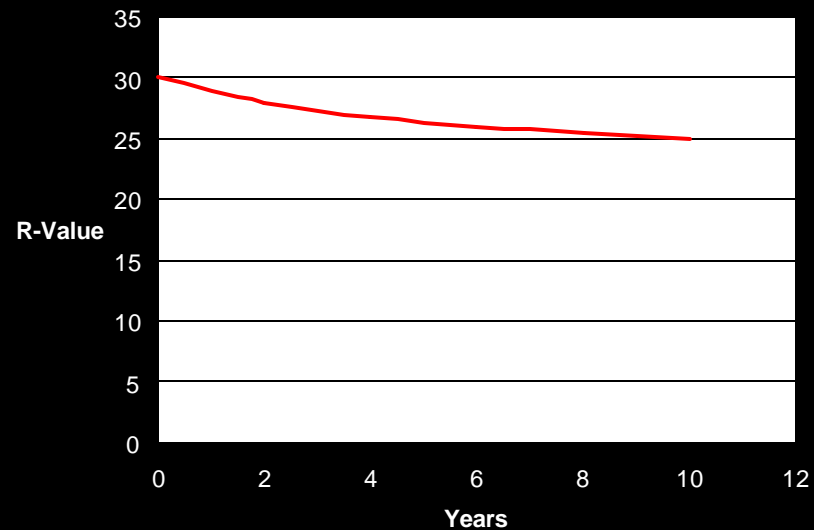


Vacuum Insulation Panel Life Prediction for Refrigerator/freezer Applications

Vacuum Panel Designed Life

- Vacuum panel life is not just predicted
- The panel is designed for a particular life



Variables That Effect Life

- R versus vacuum level of the core material
- Barrier film performance
 - ◆ Effective permeance for each gas
 - ◆ Generally non-linear with temperature and humidity level

Variables That Effect Life

- Amount of desiccant in panel
 - ◆ Absorbs water
- Amount of getter in panel
 - ◆ Absorbs oxygen, nitrogen, and other atmospheric gases
- Panel environment
 - ◆ Relative humidity
 - ◆ Temperature
 - ◆ Atmospheric gases

Design of Panel Life

- If you know
 - ◆ R versus vacuum
 - ◆ Barrier performance
 - ◆ Panel environment
- You can **design** a panel for a given life
 - ◆ Adjust amount of desiccant and getter

Refrigerator/freezer Application

- Typically it is **assumed** that the vacuum insulation panel is in the same environment as the exterior of the refrigerator/freezer
- I propose that this assumption is conservative but substantially in error

The Special Case of Refrigerator

- Virtually continuous operation over its life
- The cooling system effectively provides a moisture pump to move the moisture that gets into the wall to the cold inner wall

Exterior Wall



Inner Wall

Refrigerator/freezer

- Moisture may enter the refrigerator wall and move to the freezer inner wall
 - ◆ Coldest spot (lowest energy)
- Doors are of course handled separately

Approximate Moisture Permeance

- Permeance is a measure of the water transmission rate of a material
 - ◆ Grains of water per hour square foot, inch of mercury vapor pressure difference
- Or WVTR (water vapor transmission rate – grams/sq.Ft. Day)
- Steel* = 0 WVTR
- *Note there are penetrations
 - ◆ However, manufacturers are careful to maintain a good moisture barrier

Approximate Moisture Permeance

- Barrier film = 0.003 WVTR
- Urethane > 500 WVTR

What Is the Vacuum Panel Environment?

- Atmospheric gases – oxygen, nitrogen, etc
 - ◆ Can't escape this part
- Relative humidity and temperature
 - ◆ Vapor pressure results from both relative humidity and temperature
 - ★ Note: temperature is still important by itself since barrier performance is a function of temperature and vapor pressure

What Is the Relative Humidity and Temperature in the Wall?

- If moisture gets into the wall it rapidly moves to the cold interior wall
- The maximum vapor pressure in the wall will be the vapor pressure of 100% relative humidity at the temperature of the cold inner wall

Vapor Pressure at 100% Relative Humidity

- Refrigerator at 38°F = 0.229 in. Hg
- Freezer at -10°F = 0.022 in. Hg
- The wall cavity will be at equilibrium with one of the above

Inside the Wall at the Hot Wall

- The vapor pressure must be equal to the cold wall
 - ◆ Result of the rapid diffusion of water through urethane foam

Inside the Wall at the Hot Wall

- A relative humidity inside the wall at the hot wall can be calculated from the vapor pressure
 - ◆ Refrigerator
 - ★ If exterior temperature is 70°F, RH = 31%
 - ★ If exterior temperature is 90°F, RH = 16%
 - ◆ Freezer
 - ★ If exterior temperature is 70°F, RH = 3%
 - ★ If exterior temperature is 90°F, RH = 1.5%

Thus, Vacuum Panel Environment for Moisture Is

Refrigerator only

Frig/Freezer if connected
or Freezer only

90°F
16 %RH

38°F
100% RH

90°F
1.5 % RH

-10°F
100% RH

Half barrier area at hot wall condition and half at the cold wall condition

Proposed Panel Environment

- **Far** less severe than the original assumption of the exterior room conditions

Proposed Panel Environment

- Typical example
 - ◆ 15 year life
 - ◆ R initial = 30
 - ◆ R final = 24
 - ◆ Original assumption
 - ★ 1 getter
 - ★ 50 grams of desiccant
 - ◆ Proposed assumption
 - ★ 1 getter
 - ★ ???? 5 grams of desiccant
 - No one has done testing under the conditions proposed

Next Steps

- What is proposed is a theory based on some fact
 - ◆ It has not been proven by actual refrigerator and freezer internal wall relative humidity measurements

Next Steps

- I am looking for a good test refrigerator/freezer to obtain actual measurements
 - ◆ Standard refrigerator/freezer
 - ◆ Operating in a high temperature/humidity environment for a long time
 - ◆ Agreeable to making holes in walls for probes