Dimensions .07 Conference

Meeting the Challenges of Thermal Packaging

Designing a Cold Chain Package Doesn't Have to Take an Ice Age

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Outline

- Look at the Environment
- Three Prong Approach
- Package Design

Types of Thermal Packaging

- Active
  - Requires refrigeration system
  - Heat Pump
- Passive
  - Frozen (Dry Ice)
  - Refrigerated (2-8ºC)

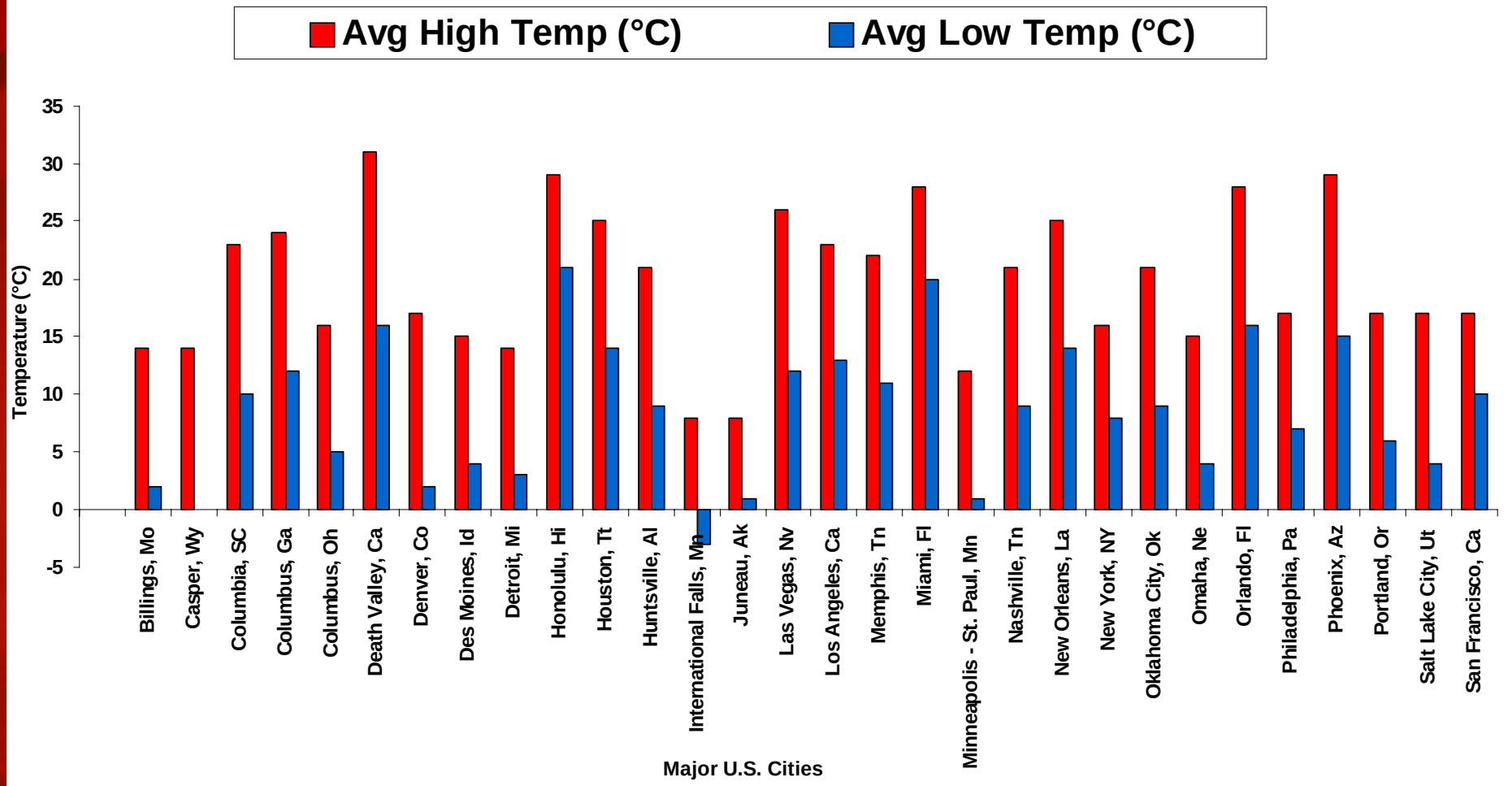
The Challenge

- Narrow Temperature Range
- Thermal Characteristics of Product
- Insulated Material Properties
- Dynamic Distribution Environment

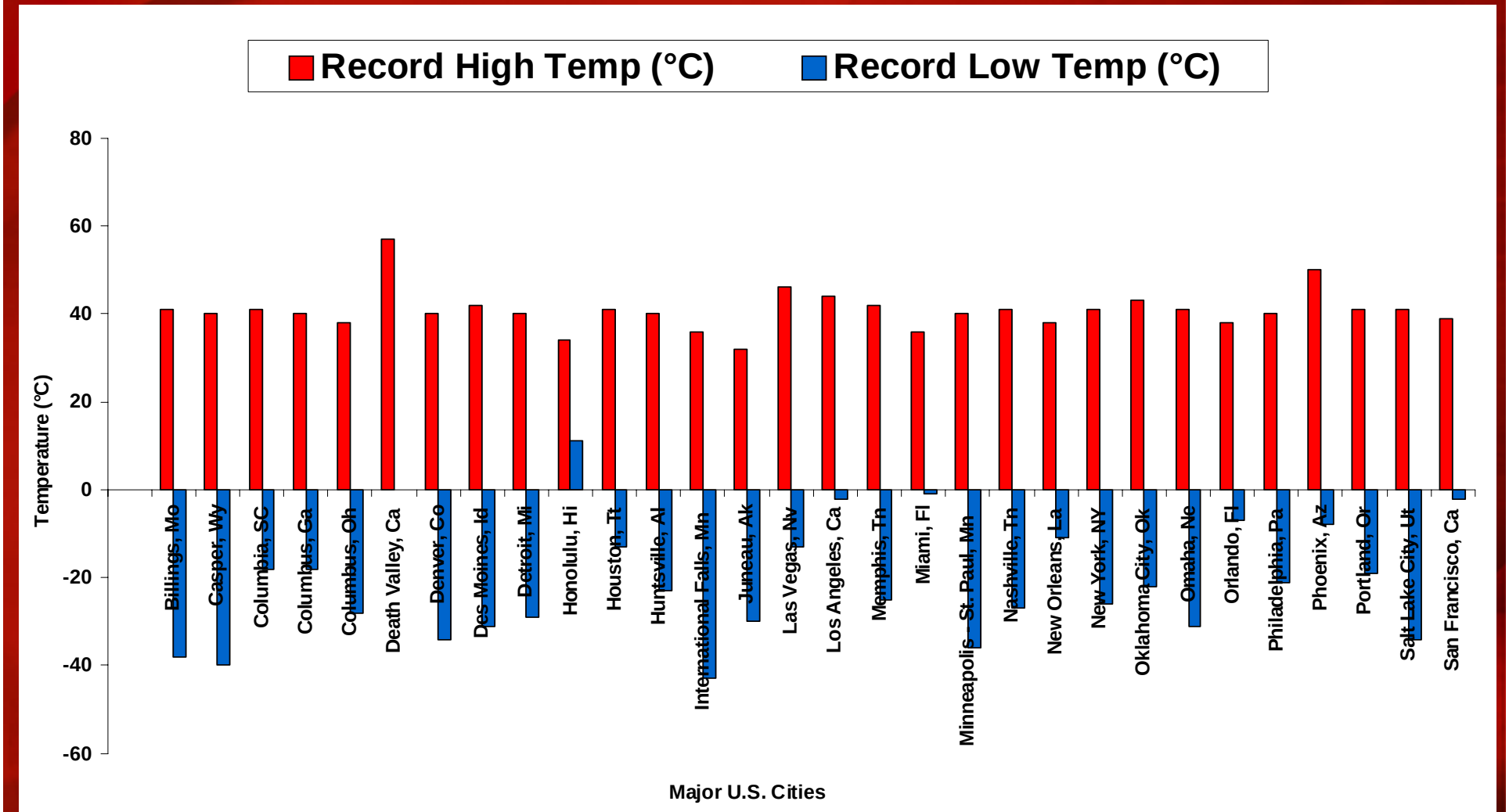
Measure the environment

- What temperature range do I design for?
- Measure the Environment
- What can we predict
  - How Long?
  - Overnight Air worst case 72 hours?
  - Distribution Center


Average Temperatures in the United States



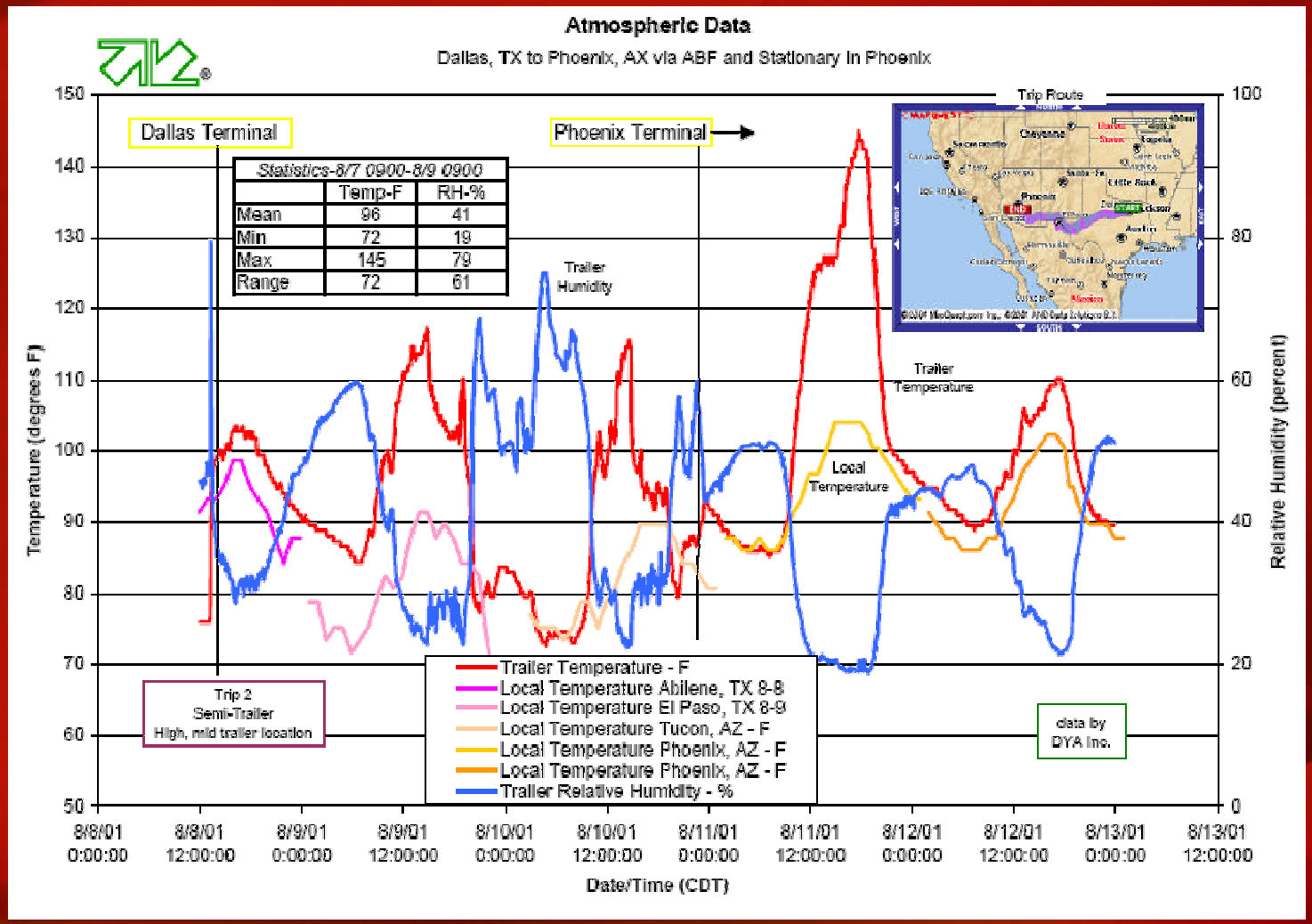
Record Temperatures in the United States



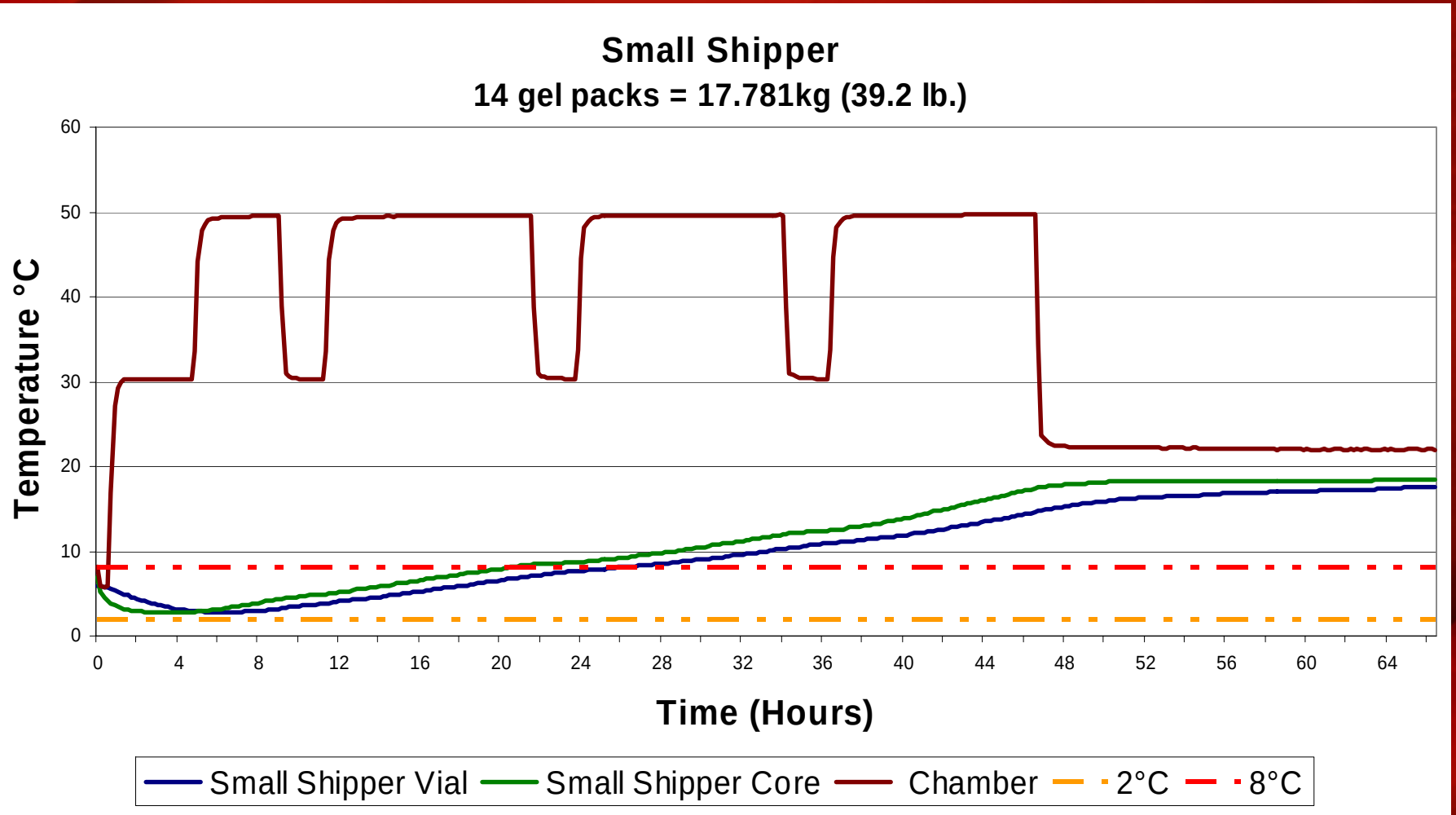
Measure the Environment

- If we measure the environment
  - We can develop our own protocol
  - Statistical significance
  - Time intensive
  - Expensive
- What about other studies
  - Literature Search
  - Data published by Standards Organizations

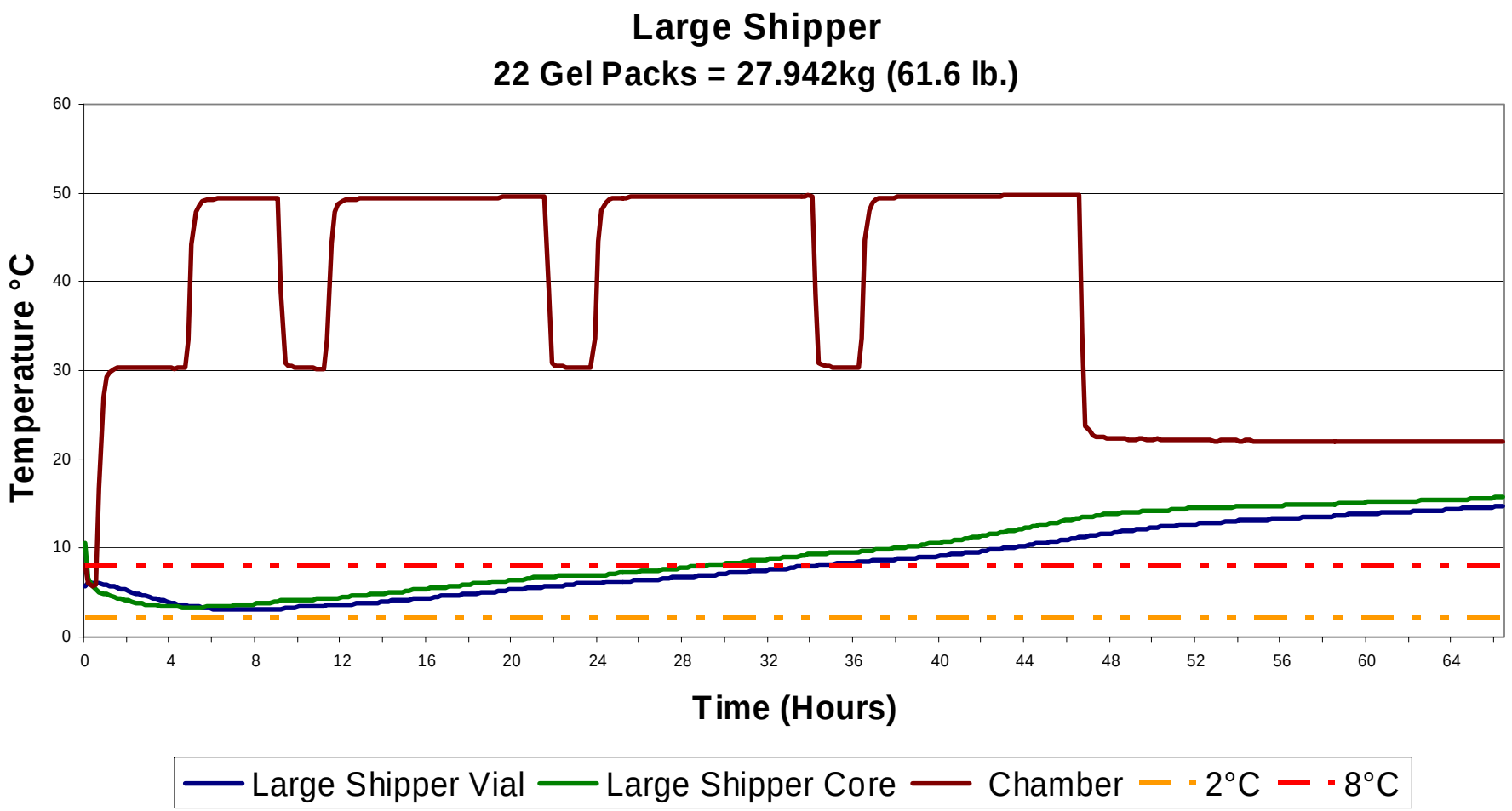
Atmospheric Conditions:
Example Temperature Study



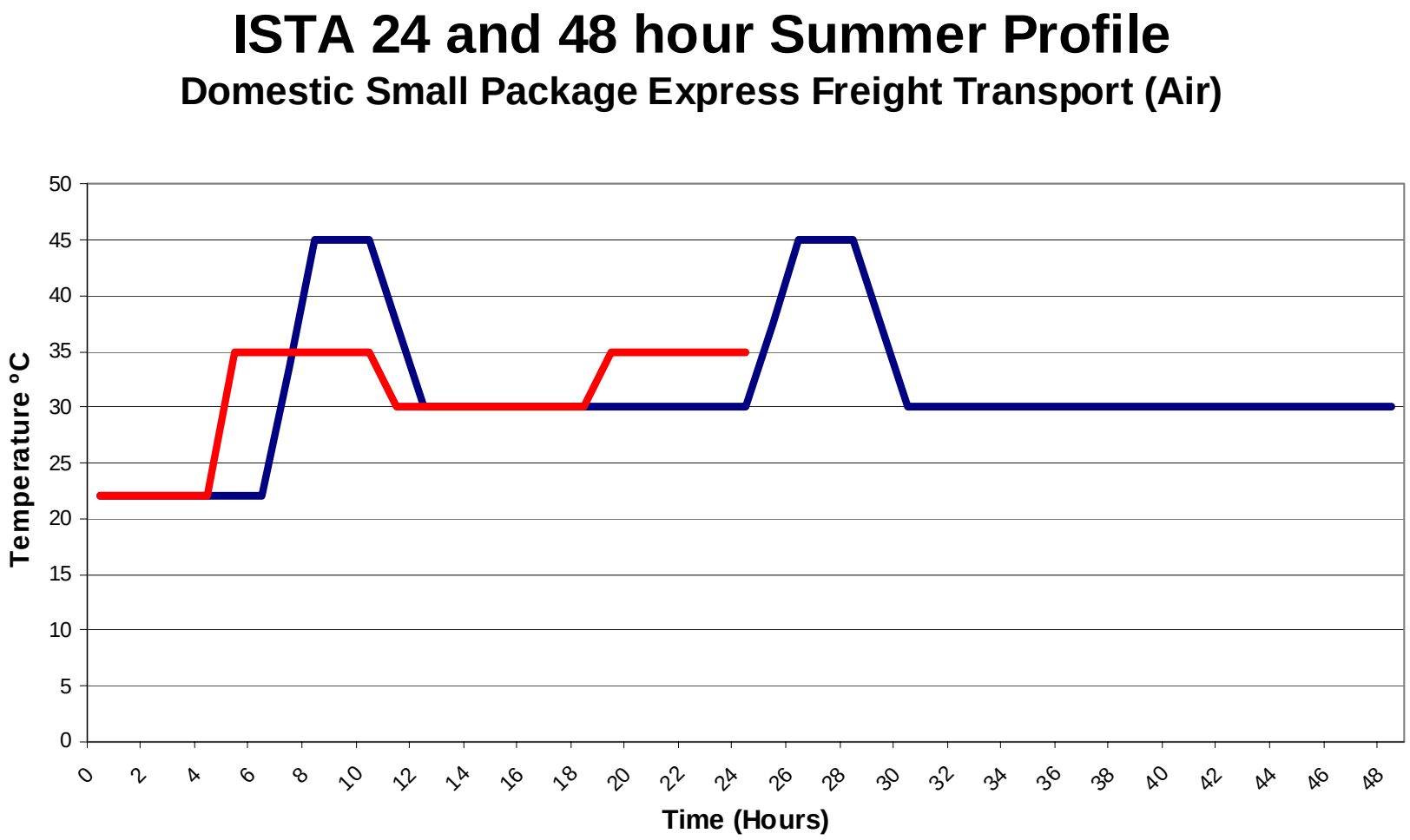
Unmodified ISTA 5B Profile



Unmodified ISTA 5B Profile



Standards Organization



Theoretical Summer Profile

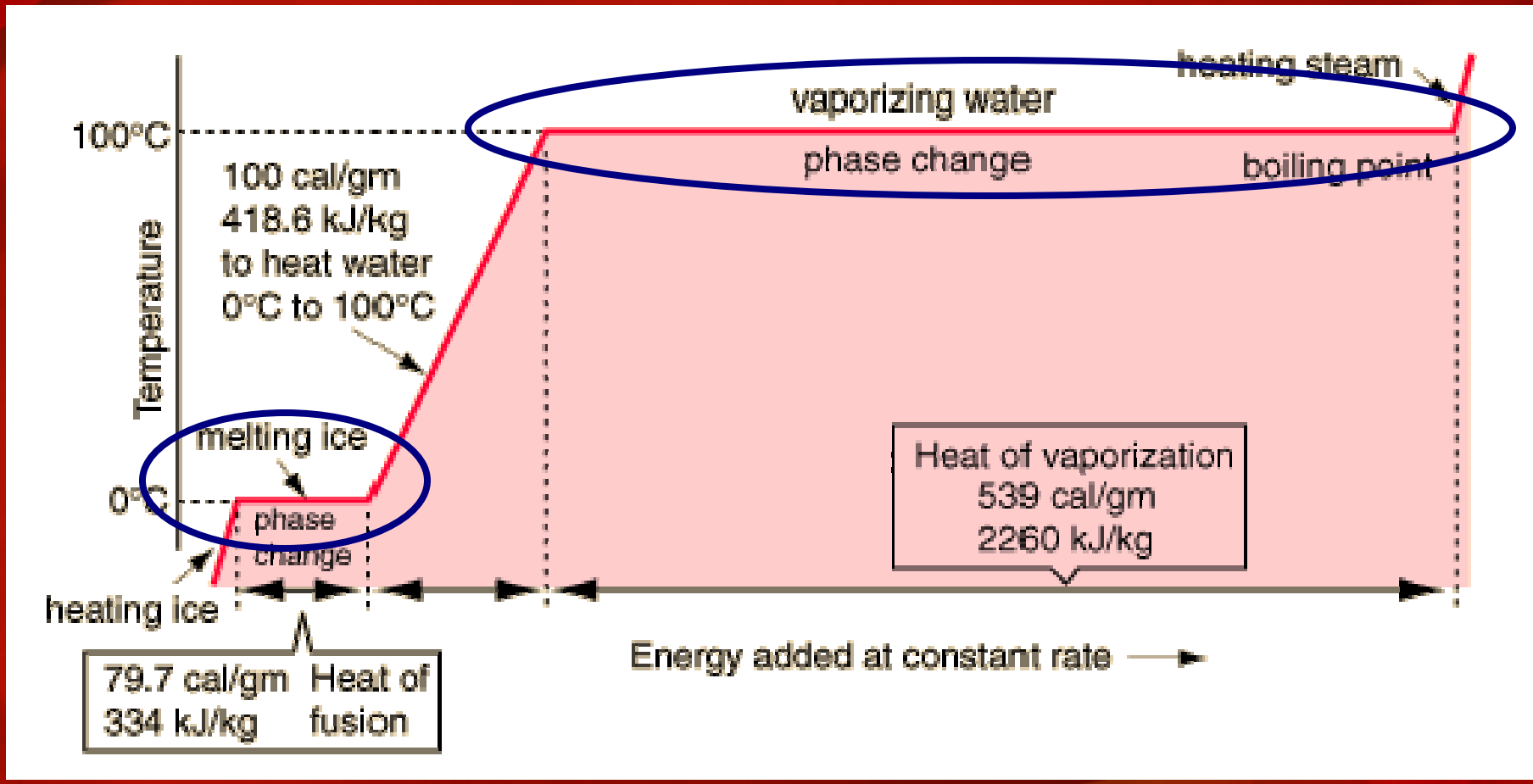
Formula for Package Design

- Heat Transfer
- Thermal Mass
- Phase Change

Water and Phase Change

- Solid (Ice)
  - Heat of Fusion 334 kJ/kg
- Liquid (Water)
  - Heat of Vaporization 2257 kJ/kg

Why is Phase Change Important?



Phase Change Materials

- Advantages
  - Energy Absorption
  - Change between solid and liquid
  - Water based materials 0C
- Disadvantages
  - Can be expensive and sometimes toxic
  - Many packages can meet requirements without these materials
  - Difficult direct contact with product

Gel Packs

Phase Change Refrigerant
-1ºC (+30ºF)

Gel Pack
0ºC (+32ºF)

Insulation

- Performance dependent on:
  - Material properties
    - Conductivity
    - Surface properties (for radiation)
  - Thickness
  - Quality of Construction

Insulated Container Types

- Expanded Polystyrene
- Rigid Polyurethane Panels
- Lined Rigid Polyurethane

Package Design Made Simple

- A lot of insulation
- Lots of Thermal Mass
- Phase Change Material

Package Design Made Simple

- Consequences of poor design
  - A very small payload
  - A very large package
  - That is difficult to move

Package Design Considerations

- Damage Criteria
- Acceptable Temperature Range
- Materials
- Refrigerant Type
- Thermal Mass of product
- Distribution Cycle
- Testing

Package Design Considerations

- Coolant Placement
  - Adjacent to Product
  - Restrain movement
  - Select largest size possible
  - Create a conditioned “core”

Evaluating the Package

- Thermal Performance Evaluation
  - Sensitivity of sensors
  - Locations of sensors
  - Duration of collection
- What about Package Performance
  - What does my package look like after distribution cycle?

Evaluate this Package

- Rigid Polyurethane container
- Flexible Polyurethane Foam Cushion top

Evaluate this Package

- Both are open cell materials
- Container is sealed with a solid poly material
- Top cushion is not

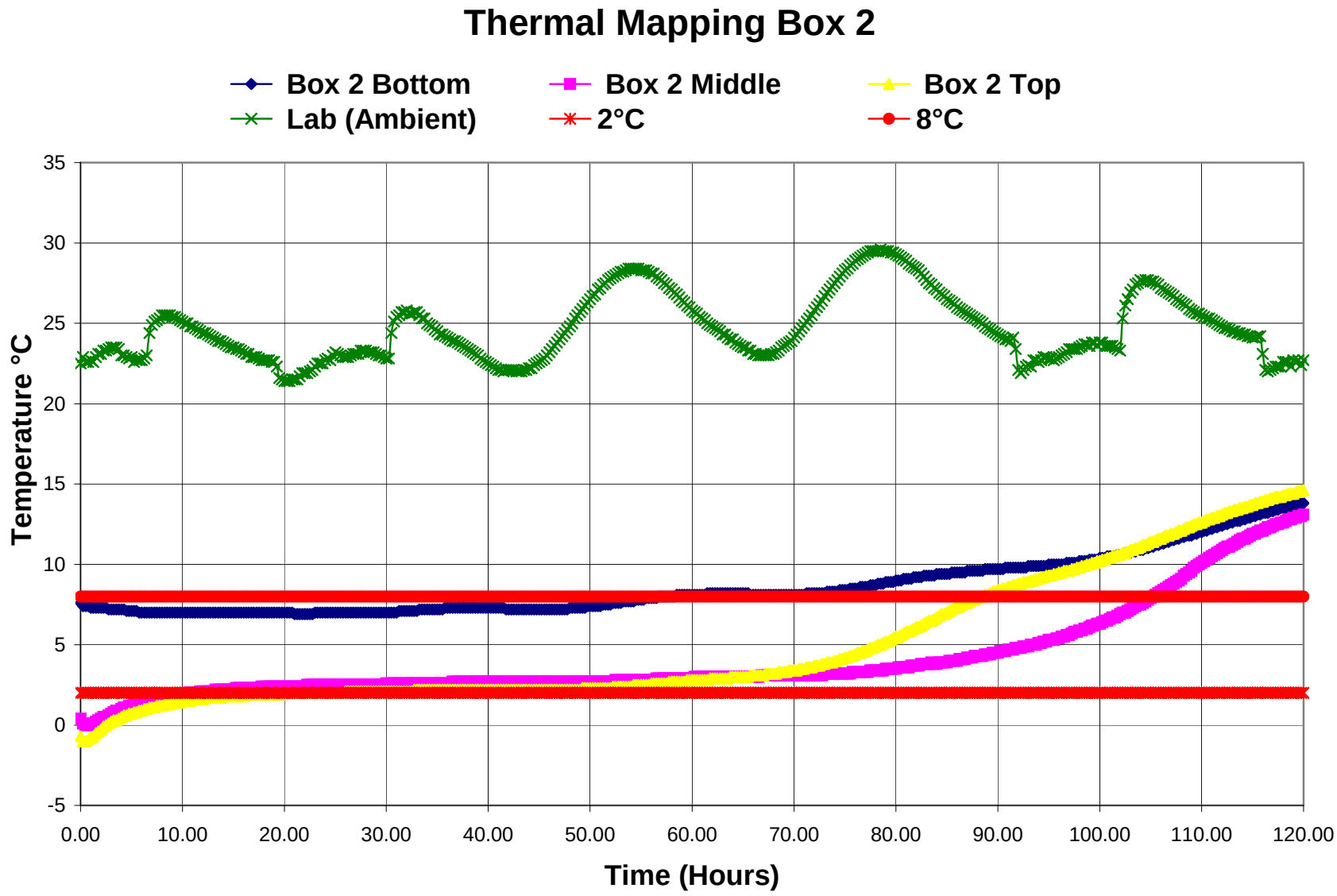
Evaluate this Package

- Gel Packs loose in top of container
- PU Foam Cushion

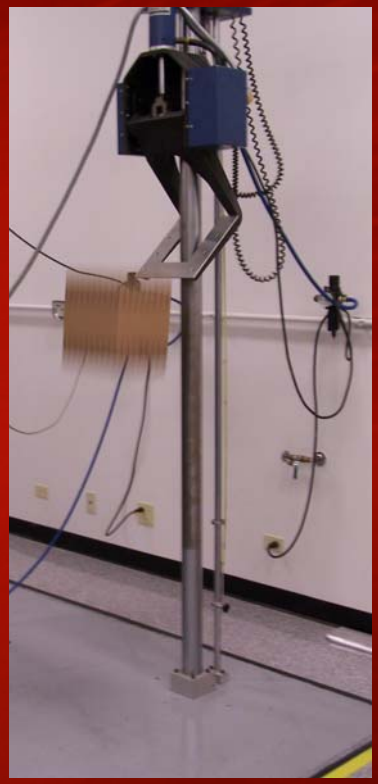
Evaluate this Package

- No thermal mass on the bottom of the container
- Leads to a non-uniform thermal condition

Evaluate this Package



Package Performance



- Vibration
  - Random
- Compression
- Shock
  - Drop, impact
- Atmospheric
- Standard performance testing protocols

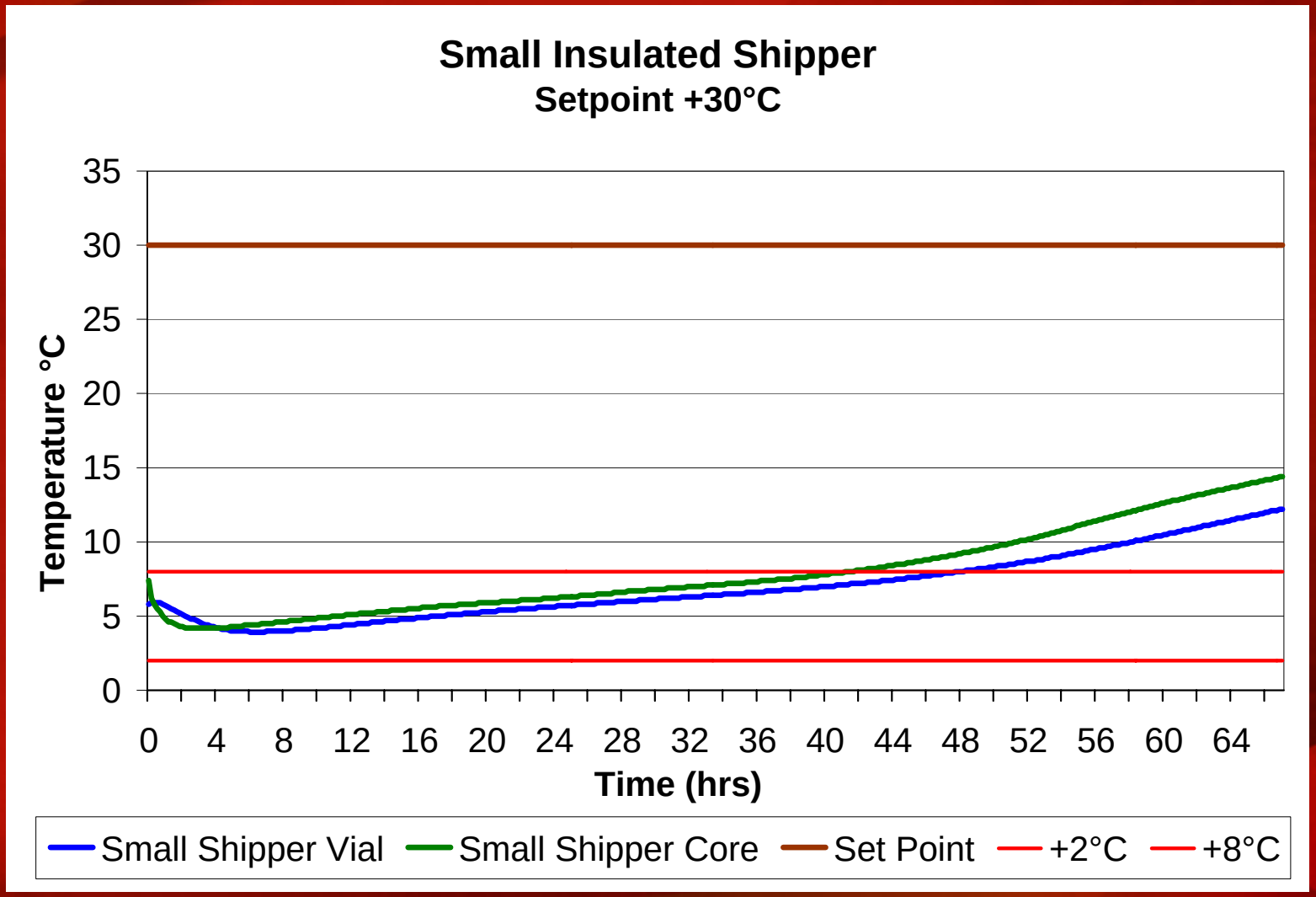
Good Package Design

- **More insulation the better, right?**
  - Insulation costs money, results in higher BOM costs
  - Large Packages are a problem
    - Hard to carry & Difficult to store
    - Increased surface area hurts performance
    - Costly to ship
  - Customer must deal with disposal

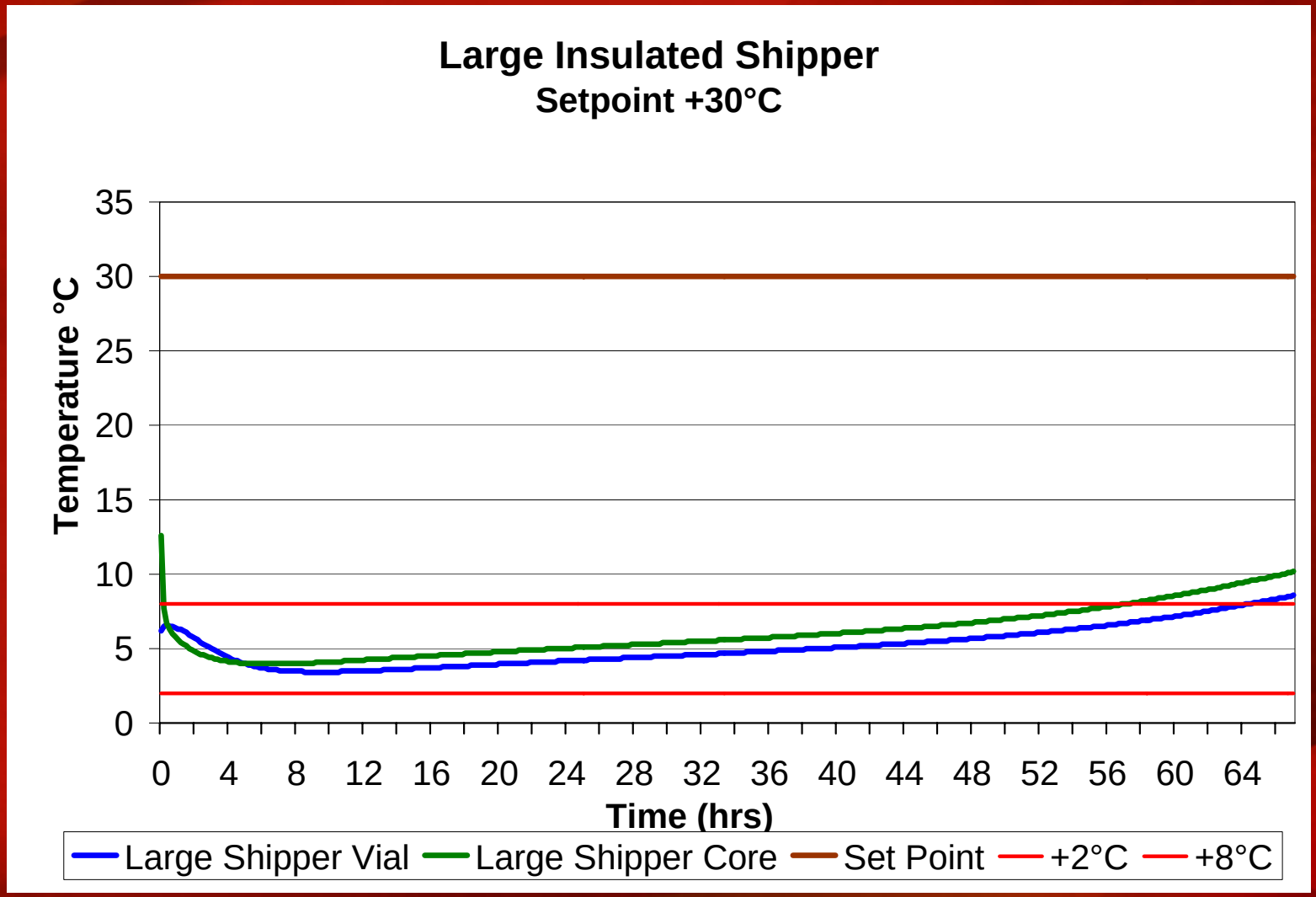
Good Package Design

- **Large Thermal Mass**
  - Lots of gel packs plus payload
  - Shipping Mostly Water (60lbs/ft^3 !)
  - Supplemental items like gel packs, bricks, etc can be expensive
  - These items must be stored at temperature prior to pack out

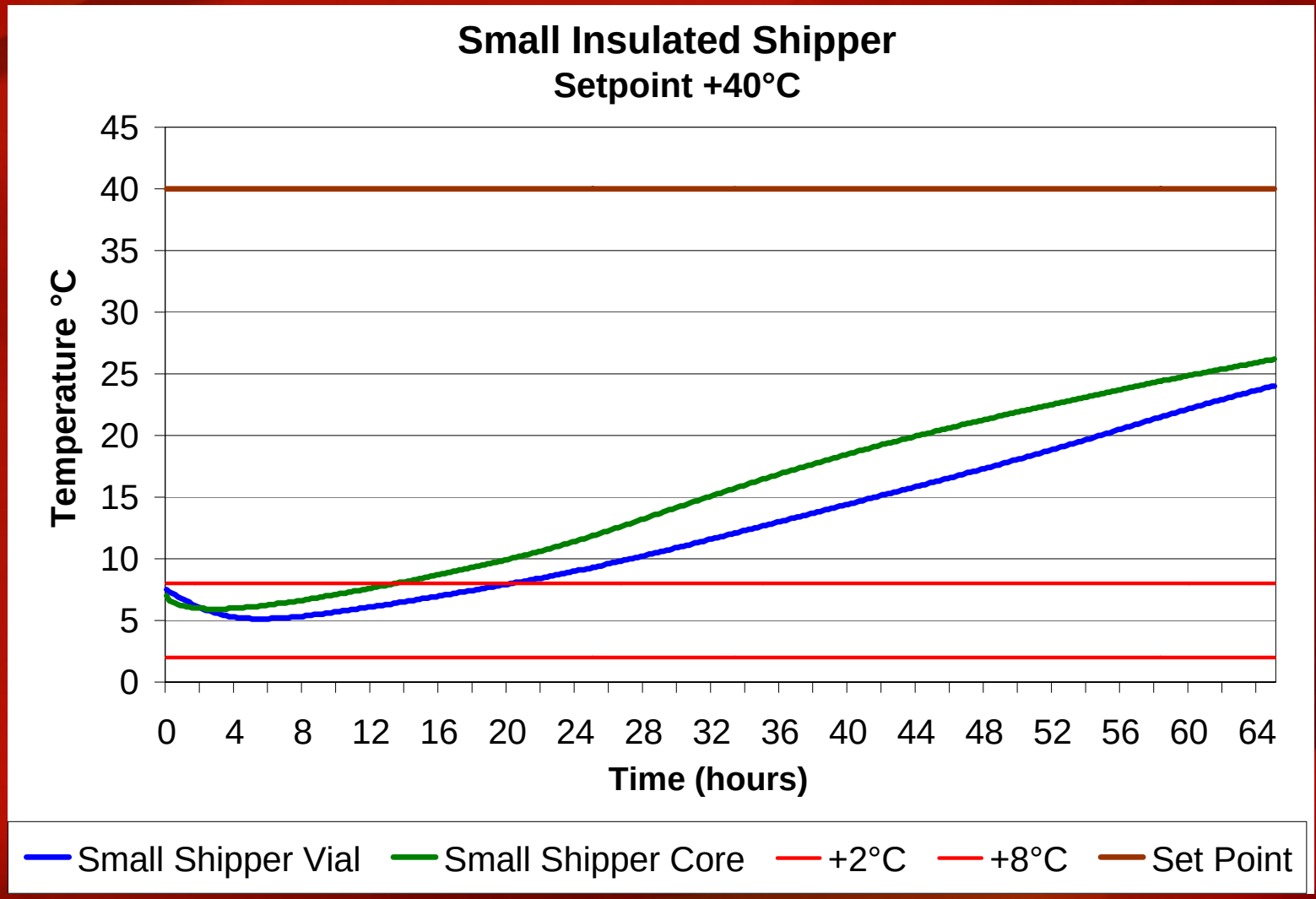
Thermal Performance



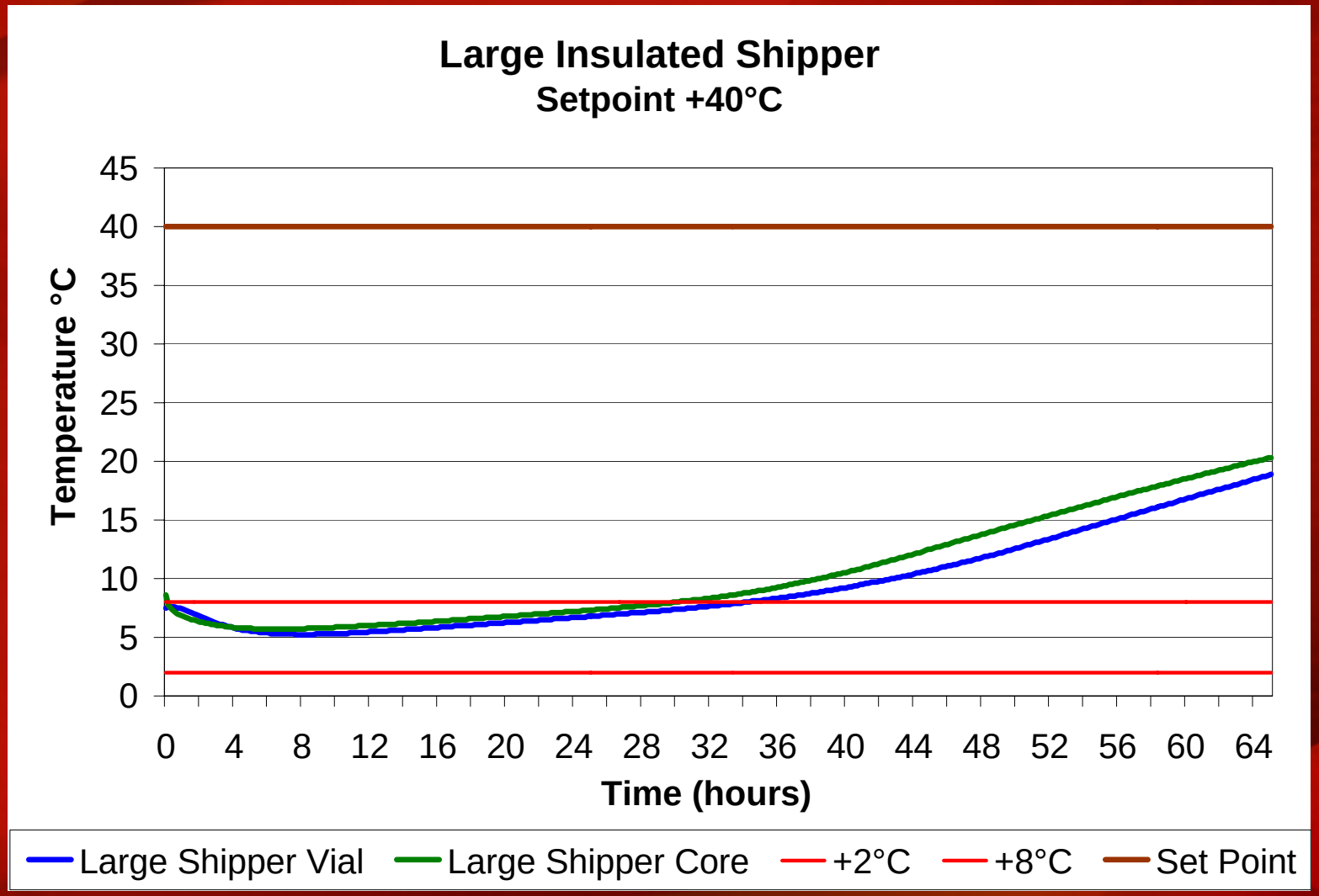
Thermal Performance



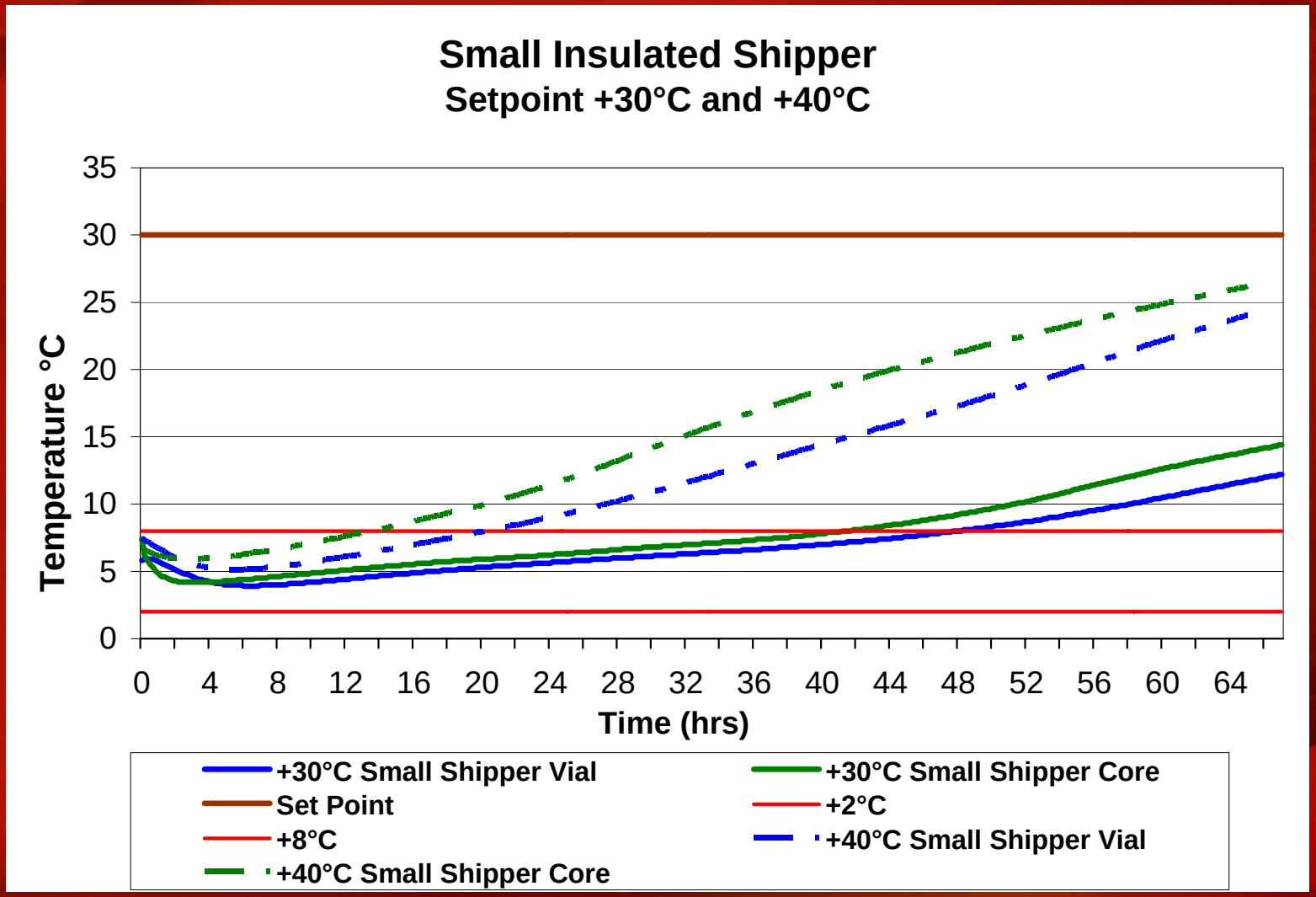
Thermal Performance



Thermal Performance



Thermal Performance



Closing Thoughts

- Know your environment
- Determine the Thermal Mass requirements
- Design a tight internal package
- Evaluate the Pack using a data logger
- Make adjustments

Closing Thoughts

- Take time to understand the fundamentals of heat transfer
  - Explore Other Configuration Options
  - Get more control over
    - Operations costs
    - Quality
    - Suppliers

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- Thank you
- Questions?