Insulation Materials: Environmental Considerations

Better Buildings by Design
February 9, 2012

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BuildingGreen, Inc.

Insulation Materials: Environmental Considerations

What this presentation will cover

- Importance of insulation
- Environmental considerations with insulation
- Insulation materials by type – a sampling of new products, innovations, and trends

Learning Objectives

At the end of this presentation, attendees will be able to:

- Learn how to make informed decisions on insulation material selections;
- Understand why the blowing agents used in certain insulation materials have a huge impact on the environmental footprint of those materials;
- Be able to explain to clients the performance and environmental differences among insulation choices; and
- Understand how some of the new insulation materials coming onto the market can serve your needs.

Importance of insulation

- Insulation is good
  - We want a lot of it
  - Used to argue the more the better
  - From GWP standpoint, sometimes more harm than good
- In colder climates
  - R-10 under floor slab
  - R-20 foundation walls
  - R-40 above-ground walls
  - R-60 ceilings

Passive House in Palo Alto , CA Photo: Alex Wilson

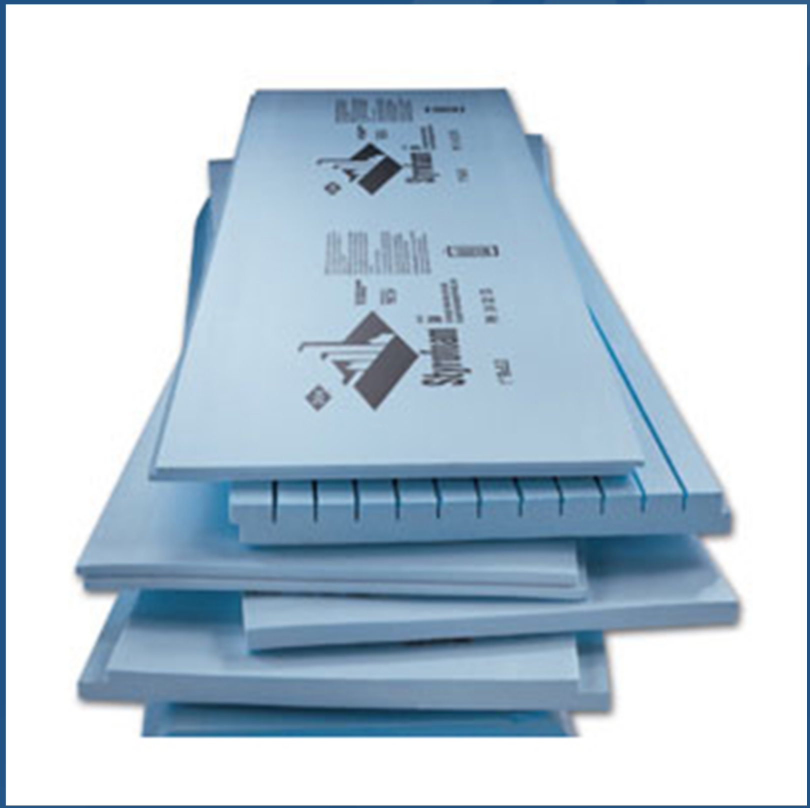
Environmental considerations with insulation materials

- Tremendous variety of insulation materials
  - Widely different forms, properties, environmental characteristics
- How do we evaluate insulation materials relative to the environment?
- What makes one material better than another?
- Relates to both the material and the application

Spray-applied soy-based polyurethane
Photo: BioBase

Energy savings

- Primary role of insulation
- R-value and U-factor
- Function of three modes of heat transfer:
  - Conduction
  - Convection
  - Radiation



Dow Styrofoam

Raw materials and recycled content

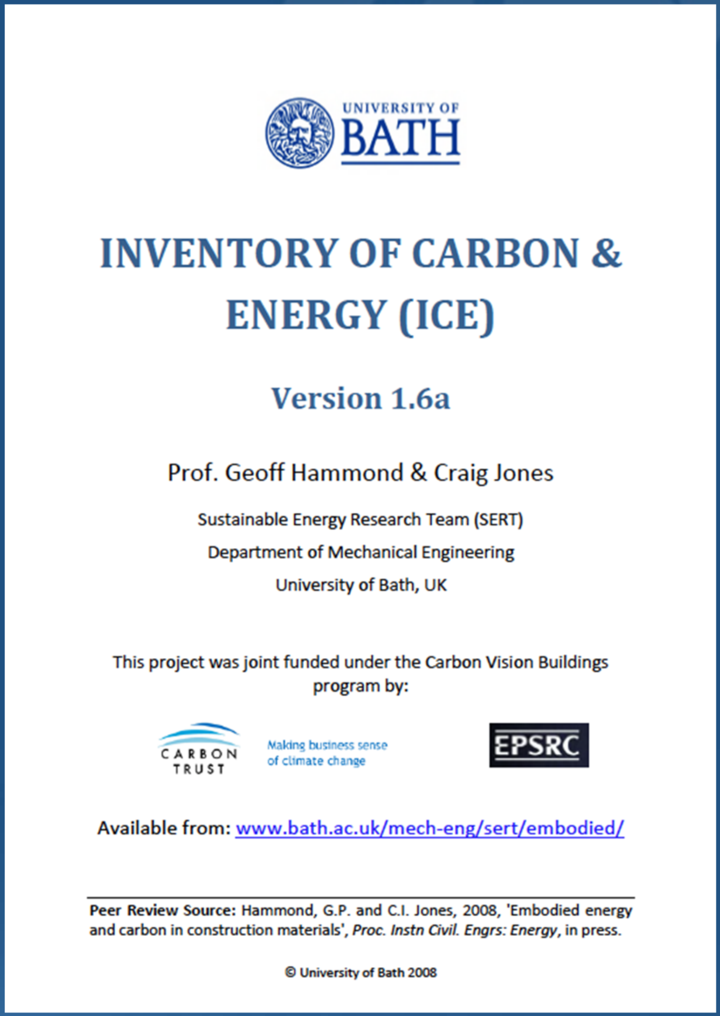
- Where the raw materials come from
- Recycled content is important
- Examples:
  - Cellulose from old newspaper
  - Fiberglass from recycled bottles
  - Cotton insulation from old blue jeans

Bonded Logic factory producing cotton insulation. Photo: Alex Wilson

Embodied energy and carbon

- Energy to make and transport the stuff
- Huge differences among materials:
  - Cellulose the lowest embodied energy
  - Foam plastics much higher
- ICE Database from the U.K. – free

Inventory of Carbon & Energy, Univ. of Bath, Sustainable Energy Research Team



UNIVERSITY OF BATH

INVENTORY OF CARBON & ENERGY (ICE)

Version 1.6a

Prof. Geoff Hammond & Craig Jones

Sustainable Energy Research Team (SERT)
Department of Mechanical Engineering
University of Bath, UK

This project was joint funded under the Carbon Vision Buildings program by:

CARBON TRUST Making business sense of climate change

EPSRC

Available from: www.bath.ac.uk/mech-eng/sert/embodied/

Peer Review Source: Hammond, G.P. and C.I. Jones, 2008, 'Embodied energy and carbon in construction materials', *Proc. Instn Civil. Engrs: Energy*, in press.

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Global Warming Potential (GWP)

- Insulation saves energy—and thus reduces carbon emissions
- But the insulation also has GWP associated with it
- From embodied energy (all mat'ls)
- Blowing agents in extruded polystyrene and closed-cell spray polyurethane foam far greater GWP

Net-zero-energy house with 4" XPS wrapped around 2x6 walls with cellulose. Photo: Bensonwood

Blowing agents in foam insulation

Type of Insulation	Blowing Agent	Atmospheric lifetime (yr)	ODP	GWP
Polyisocyanurate				
Original	CFC-11	45	1	4,750
2nd Generation	HCFC-141b	9.3	0.11	725
3rd Generation	Pentane, cyclopentane		0	7
Spray Polyurethane				
Original	CFC-11	45	1	4,750
2nd Generation	HCFC-141b	9.3	0.11	725
3rd Generation	HFC-245fa	7.2	0	1,030
3rd Generation	CO2		0	1
4th Generation (~2013)	HFO-1233zd	< 0.1	0	7
Extruded Polystyrene (XPS)				
Original	CFC-12	100	1	10,900
2nd Generation	HCFC-142b	17.9	0.065	2,310
3rd Generation	HFC-134a	13.8	0	1,430
4th Generation (~2013)	HFO-1234ze[4]	< 0.1	0	7

Issue addressed in June, 2010 issue of Environmental Building News

Environmental Building News™

The Leading Newsletter on Environmentally Responsible Design & Construction

A Publication of BuildingGreen, LLC www.BuildingGreen.com Volume 19, Number 6 · June 2010

Avoiding the Global Warming Impact of Insulation

Insulation is key to reducing carbon emissions from buildings. But the blowing agents in extruded polystyrene and spray polyurethane foam offset much of that benefit.

by Alex Wilson

TWO COMMON FOAM INSULATION materials are produced with hydrofluorocarbon (HFC) blowing agents that are potent greenhouse gases—extruded polystyrene (XPS) such as Dow Styrofoam of Owens Corning Foamular, and standard closed-cell spray polyurethane foam (SPF). While all insulation materials reduce greenhouse gas emissions (by saving energy), insulating with thick layers of either of these two particular foams results in very long "payback periods" for the global warming potential of the insulation, thwarting even the best attempts to create carbon-neutral buildings. The bottom line is that designers and builders aiming to minimize the global warming impacts of their buildings should choose fiber insulation (cellulose, fiberglass, or mineral wool) or non-HFC foam insulation.

"The more insulation the better" is a common refrain in the green building industry. *EBN* has long advocated very high levels of insulation, particularly in residential and small commercial buildings, which are skin-dominated. At the furthest end of the spectrum is the Passive House movement (see *EBN* Apr. 2010), where it is not uncommon to provide R-50 under a floor slab, R-60 in the walls, and as much as R-100 in the attic. High levels of insulation are seen as a key strategy for achieving net-zero-energy and carbon-neutral performance—the latter meaning that the building will have no net contribution to climate change.

How we achieve high levels of insulation is a very significant issue, however. We rarely pay attention to the fact that insulation materials themselves contribute to greenhouse gas emissions and global warming. This happens in two ways: through the embodied energy of the insulation (the energy use and greenhouse gas emissions that result from manufacturing

(continued on p. 9)

Photo: Bensonwood

Unaware of the recently reported GWP implications of certain foam insulation materials, builder Todd Benson specified four inches of extruded polystyrene over 2x6 studs insulated with dense-pack cellulose in this net-zero-energy home.

In This Issue

Quote of the month:

"Specifying a high-GWP insulation completely defeats the point of using it."

– Scott Shell, FAIA of EHDD Architecture commenting on new information on the global warming potential of insulation materials (page 12)

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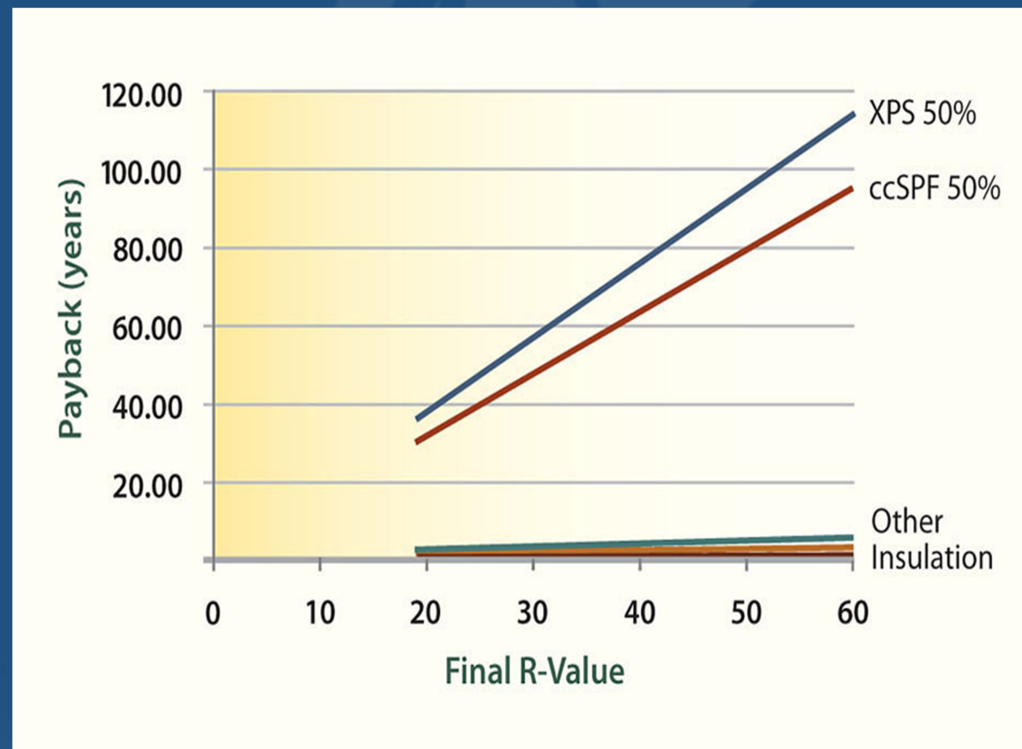
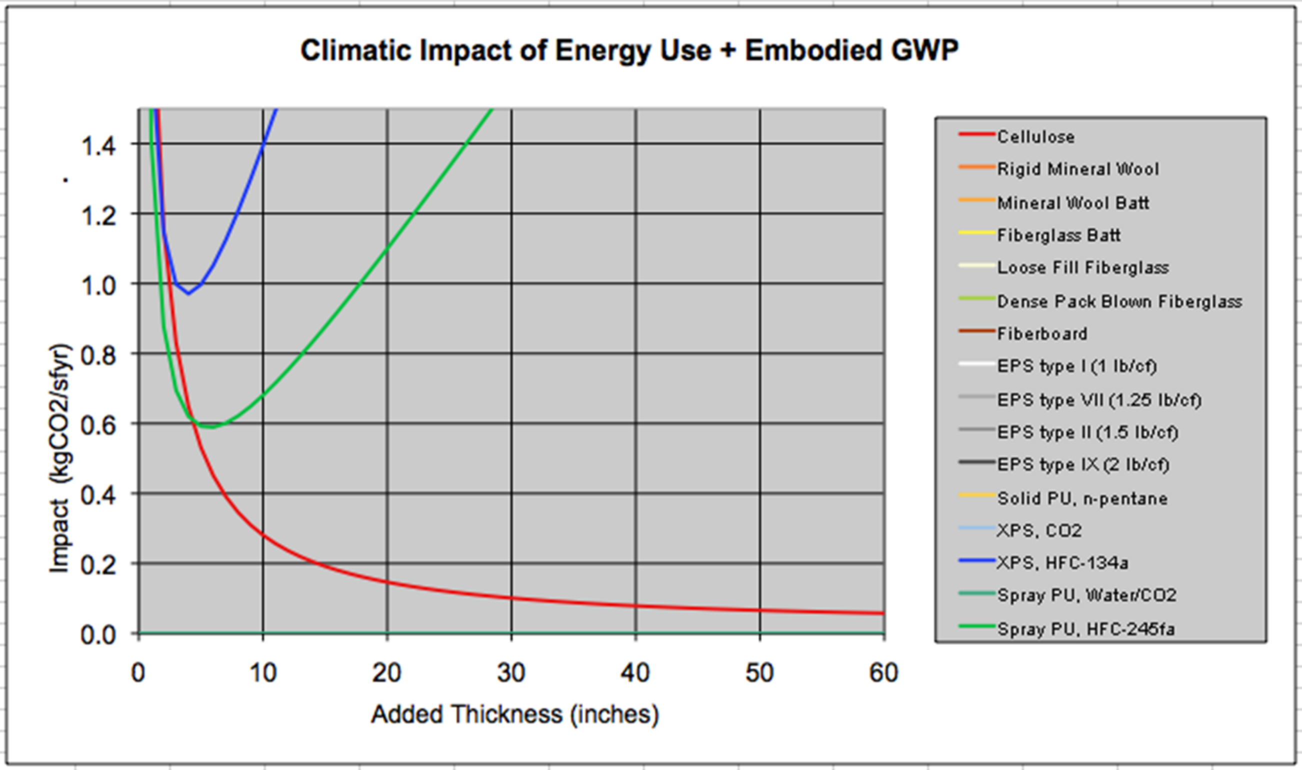


June 2010 Environmental Building News

Calculating the GWP of insulation – David White's calculator

Total Climatic Impact of Insulation	
Inputs	
Climate HDD (°Fd)	6,000
Reference R Value	2
Heating Fuel	Natural Gas
Heating Efficiency/COP	0.90
Life Span of Insulation (Years)	50
BA Release Rate	High
Chart Type	Thickness
R Value Chart x-axis maxiumum	60
Thickness Chart x-axis maximum	10
Chart y-axis maximum	1.5
Displayed in Graph (mark with "x")	
Cellulose	x
Rigid Mineral Wool	
Mineral Wool Batt	
Fiberglass Batt	
Loose Fill Fiberglass	
Dense Pack Blown Fiberglass	
Fiberboard	
EPS type I (1 lb/cf)	
EPS type VII (1.25 lb/cf)	
EPS type II (1.5 lb/cf)	
EPS type IX (2 lb/cf)	
Solid PU, n-pentane	
XPS, CO2	
XPS, HFC-134a	x
Spray PU, Water/CO2	
Spray PU, HFC-245fa	x



www.RightEnvironments.com - download

Hazardous chemical constituents - formaldehyde

- Formaldehyde a "known human carcinogen" (12th U.S. Report on Carcinogens - 2011)
- Phenol-formaldehyde used in some fiberglass and all mineral wool insulation
- Less formaldehyde offgassing from phenol formaldehyde than urea-formaldehyde

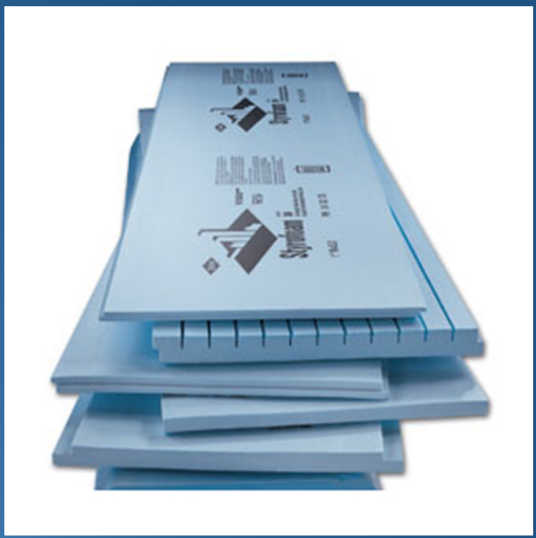
Photo: Peter Yost

Hazardous chemical constituents – Flame Retardants

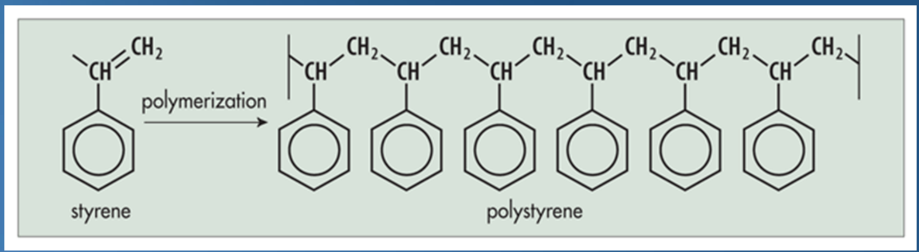
- Growing concern with brominated flame retardants
- PBDEs being phased out
- HBCD, used in all polystyrene building insulation, next in line?
- Also concern with chlorinated flame retardants used in polyisocyanurate and SPF

EPS widely used in Sweden – Alex Wilson photo

Will HBCD be next?
Impact on polystyrene



Dow Styrofoam and EPS board - images from HomeConstruction Improvement.com



August, 2009 issue of EBN

Environmental Building News™
The Leading Newsletter on Environmentally Responsible Design & Construction
A Publication of BuildingGreen, LLC www.BuildingGreen.com Volume 18, Number 8 · August 2009

Polystyrene Insulation
Does It Belong in a Green Building?

by Alex Wilson

POLYSTYRENE, IN BOTH EXTRUDED and expanded forms, is very widely used as rigid insulation in North America and worldwide. In below-grade applications, owing to its good insulation value, superb moisture resistance, strength, performance, and affordability, polystyrene dominates the market.

But a chemical that's added to polystyrene to provide fire resistance has recently raised significant concerns. Indeed, the European Union may be on the verge of significantly restricting the use of this chemical—HBCD. Given other environmental concerns about polystyrene, this latest development raises the question of whether this insulation material belongs in green buildings at all.

This article describes why polystyrene is such a popular insulation material, reports on new information about health and environmental concerns about the material, and examines alternatives that are available to the building industry—especially in below-grade applications where polystyrene is ubiquitous.

About Polystyrene

Polystyrene had its origins in 1839 when a German apothecary, Eduard Simon, accidentally formed a jelly-like substance from resin he had collected from a Turkish sweetgum tree. It was not until the early 1920s that another German chemist, Hermann Staudinger, figured out that the mysterious substance Simon created was a polymer and developed his theories of polymer chemistry, for which he was later awarded the Nobel Prize in chemistry. In 1930, scientists at the pioneering German company Badische Anilin & Soda-Fabrik (known today as BASF) figured out how to synthesize this hard plastic—polystyrene—and the company remains one of the leading manufacturers of polystyrene chemicals today.

In 1937, Dow Chemical introduced polystyrene plastic to the United States, and in 1953 the company introduced a lightweight, *foamed* version of the polymer as an insulation material, trademarked Styrofoam. Dow chemist Ray McIntire invented Styrofoam by accident when he sought to make a new

(continued on p. 10)

Rigid mineral wool can be an excellent substitute for polystyrene, owing to its moisture repellency and insect resistance. Photo: Rockwool International A/S

In This Issue

Quote of the month:

"It is absolutely essential that we introduce this issue of performance into LEED."

– Scot Horst, U.S. Green Building Council, on new energy- and water-performance reporting requirements.

(page 2)

August, 2009 issue of EBN

Hazardous chemical constituents – Boric acid flame retardant

- New concern with boric acid, the most common flame retardant in cellulose
- Added in 2010 to the list of “substances of very high concern” by the European Chemicals Agency—first step in listing of chemical in the REACH program
- BuildingGreen digging into this issue and will report on it

Damp-spray cellulose – screeding surface Photo: EnerSol

Hazardous chemical constituents – styrene

- Constituent of both extruded and expanded polystyrene
- Just classified as "reasonably anticipated to be a human carcino-gen" (12^{th} Report on Carcinogens)

12" of XPS used in passive house foundation– Jordan Dentz photo

Hazardous chemical constituents – Isocyanates

- Spray polyurethane foam (SPF) has two components
  - Polyol
  - Isocyanate
- Isocyanate toxic; U.S. EPA looking into risk
- Skin, eye and lung irritation; chemical sensitation
- Precursor to isocyanate, 4,4'-diaminodiphenylmethane (MDA), added to list of "substances of very high concern" by the European Chemicals Agency (REACH Program)

Closed-cell SPF – John Straube photo

Other IAQ Concerns

- Fiber shedding
  - Respirable fibers from fiberglass and mineral wool
  - Potential carcinogen
- Moisture and mold
  - Can be an issue with almost any insulation material
  - Importance of air barriers and vapor retarders

Fiberglass installed in a Cape Cod basement
Photo: Alex Wilson

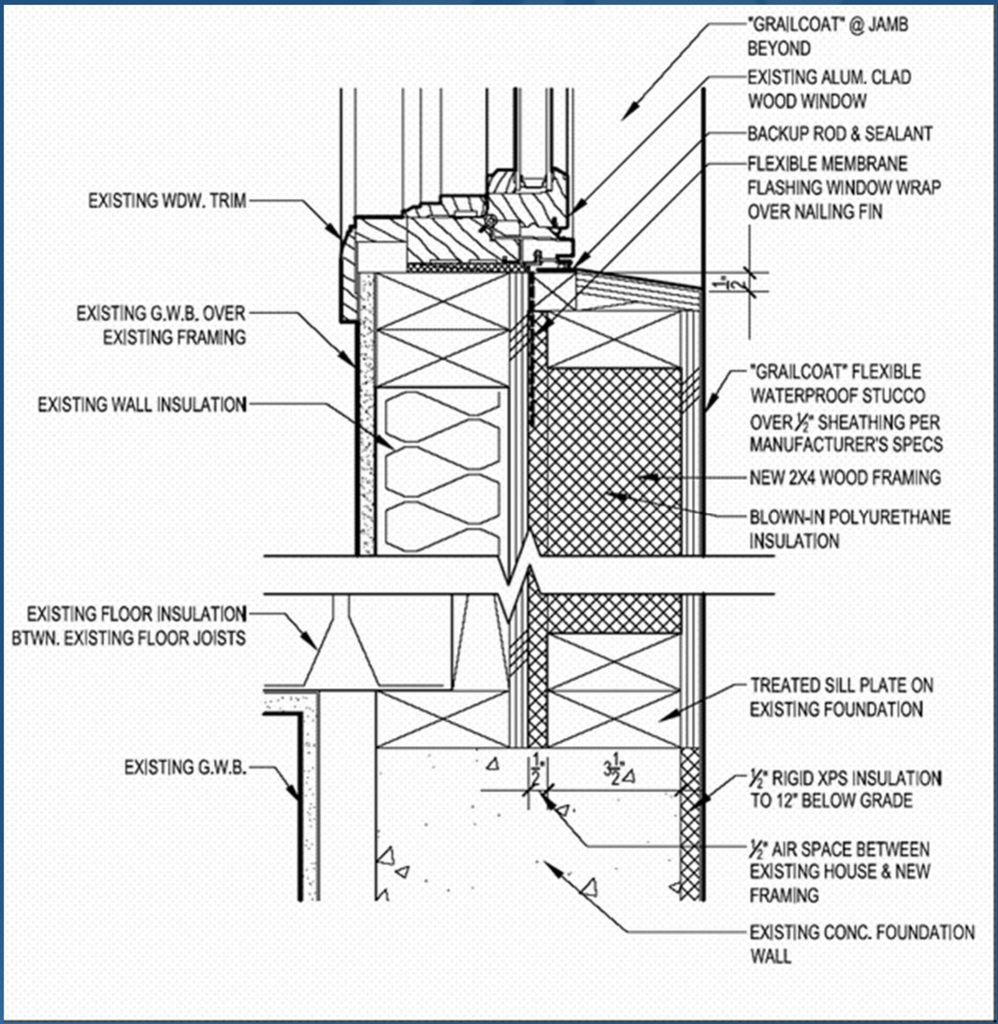
End-of-Life issues with insulation

- Recyclable?
  - Can old insulation be recycled into new insulation – or something else?
  - Very limited options today
- Safe disposal
  - Release of environmental or health hazards
  - Especially blowing agents

Charlotte, NC landfill

Long-term performance and durability

- Moisture dynamics
  - Can be pretty complicated!
- Decomposition and decay
  - Not only of the insulation, but other components
- Fire resistance
  - Issue in some situations
- R-value drift
  - Only an issue with insulation using low-conductivity gas fill

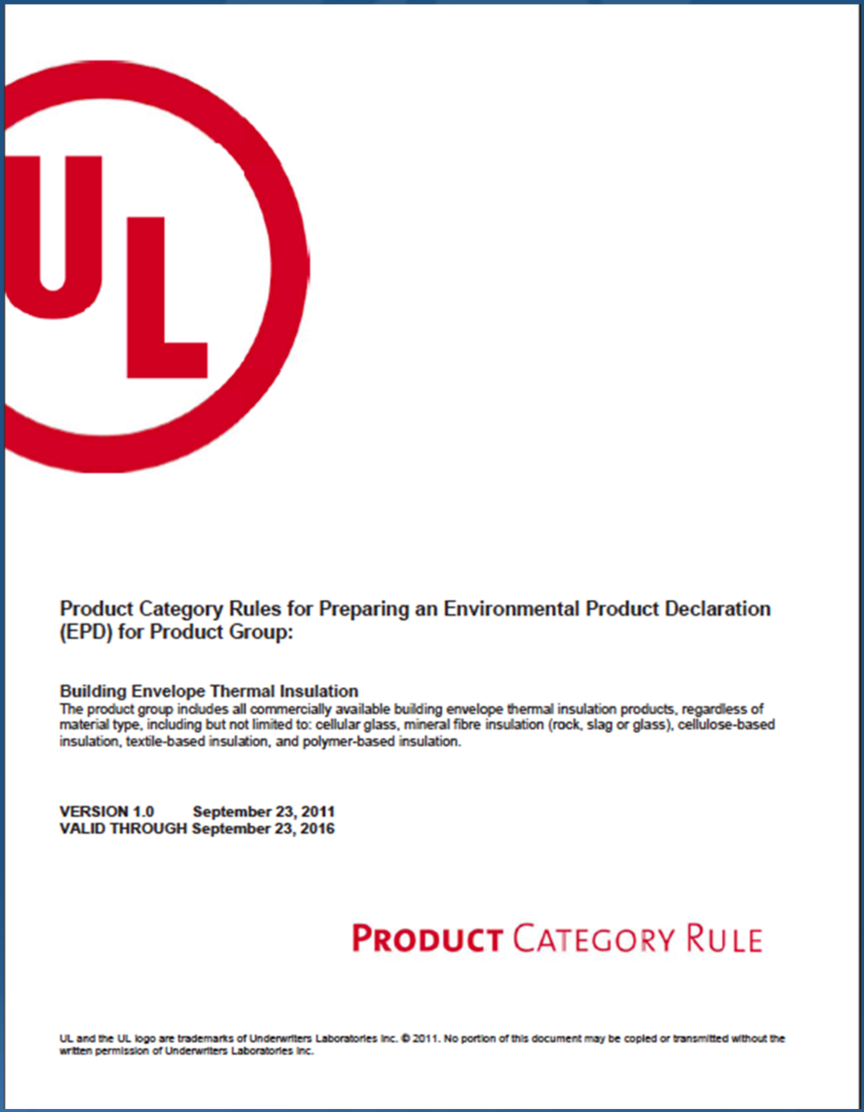


Source: Eric Daub

Environmental Product Declarations (EPDs) for insulation

- UL-Environment published “Product Category Rule” for preparing EPDs on insulation
- Coalition of all the trade organizations representing insulation manufacturers
- Life-cycle assessment (LCA) from raw material acquisition through disposal/recycling
- Environmental Attributes
  - Global warming
  - Acidification
  - Eutrophication
  - Smog creation potential
  - Ozone depletion potential

UL-Environment
Published Sept. 2011



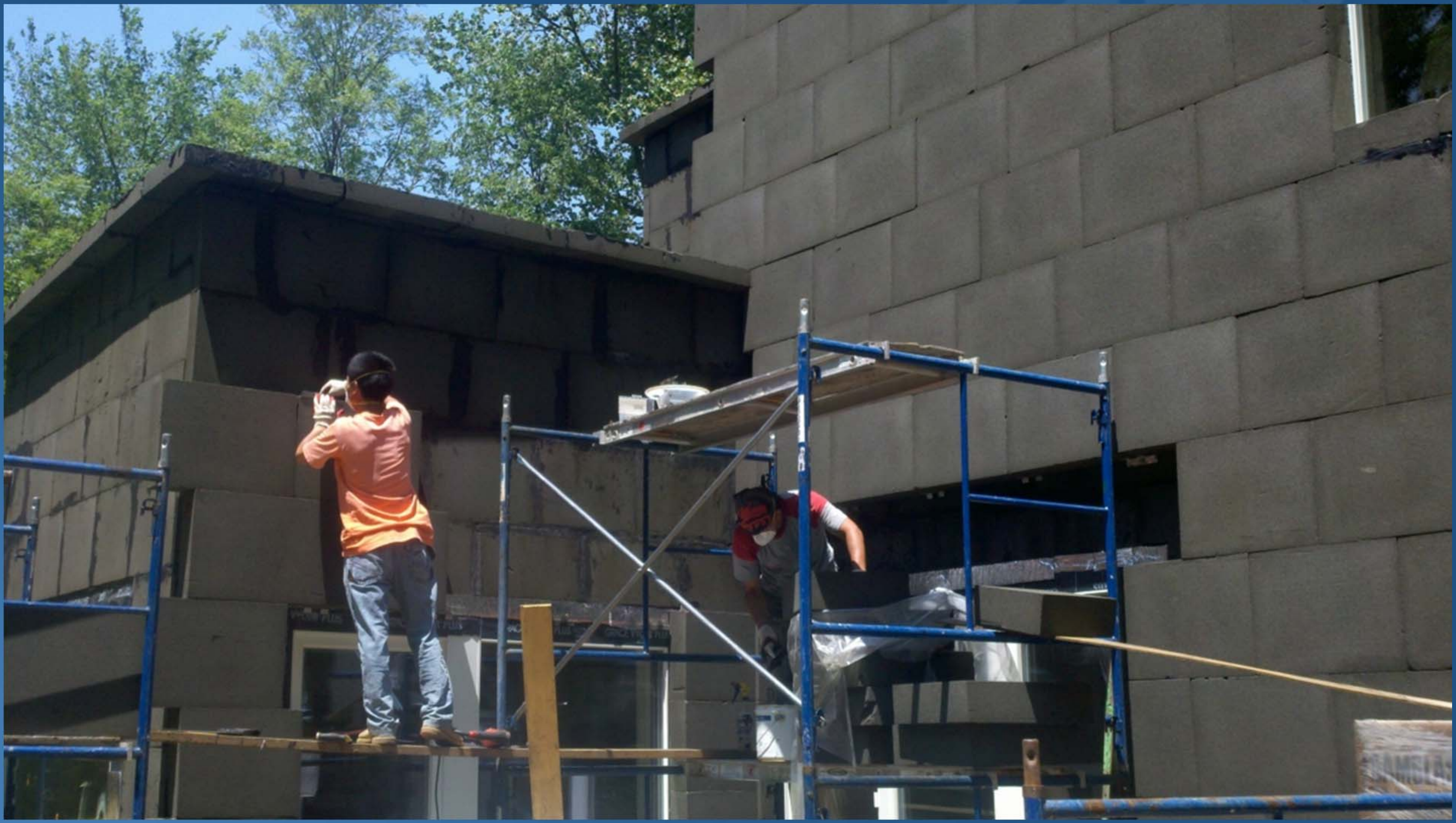
Product Category Rules for Preparing an Environmental Product Declaration (EPD) for Product Group:

Building Envelope Thermal Insulation
The product group includes all commercially available building envelope thermal insulation products, regardless of material type, including but not limited to: cellular glass, mineral fibre insulation (rock, slag or glass), cellulose-based insulation, textile-based insulation, and polymer-based insulation.

VERSION 1.0 September 23, 2011
VALID THROUGH September 23, 2016

PRODUCT CATEGORY RULE

Insulation materials by type – A sampling of products & trends



Passive House in Westport, Connecticut insulated with 12" of Foamglas insulation

Fiberglass - non-formaldehyde products

Batts: ≈R-3.3/in

Photos: Owens Corning (above) and CertainTeed

- 2002 Johns Manville – acrylic binder
- 2009 Knauf introduced Ecose biobased binder in 2009
- In 2010, CertainTeed introduced its new “Sustainable Insulation” with bio-based binder
- 2011 – Owens Corning EcoTouch (now converted entire line of batt and loose-fill insulation)

Spray-applied fiberglass

JM Spider from Johns Manville

- Blow-in-Blanket option – using mesh
- Spray-in fiberglass with binder (JM Spider®)
  - Allows use in open cavity
  - A lot of building science experts like this option
  - Also free of formaldehyde

R/inch: 3.7 - 4.2

Spray-applied fiberglass – JM Spider

Cellulose insulation – growing market share

Damp-spray cellulose Photo: EnerSol

- High recycled content - over 80%
- Better air leakage control than fiberglass batts
- Damp spray and dense-pack
- With damp-spray, excess captured for reuse
- Made with borate (or boric acid) flame retardant and/or ammonium sulfate

R/inch: -3.6 - 3.9

Cellulose insulation

Cellulose insulation - damp-spray and dense-pack behind mesh
Photo: EnerSol

Mineral wool – an alternative to polystyrene rigid insulation

Rockwool International

Boardstock: R-3.7 - 4.3/in

- Growing interest in rigid mineral wool
- No flame retardant
- Totally fire-safe
- Inert
- Superb drainage below-grade
- Resistant to termites
- High recycled content
- Contains phenol-formaldehyde binder, but very low emissions

Thermafiber– highest recycled content

Thermafiber rigid mineral wool insulation products

Rigid mineral wool for sub-slab

Toprock installation in the Vancouver area - Photo: Roxul

- Rigid mineral wool
- Roxul Toprock
- Mainly used for roofs, but recent applications beneath slabs
- Zero GWP
- Should be cost-competitive with XPS
- Not as available

Cotton insulation – recent developments

- Bonded Logic now using 100% post-consumer recycled cotton
  - Batt
  - Soundboard
- Redesigned batts easier to cut
  - Factory-scored
- New manufacturer – Applegate
- Also using boric acid flame retardants, though

Bonded Logic factory
Photo: Alex Wilson

Batts: ≈R-3.4/in

Cotton insulation – Bonded Logic

Bonded Logic factory, Phoenix. Photo: Alex Wilson

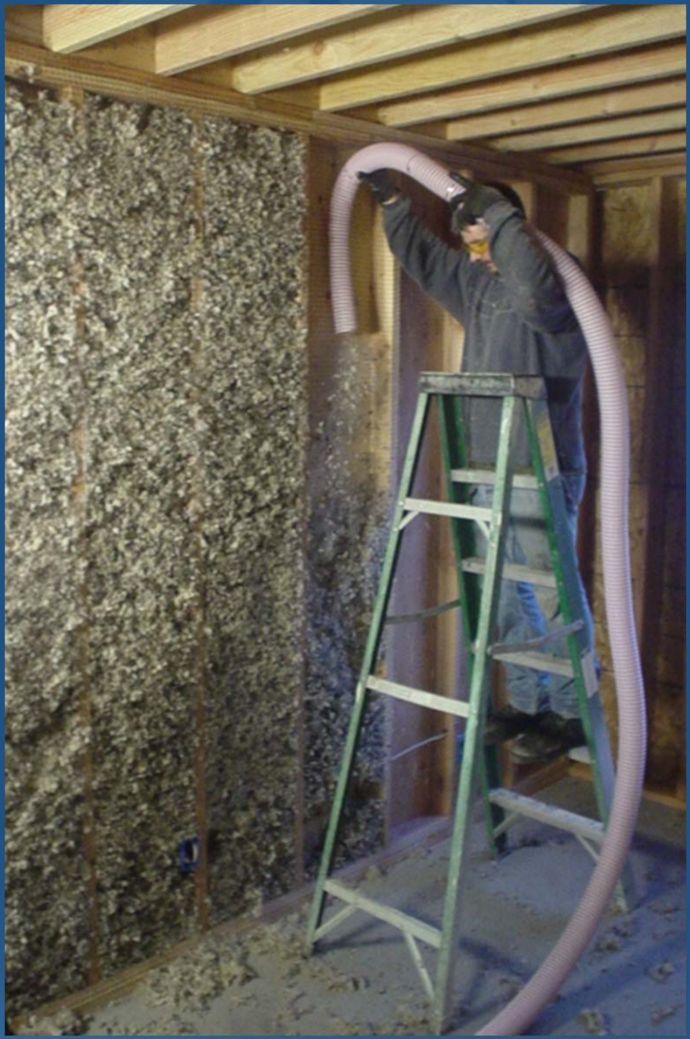
Polyester batt insulation

Vita Nonwoven - EnGuard

- Dow Chemical had a product for a year or two – SafeTouch
  - Discontinued in 2011
- Vita Nonwoven EnGuard
  - 50% recycled content
- Polyester batts meet fire codes – because of the way the ASTM E-84 test is designed

Batts: ≈R-3.7/in

Sheep's wool insulation



Oregon Shepherd
loose-fill wool insulation

Loose-fill: ≈R-3.5/in

Perlite loose-fill insulation

DFL Minmet Refractories Corp.

R-2.4 - 3.7/in

- Expanded perlite used in horticulture and as a building insulation
- Relatively uncommon today – but attractive environmentally
- Over 20 manufacturers
- Totally inert, firesafe
- R-value up to R-3.7 per inch
- Not related to vermiculite, which is often contaminated with asbestos

Polyisocyanurate

Fine Homebuilding photo

R-6.0 – 6.5/in

- Blowing agent not significant contributor to global warming
  - GWP of 7 instead of over 1,400 (HFC)
- Chlorinated rather than brominated flame retardant (TCPP)
- It may be possible to meet codes without any flame retardant
- Thermoset plastic rather than thermo-plastic
- Same concern with MDA (precursor to making isocyanate)

Polyisocyanurate

- Able to stack multiple layers to achieve high R-values
- Can serve as air barrier if joints taped
- Highest R-value of any common insulation material today

Photo: John Straube

Extruded polystyrene (XPS)

- Great properties
  - Moisture proof
  - Good R-value
  - Durable
  - Inexpensive
  - Recycled content - Pactiv
- Three problems
  - High GWP blowing agent (1,430)
  - HBCD flame retardant
  - Styrene a possible carcinogen 12th Report on Carcinogens

R-5.0/inch

House in Naperville, IL wrapped with XPS
Photo: Alex Wilson

Could polystyrene be reformulated for below-grade to eliminate flame retardants?

Photo: Bensonwood

- Building codes do not require fire-resistant ratings when separated from living space by 1” masonry or concrete
- Possible to offer line of non-FR polystyrene labeled for below-grade
- Industry focusing, instead, on alternatives to HBCD

Expanded polystyrene (EPS)

- Pentane instead of HFC blowing agent
- Can use in sub-slab applications – higher density recommended
- Still has HBCD flame retardant
- This is PolyForm's T&G EPS insulation
  - R-10 for 2.5" thickness
  - Cost-competitive with XPS

PolyForm T&G EPS insulation
Photo: John Straube

R-3.7 - 4.5/inch

EPS for sub-slab

Photo: John Straube

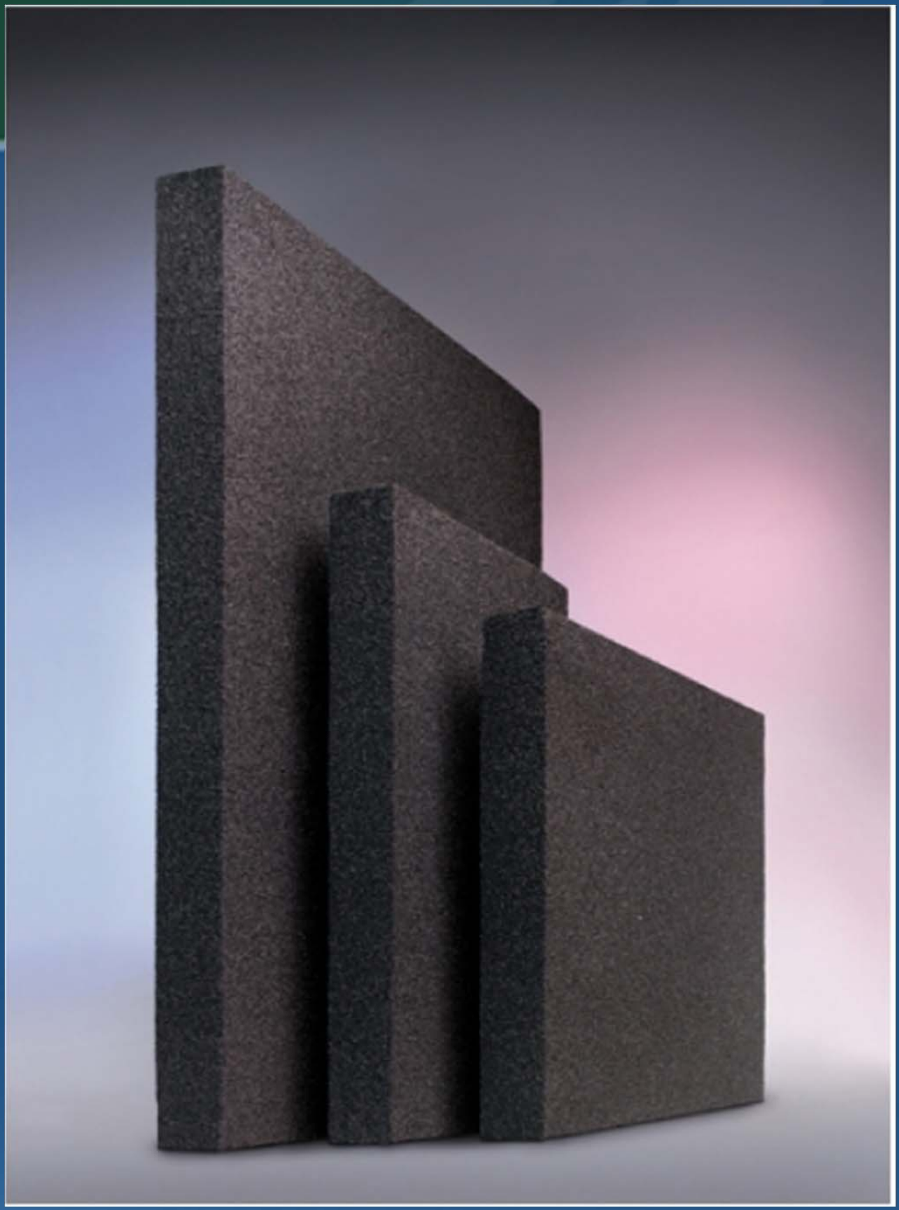
Cellular glass: Foamglas

- Produced since 1937
- Alternative to XPS for foundations & sub-slab
- 100% inorganic - noncombustible without flame retardants
- High compressive strength
- CO_2 as fills the cells, not HFC (GWP of 1 vs. 1,400)
- Made in the U.S. and can be shipped anywhere
- 2-1/2 times as expensive as XPS
- R-3.4 per inch

Foamglas with bitumen facing
Photo: Pittsburgh Corning

R-3.4/inch

Foamglas



Unfaced Foamglas
Photo: Pittsburgh Corning

Closed-cell spray polyurethane foam (SPF)

Biobase water-blown SPF - Photo: Biobase

R-5.5 - 6.0/inch

- Most made with HFC 245fa blowing agent
- Water-blown products were available (near zero GWP)
- Bio-based products with some soy polyol replacing standard polyol
- Some installation and performance concerns with water-blown formulations – still a work in progress
- Isycyanate concern

Open-cell spray polyurethane foam (SPF)

- Water-blown (near zero GWP)
- More flexible than closed-cell – cracks unlikely
- Overfill cavities, screed off extra
- Lower R-value than closed-cell, but still good (about R-3.7 per inch)
- Isycyanate still a health concern
- Chlorinated flame retardant (TCPP) still used

Open-cell SPF - Photo: Icynene

R-3.7/inch

Cementitious foam - Air Krete

Photo: Air Krete

- 100% inorganic
- Magnesium oxide cement
- Inert, noncombustible
- Friablility the biggest drawback
  - Requires careful controls during installation

R-3.9/inch

Air Krete – masonry applications

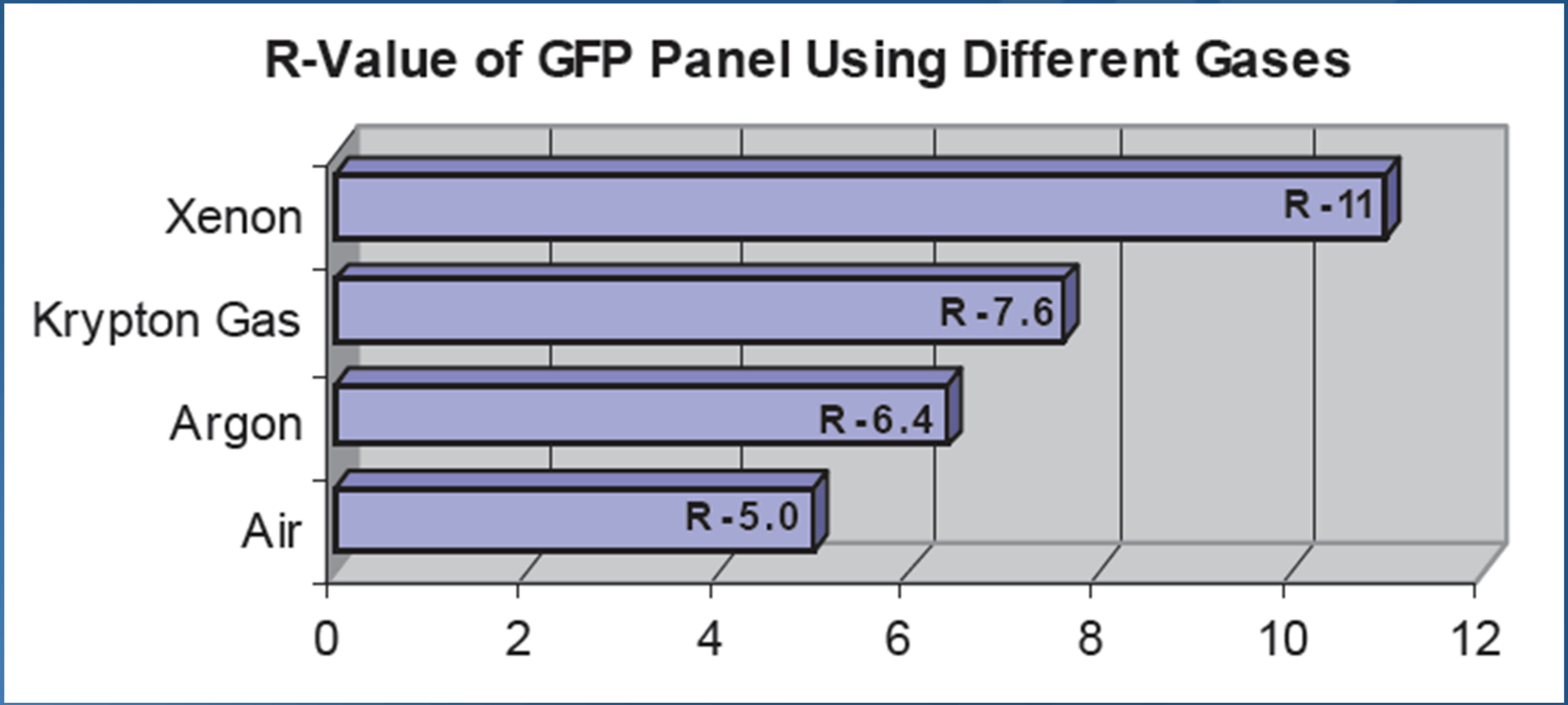
Photos: Air Krete

Gas-filled panels

Photo: FiFoil

- Honeycomb structure filled with low-conductivity gas
- Same principle as glazings using gas-fill
- Technology developed at Lawrence Berkeley National Lab
- Licensed to FiFoil (manufacturer of radiant insulation)
- Long-term performance uncertain

Gas-filled panels – R-value 1.5” thickness



R-value of 1.5” thick panel. Source: FiFoil

Translucent insulation - Silica Aerogel

- Granules of silica aerogel – the lightest-weight solid known
- Spongy, translucent
- Can be used in glazing (for daylighting)
- Also applications as appliance insulation
- Made by Cabot Corp. – Lumira (was called Nanogel)

Photo: Cabot Corp.

≈R-8/inch

Silica Aerogel

Nanogel Properties

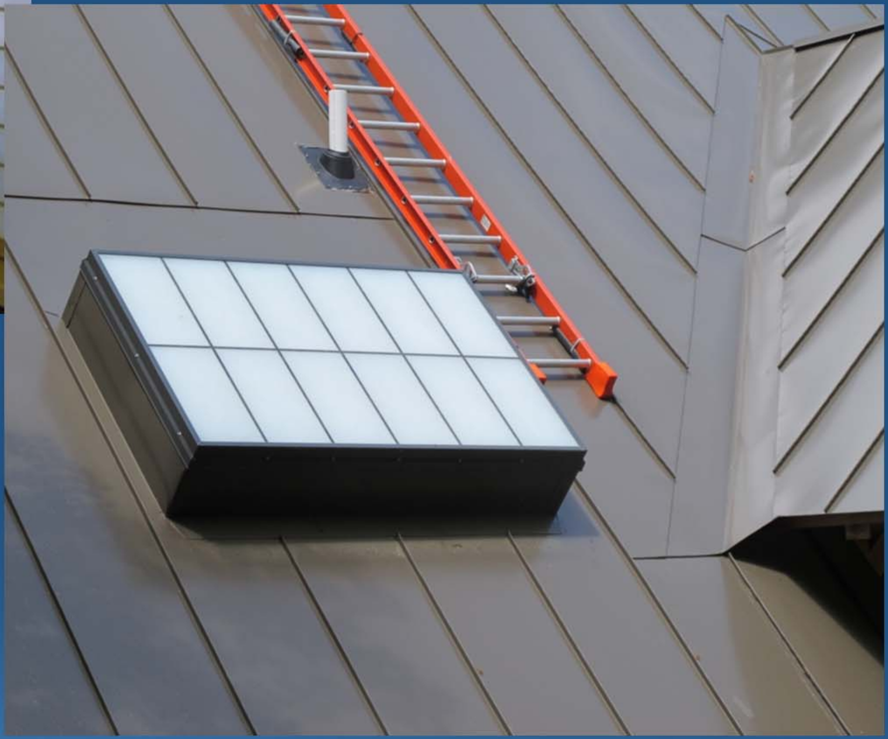
Aerogel Thickness	Solar Heat Gain Coefficient	Visible Lght Transmission	U-Factor (Btu/hr· ft²· ° F)	K-Factor (W/m²· K)	R-Value (hr· ft²· ° F/Btu)
0.50" (13 mm)	0.73	73%	0.250	1.40	4.0
1.00" (25 mm)	0.52	53%	0.125	0.70	8.0
1.25" (31 mm)	0.43	45%	0.100	0.57	10.0
1.50" (38 mm)	0.39	39%	0.083	0.47	12.0
2.00" (50 mm)	0.26	26%	0.063	0.35	15.9
2.50" (64 mm)	0.21	21%	0.050	0.28	20.0

Source: Cabot Corporation

From Environmental Building News

Silica Aerogel – turning glazing into insulation

Translucent wall panels
Photo: Cabot Corp.



Lumira skylight on
home in Warren, VT
Photo: Alex Wilson.

Vacuum insulation

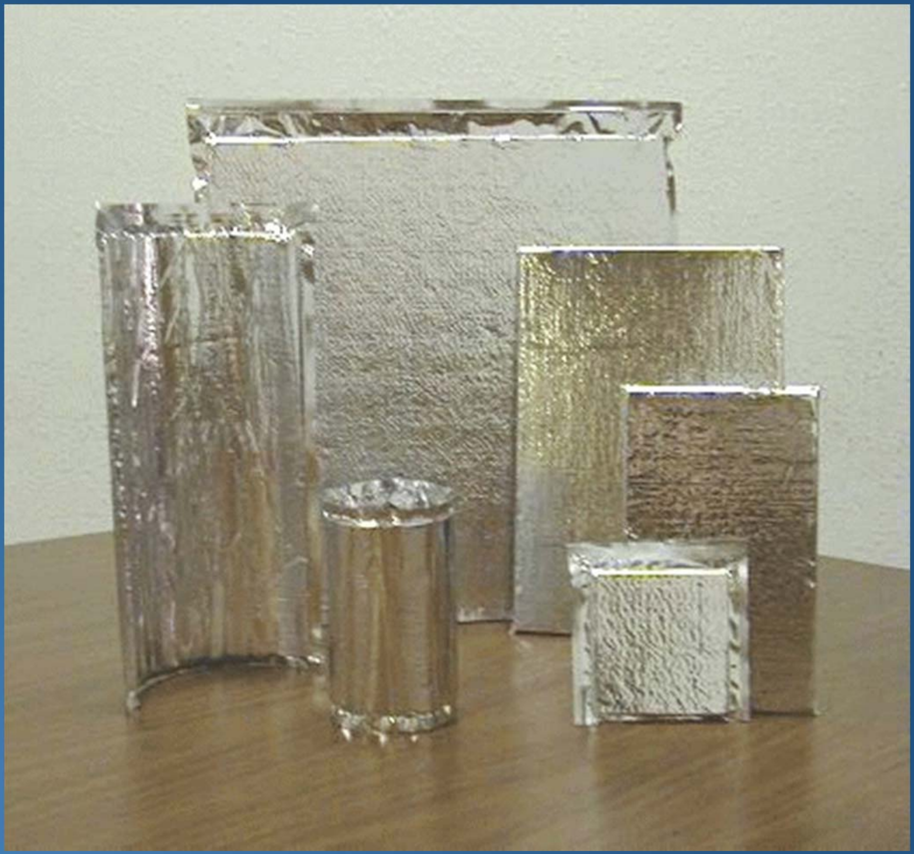


Photo: Nanopore

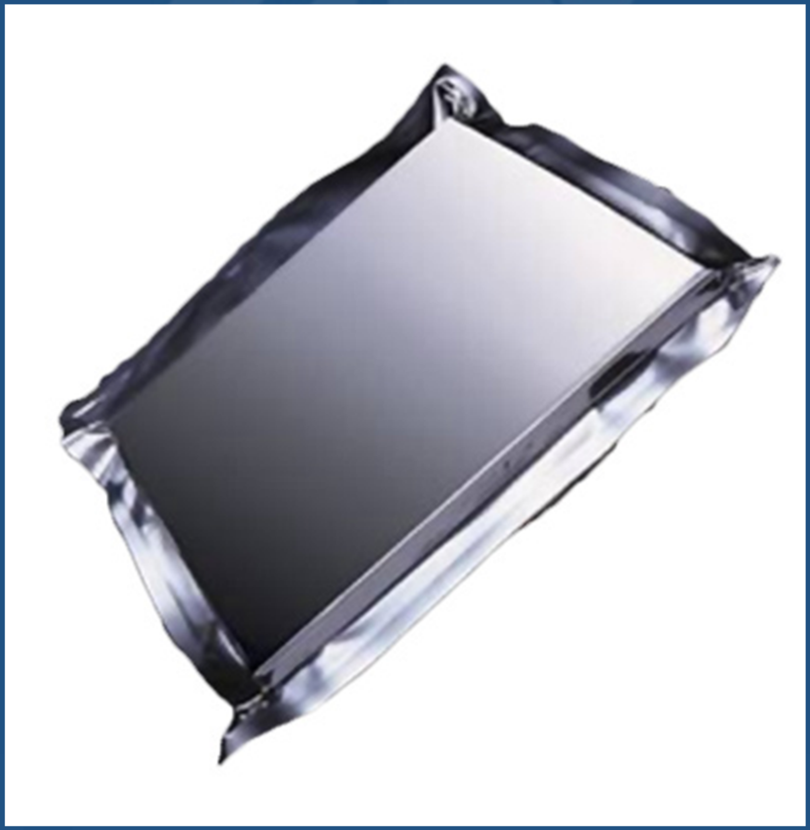


Photo: Panasonic VIP

Up to R-25/inch

Microporous amorphous silica insulation – from the Belgian company Microtherm

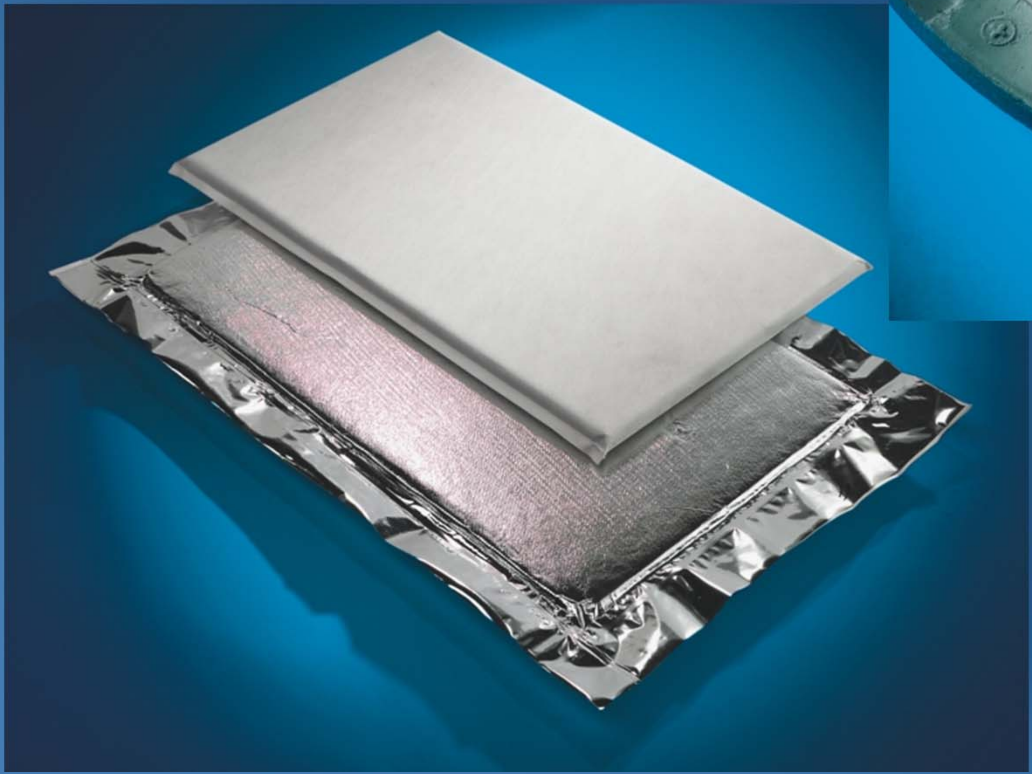
- Like silica aerogel, higher R-value than polyiso
- Strings of tiny particles creating air pockets smaller than the free path of an air molecule – almost no gas-phase conductivity
- Suitable for specialized high-temp applications
- Insulating behind ceramic burners, glass furnaces, pipe insulation, etc.

R-7/inch
(non-vacuum)

Photos: Microtherm

Microtherm insulation

Microtherm SG machined for stove burner



Microtherm SlimVac

Insulation Properties

Key Environmental and Performance Factors for Insulation Materials

Insulation Type		R-value Per Inch*	Estimated Installed Cost Per ft² for R-19**		Vapor Permeability†	Air Barrier‡	Environmental Notes (see below for legend)
			Low end	High end			
FIBER, CELLULOSIC, AND GRANULAR							
Fiberglass	Batt	3.3	$0.88	$1.88	Class III: Semi-Permeable	Not an air barrier—batts especially susceptible to air infiltration	Avoid formaldehyde binders
	Blown-in	3.8	$0.66	$0.83			
	Spray-applied	3.7–4.2	$0.60	$0.79			
Cellulose	Spray-applied	3.8–3.9	$0.73	$1.59	Class III: Semi-Permeable	Not an air barrier, but dense-packed cellulose enhances air resistance of an assembly	
	Loose fill	3.6–3.7	$0.64	$0.80			
Mineral wool		3.3	$1.20	$1.44	Class III: Semi-Permeable	Not an air barrier	Choose low-emitting products
Cotton		3.4	$1.50	$2.16	Class III: Semi-Permeable	Not an air barrier	Shipping energy may be significant
Polyester		3.7	$1.26		Class III: Semi-Permeable	Not an air barrier	
Sheep's wool		3.5	$3.50	$4.50	Class III: Semi-Permeable	Not an air barrier	Wool agricultural practices are a high contributor to

Source:

1st page of 4-page table of insulation properties in BuildingGreen's new Insulation Report

Insulation Recommendations

Recommended Insulation Materials	Environmental Issues	Performance and Cost Issues
RESIDENTIAL CAVITY FILL None of the following recommended products are air barriers; include a continuous air barrier separately from the insulation with all cavity-fill insulation options. All of the following products are vapor-permeable, although hygroscopic properties differ considerably. Insulation choices may be affected by the cavity design, framing materials, and other factors.		
✓ BuildingGreen Top Pick **Dense-packed cellulose**	Low embodied energy and carbon. Renewable, high recycled content. Flame retardant toxicity not a big concern.	Fills cavities completely, impedes air leakage. Settling is not a factor with dense-packing. Hygroscopic: can help manage moisture by seasonally absorbing and releasing water vapor as long as at least one side of the assembly is vapor-permeable, and as long as the wetting rate does not exceed the drying rate on an annual basis.
Spray-applied or dense-packed fiberglass	Higher embodied energy than cellulose. Not a renewable material.	Fills cavities completely, impedes air leakage at higher densities.
Mineral wool batts	Higher embodied energy than cellulose. Some emissions concerns.	Use when greater fire rating is desired or as a superior option (compared to fiberglass batts) for small jobs. Can be hard to source.
Air-Krete, cotton batts, polyester batts, or dense-packed wool	Use when the owner has unique air quality concerns about other options.	More expensive than other options and harder to source. Specific performance downsides by insulation type: see body of report.
Fiberglass batts	Higher embodied energy; often poorly installed (see performance issues).	Difficult to install well (requires time to cut carefully around irregularities). Use only for budget-conscious jobs too small for an insulation contractor and where mineral wool batts are not available.

Note: *Recommendations in this table are based on environmental and performance factors—and combinations of the two. Check both columns for background.*

Source:

1st page of 4-page table in BuildingGreen's new Insulation Report

For more information

- BuildingGreen's new in-depth guide to insulation
- Comprehensive coverage of insulation material properties, performance, and environmental issues
- $129 from BuildingGreen; less for subscribers
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