

## Advanced Benchtop Mini Cooler Development for Laboratory Applications

ESi guided a laboratory equipment manufacturer through a comprehensive product development program to create next-generation laboratory mini coolers with superior thermal performance and market-ready design.

### The Situation

Our client, a leading laboratory equipment manufacturer specializing in cryogenic storage solutions for chemistry and biochemistry laboratories, needed to develop next-generation mini cooler products for maintaining laboratory cultures and specimens at precise low temperatures. The existing product line required comprehensive analysis and optimization to understand the underlying thermal mechanisms and improve performance. ESi was engaged to conduct a systematic 5-phase product development program starting with reverse engineering the existing gel-based thermal storage system, evaluating alternative phase change materials (PCMs), and ultimately developing prototype products.

### Our Approach

ESi implemented a systematic development methodology combining advanced materials characterization, market analysis, and performance testing. The project aimed to create temperature-specific variants optimized for laboratory applications requiring precise thermal control at 0°C and -20°C operating points.

#### ESi Consultants:



Gaurav Nagalia  
Senior Consultant



Dale Mann  
Senior Managing Consultant



Paul Josten  
Senior Technologist

Sebastian Chialvo  
No longer Employed

#### Services Utilized:

- Lab & Inspection Services
- Materials Testing
- Product Design & Analysis

## Our Approach *cont.*

**Phase I** involved comprehensive reverse engineering of existing product PCMs using Fourier-Transform Infrared (FTIR) spectroscopy, Differential Scanning Calorimetry (DSC) analysis, Thermogravimetric Analysis (TGA) testing, and optical microscopy to understand the two-phase system comprising polystyrene spheres dispersed in water-starch gel matrices.

**Phase II** expanded this analysis through detailed compositional studies, determining that one of the mini cooler products contained 80-89% water content, and the other variants had 72-79% water content, with different starch types and polystyrene bead concentrations affecting thermal performance.

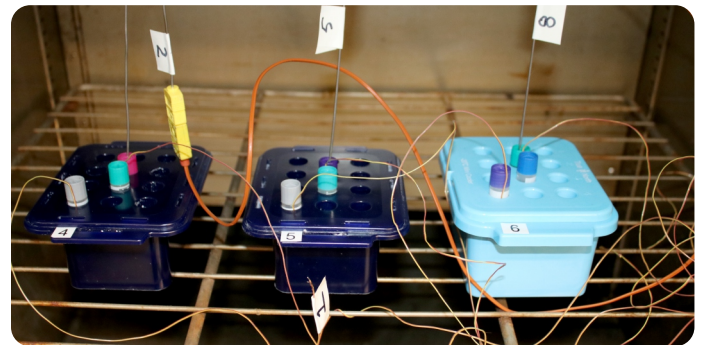
**Phase III** conducted an extensive market survey of phase change material suppliers, evaluating five major manufacturers across over 200 different PCM formulations. This comprehensive analysis identified optimal candidates with latent heat values ranging from 169-395 J/g and transition temperatures suitable for laboratory applications from -21°C to +18°C.

**Phase IV** evaluated selected candidate PCMs through FTIR analysis and extensive thermal cycling, identifying a water-ammonium chloride eutectic solution and a methyl laurate, both showing superior performance characteristics compared to existing formulations.

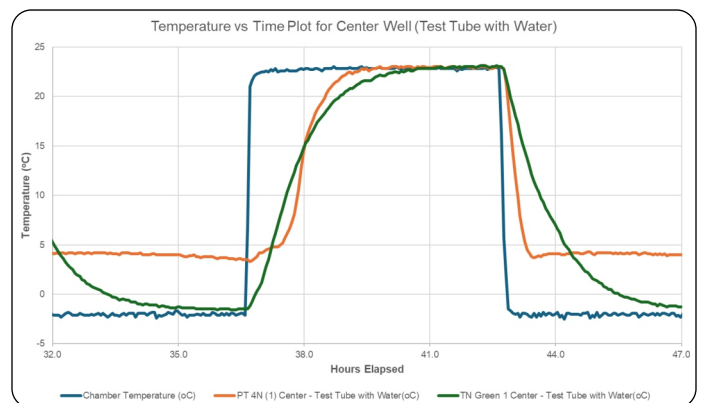
**Phase V** involved comprehensive prototype testing of new housing designs with the identified and optimized PCM formulations. Testing was performed utilizing thermocouple arrays to measure temperature profiles across center and corner wells under controlled environmental cycling between room temperature and target operating conditions. Data analysis revealed that prototypes achieved significantly faster cooling response and superior temperature stability compared to existing mini cooler product lines.

## The Outcome

The development program successfully delivered two market-ready mini cooler variants with demonstrably superior performance characteristics. The high-temperature prototypes clearly outperformed existing mini cooler products with faster cooling response, superior temperature stability, and better thermal buffering capabilities. Testing confirmed consistent performance between duplicate samples, validating reliable manufacturing processes. Comprehensive material characterization and performance data provided our client with the technical foundation needed for commercial production and regulatory submissions, positioning them to launch a competitive product line that addressed existing market limitations while offering enhanced user experience for laboratory professionals.



*Prototype Mini cooler Thermal Performance Testing in the Environmental Chamber at ESI-Seattle*



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