Ontario Building Officials Association(OBOA), 2010 AMTS Technical Committee Meeting, 06 October 2010

Green in Blue Mountains

NRC·CNRC

Institute for Research in Construction

High-Performance Vacuum Insulation Panel in Building Envelope Construction

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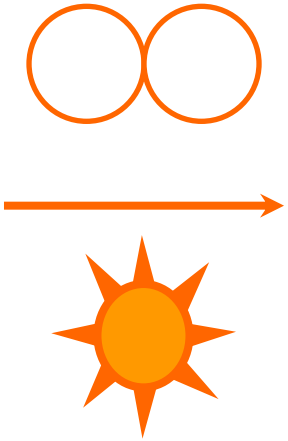
Senior Research Officer

Presentation Outline

- What is high performance thermal insulation?
- Vacuum insulation panel – advantages and challenges
- Various applications
- Conclusions

Heat Transfer Mechanisms

- Primary mechanisms
  - Conduction
  - Convection
  - Radiation

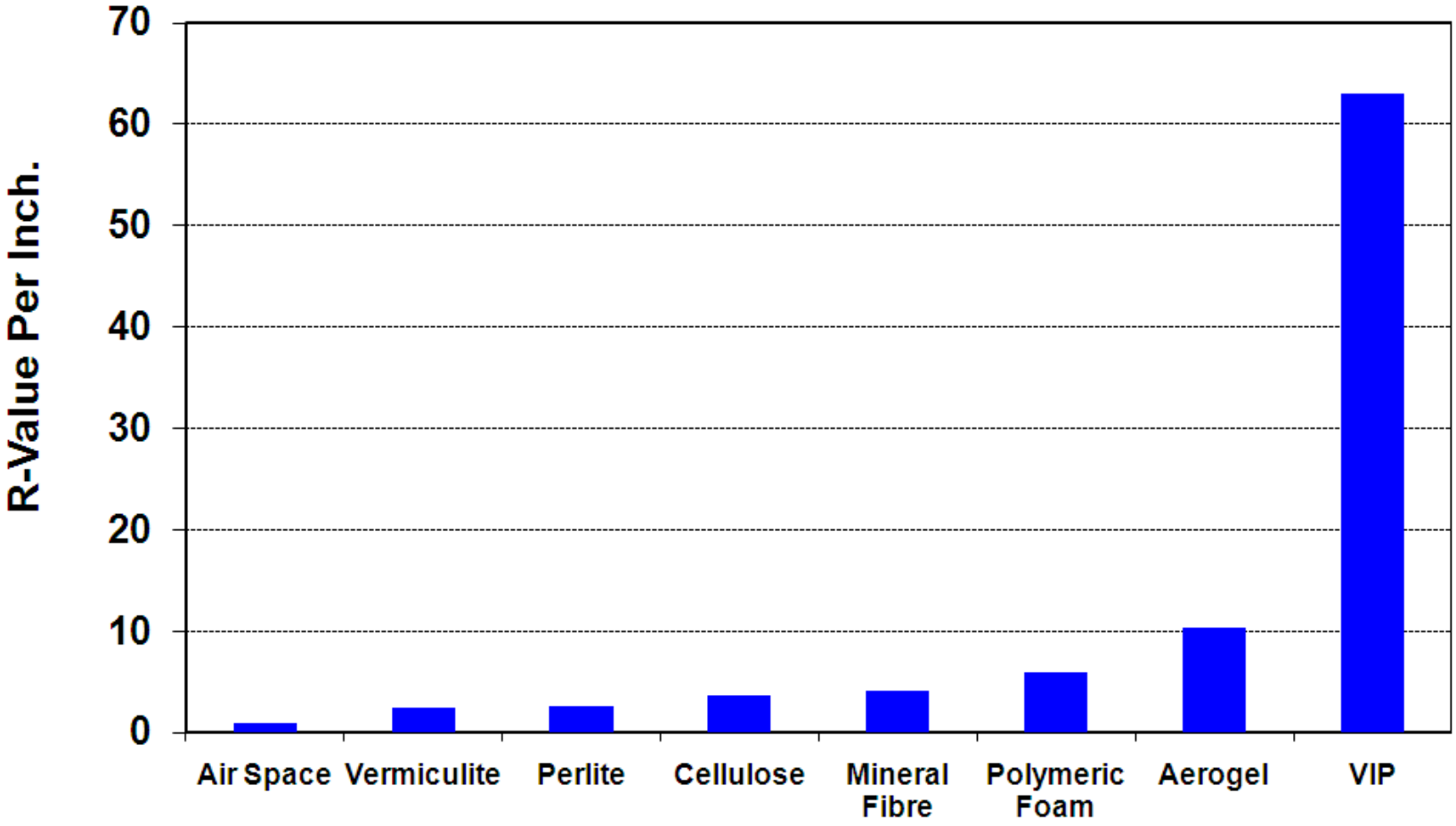


- Influenced by
  - Air infiltration
  - Air intrusion
  - Moisture accumulation

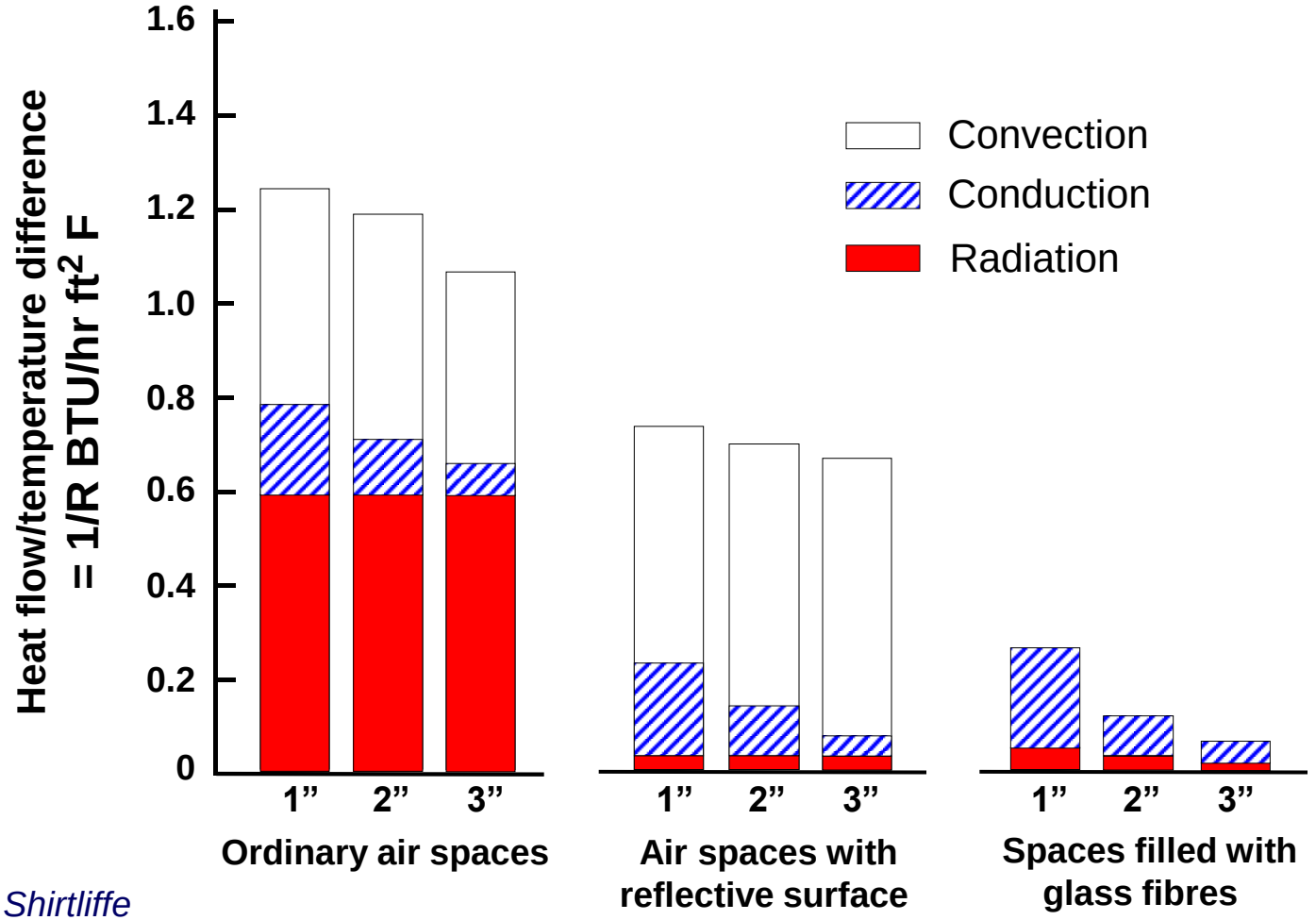
High Performance Thermal Insulation ?

- Higher thermal resistance
- Long service life
- Environmentally friendly
- Sustainable systems

Thermal Performance Improvement Continues



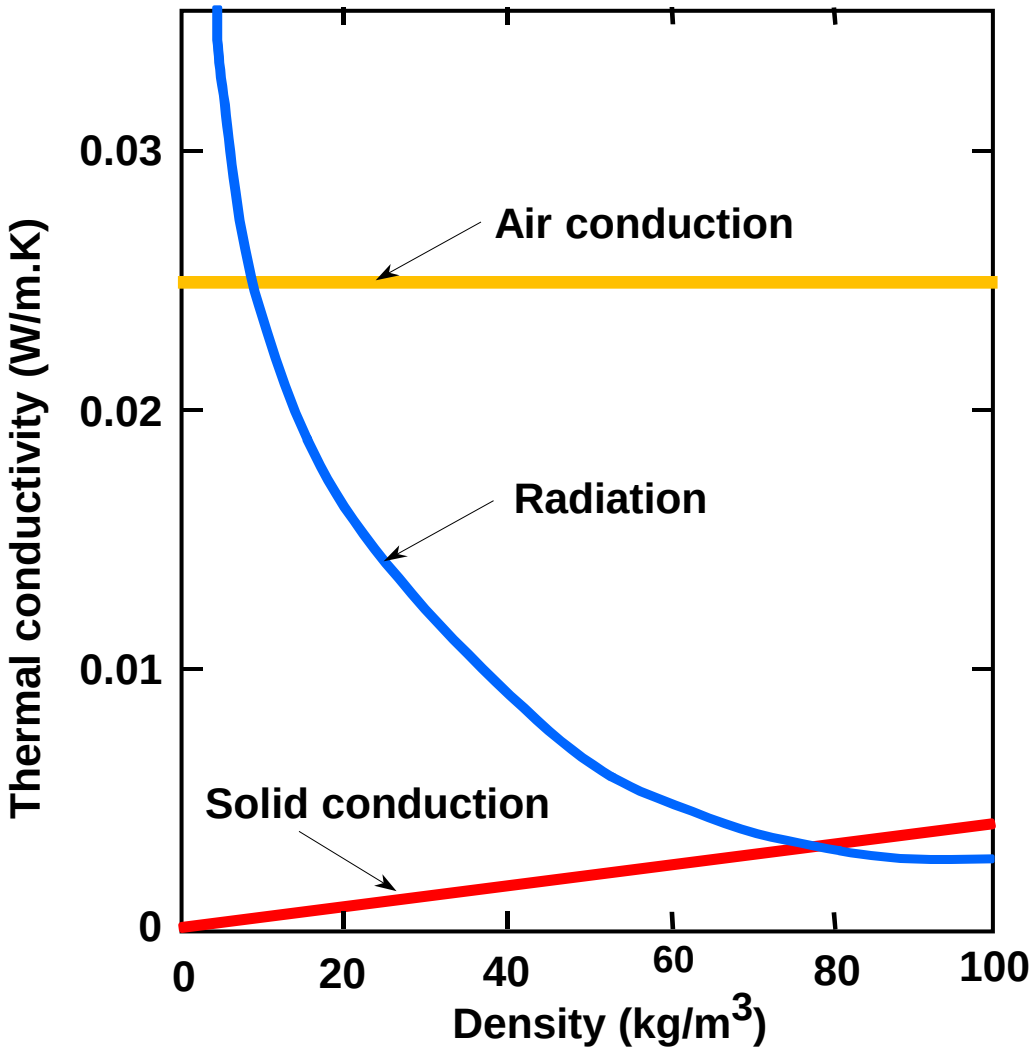
Basics for High Performance Thermal Insulation



CBD – 149; Shirtliffe

Heat Transfer Across Air Spaces – Contribution by Radiation, Conduction and Convection

Insulation – Components for Heat Transfer



Thermal conductivity ($W\ m^{-1}\ K^{-1}$)	R-value per inch
0.040	3.6
0.035	4.1
0.030	4.8
0.025	5.8
0.020	7.2
0.015	9.6
0.010	14.4
0.005	28.9

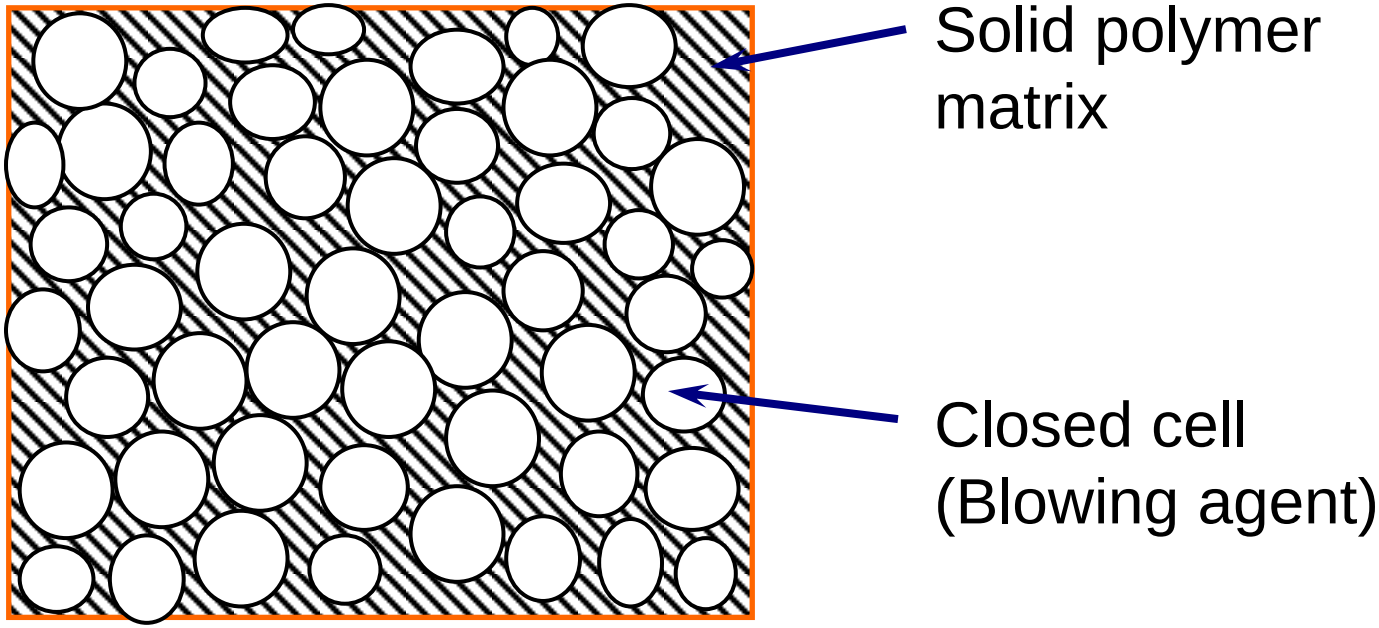
Reduce Air Conduction Component – High Thermal Resistance

High Performance Thermal Insulation

- Closed-cell foam insulation
  - Blowing agent conductivity < Air conductivity
- Aerogel
  - Air conductivity (nanopore) < Air conductivity (macropore)
- Vacuum insulation
  - Air conductivity ≅ Zero

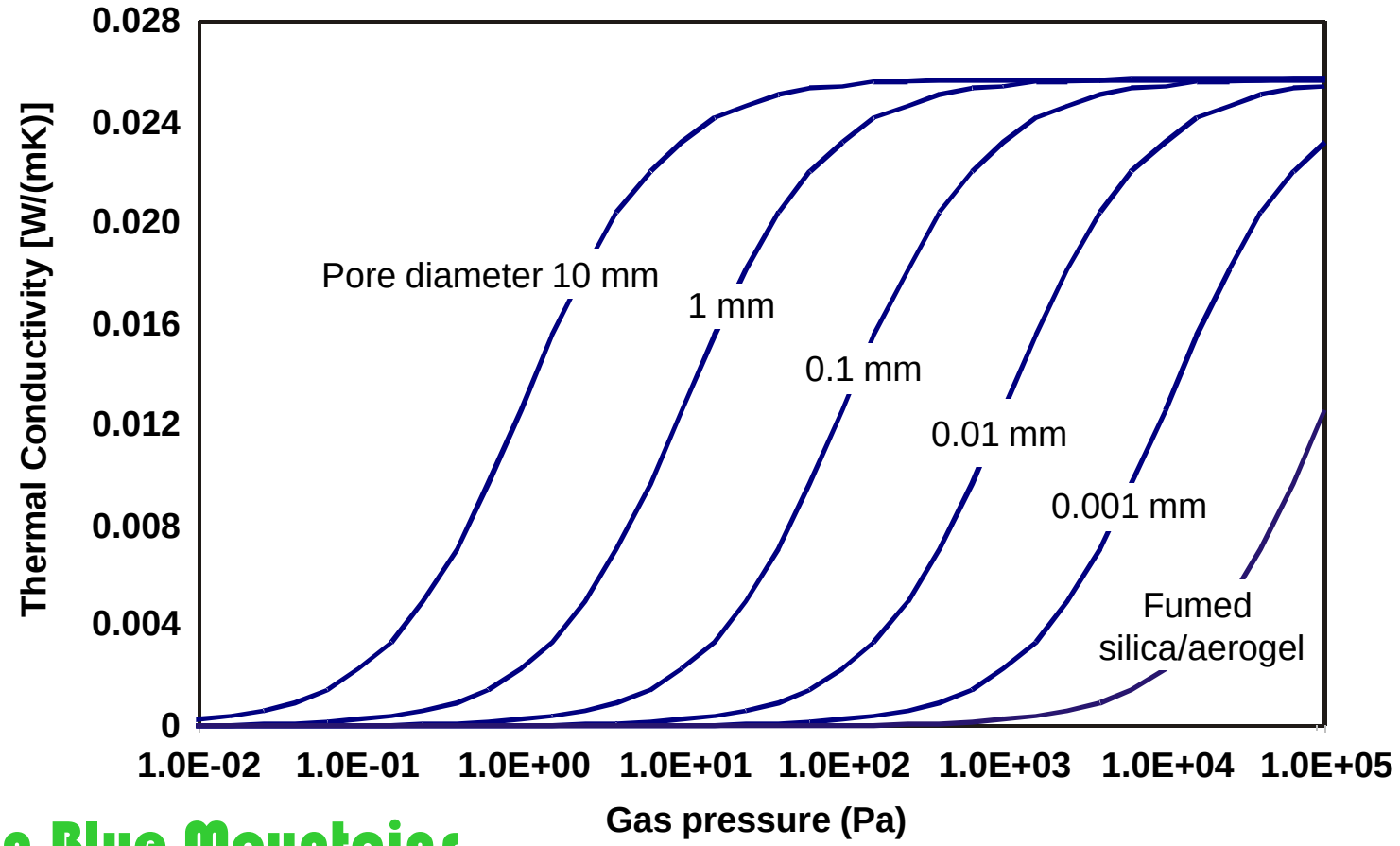
High Performance Thermal Insulation

- Closed cell foam insulation



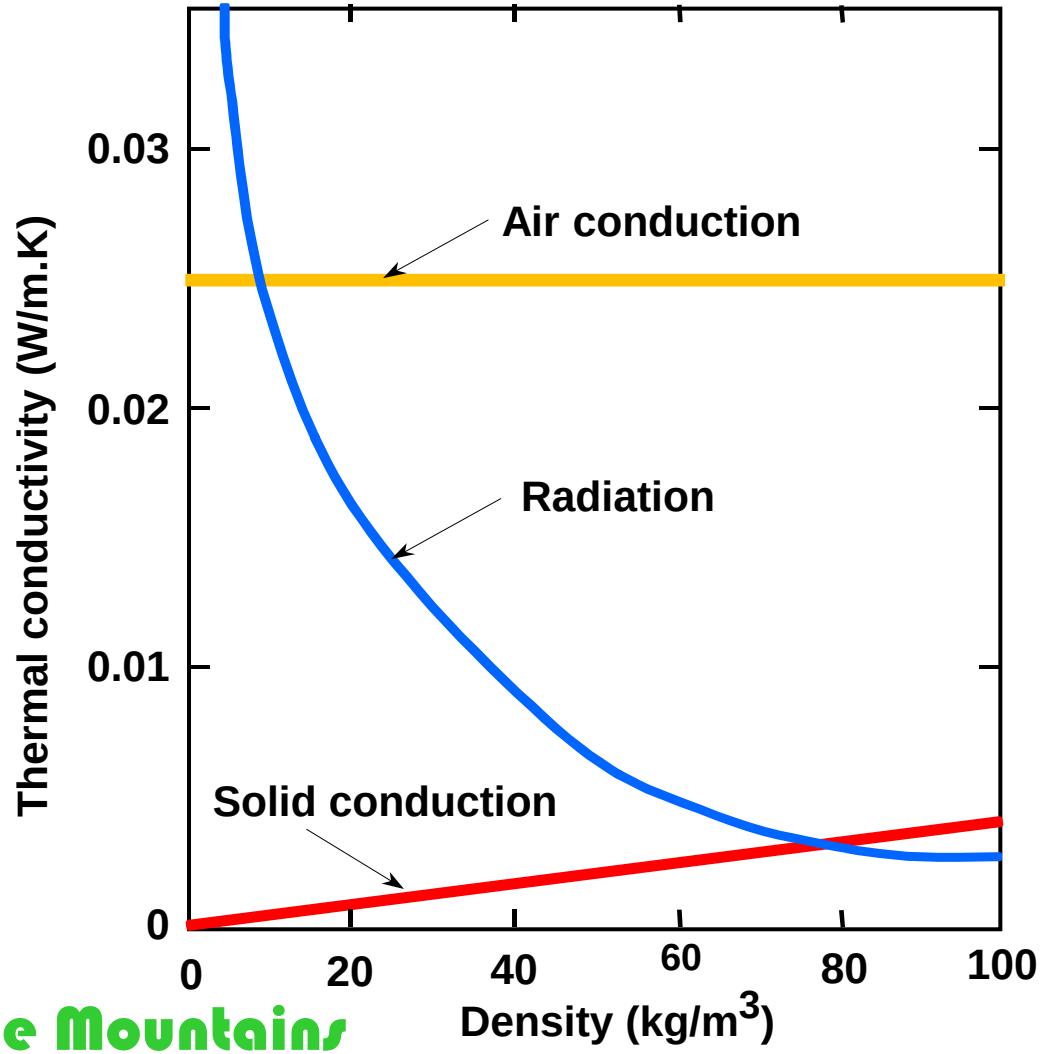
High Performance Thermal Insulation

- Aerogel: Air conductivity (nanopore) < Air conductivity (macropore)



High Performance Thermal Insulation

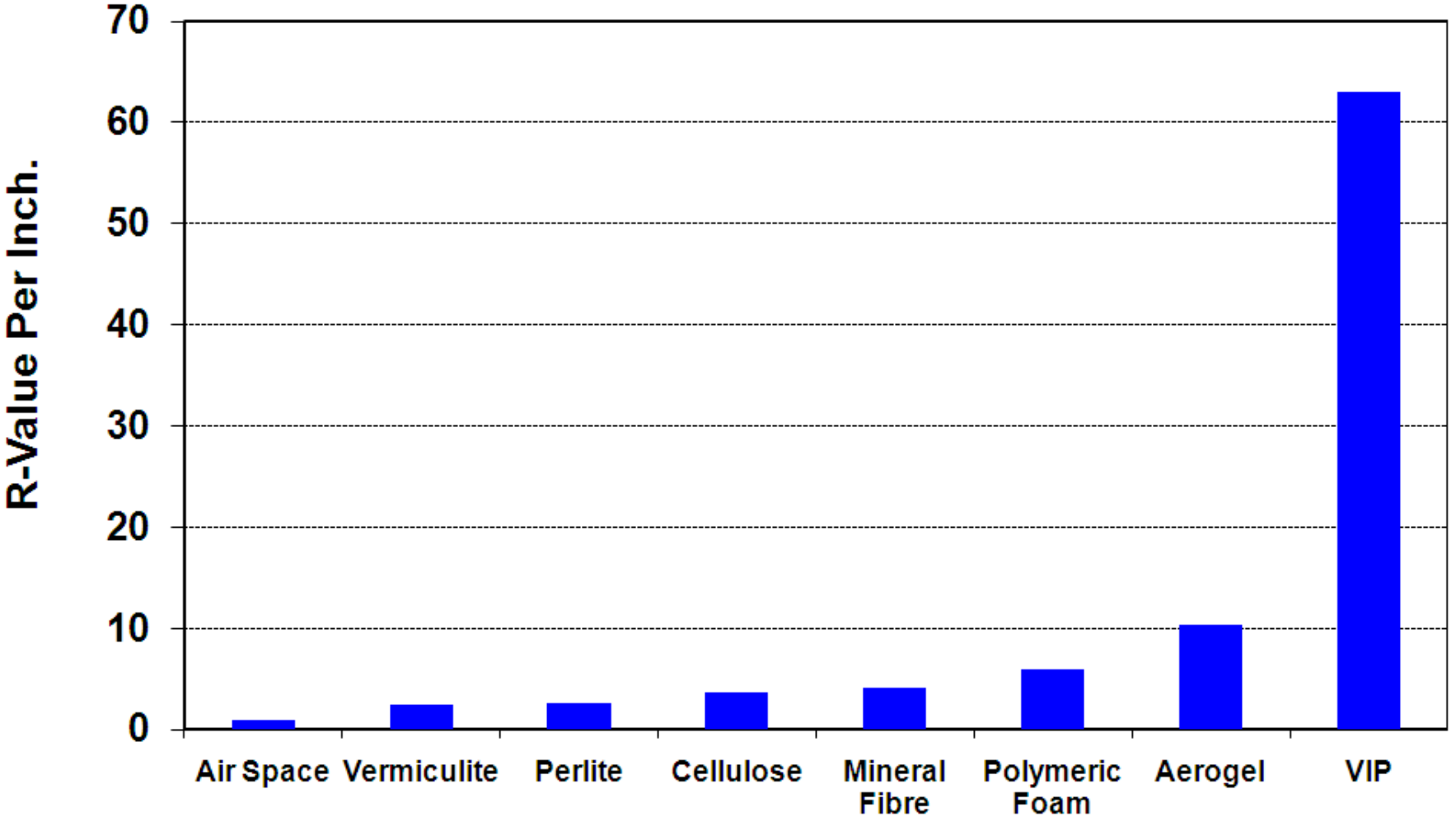
- VIP: Air conductivity component ≈ zero



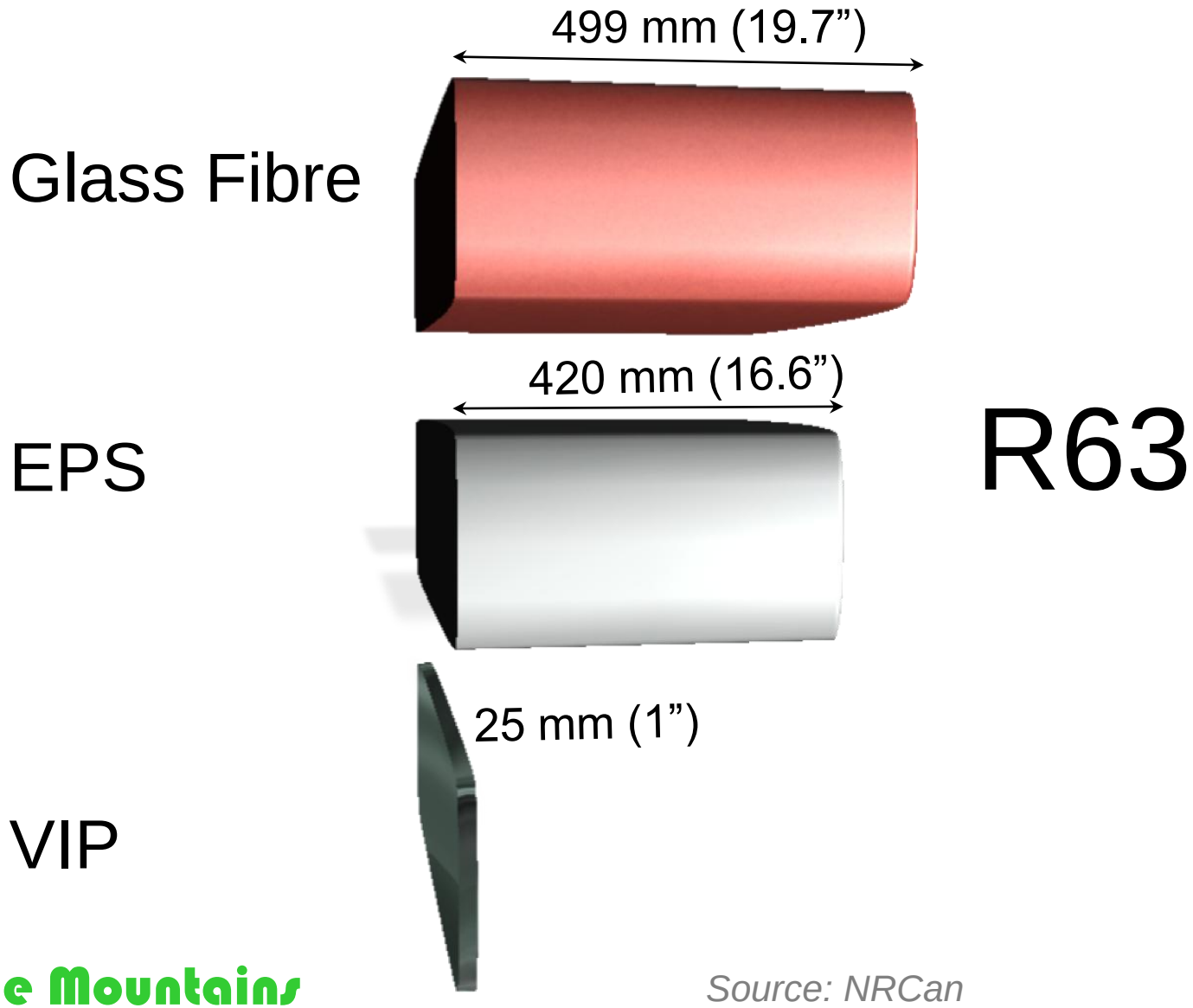
Vacuum Insulation Panel (VIP)

Source: NRCan

Vacuum Insulation Panel (VIP)



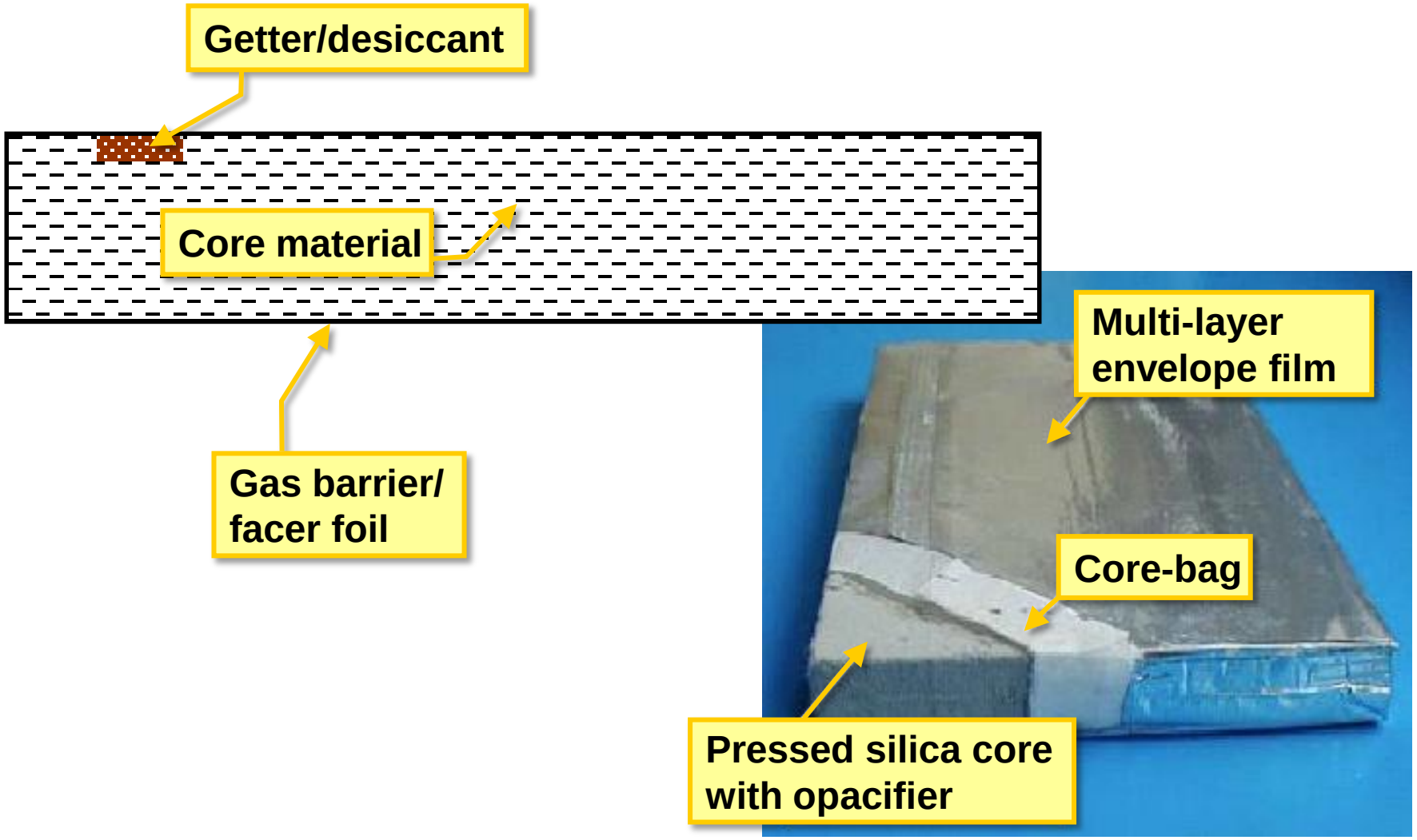
Vacuum Insulation Panel (VIP)



Green in Blue Mountains

Source: NRCan

Vacuum Insulation Panel (VIP)



Source: IEA/ECBCS Annex 39

Vacuum Insulation Panel (VIP)

1. Core Material – imparts mechanical strength and thermal insulating capacity

2. Gas Barrier / Facer Foil – provides air and vapour tight enclosure for core material

3. Getter / Desiccant – adsorbs residual or permeating atmospheric gases or water vapour in the VIP enclosure

Vacuum Insulation Panel (VIP)

- Inherent advantages
  - Higher thermal resistance*
  - Reduced thickness of the component
  - Recyclable

* *Any damage in the vacuum system (even a small pinhole) will severely destroy the thermal insulating capacity of VIPs*

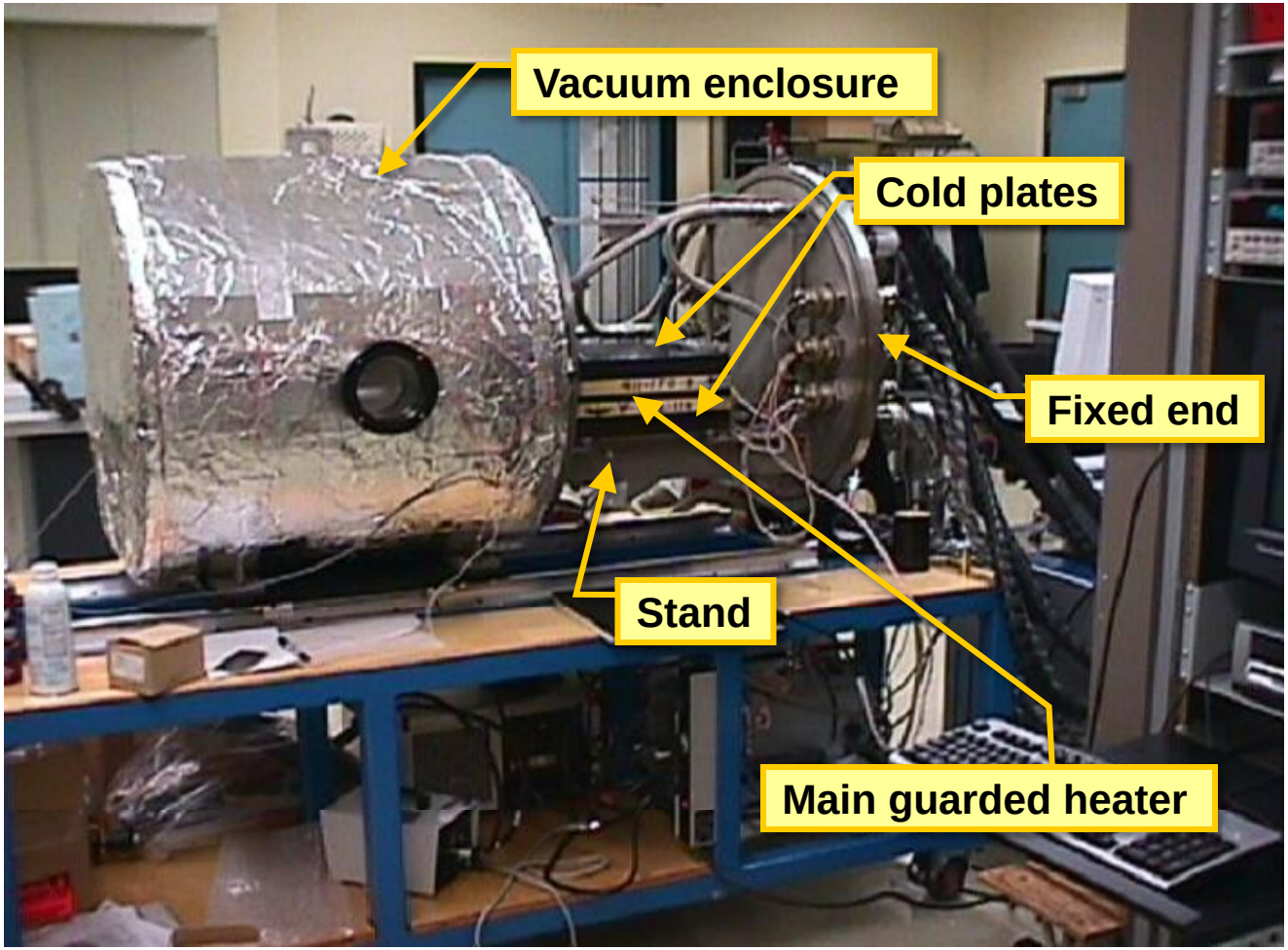
Vacuum Insulation Panel (VIP)

- Challenges
  - Cost (relatively expensive)
  - Building physics and engineering
    - Aging and durability
    - Thermal bridge effects at edges
    - Condensation

Alternative Core Materials for VIP

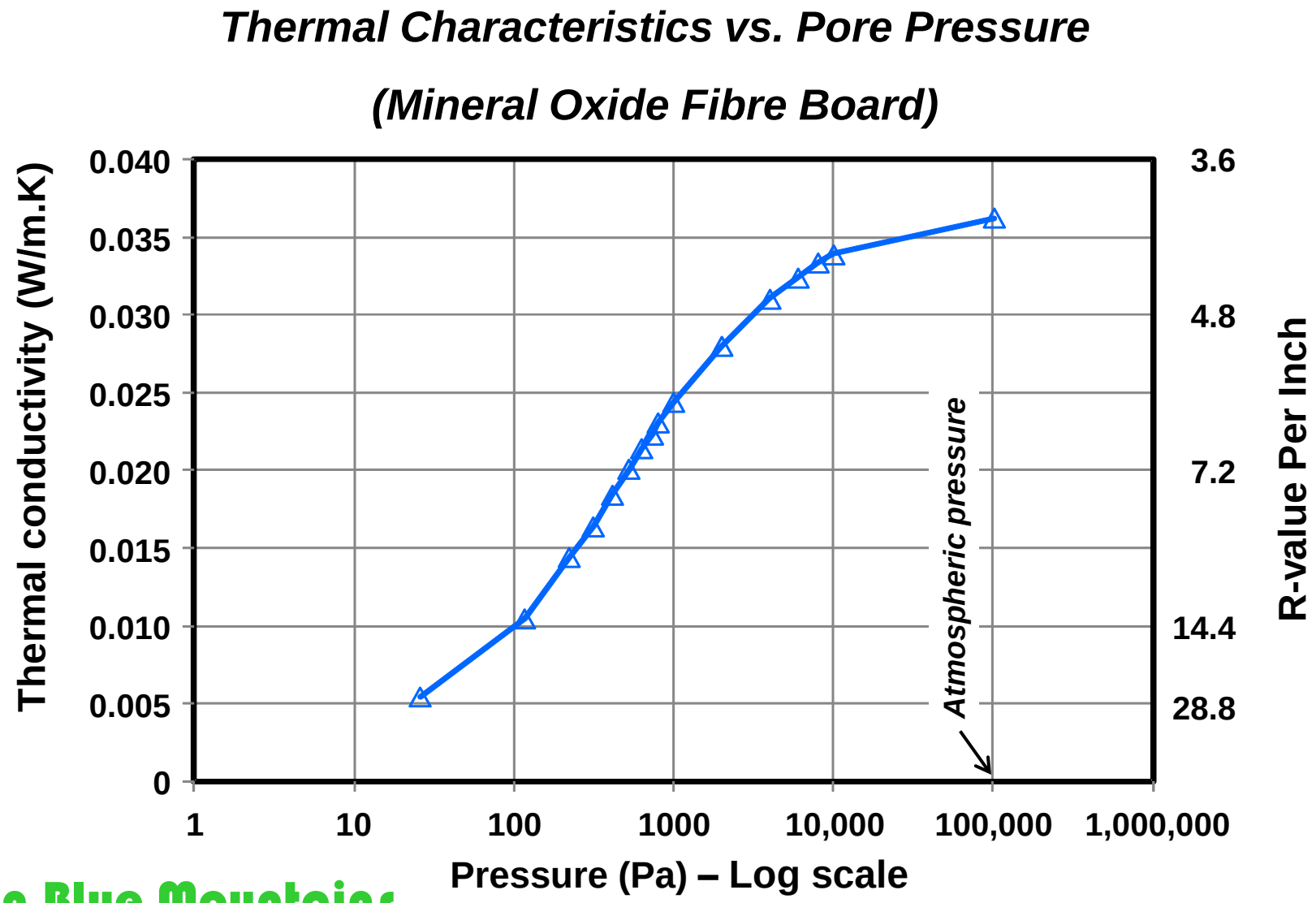
- Precipitated silica, fumed silica, nanogel (silica aerogel) are used as core materials
- Core materials are expensive
- Alternative core materials can reduce the cost of VIP

Vacuum Guarded Hot Plate (VGHP)

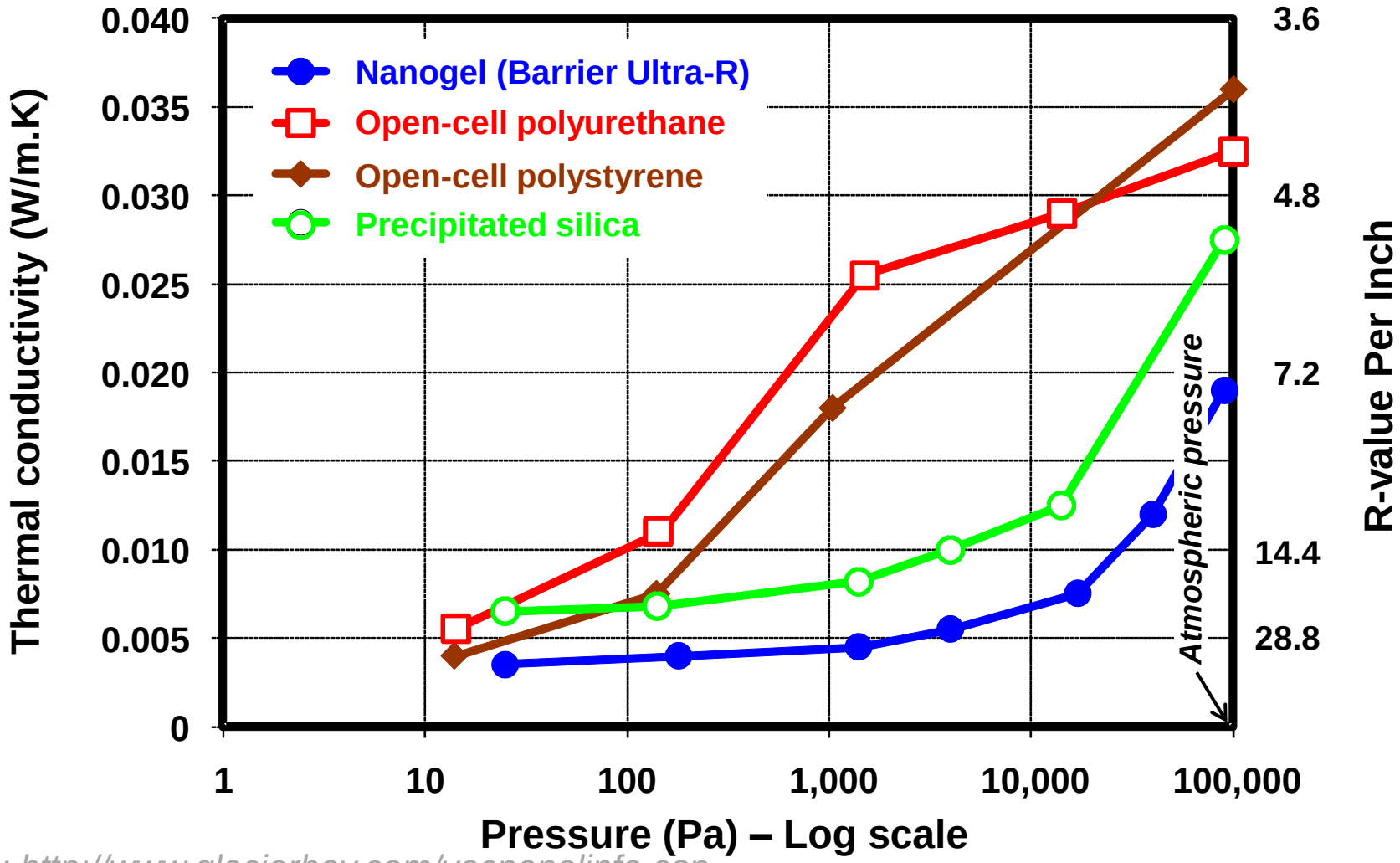


VGHP Operation

Thermal Characteristics of Core Materials



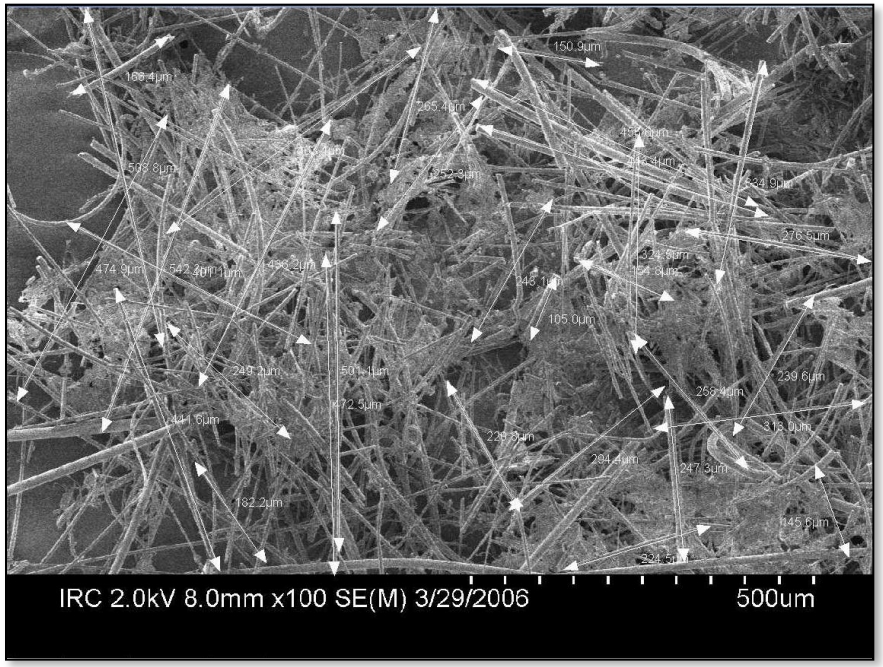
Thermal Characteristics of Core Materials



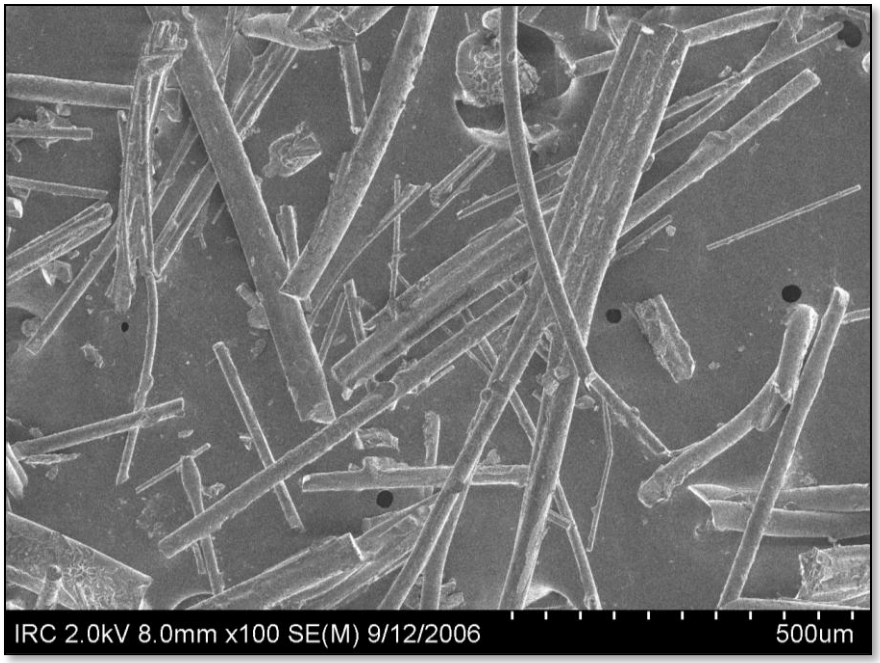
Source: http://www.glacierbay.com/vacpanelinfo.asp

Alternative Nano-Porous Core Materials

Pore Structure Analysis – Scanning Electron Microscopic



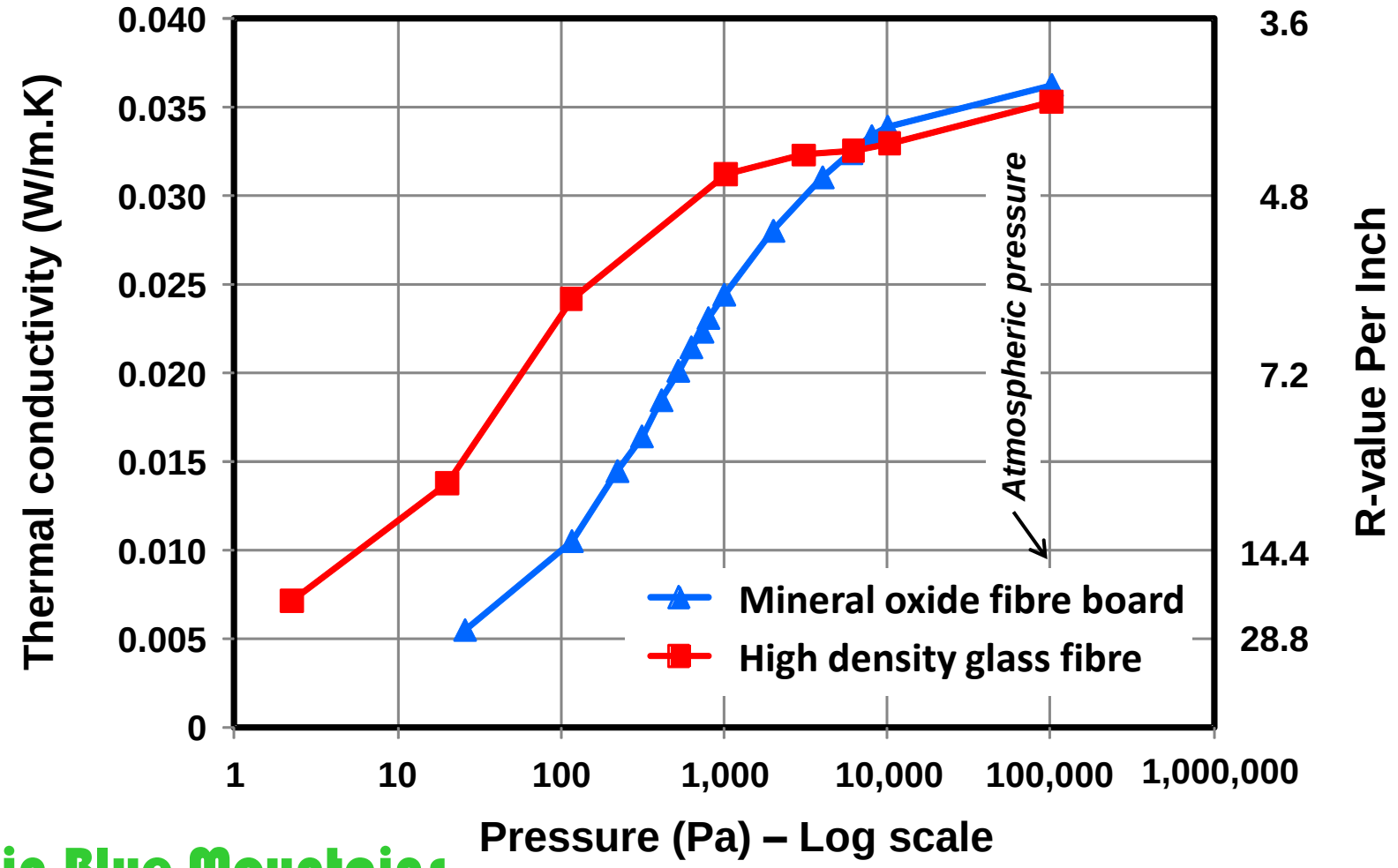
Mineral Oxide Fibre Board (MOFB)



High Density Glass Fibre (HDGF)

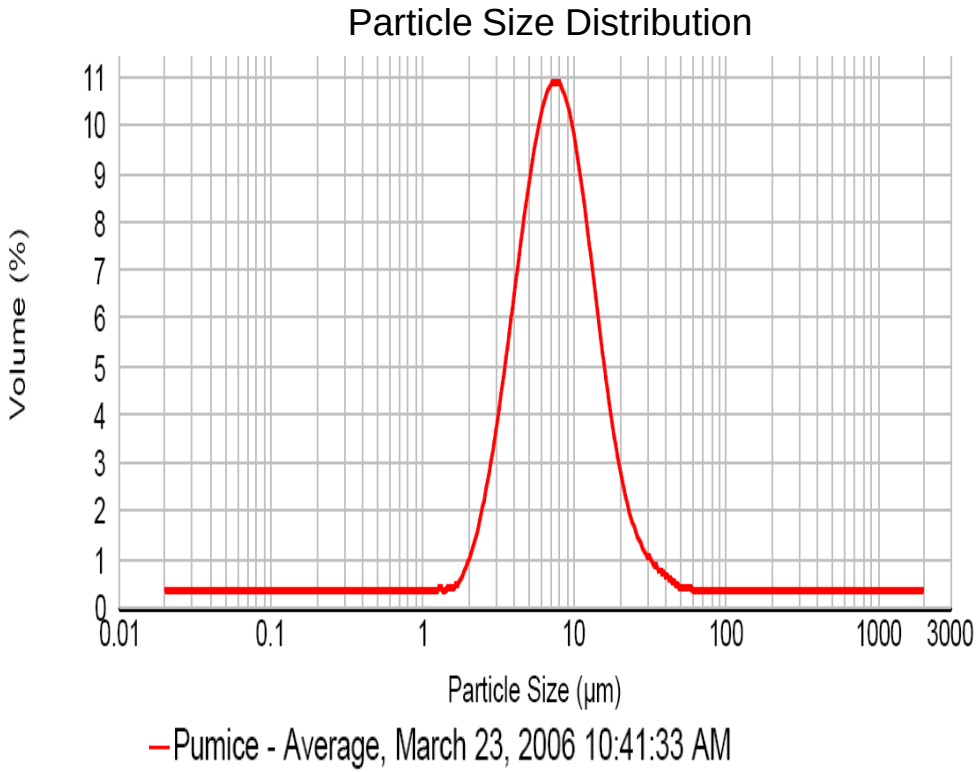
Alternative Nano-Porous Core Materials

Thermal Characteristics of MOFB and HDGF

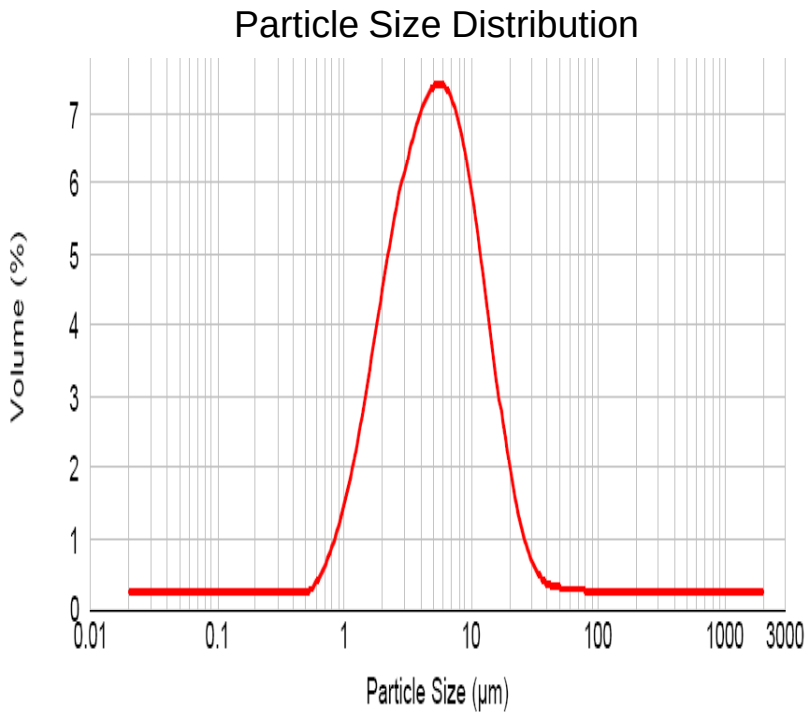


Alternative Nano-Porous Core Materials

Particle Size Analysis – Output from Particle Analyzer



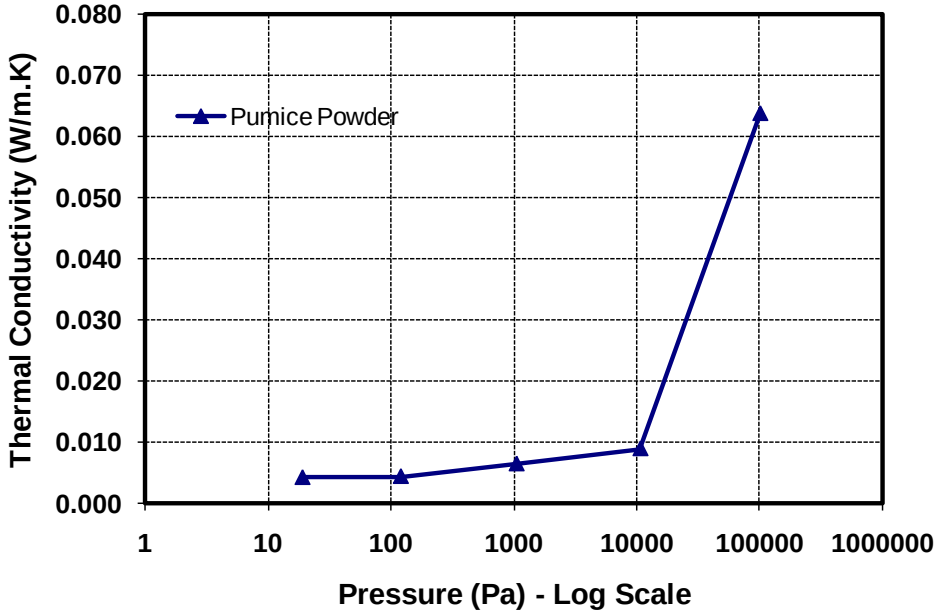
Pumice

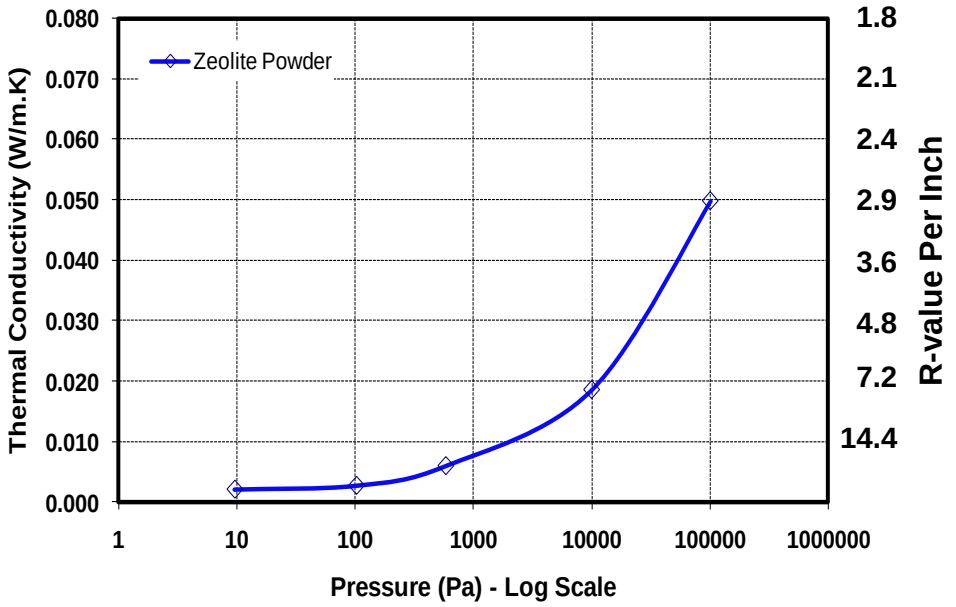


Zeolite

Alternative Nano-Porous Core Materials

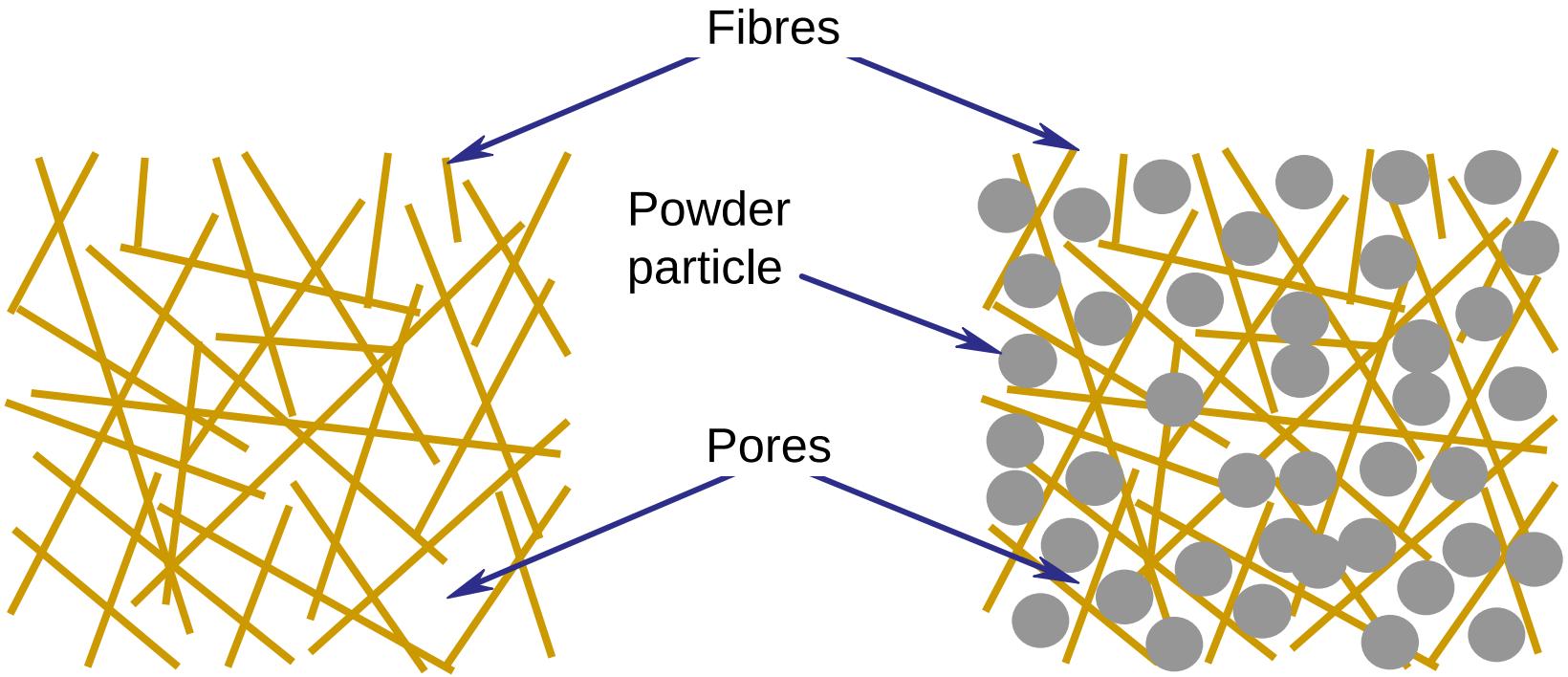
Thermal Characteristics of Pumice and Zeolite Powders





Alternative Nano-Porous Core Materials

Basic Hypothesis of Fibre-Powder Composite

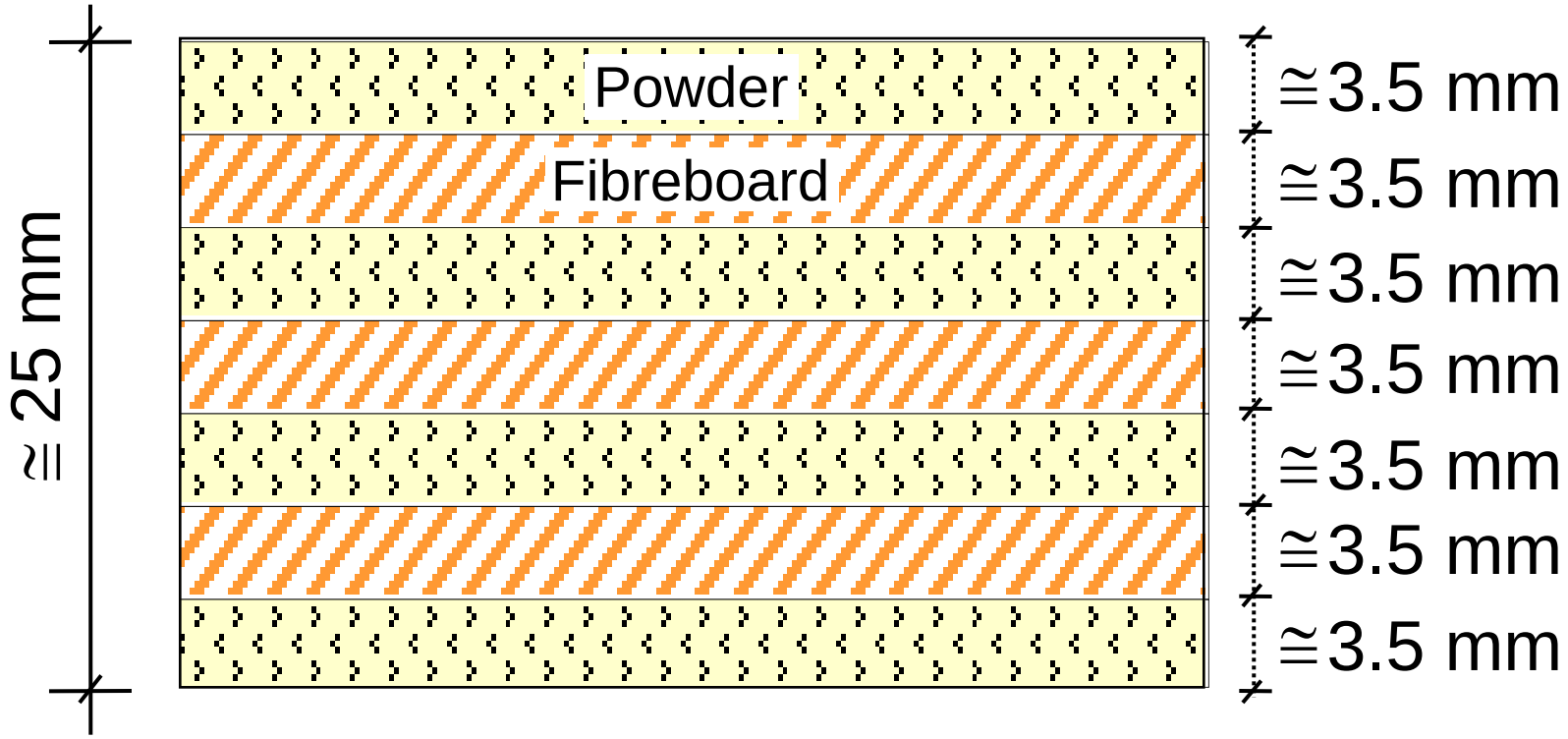


(a) Fibrous pore structures

(b) Fibrous pore structures packed with particles

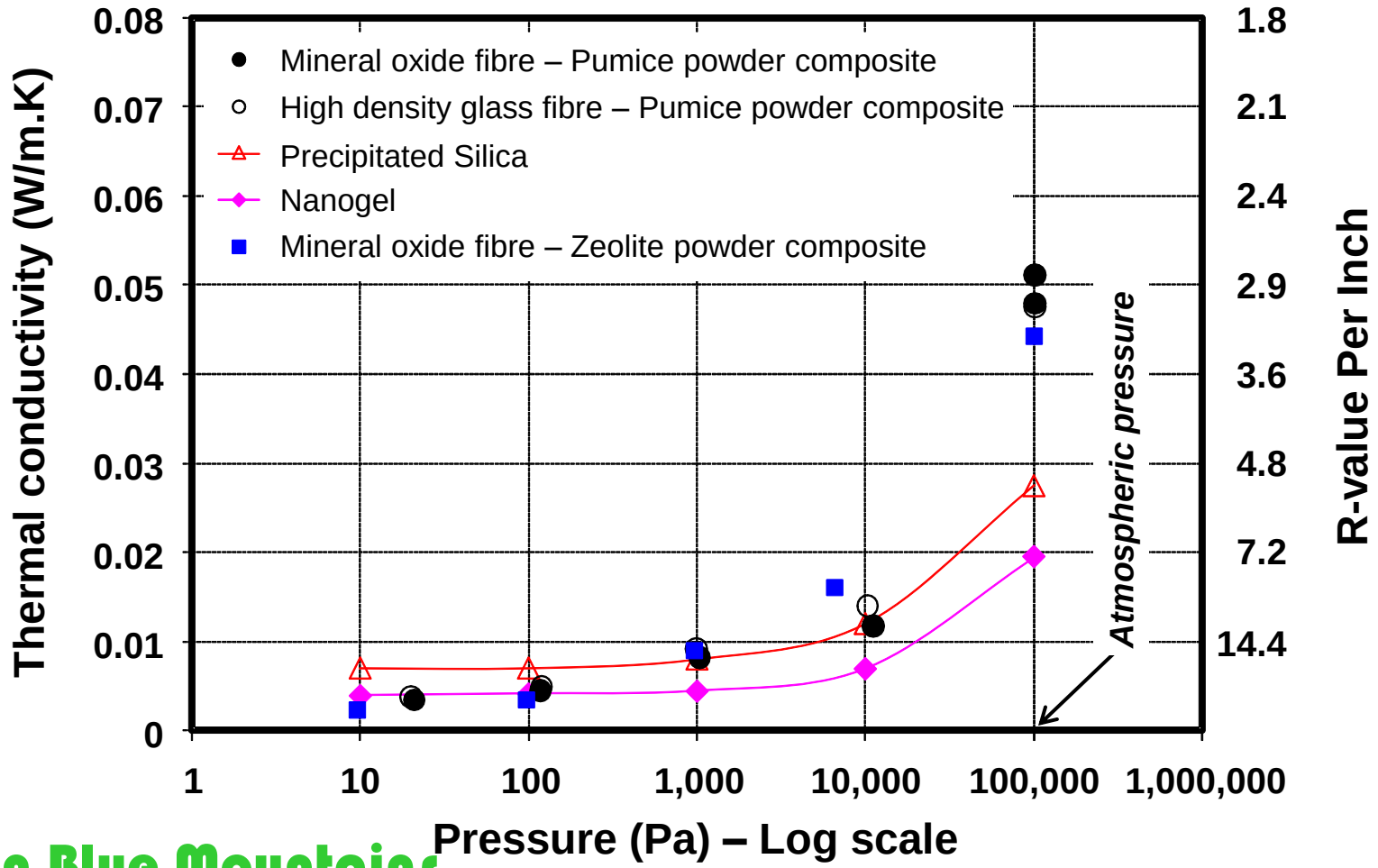
Alternative Nano-Porous Core Materials

Basic Hypothesis of Fibre-Powder Composite



Alternative Nano-Porous Core Materials

Comparison of Thermal Characteristics –
New/Alternative Core Materials vs. Nanogel and Precipitated Silica



Alternative Nano-Porous Core Materials

New Vacuum Packaging Facility at NRC-IRC

Vacuum Insulation Panel

- Challenges
  - Building physics and engineering
    - Aging and durability
    - Thermal bridge effects at edges
    - Condensation

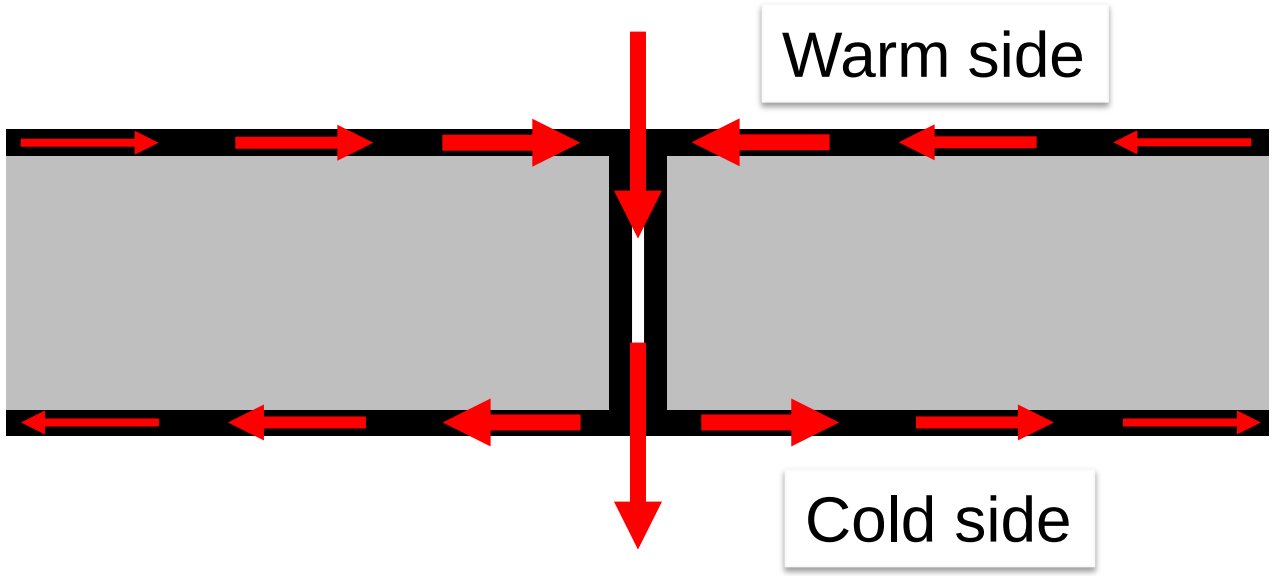
Aging and Durability

- Manufacturing
- Properties of core materials
- Handling and exposure

 Source: IEA/ECBCS Annex 39

Thermal Bridge

- Use large panels
- Overlap panels
- Fill gaps at edges with insulating materials



Source: IEA/ECBCS Annex 39

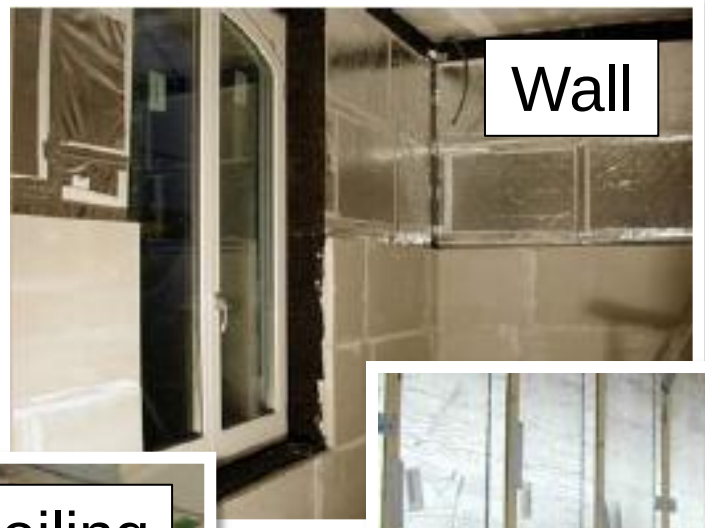
Condensation

- VIP is an absolute vapour barrier
- Avoid damp construction materials
- Consequences of vacuum failure

Various Applications

Source: IEA/ECBCS Annex 39

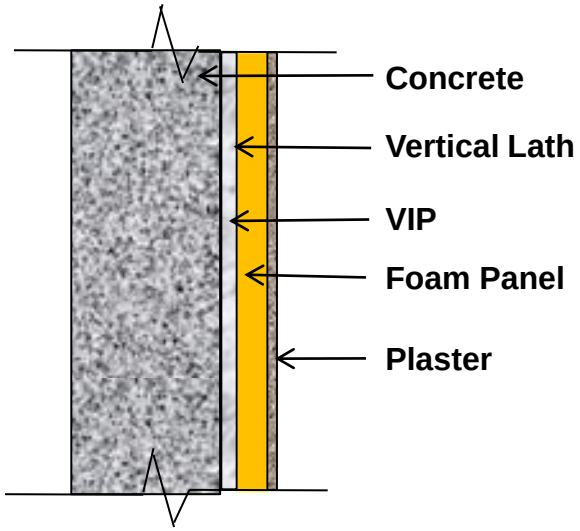
Various Applications



Source: IEA/ECBCS Annex 39

Apartment and Office Block (Europe)

Façade Renovation



After

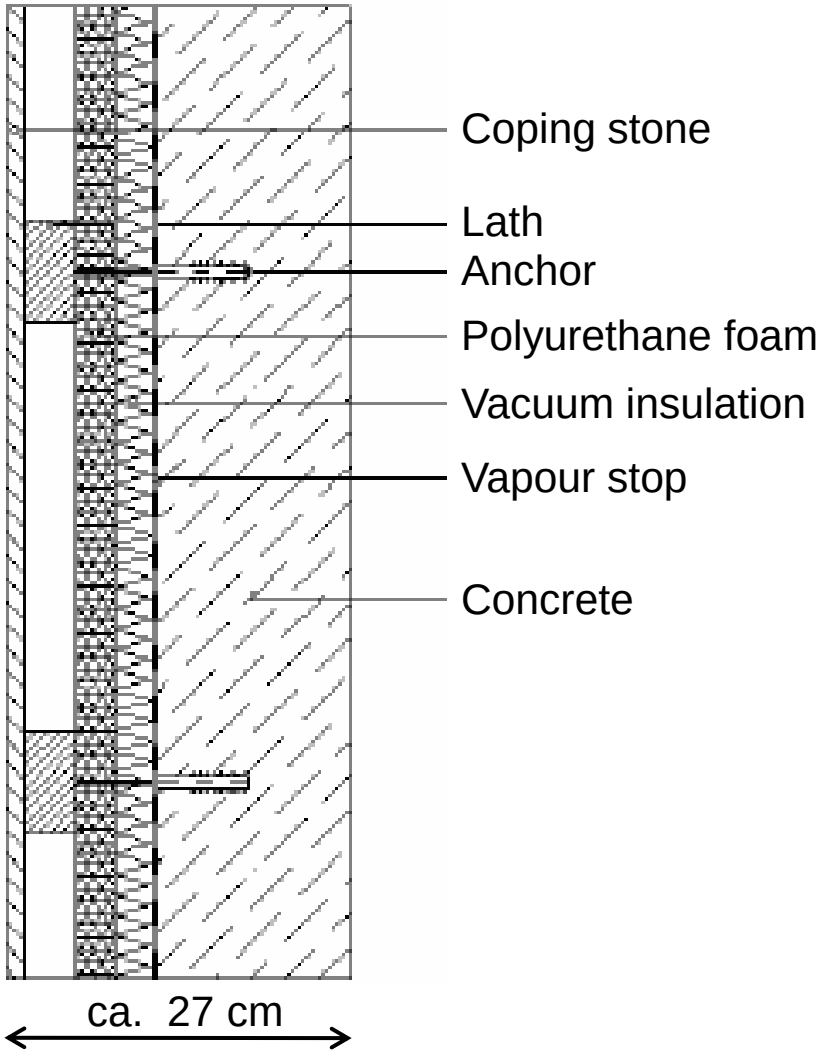
 Source: IEA/ECBCS Annex 39

Office Building (Europe)

Insulated Prefabricated Concrete Elements

Source: IEA/ECBCS Annex 39

Prefabricated Wall Elements



Source: IEA/ECBCS Annex 39

Semi-detached House (Europe)

Façade Renovation

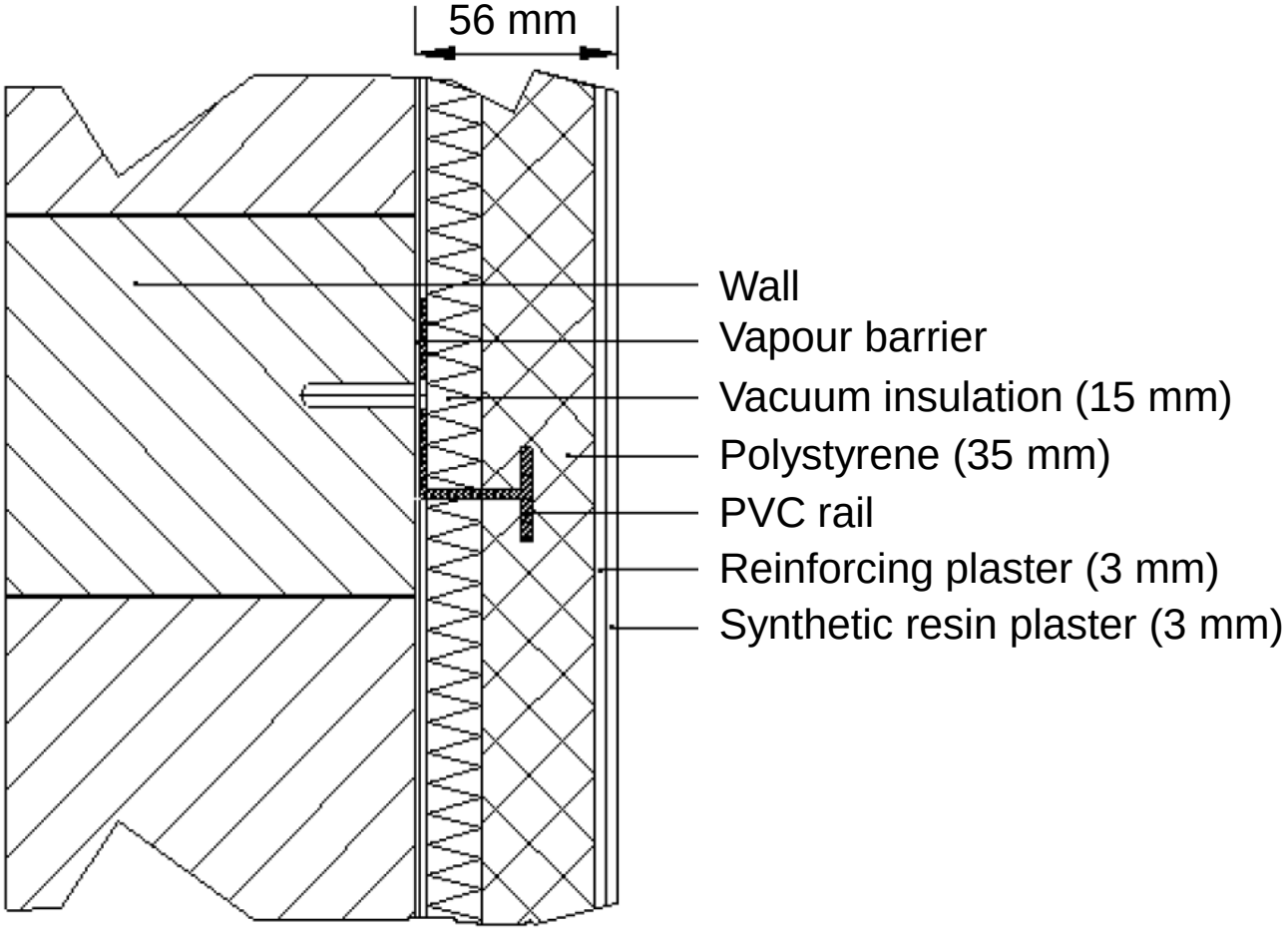
Before

After

 Source: IEA/ECBCS Annex 39

Semi-detached House

Cross-section of Insulated Wall



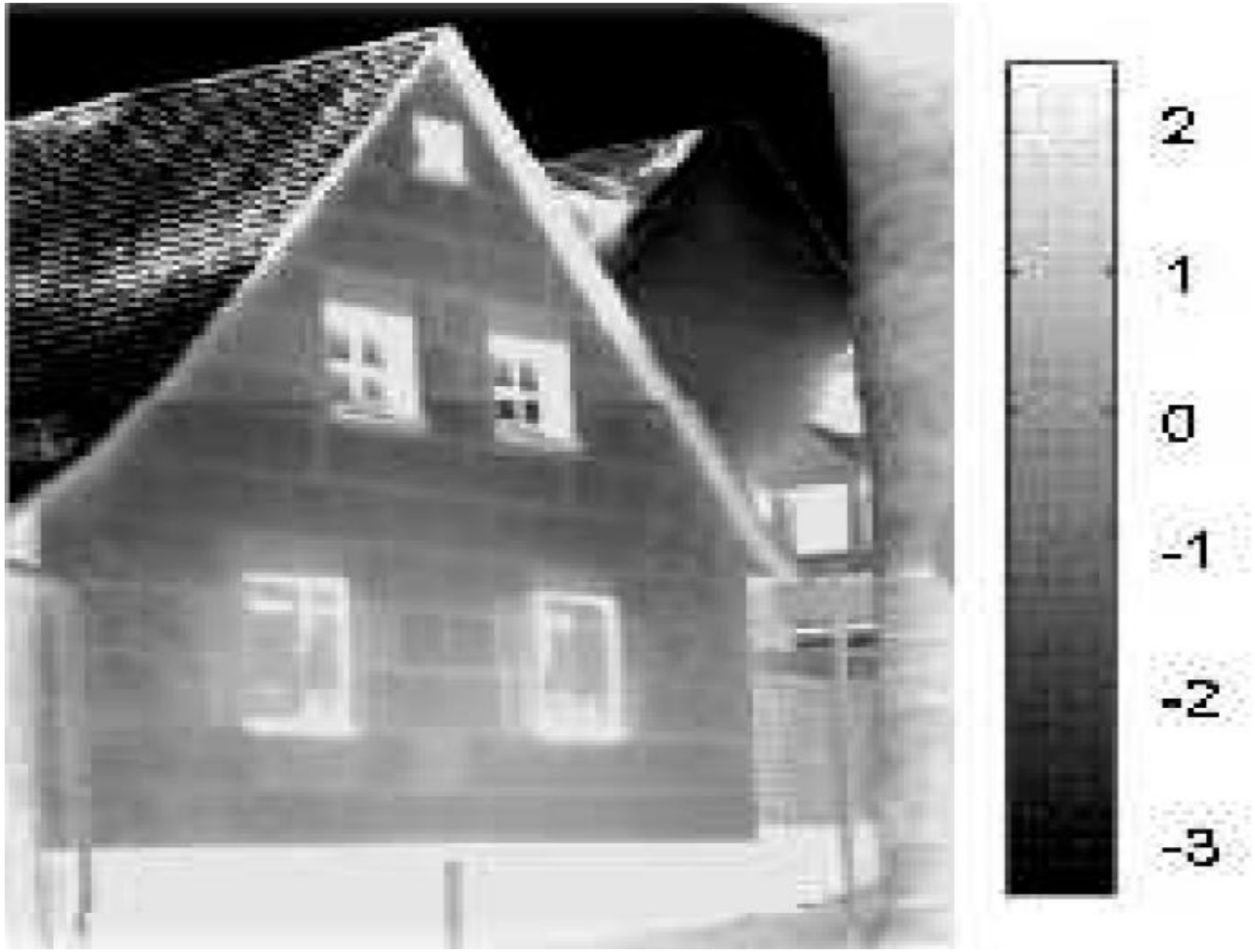
Source: IEA/ECBCS Annex 39

Semi-detached House

Installation

Source: IEA/ECBCS Annex 39

Performance Assessment



Source: IEA/ECBCS Annex 39

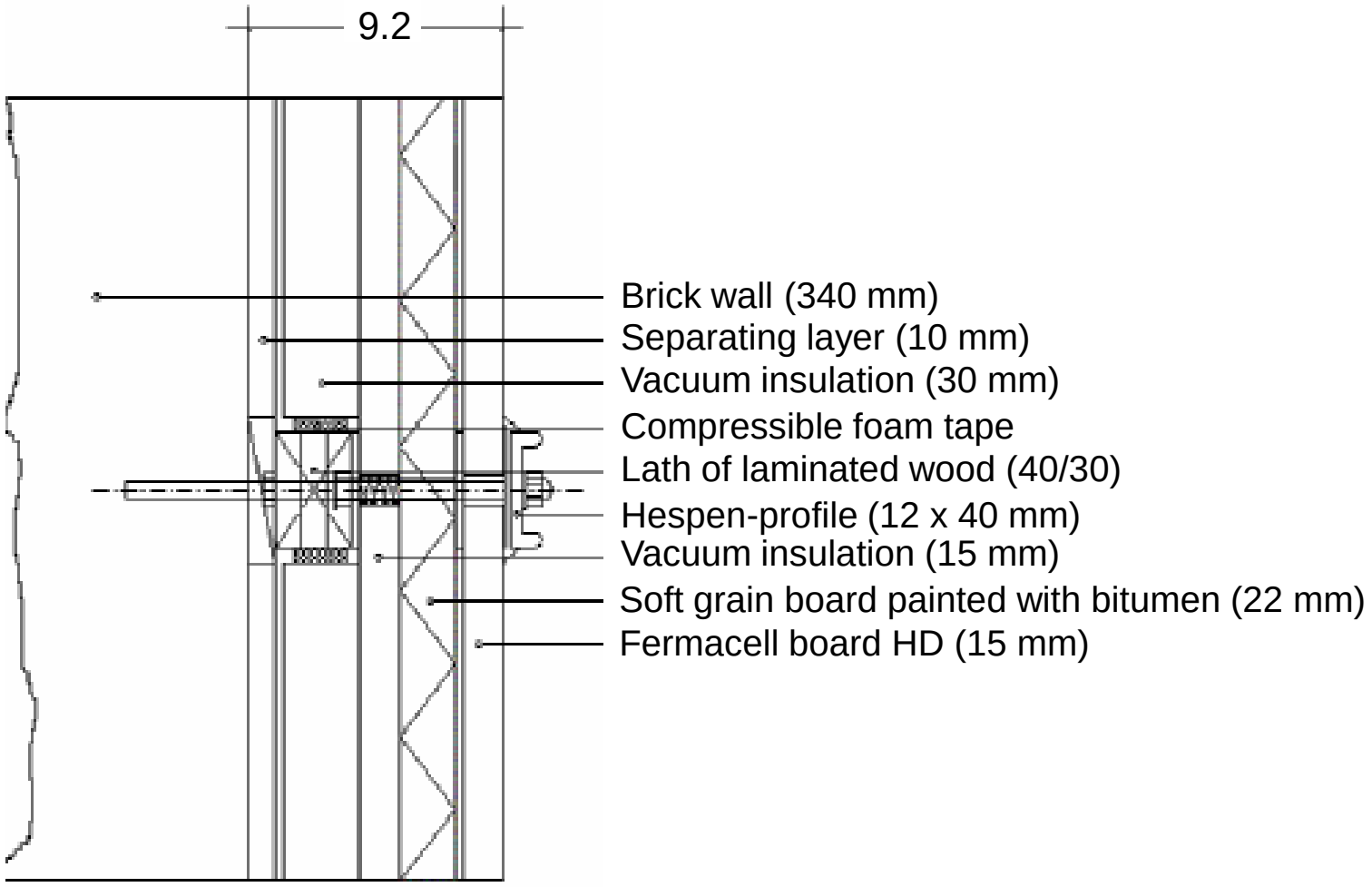
Terraced House (Europe)

Building Envelope Renovation

Source: IEA/ECBCS Annex 39

Terraced House

Cross-section of Insulated Wall

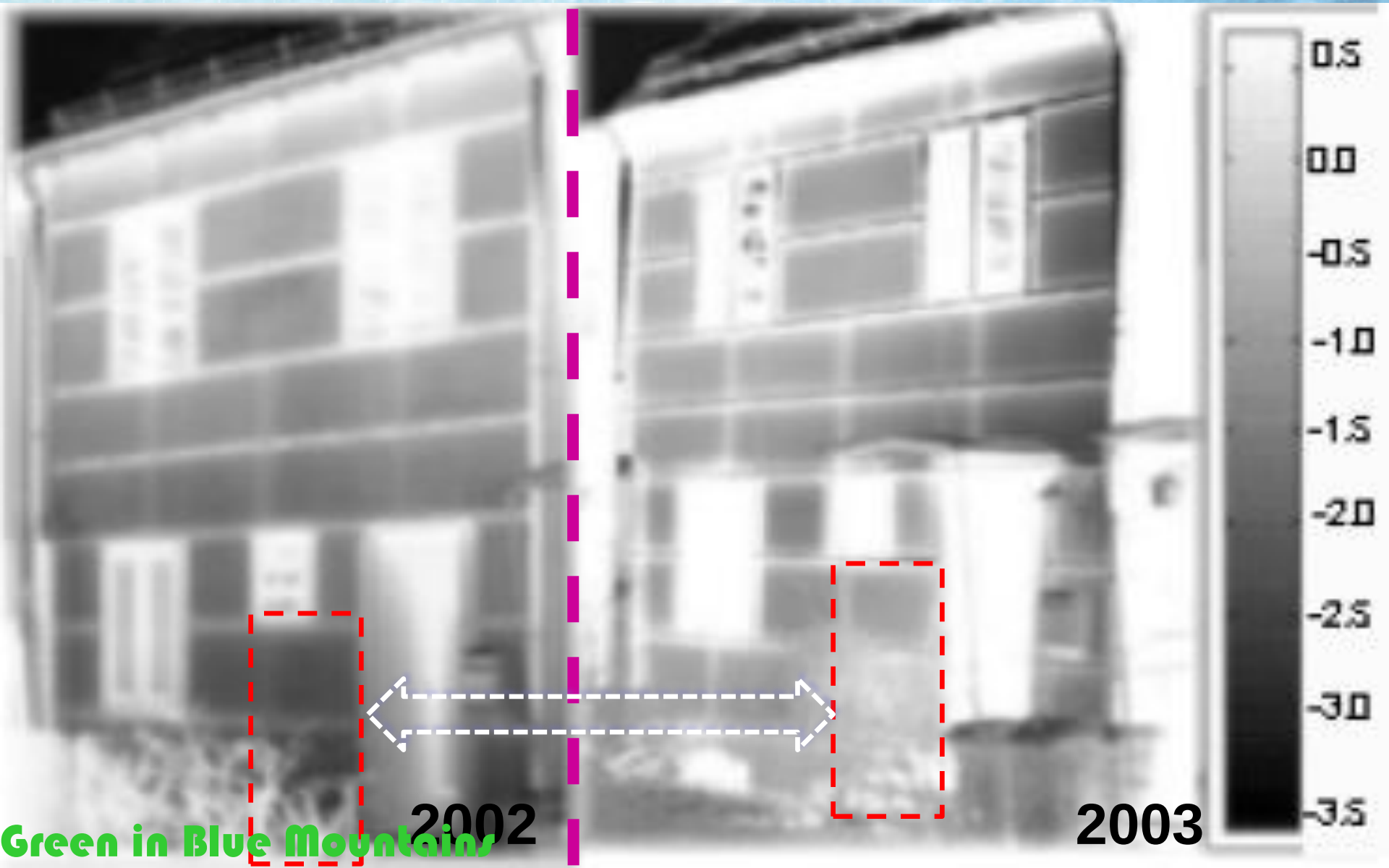


Source: IEA/ECBCS Annex 39

Performance Assessment

Green in Blue Mountains

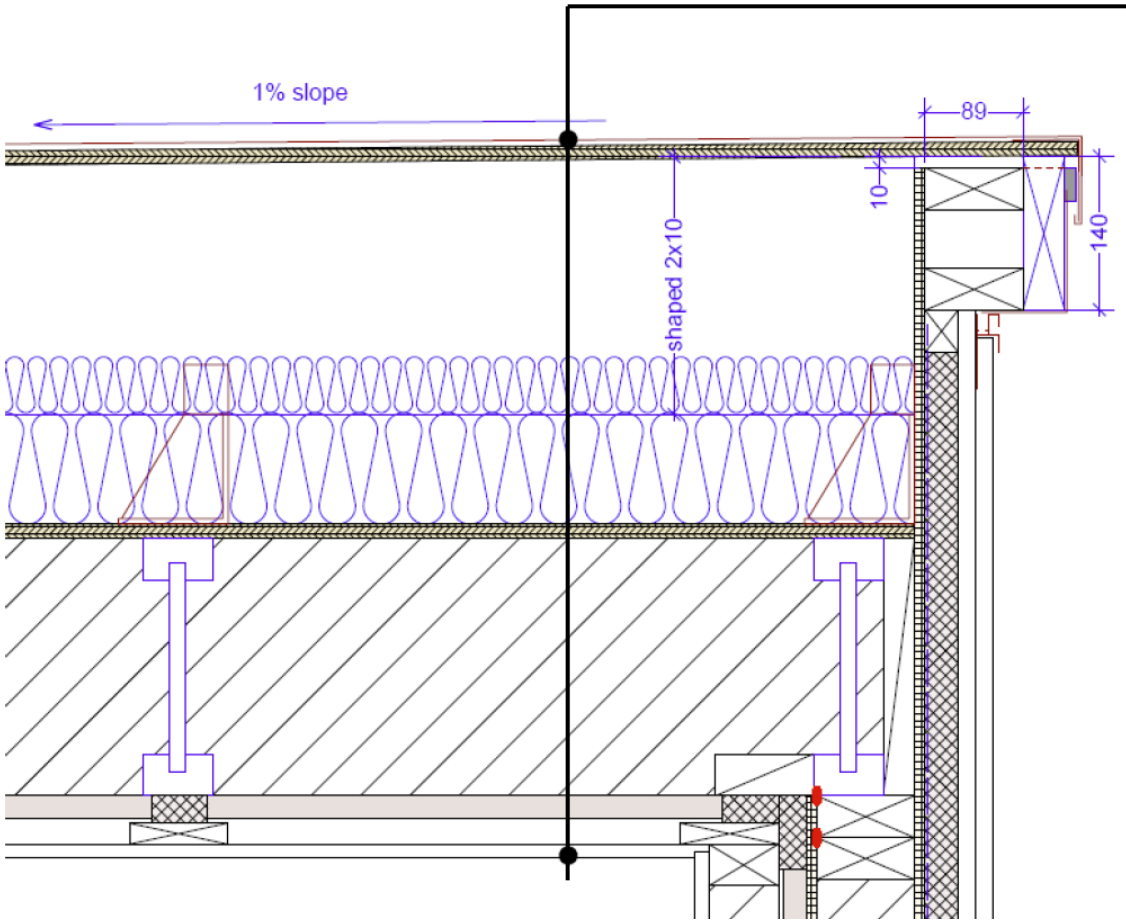
Source: IEA/ECBCS Annex 39



Net Zero Energy Super E House (Japan)

Source: Chris Mattock MRAIC, Habitat Design Plus Consulting Ltd.

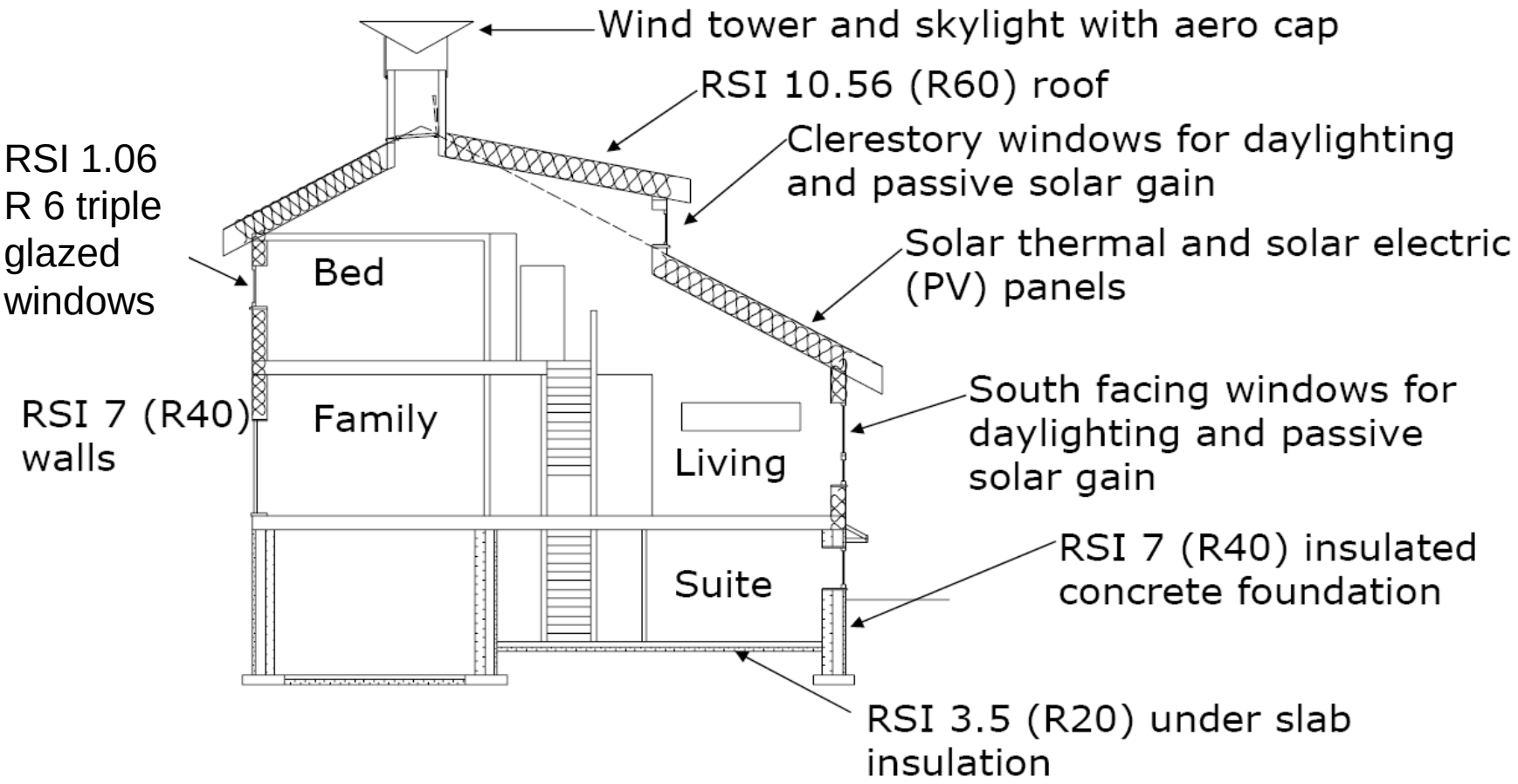
Flat Roof Assembly



TYPICAL FLAT ROOF
Metal roof
Roofing paper
12.5 mm plywood sheathing
shaped 38x184 @ 610mm o.c.
Fibreglass bracket
150 mm Rock wool (R22)
Roofing paper
12.5 mm plywood sheathing
241 mmI-joist @610mm o.c.
241 mm Icynene A.B. (R34.2)
21 mm VIP (R43)
19x89 strapping @610mm o.c.
12.5mm drywall ceiling
Paint finish

Source: Chris Mattock MRAIC, Habitat Design Plus Consulting Ltd.

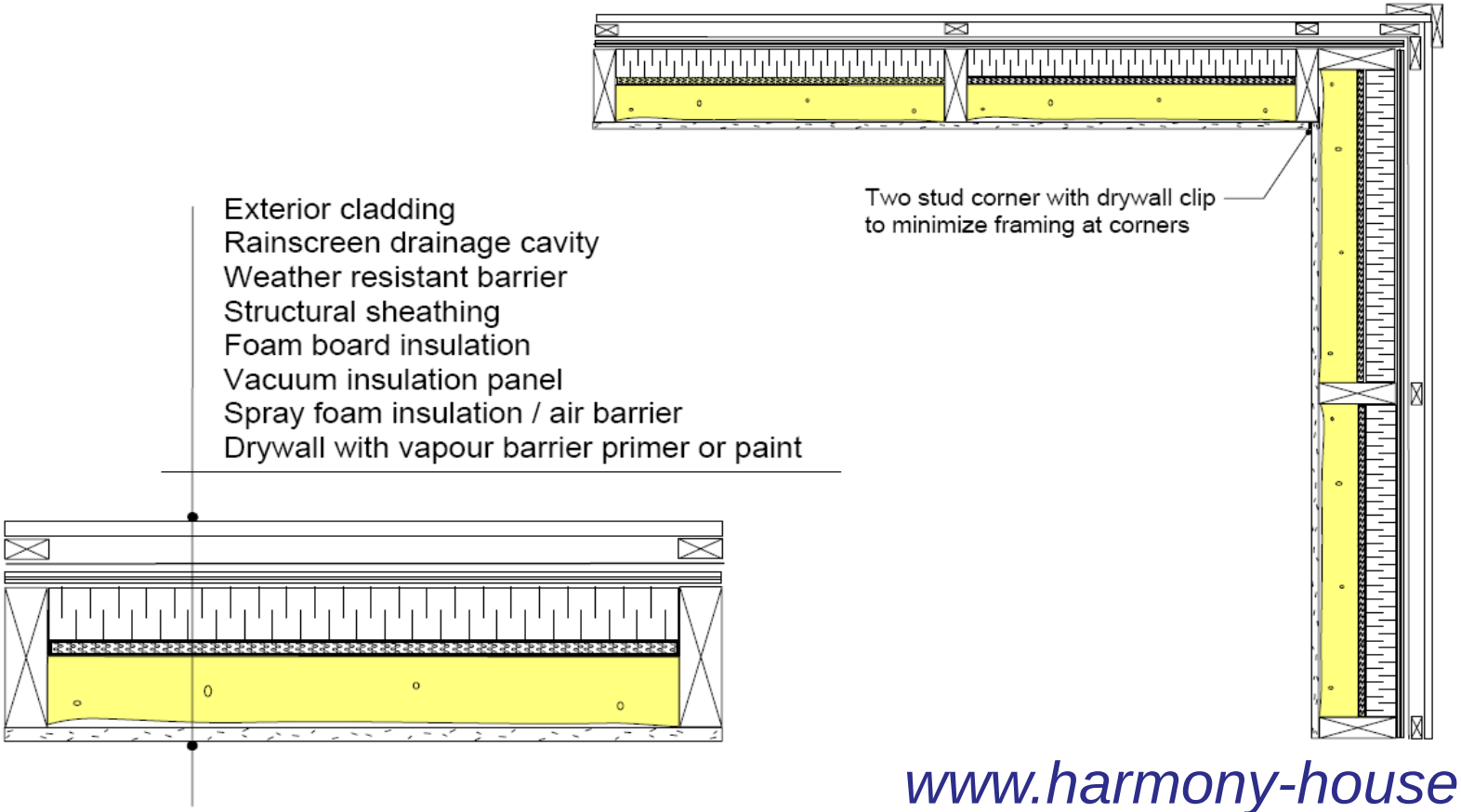
Harmony House Equilibrium Project (Canada)



Source: Chris Mattock MRAIC, Habitat Design Plus Consulting Ltd.

Wall Assembly

RSI 11.9 (R 67.6) Nominal
RSI 6.6 (R 37.7) Composite



www.harmony-house.ca

Source: Chris Mattock MRAIC, Habitat Design Plus Consulting Ltd.

Upcoming Northern Canada Project

House in Yukon

Conclusions

- High performance thermal insulation can be used in various components of the exterior building envelopes.
- Vacuum Insulation Panel (VIP) offers a great new opportunity for the thermal insulation industry in Canada.
- NRC-IRC is in the forefront of VIP technology research and application.

Parting Shot

Keeping it cool

Thanks to a discovery by a Royal Institution scientist, we can all keep our drinks hot or cold.

The thermos flask was the brainchild of James Dewar. He worked on cryogenics, the science of extreme cold and for this he needed to find a way to stop very cold liquids evaporating while he worked with them. He tried boxes insulated with cork, hay or crumpled newspapers, but none kept the liquids cold enough.

Eventually in 1892 he designed the double-walled, silver-coated glass flask shown here. He removed the air between the two walls, creating a vacuum through which heat could not transfer. He used the flask when he first liquefied hydrogen, which at the time was the coldest substance ever produced.

Parting Remarks

All the forces in the world are not so powerful as an idea whose time has come.

Victor Hugo

Insulation and Building Materials Laboratory (IBML)

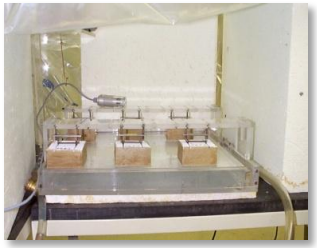
NRC·CNRC

Heat flow metre – thermal conductivity

Measurement to Innovation

Focus Areas

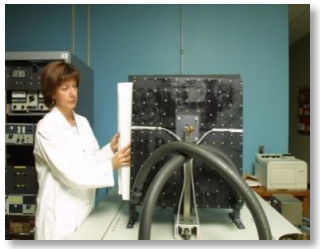
- Thermal and moisture performance assessment of insulation and building materials
- National thermal measurement calibration laboratory
- Research support to CCMC and CCC
- Development of standard test methods
- Analytical techniques for thermal and moisture transport process
- Maintain and enhance unique hygrothermal material property database
- Research on innovative building materials



Partial immersion – water absorption coefficient

Vacuum guarded hot plate – thermal conductivity

Sorption / desorption measurement – sorption / desorption isotherm



Guarded hot plate – thermal conductivity

Pressure plate apparatus – desorption isotherm

Air permeability apparatus – air permeability

Constant temperature and humidity chambers – water vapour diffusion

Thank You

- Natural Resources Canada (NRCan)
- Canada Mortgage and Housing Corporation (CMHC)
- Kingspan Insulated Panels
- Yukon Housing
- Yukon Cold Climate Innovation Centre
- Panasonic Canada
- Energy Solutions Centre
- Yukon College

Upcoming International VIP Conference

NRC-IRC to host 10th International Vacuum Insulation Symposium (IVIS-X)

On 15-16 September 2011, the 10th International Vacuum Insulation Symposium (IVIS-X) will be held in Ottawa with the focus on 'Advances in Applications'.

For more information, visit the website at

www.ivis2011.org

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www.nrc-cnrc.gc.ca/irc

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