Enhancing Vacuum Insulation Value for End Use Applications

Design – The Path to Vacuum Insulation Value

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1999 Design Experience

- Over the past year we have been involved in many product designs incorporating vacuum insulation
- Our experience involves
  - VIP manufacture
  - Product design
  - Product test

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Types of Products

- Refrigerators/freezers
- Merchandisers
- Shipping containers
- Generic information will be presented to protect our customer's confidentiality

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Typical Customer Request

- "Just substitute vacuum insulation into my product"
- Customer views it as quick & dirty but will give an idea of the benefit
- Usually does NOT provide an estimate of potential benefit
- You can not change the performance of the insulation by a factor of 4 to 7 without changing the design

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VIP Substitution Analogy

- You can not substitute a large powerful V8 engine into a small inexpensive car previously powered by a small 4 cylinder engine and see even half the potential benefit

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Shipping Containers

- Heat gain will be drastically reduced using VIP
  - Consequently less coolant is required
- Entire container should be down sized
  - This provides more benefit
    - Smaller size
    - Less weight
    - Reduced surface area which further reduces the heat flow into the container

Shipping Containers Cont.

- The greatly reduced heat flow can result in changes in the temperature the payload sees
  - Frozen coolant that is used to maintain payload at refrigerated temperature may need to be redesigned to keep the payload from freezing
- VIP shipping containers should be designed from the payload out

Container Design Information

- Payload
  - Dimensions
  - Weight
  - Material
  - Heat capacity
  - Allowable temperature range
  - Required total thermal protection time
  - Other criteria such as orientation, access, etc

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Container Design Information Cont.

- External temperature including transient excursions
- Coolant
  - Type
  - Amount
    - 5 pound limit on dry ice?
  - Any constraints on coolant location
- Method of transport
- Cost objectives
  - Container, freight, and total

Container Design

- Rapid transient computer analysis can be used to:
  - Iterate on the design
  - Optimized container dimensions, insulation wall thickness, amount of coolant
  - Prediction of payload temperature and coolant exhaustion versus time
  - Determines the theoretical potential performance

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Container Design Cont.

- Construct prototype containers
- Conduct testing of prototype containers
- It is extremely important to know the theoretical potential performance
  - Compare to test results
  - It lets us know when we have reached optimum performance and stop working on the design
  - If test results and predicted performance disagree, there is something we don't understand
    - Time to dig in and figure it out

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Container Design Cont.

- Internal container temperature control
  - VIP control heat flow through the container walls and can effect but not control the internal temperature
  - Internal container temperature can vary greatly from top to bottom and even side to side
  - Both internal insulations and conductors may be required to obtain the desired temperature at the specified location

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Container Design Example

- Original container
  - 22.5 x 19.25 x 19.5
  - 1.5 inch urethane
  - 48 pounds coolant
  - 120 hour endurance
- Optimized VIP container
  - 13 x 18 x 11
  - 1.0 inch VIP
  - 15.5 pounds coolant
  - 200 hour endurance

Container Design Example Cont.

- Exterior size reduced 70%
- Coolant reduced 68%
- Endurance increased 66%

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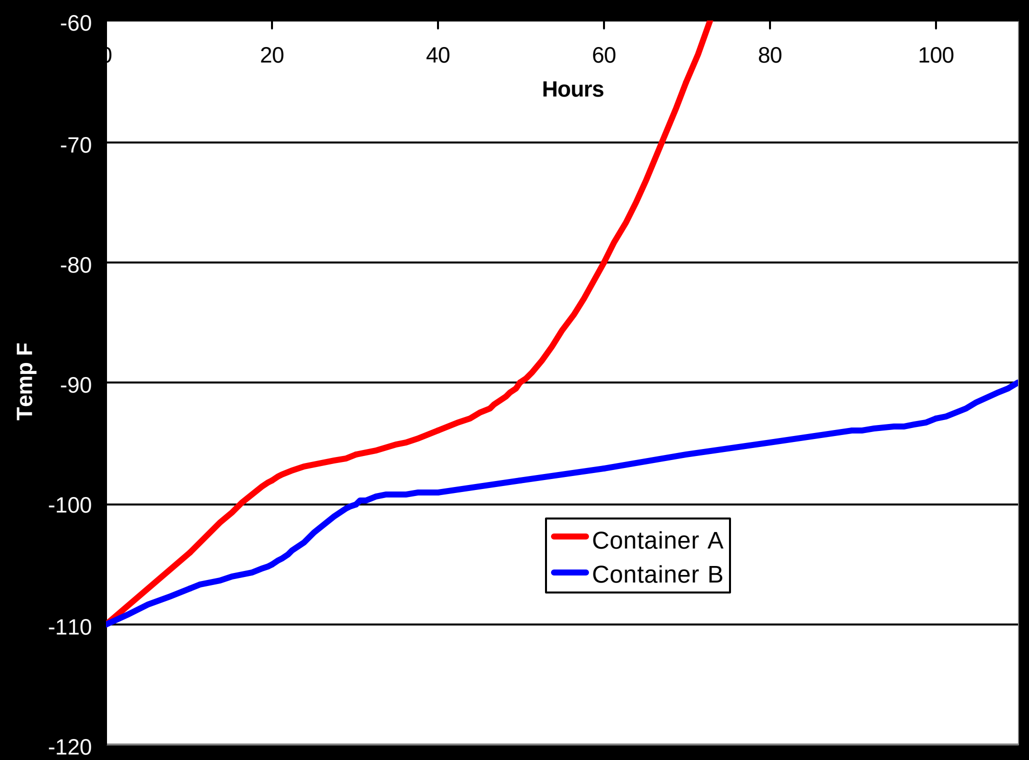
Importance of Detailed Design

- Little things make a big difference
- Both containers are same size with 2 inch thick VIP and 5 pounds of dry ice



Refrigerator/freezer and Merchandisers

- Determine the design objectives
  - Reduced energy
  - Increased volume
  - Allow local room for a feature
  - Condensation control
- Ideally, you want to be involved in the new design at the very beginning

Refrigerator/freezer and Merchandisers

- Characterize the existing design through calorimetry testing
  - Checks the thermal envelope alone not the refrigeration cycle combined with the thermal envelope
- Determine the theoretical performance potential
  - Finite Element Analysis (FEA) can be used to estimate the heat flow through discontinuities

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Refrigerator/freezer and Merchandisers

- Develop the new design
  - Optimum VIP performance requires thermal shorts be eliminated
- Conduct calorimetry validation testing of the new design

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Refrigerator/freezer and Merchandiser Example

- VIP full coverage incorporation into existing design
  - Study shows energy savings of 15%
- Full redesign for maximum performance
  - Study shows energy cut to 25%
    - **75% energy savings**
  - Calorimetry testing showed slightly greater savings
  - VIP is not responsible for all the savings
  - However, once the whole design is improved the VIP can offer maximum benefit

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High Performance Analogy

- My experience with high performance and higher cost materials such as composite materials has taught me
  - A direct substitute for a low cost material in an existing design will not succeed
  - A new design is required to take advantage of the new performance and result in the required value to be successful
  - This is a slow market penetration process but it will happen

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VIP Industry

- Should work toward new application product designs
- Gear toward a long and hard but successful market penetration

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