# Infrared Calibration Targets

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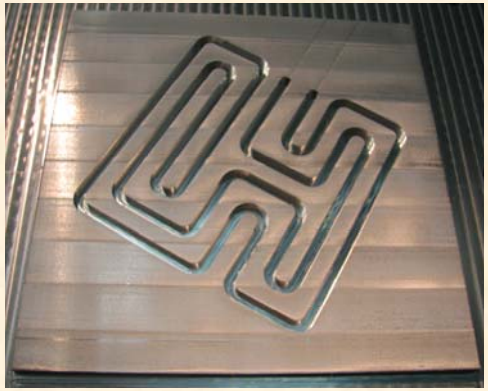
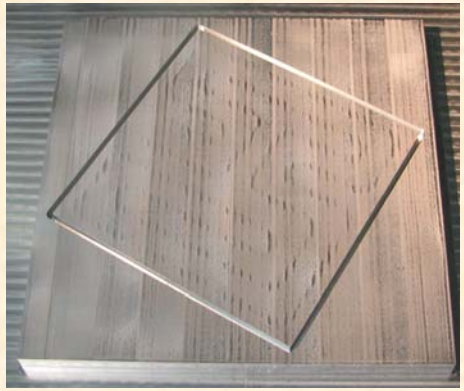
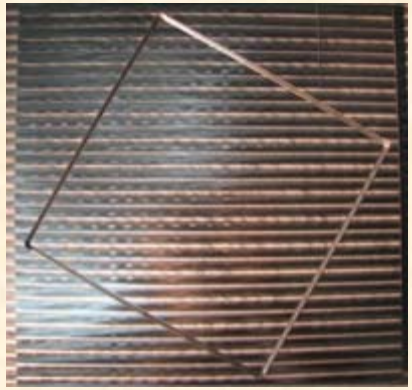
# Project Objectives

1. Create uniform-temperature thermal target for calibration of infrared devices
2. Investigate the use of ultrasonic consolidation as a fabrication method

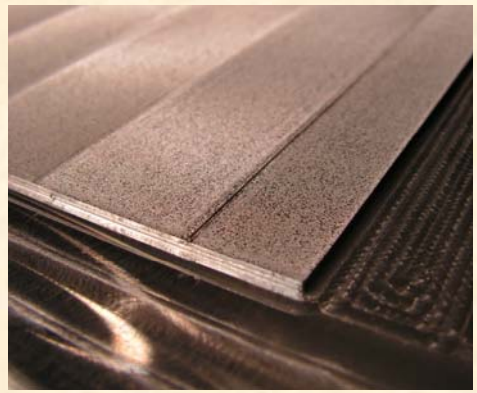


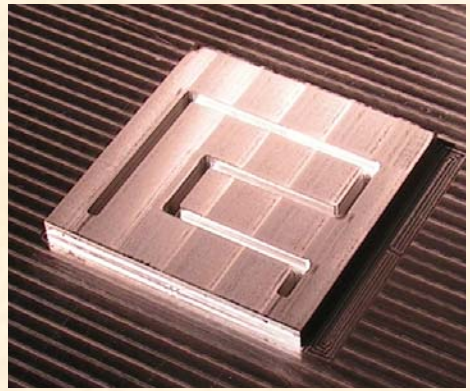




# Advantages of Ultrasonic Consolidation

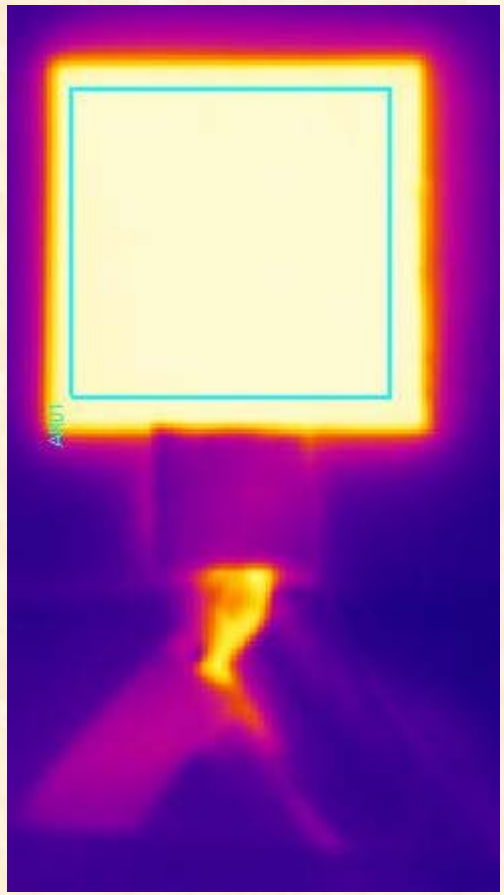
- Complex internal geometry
  - Sealed internal cavities and channels
  - Impossible to create using traditional machining methods
- Complex external geometry
  - Integrated 3-axis CNC milling head can create desired surface features
- Multi-material parts
  - Dissimilar metals can be welded
  - Strong bonds form between compatible materials



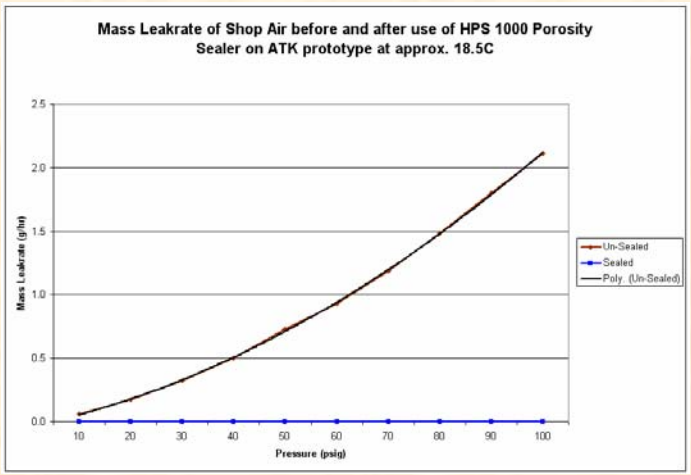


# Target Performance Parameters

- Operating Conditions for the Thermal Target
  - Plate operates in typical room conditions
    - Air temperature is 20 degrees Celsius
    - No strong air currents present
    - Standard atmospheric pressure and humidity
  - Coolant supply is at 65 degrees Celsius
    - Coolant is water or water/ethylene glycol mixture
- Desired Thermal Performance
  - 0.1 degree Celsius uniformity on the radiating surface
  - Come to thermal equilibrium quickly
    - Secondary concern to thermal uniformity
- Structural Integrity
  - Able to withstand pressures in a refrigeration system (500+ psi)
  - No fluid leakage from internal cavities



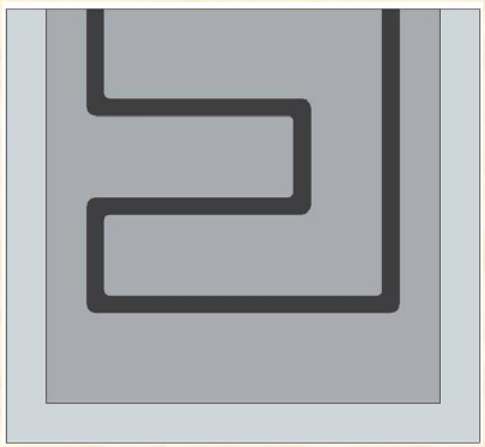
# Structural Information




- Structural Integrity
  - Current product is solid aluminum
    - Walls designed to withstand high load
    - Current parts have good structural integrity
      - Safety factor of over 3.0 at 1000 psi
  - UC Fabrication traits
    - Slight porosity of deposited aluminum
      - Allows leakage laterally from internal cavities
      - Commercial porosity sealant effectively seals parts
    - Reduced thermal conductivity in build height
      - Porosity slightly reduces thermal conductivity
      - Becomes a factor that must be tracked in designs
      - Can be used to improve part performance

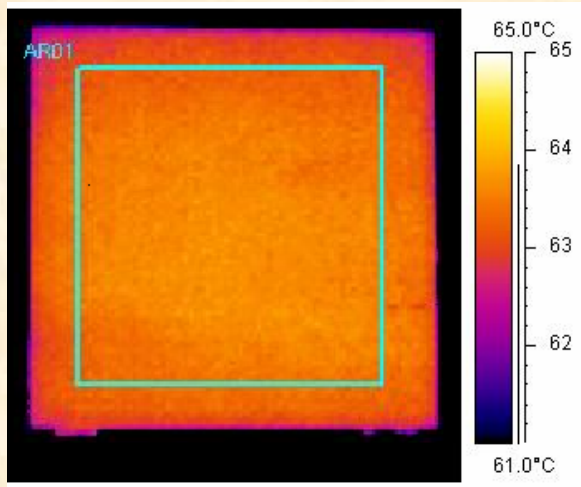
# First Generation Plate

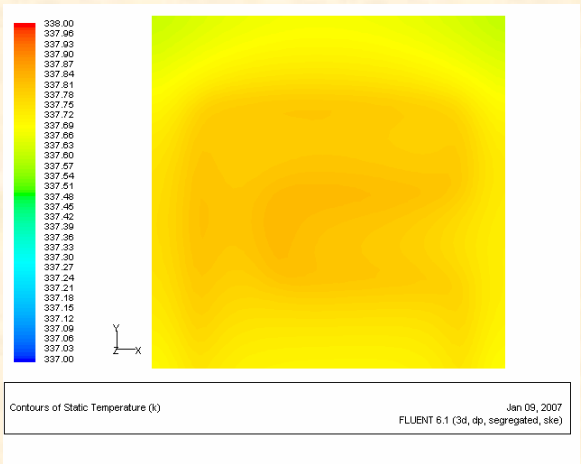
- Proof of concept part
  - Simple channel design
    - Could be gun drilled and plugged
  - Show capabilities of fabrication process
  - Provide a suitable test piece
- Part dimensions
  - Radiating Surface (black)
    - 5.0x5.0 inches
  - Base plate
    - 5.5x6.0 inches
  - Internal channel
    - 0.225x0.225 inches
  - Channel to surface thickness
    - 0.137 inches



# First Generation Plate

- Testing Results (infrared camera)
  - Average temperature – 63.5$^{o}$ C
  - Standard deviation – 0.3$^{o}$ C

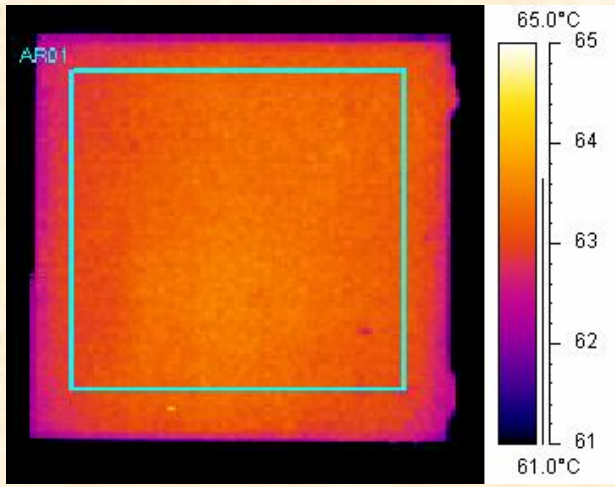



- Analytical Results (Fluent)
  - Average Temperature – 64.6$^{o}$ C
  - Variation - ± 0.2$^{o}$ C

# Multi-Material First Generation Plate

- Proof of concept part
  - Same design as original part
  - Prove multi-material capability
    - 0.006 inch thick layer of copper added
  - Create suitable test piece
- Results
  - Thermal uniformity of radiating surface improved by 9%

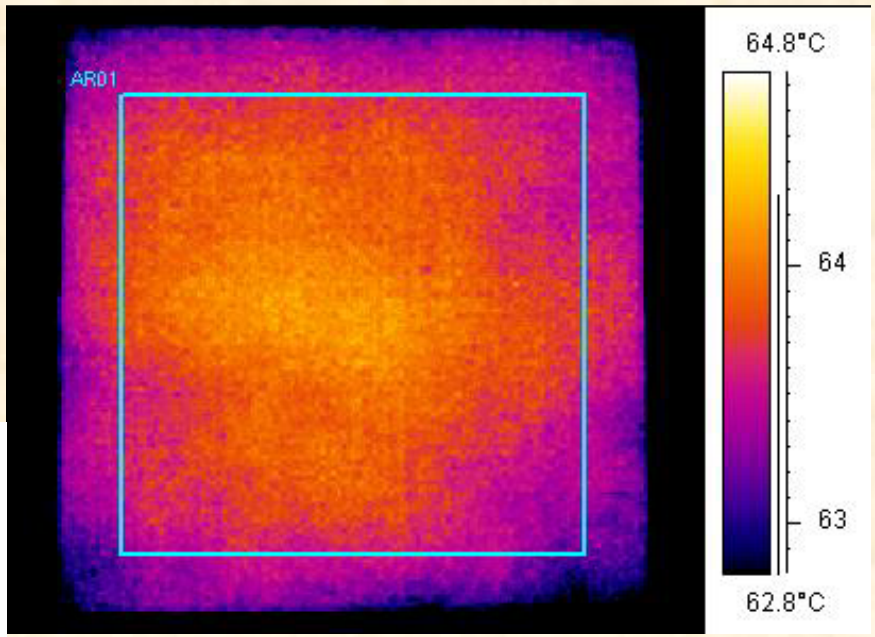


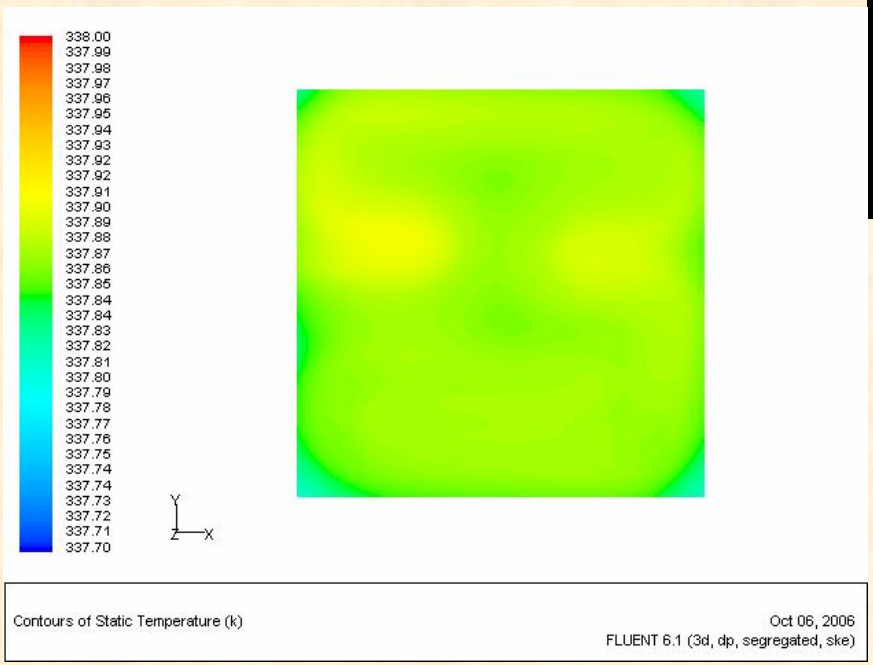
# Second Generation Plate

- Improve part functionality
  - Increased target surface area
  - Improved surface temperature characteristics
  - Equivalent or better structural integrity
  - Multiple design iterations analyzed
    - Design with best thermal uniformity selected
- Dimensions
  - Surface ~6x6 inches (155x155 mm)
  - Channels ~0.25x0.25 inches (6x6 mm)
  - Channel to surface height ~0.4 inches (10 mm)

# Second Generation Plate

- Experimental Results
  - Average Temperature – 63.8$^{o}$ C
  - Standard Deviation – 0.2$^{o}$ C

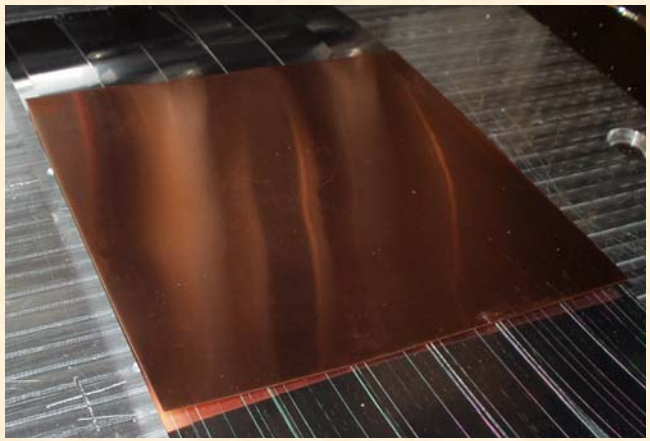



- Analytical Results
  - Average Temperature – 64.5$^{o}$ C
  - Variation – ± 0.05$^{o}$ C

# Future Work

- Additional Thermal Measurement Techniques
  - Additional method to measure surface temperature
  - Confirm measurements
  - Improve analytical model
- Multi-material Part Parameters
  - Layer thickness
  - Layer location
  - Layer material



# Future Work

- Surface Geometry and Size
  - Half cylinder
    - Add curvature in one dimension
    - Increased fabrication complexity
  - Hemisphere
    - Add curvature in two dimensions
    - High fabrication complexity