Vacuum Insulation Panel Life Prediction for Refrigerator/freezer Applications

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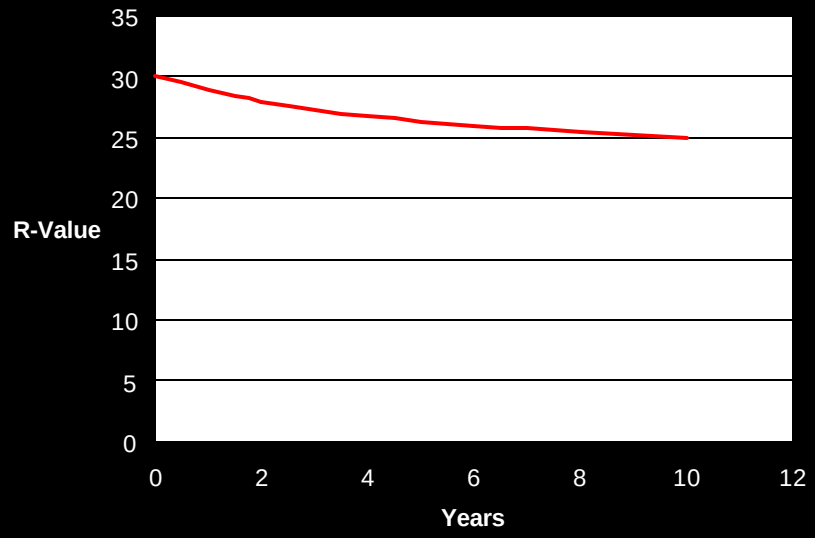
Vacuum Panel Designed Life

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



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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

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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

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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

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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

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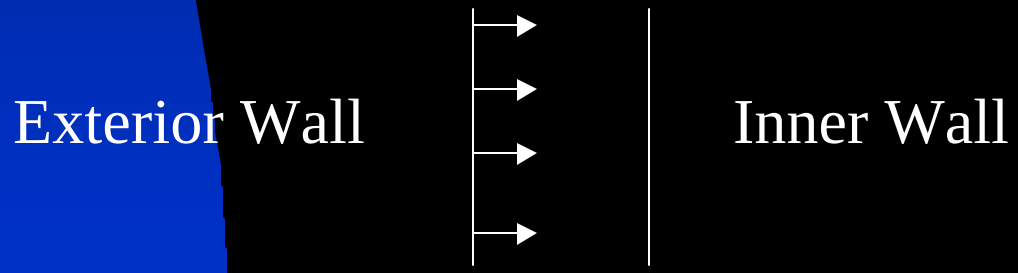
The Special Case of Refrigerator

- 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



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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

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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

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Approximate Moisture Permeance

- Barrier film = 0.003 WVTR
- Urethane > 500 WVTR

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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

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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

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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

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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

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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%

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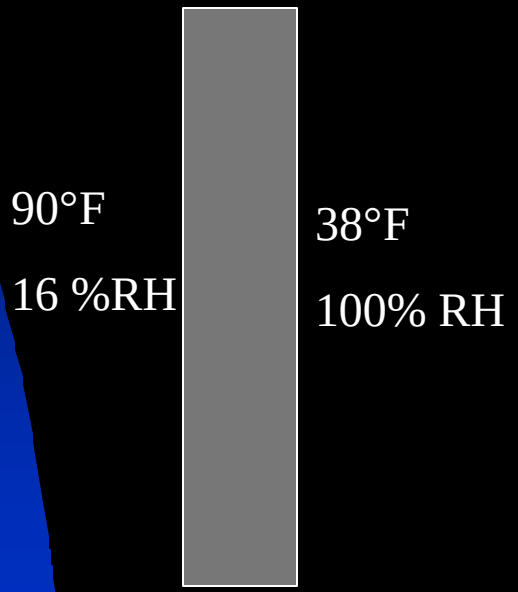
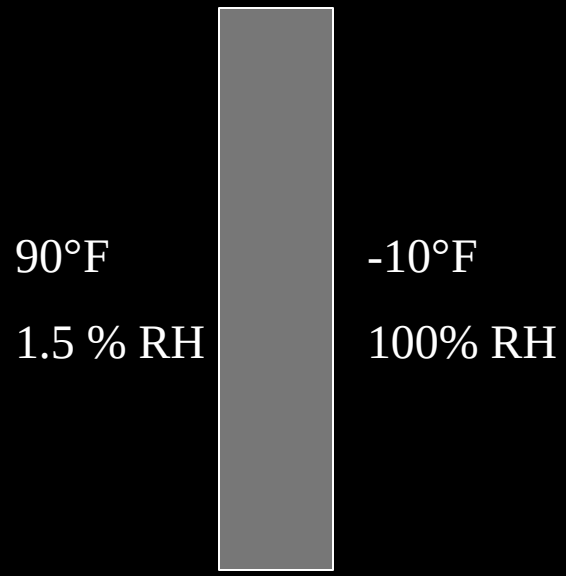
Thus, Vacuum Panel Environment for Moisture Is

Refrigerator only



Frig/Freezer if connected

or Freezer only



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

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Proposed Panel Environment

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

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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

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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

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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

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