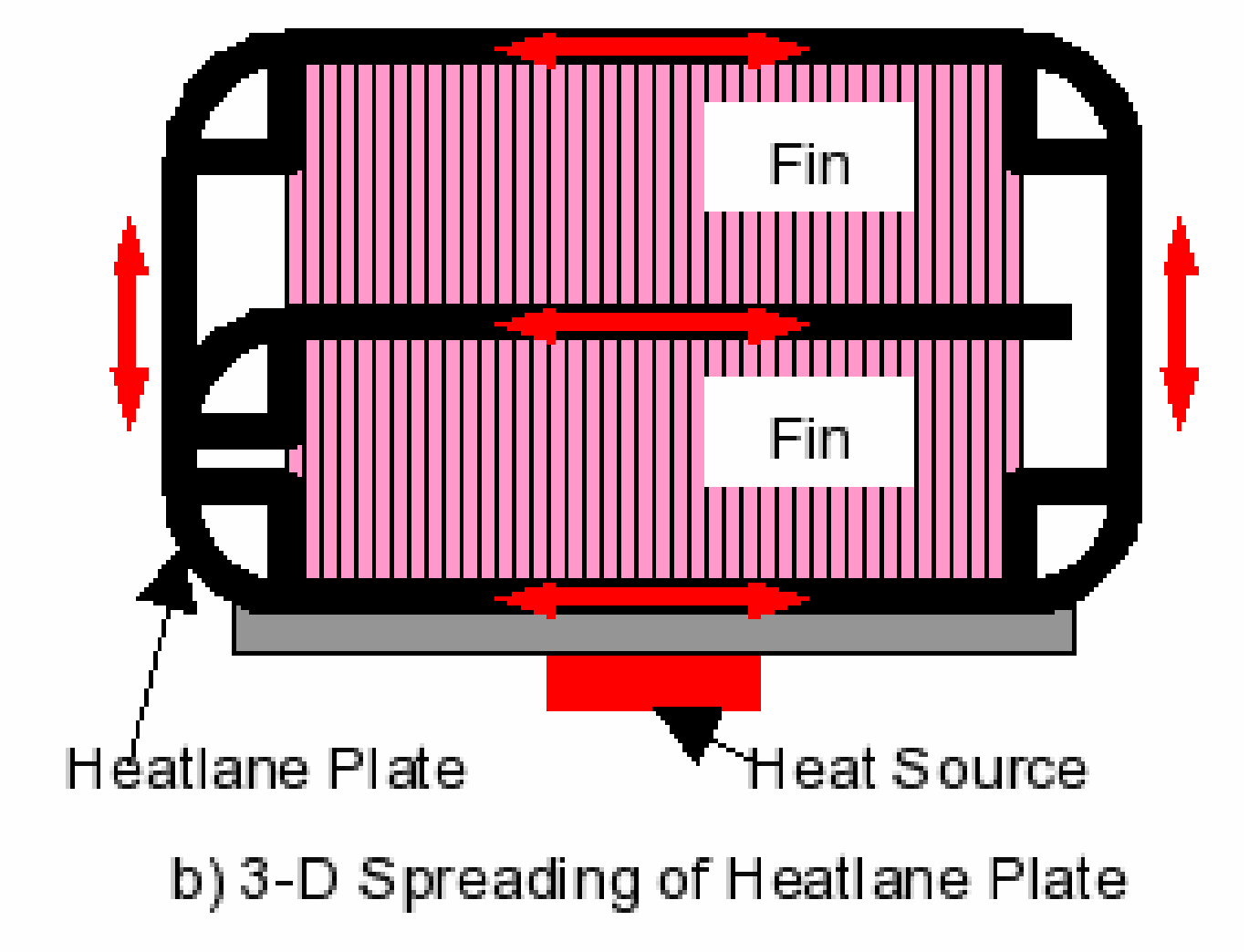
# Vapor Chamber Base Prototype - Thermacore



# Oscillating Heat Pipe Heat Sink

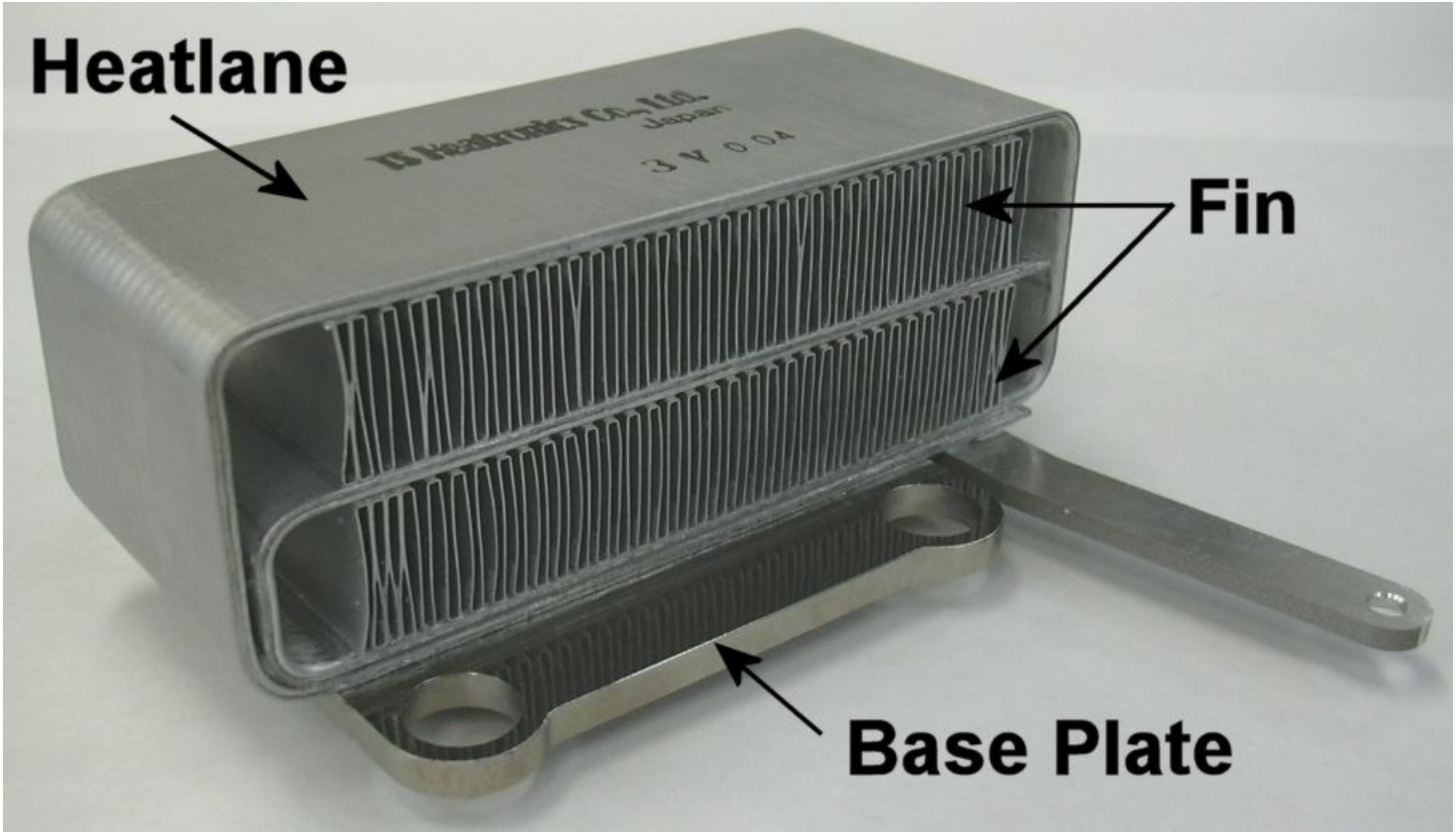


# 3-Dimensional Heat Spreading - Oscillating Heat Pipe

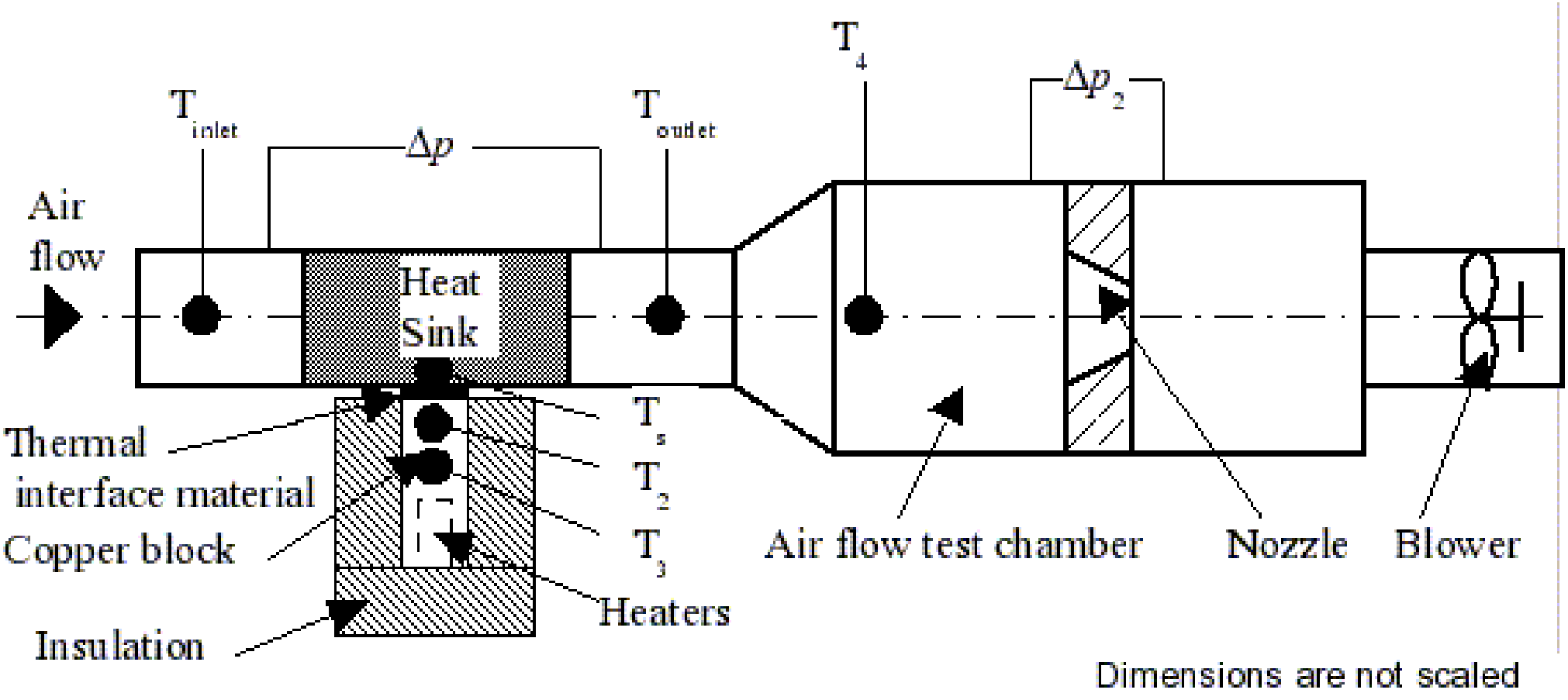



b) 3-D Spreading of Heatlane Plate

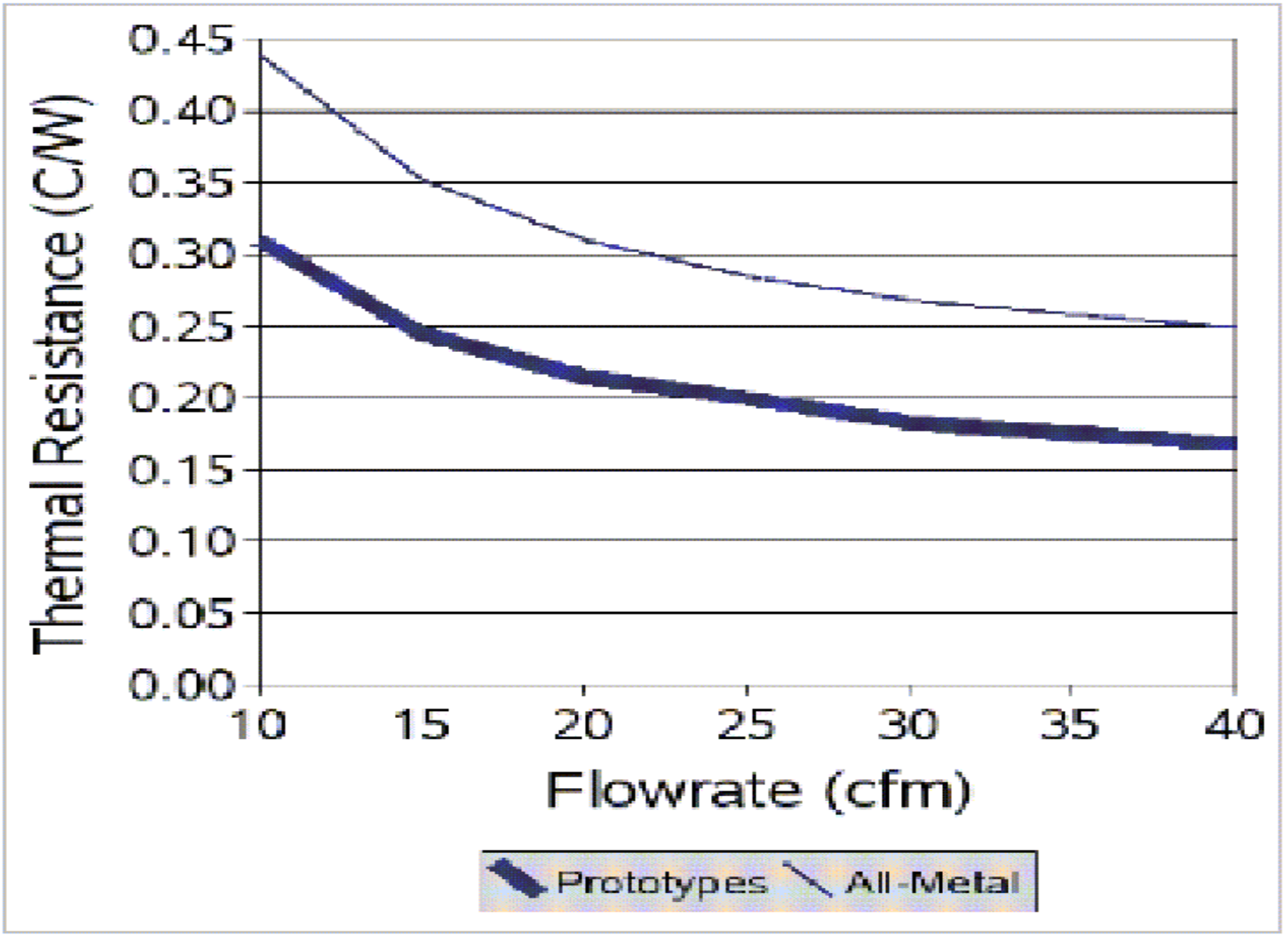
# Oscillating Heat Pipe Prototype - TS Heatronics



# Wind Tunnel


T inlet
Δp
T outlet
T 4
Δp 2
Air flow
Heat Sink
Thermal interface material
Copper block
Insulation
Heaters
T s
T 2
T 3
Air flow test chamber
Nozzle
Blower
Dimensions are not scaled

# Predicted & Measured Sink-Air Thermal Resistances



# Summary

- Heat Sink with Internal Fluid Phase change required to meet thermal specification (0.18 C/W)
- 15% reduction in CPU electrical performance if an optimized all-metal design was utilized
- Only 4 Suppliers were are able to meet the spec requirements (remaining suppliers also utilized “similar” fluid phase change approaches)
- CPU power levels are increasing, requiring increased fin area to meet coolable power requirements

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# Use of Fluid is Here to Stay!!