

Enhancing Vacuum Insulation Value for End Use Applications

Design – The Path to Vacuum
Insulation Value

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

Types of Products

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

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

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

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

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

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

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

Container Design Example

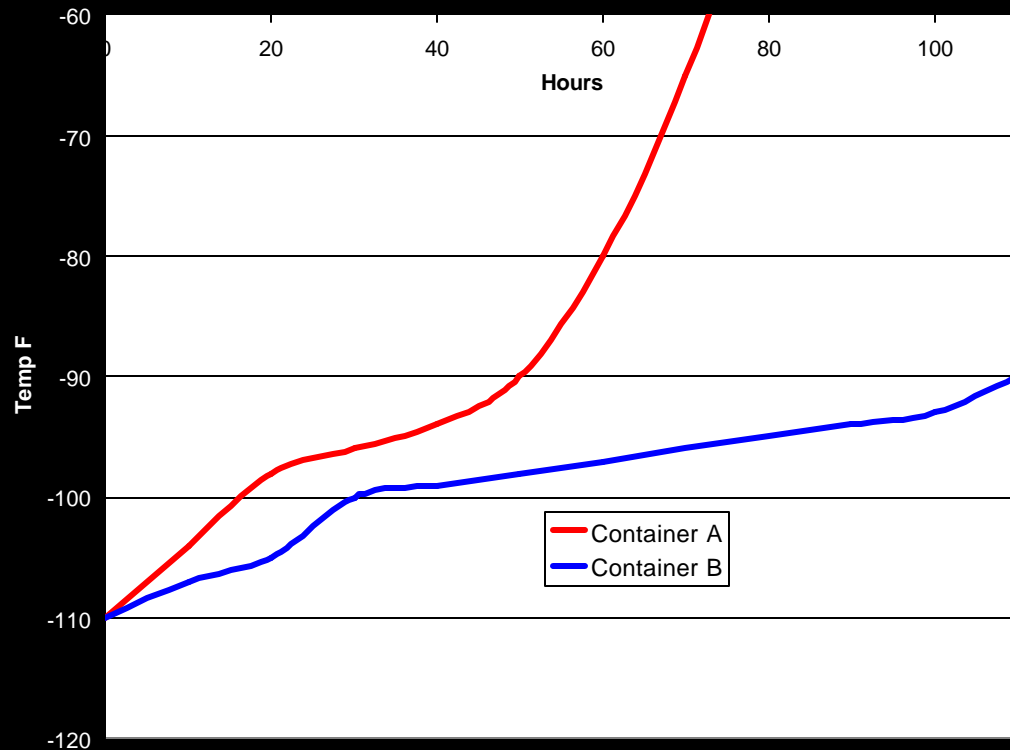
- Original container
 - ◆ 22.5 x 19.25 x 19.5
 - ◆ 1.5 inch urethane
 - ◆ 48 pounds coolant
 - ◆ 120 hour endurance
- Optimized VIP container
 - ◆ 13 x 18 x 11
 - ◆ 1.0 inch VIP
 - ◆ 15.5 pounds coolant
 - ◆ 200 hour endurance

Container Design Example Cont.

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

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

Refrigerator/freezer and Merchandisers

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

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

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

VIP Industry

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

