POLYISO INSULATION: THE FOUNDATION FOR 21ST CENTURY ROOF SYSTEMS

John B. Letts
Technical Director, Insulations
Firestone Building Products

Agenda

1. Insulation Overview
2. Energy Efficiency & Higher R-Values
3. Energy Efficiency & The Reroofing Challenge
4. Environmentally Friendly Polyiso
5. Enhanced Understanding and Testing of Dimensional Stability
6. High Density Polyiso Cover Boards
7. Conclusions

Insulation Overview

- High prices of energy
  - Insulation never more important
- Saves Money

Insulation Overview

- High prices of energy
  - Insulation never more important
- Saves Money
- Reduces a Country's Dependence on Foreign Oil / National Security Issues

Insulation Overview

- High prices of energy
  - Insulation never more important
- Saves Money
- Reduces a Country's Dependence on Foreign Oil / National Security Issues
- Energy Efficiency is Key
- Ultimate Goal: "Passive Building"!?

Insulation Overview

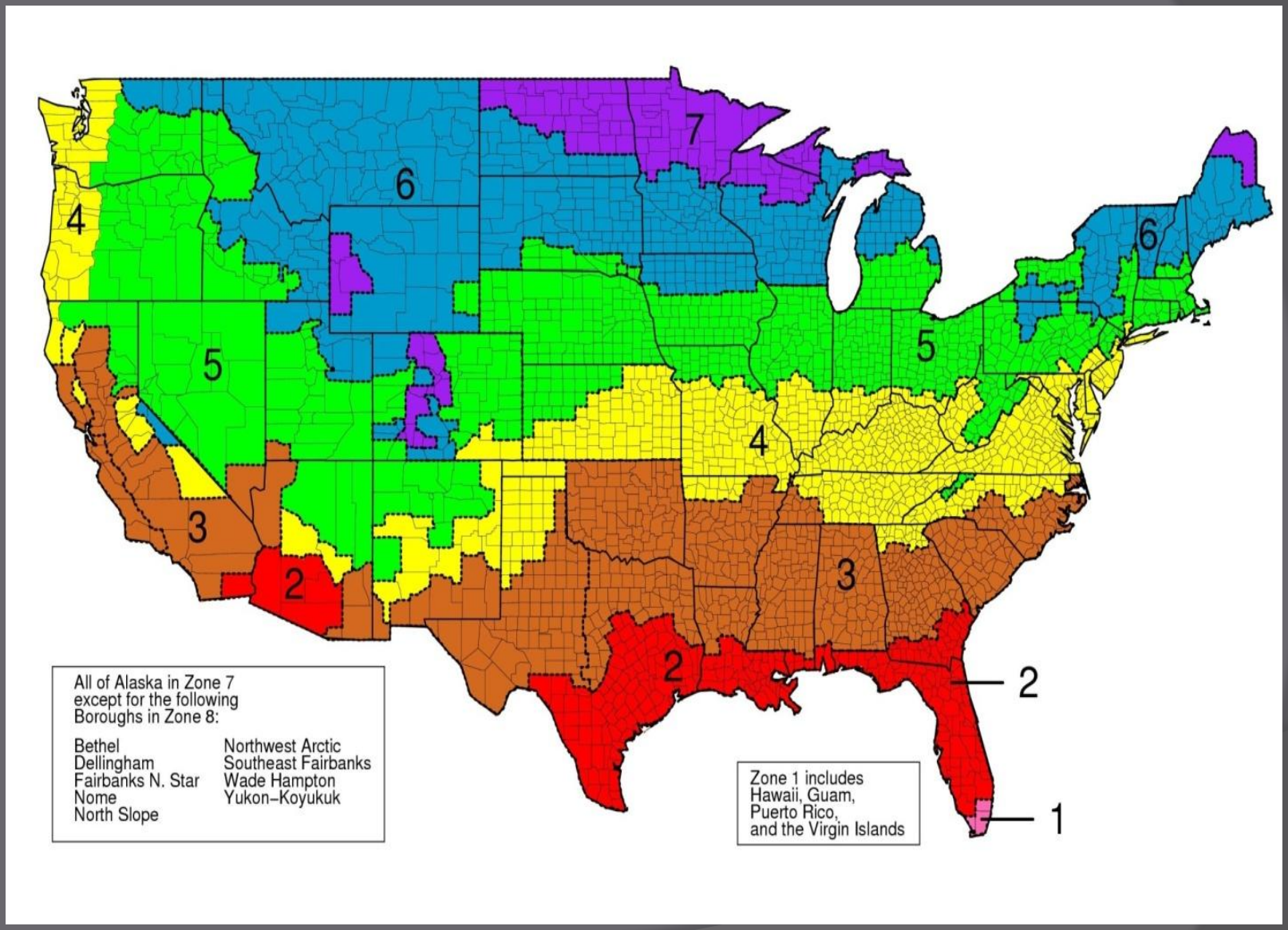
- High prices of energy
  - Insulation never more important
- Saves Money
- Reduces a Country's Dependence on Foreign Oil / National Security Issues
- Energy Efficiency is Key
- Ultimate Goal: "Passive Building"!?
- Today's Commercial Roof Requirements for Insulation are More Demanding and Complex
  - High R-Values / Minimize Thickness
  - More Durable
  - More Environmentally Friendly

Energy Efficiency – Higher R-Values

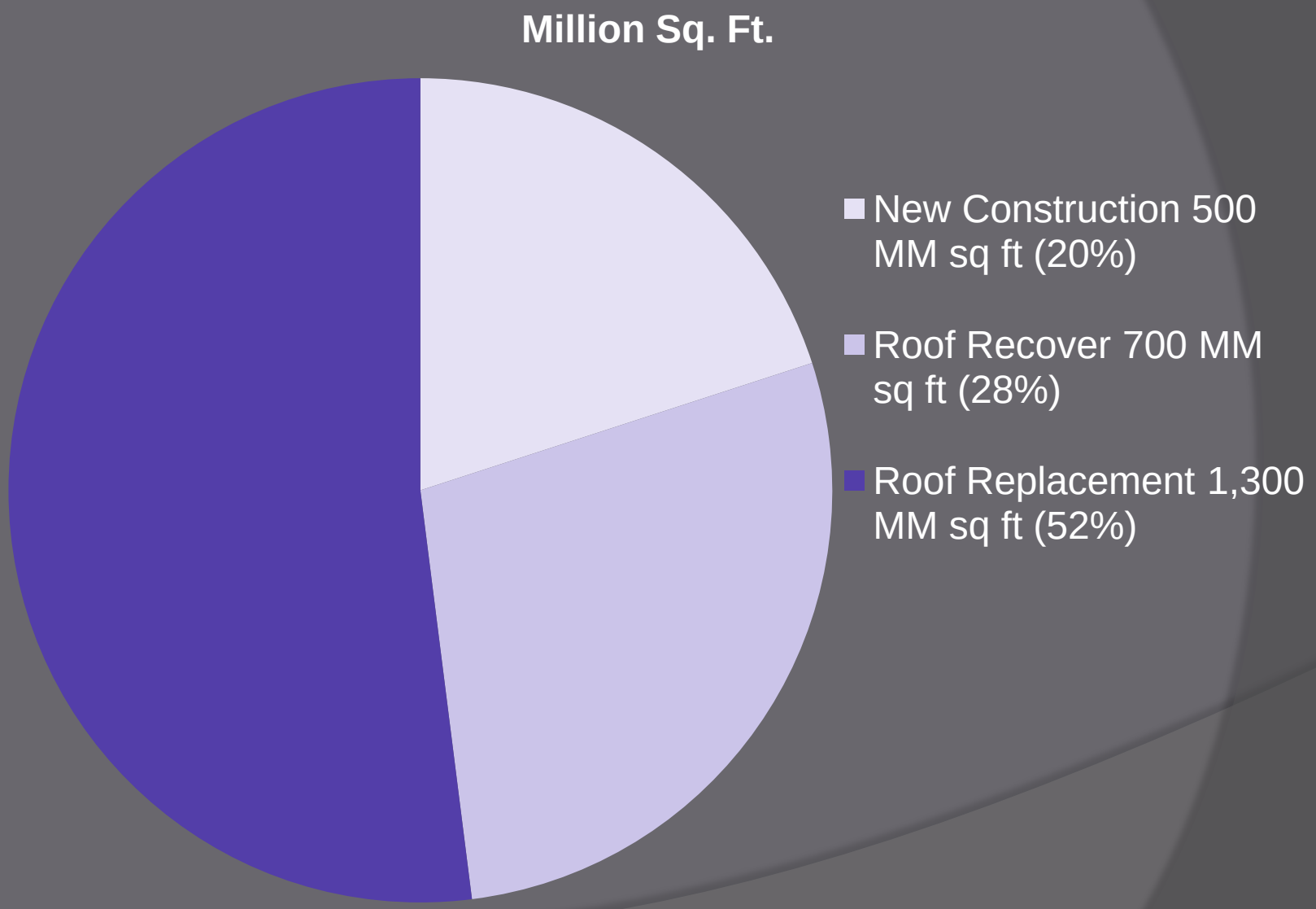
- ASHRAE 90.1 – 2007
  - Approx. 35% higher than ASHRAE 90.1 - 2004

Energy Efficiency – Higher R-Values

- ASHRAE 90.1 – 2007
  - Approx. 35% higher than ASHRAE 90.1 - 2004
- 2012 IECC (International Energy Conservation Code)
  - **35%** higher than ASHRAE 90.1 – 2007
  - **80%** higher than ASHRAE 90. 1 – 2004


7
6
4
6
5
5
4
3
3
2
2
2
1
All of Alaska in Zone 7
except for the following
Boroughs in Zone 8:
Bethel
Dellingham
Fairbanks N. Star
Nome
North Slope
Northwest Arctic
Southeast Fairbanks
Wade Hampton
Yukon–Koyukuk
Zone 1 includes
Hawaii, Guam,
Puerto Rico,
and the Virgin Islands

Climate Zone	ASHRAE 90.1 - 2004	ASHRAE 90.1 - 2007	ASHRAE 189.1 - 2009	IECC - 2012
1	1.76 (10)	2.64 (15)	3.52 (20)	3.52 (20)
2	2.64 (15)	3.52 (20)	4.40 (25)	3.52 (20)
3	2.64 (15)	3.52 (20)	4.40 (25)	3.52 (20)
4	2.64 (**15**)	3.52 (**20**)	4.40 (**25**)	4.40 (**25**)
5	2.64 (15)	3.52 (20)	4.40 (25)	4.40 (25)
6	2.64 (15)	3.52 (20)	5.28 (30)	5.28 (30)
7	2.64 (15)	3.52 (20)	6.16 (35)	6.16 (35)
8	2.64 (15)	3.52 (20)	6.16 (35)	6.16 (35)
Status	"Old Code"	"Current Code"	"Green Code"	"Next Code"

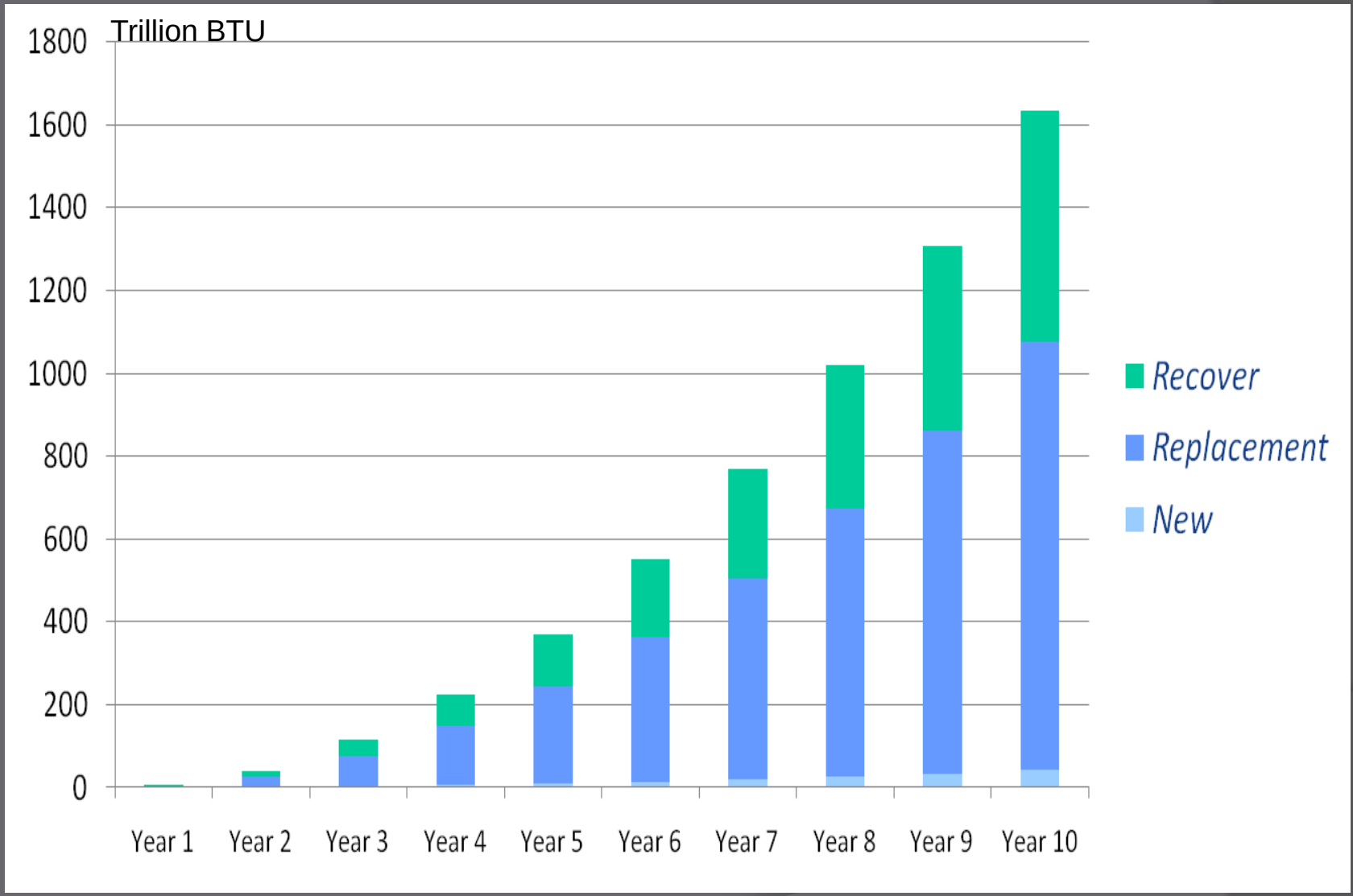

Million Sq. Ft.
New Construction 500 MM sq ft (20%)
Roof Recover 700 MM sq ft (28%)
Roof Replacement 1,300 MM sq ft (52%)

Energy Efficiency – The Reroofing Challenge

- Reroofing Constitutes the Largest Portion of Commercial Roofing
- Roof Recover is Exempt from 2012 IECC
- Huge Opportunity

Energy Efficiency – The Reroofing Challenge

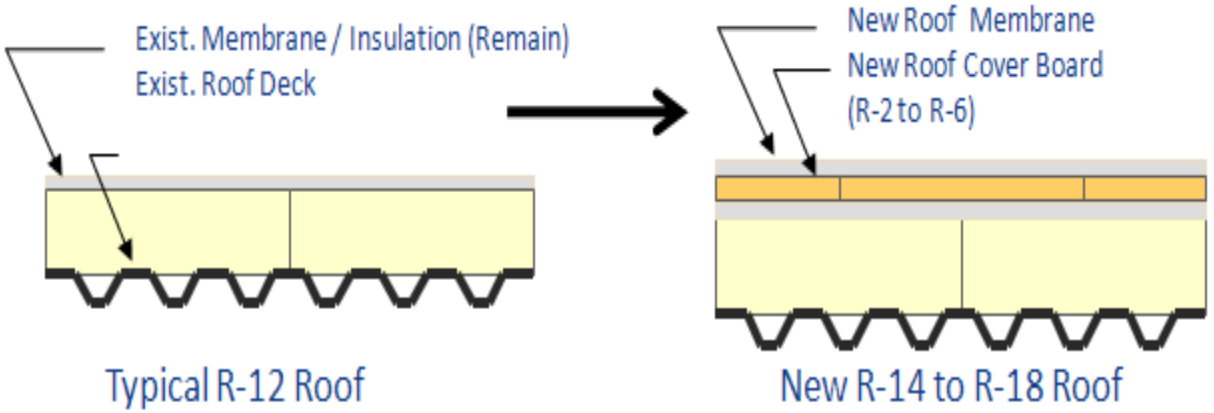
- Reroofing Constitutes the Largest Portion of Commercial Roofing
- Reroofing is exempt from 2012 IECC
- Huge Opportunity
- Dr. Jim Hoff Paper
  - Research Director, Center for Environmental Innovation in Roofing
  - “Nonresidential Roofing and National Building Energy Transformation: Opportunities, Barriers and Strategies
  - www.roofingcenter.org


Trillion BTU
1800
1600
1400
1200
1000
800
600
400
200
0
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7
Year 8
Year 9
Year 10
Recover
Replacement
New

Energy Efficiency – The Reroofing Challenge

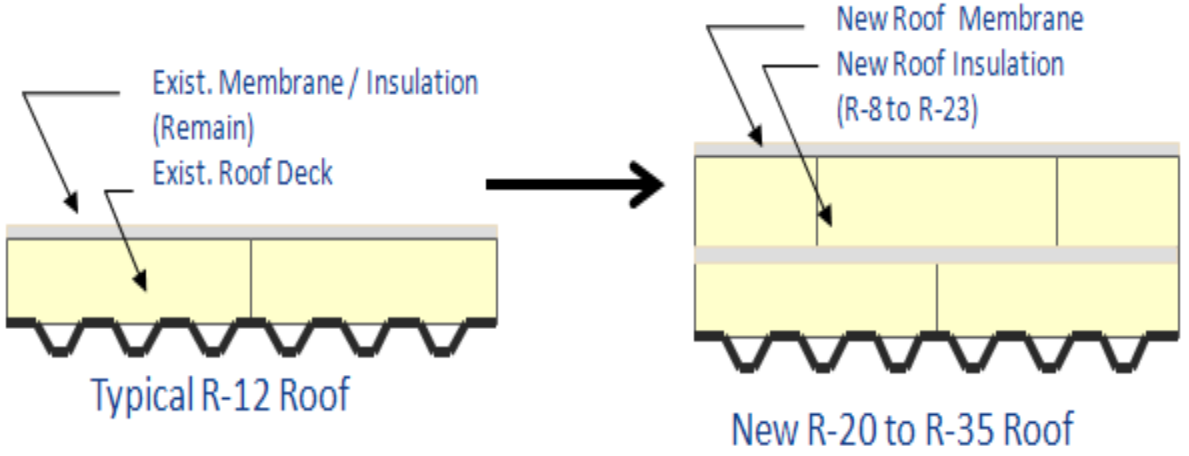
- Reroofing Constitutes the Largest Portion of Commercial Roofing
- Reroofing is exempt from 2012 IECC
- Huge Opportunity
- Dr. Jim Hoff Paper
  - Research Director, Center for Environmental Innovation in Roofing
  - "Nonresidential Roofing and National Building Energy Transformation: Opportunities, Barriers and Strategies
  - www.roofingcenter.org
- Cost Barrier

Exempt Roof Recover



$5.00 / Sq. Ft.

Non-Exempt Roof Recover



$6.00 / Sq. Ft. (20% Increase)

Energy Efficiency – The Reroofing Challenge

- Reroofing Constitutes the Largest Portion of Commercial Roofing
- Reroofing is exempt from 2012 IECC
- Huge Opportunity
- Dr. Jim Hoff Paper
  - Research Director, Center for Environmental Innovation in Roofing
  - "Nonresidential Roofing and National Building Energy Transformation: Opportunities, Barriers and Strategies
  - www.roofingcenter.org
- Cost Barrier
- Include all commercial roofs in the energy code

Environmental Friendly

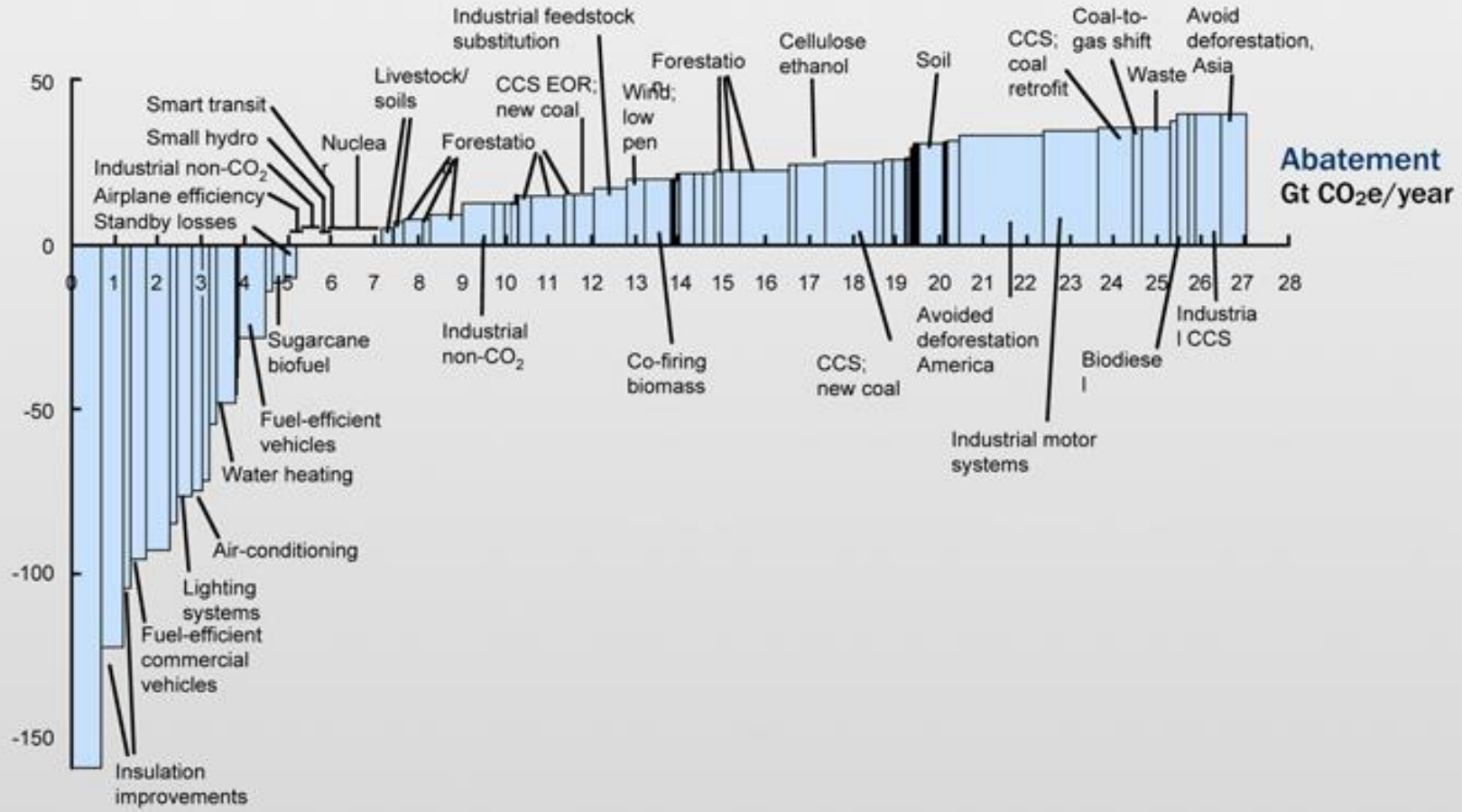
- Recycling Status
  - Std 2” Polyiso
    - 24% Post Consumer Recycled Content
    - 15% Post Industrial Recycled Content
  - Preliminary Work Recycling Foam into Raw Materials
  - Reusing Polyiso Boards in Reroofing Jobs

Environmental Friendly

- Recycling Status
  - Std 2” Polyiso
    - 24% Post Consumer Recycled Content
    - 15% Post Industrial Recycled Content
  - Preliminary Work Recycling Foam into Raw Materials
  - Reusing Polyiso Boards in Reroofing Jobs
- Carbon Dioxide Reduction
  - McKinsey Report
  - Insulation is cost effective

THE COST CURVE PROVIDES A "MAP" OF ABATEMENT OPPORTUNITIES

Cost of abatement, 2030, €/tCO₂e*



* Cubic feet of carbon equivalents.

Source: McKinsey and Vattenfall analysis

Environmental Friendly

- Recycling Status
  - Std 2” Polyiso
    - 24% Post Consumer Recycled Content
    - 15% Post Industrial Recycled Content
  - Preliminary Work Recycling Foam into Raw Materials
  - Reusing Polyiso Boards in Reroofing Jobs
- Carbon Dioxide Reduction
  - McKinsey Report
  - Insulation is cost effective
- Life Cycle Analysis
  - Environmental payback in approx. 4 weeks

Understanding Dimensional Stability

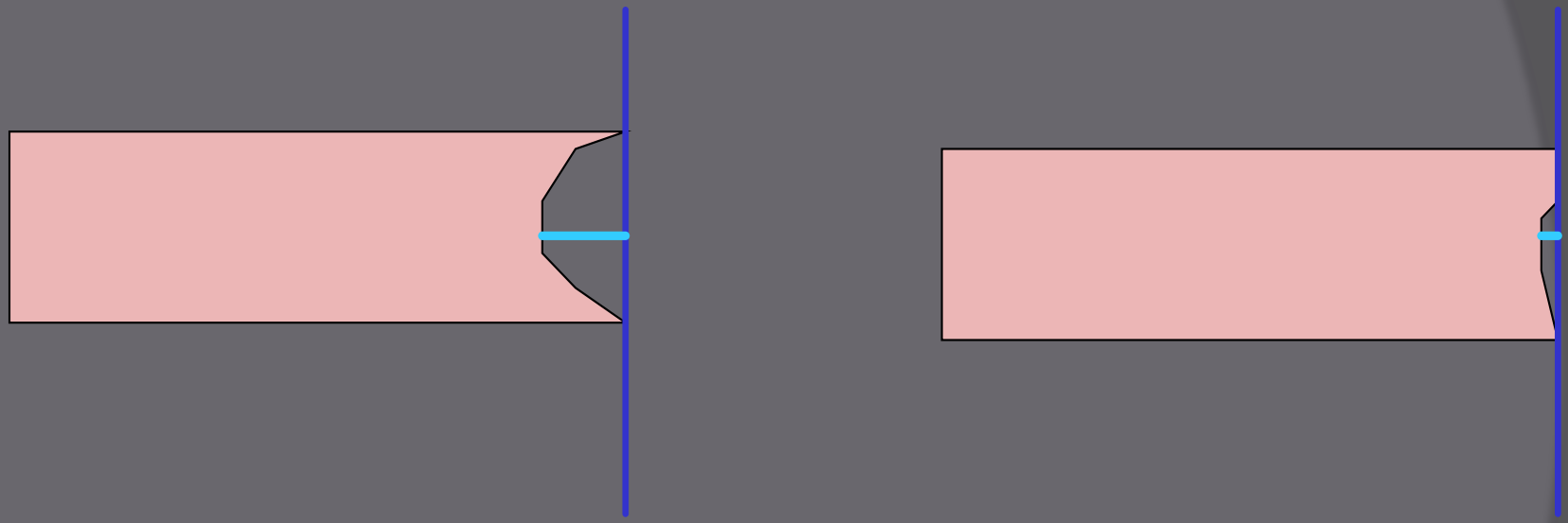
- Dimensional Stability is an Important Physical Property
  - Problems are rare but when they happen they can be frustrating, time consuming and expensive

Understanding Dimensional Stability

- Dimensional Stability is an Important Physical Property
  - Problems are rare but when they happen they can be frustrating, time consuming and expensive
- ASTM C1289/D2126 Test Boards at -40C/-40F
  - 12” by 12” Samples
  - Focus is on Overall Sample Dimensional Stability

Understanding Dimensional Stability

- Dimensional Stability is an Important Physical Property
  - Problems are rare but when they happen they can be frustrating, time consuming and expensive
- ASTM C1289/D2126 Test Boards at -40C/-40F
  - 12” by 12” Samples
  - Focus is on Overall Sample Dimensional Stability
- Most Dimensional Stability Problems have Edge Collapse



Understanding Dimensional Stability

- Dimensional Stability is an Important Physical Property
  - Problems are rare but when they happen they can be frustrating, time consuming and expensive
- ASTM C1289/D2126 Test Boards at -40C/-40F
  - 12” by 12” Samples
  - Focus is on Overall Sample Dimensional Stability
- Most Dimensional Stability Problems have Edge Collapse
- Edge Collapse is “Ground Zero” in Eliminating Most Dimensional Stability Problems

Understanding Dimensional Stability

- Dimensional Stability is an Important Physical Property
  - Problems are rare but when they happen they can be frustrating, time consuming and expensive
- ASTM C1289/D2126 Test Boards at -40C/-40F
  - 12” by 12” Samples
  - Focus is on Overall Sample Dimensional Stability
- Most Dimensional Stability Problems have Edge Collapse
- Edge Collapse is “Ground Zero” in Eliminating Most Dimensional Stability Problems
- ASTM C1289 / D2126
  - 12” by 12” Samples don’t have to include the edges
  - Averaging the results minimizes the effect of the edges

Understanding Dimensional Stability

- Dimensional Stability is an Important Physical Property
  - Problems are rare but when they happen they can be frustrating, time consuming and expensive
- ASTM C1289/D2126 Test Boards at -40C/-40F
  - 12” by 12” Samples
  - Focus is on Overall Sample Dimensional Stability
- Most Dimensional Stability Problems have Edge Collapse
- Edge Collapse is “Ground Zero” in Eliminating Most Dimensional Stability Problems
- ASTM C1289 / D2126
  - 12” by 12” Samples don’t have to include the edges
  - Averaging the results minimizes the effect of the edges
- Why are the 8-foot Edges the Most Susceptible Part of the Board to Dimensional Stability Problems?

Understanding Dimensional Stability

- Back To Basics
  - PV = nRT (Ideal Gas Law)

Understanding Dimensional Stability

- Back To Basics
  - PV = nRT (Ideal Gas Law)
  - At Manufacture & 2 Weeks After Manufacture

Understanding Dimensional Stability

- Back To Basics
  - PV = nRT (Ideal Gas Law)
  - At Manufacture & 2 Weeks After Manufacture
  - $P_m = T_m$ $P_{2w} = T_{2w}$

Understanding Dimensional Stability

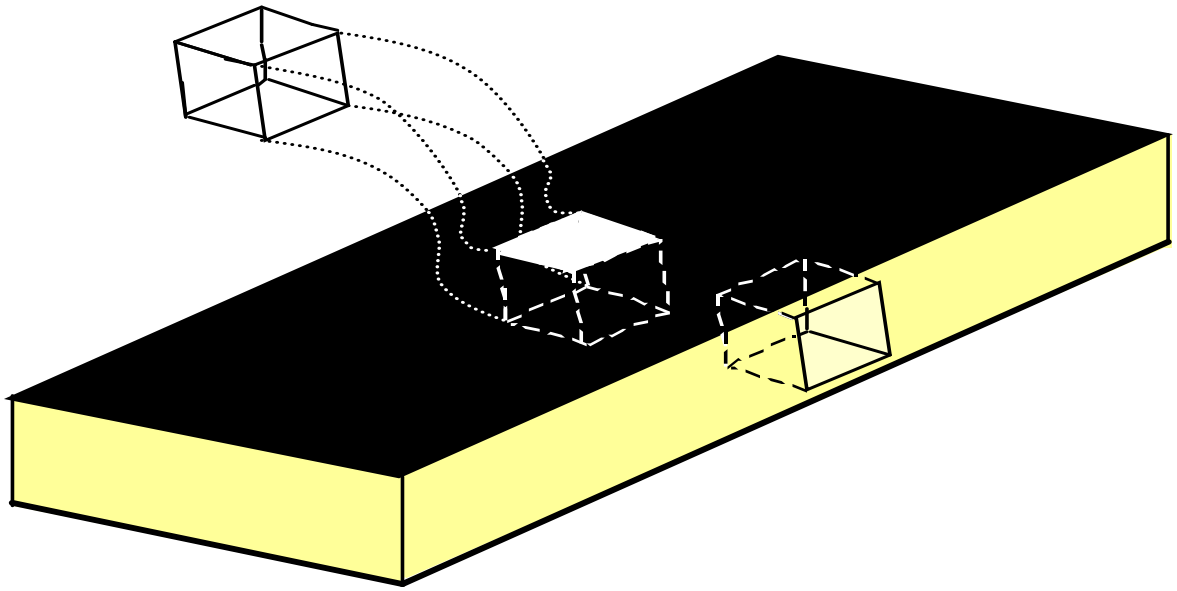
- Back To Basics
  - PV = nRT (Ideal Gas Law)
  - At Manufacture & 2 Weeks After Manufacture
  - $P_m = T_m$ $P_{2w} = T_{2w}$
  - Foam / Bundle Temperature is Greater than 300 F
  - Formation of Key Reaction (Trimerization) is Most Effective at 160 F (71 C)

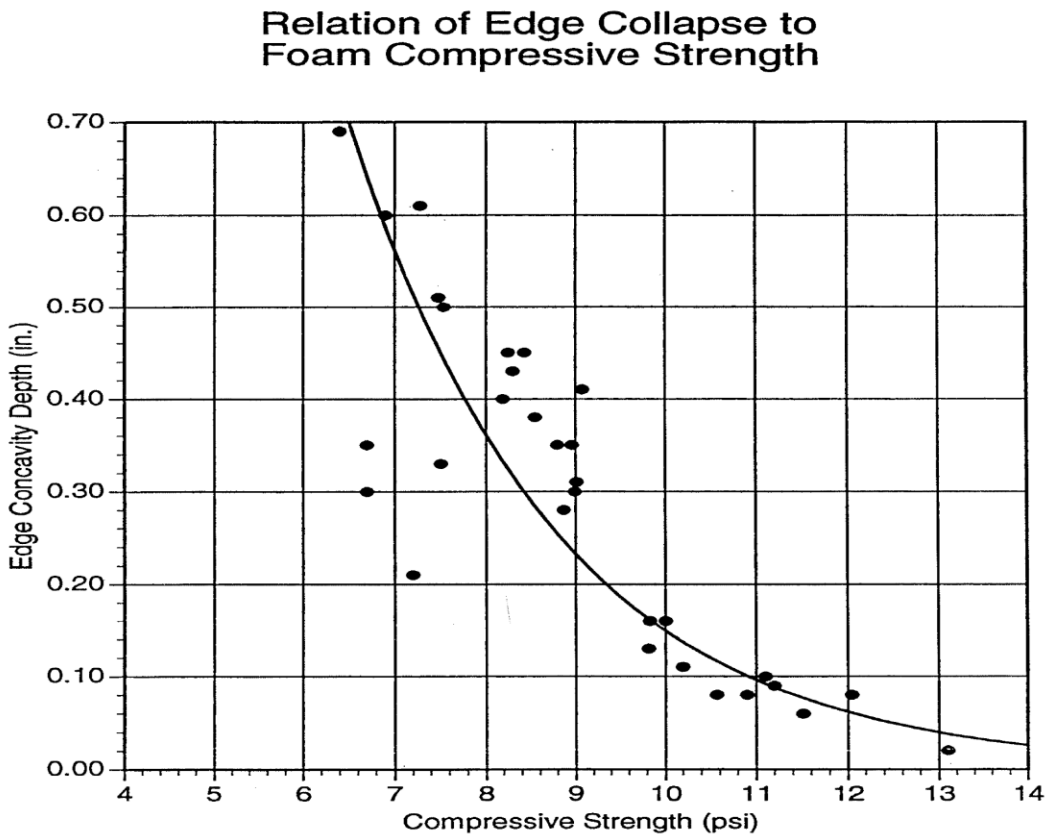
Understanding Dimensional Stability

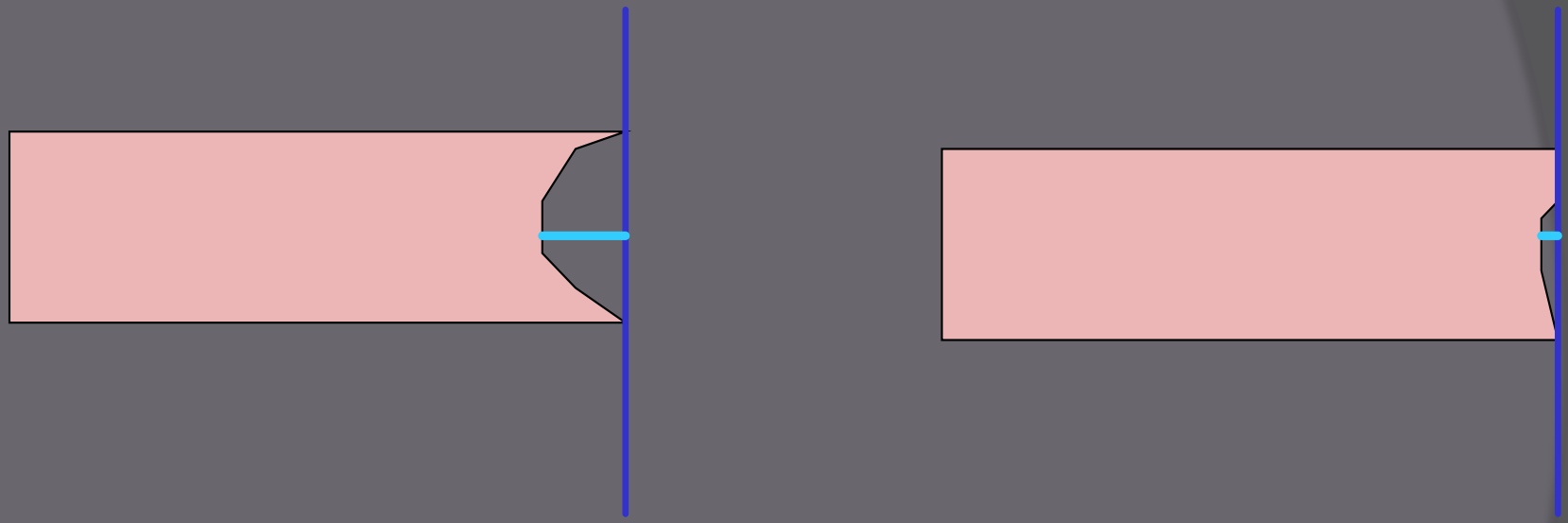
- Back To Basics
  - PV = nRT (Ideal Gas Law)
  - At Manufacture & 2 Weeks After Manufacture
  - $P_m = T_m$ $P_{2w} = T_{2w}$
  - Foam / Bundle Temperature is Greater than 300 F
  - Formation of Key Reaction (Trimerization) is Most Effective at 160 F (71 C)
- Edges of the Board Don't Reach this Temperature

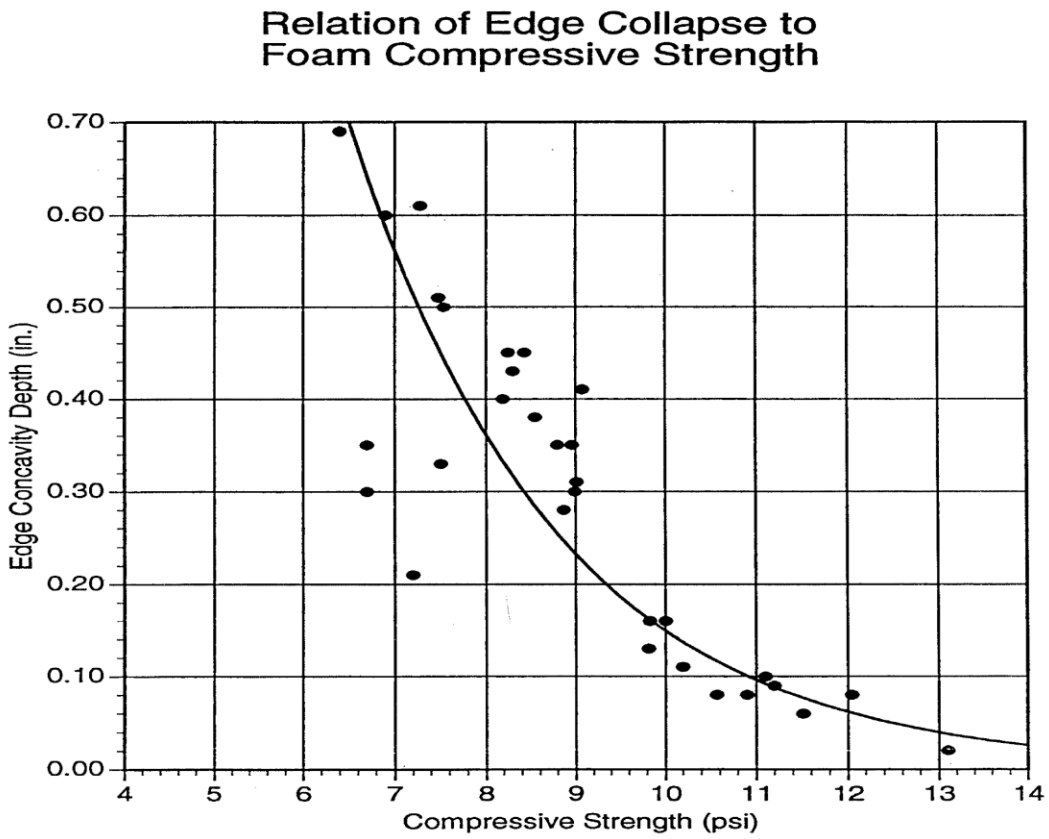
Understanding Dimensional Stability

- Back To Basics
  - PV = nRT (Ideal Gas Law)
  - At Manufacture & 2 Weeks After Manufacture
  - $P_m = T_m$ $P_{2w} = T_{2w}$
  - Foam / Bundle Temperature is Greater than 300 F
  - Formation of Key Reaction (Trimerization) is Most Effective at 160 F (71 C)
- Edges of the Board Don't Reach this Temperature
- Measure of the Strength of the Foam in the Cross Machine or Z Direction Correlates to Amount of Reaction and Crosslinking




Relation of Edge Collapse to
Foam Compressive Strength
Edge Concavity Depth (in.)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
4
5
6
7
8
9
10
11
12
13
14
Compressive Strength (psi)




Relation of Edge Collapse to
Foam Compressive Strength
Edge Concavity Depth (in.)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
4
5
6
7
8
9
10
11
12
13
14
Compressive Strength (psi)

Continuous Monitoring During Manufacture

- Continuously Measure Compressive Strength in the Cross Machine Direction (Z- Direction) called in-line ZCS
- Operator adjust equipment and / or formulation to maintain high ZCS numbers
- Continuous monitoring of Boards 2” and Greater

Dimensional Stability as a Function of Time & Temperature

- Is it possible for a board with edge collapse to recover?

Dimensional Stability as a Function of Time & Temperature

- Is it possible for a board with edge collapse to recover?
- Anecdotal example

Dimensional Stability as a Function of Time & Temperature

- Is it possible for a board with edge collapse to recover?
- Anecdotal example
- Air Diffusion is Key
  - Air Diffuses in Over the Course of a Year or So
  - Pentanes Have Half Lives of 75 to 100 Years

Dimensional Stability as a Function of Time & Temperature

- Is it possible for a board with edge collapse to recover?
- Anecdotal example
- Air Diffusion is Key
  - Air Diffuses in Over the Course of a Year or So
  - Pentanes Have Half Lives of 75 to 100 Years
- Laboratory Studies
  - Samples Three Weeks at 100 F or 150 F

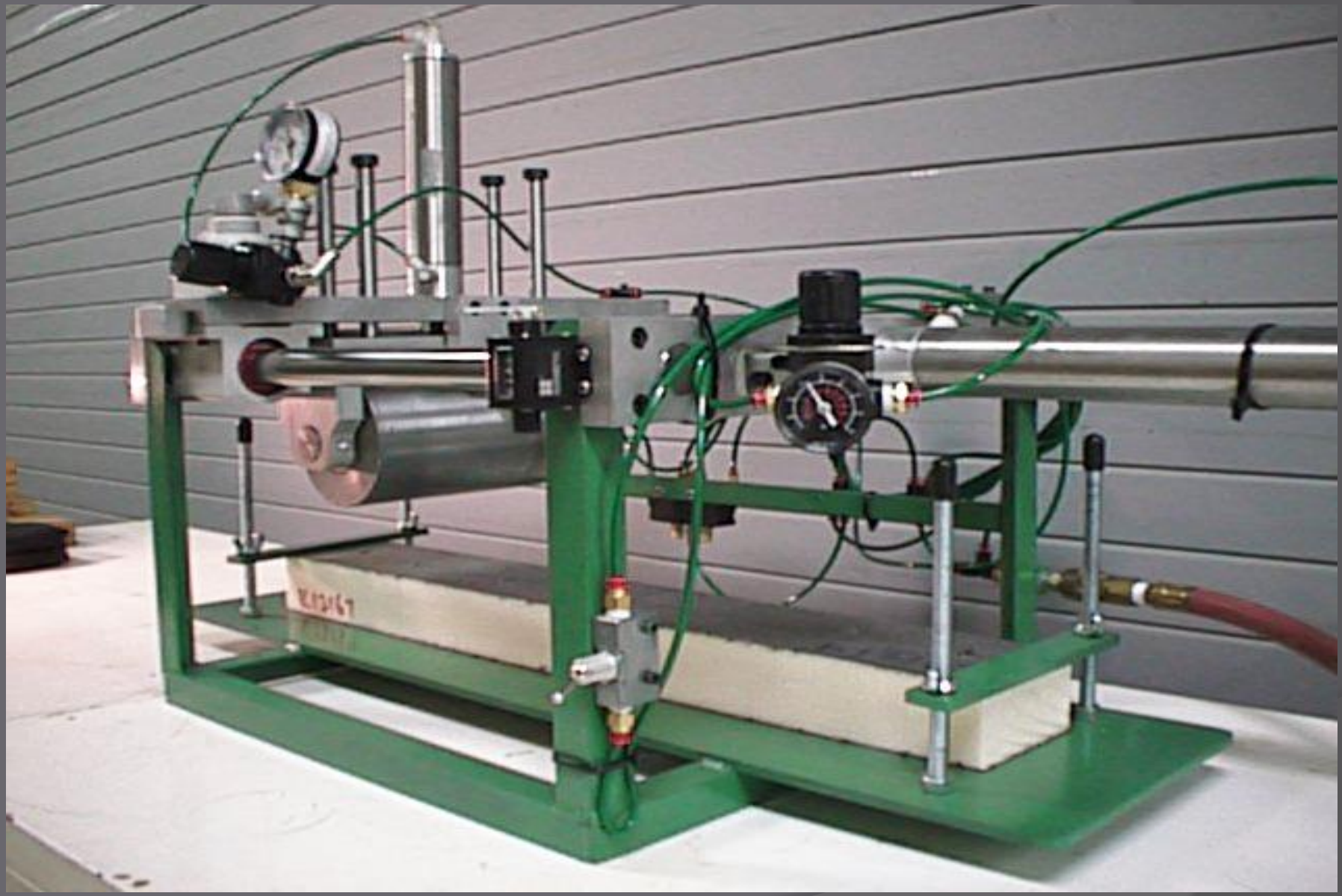

150°F
100°F
AS REC'D

Dimensional Stability as a Function of Time & Temperature

- Is it possible for a board with edge collapse to recover?
- Anecdotal example
- Air Diffusion is Key
  - Air Diffuses in Over the Course of a Year or So
  - Pentanes Have Half Lives of 75 to 100 Years
- Laboratory Studies
  - Samples Three Weeks at 100 F or 150 F
- Survey of Old Roofs

High Density Polyiso Cover Boards

- Need for a Lighter Weight, Tougher, Higher R-Value, Dimensionally Stable Cover Board
- Higher Density, Specially Modified Polyiso foam
- Combined with Coated Fiberglass Mat Facers
- Toughness: Approximately 6000 Passes on the RLE at 20 psi



High Density Polyiso Cover Boards

- Need for a Lighter Weight, Tougher, Higher R-Value, Dimensionally Stable Cover Board
- Higher Density, Specially Modified Polyiso foam
- Combined with Coated Fiberglass Mat Facers
- Toughness: Approximately 6000 Passes on the RLE at 20 psi
- Good fire performance but not quite as good as the fiberglass mat gypsum based board
- Cold Applied Asphalt but No Hot Asphalt

Property	Fiberglass Mat Faced Polyiso (HD)	Fiberglass Mat Facer Gypsum	Woodfiber
Thickness, mm (in)	25.4 – 50.8 (¼ - ½)	25.4 (¼)	50.8 (½)
R-Value	0.176 – 0.44 (1.0 – 2.5)	0.049 (0.28)	0.246 (1.4)
Board Weight 1.2 m X 2.4 m (4’ X 8’), Kg (lb)	5.44 (12)	17.41 (38.4)	9.29 (20.5)
Ease of cutting*	Yes	No	No
Mold resistance (D 3273)	Yes	Yes	No
Water Absorption	<3%	10%	10%
Dimensional Stability	Excellent	Excellent	Excellent; poor if wet

*Contractor’s comments

Conclusions

- The IECC 2012 Code: Approximately 80% Higher R-Values Compared to ASHRAE 90.1 – 2004
- Reroofing Offers a Huge Opportunity for Energy Savings with Changes in the Energy Code
- Polyiso Insulation is an Environmentally Friendly Product

Conclusions

- The Physics of Polyiso Dimensional Stability was Elucidated and Innovative Tests Developed to Ensure Boards are Dimensionally Stable in the Field
- High Density Cover Boards Offer the Roofing Professional
  - Light Weight
  - Higher R-Value
  - High Performance and Strength
  - Mold Resistance
  - Toughness and Durability