Understanding R-values

Presented to

SprayFoam 2009

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Presentation summary

- What is an R-value? How is it defined?
- What is the state of the art in measuring the R-value of foam plastics?
- Why cannot air leakage be included?
- What are some other examples of energy savings not included in R-values numbers?
ASTM C168 R-value definition

- The quantity determined by the temperature difference, at steady state, between two defined surfaces of a material or construction that induces a unit heat flow rate through a unit area.

\[ R = \frac{\Delta T}{q} \]
Typical procedure for measuring “material” R-values

- ASTM C 518, heat flow meter apparatus (pictured)
- ASTM C 177, guarded hot plate apparatus
- ASTM C 335, pipe tester apparatus
Typical procedure for measuring “construction” R-values

- ASTM C 1363, guarded or calibrated hot box apparatus
Limitations to ASTM C 1363 method

- Not applicable to dynamic tests (Section 1.13)
- Air leakage not allowed (Section 1.14)
R-value allows comparison of ALL insulations under ALL conditions.

- **Hot 32°C (90°F)**
  - Fiberglass Batt (3.5 R/in.)
  - Foam (5 R/in.)
  - Vacuum Panel (20 R/in.)

- **Cold 4°C (40°F)**
  - 46 W/m²
  - 32 W/m²
  - 8 W/m²
Which R-value should you use for a product that ages?
Development of ASTM C1303, the slicing and scaling method

- Determine when a test is applicable
- Determine how to get the most accurate results
- Working issue - how do you best prepare the foam test specimen?
How does ASTM C1303 work?

- Aging follows Fick’s Law of gas diffusion
- Cutting thickness by 2 reduces aging time by factor of 4

Gas at centerline same as outside in 4 years

Gas at centerline same as outside in 1 year
Ruggedness: testing the test

- Four manufacturers, eight products and three product thicknesses
- Three slice thicknesses and four stack configurations
- Full thickness aging for comparison at 5 years
- No spray foam
Test method development - rating results impacts credibility

• Roofing organizations haven’t accepted published R-values for foam insulation for many years
What are other energy saving features that are not R-values?

• Cool roofs
• Roof ballast
• Garden roofs
• Massive walls
• ?????
Measuring thermal performance of cool roofs

East Tennessee Climate

Reflectance and Emittance for 28 Roofs

1.5 in. of Wood Fiberboard Insulation

Conditioned Interior of Test Building

0.75 in. Deck
Validating benefit of cool roofs

Effect of ±R, ±E: ±3°F at Peak
Energy savings associated with the ballast tests
Test results –
one month exposure data

- Bare Black EPDM
- Under 10 lb/ft² Stone
- Under 24 lb/ft² Stone
- Bare White TPO
- Under 17 lb/ft² Stone
- Under Uncoated Paver

Heat Flux through Insulation [Btu/(h·ft²)]

Membrane Temperature (°F)

0 2 4 6 8 10 12 14 16 18 20 22 24

Hours into 4/5/2004
Garden Roof Energy Performance

Soil

8” Garden

Plant Layer
Growing Media
Drainage Layer
Root Barrier
Protection Layer
Membrane

4” Garden

Tray System

Thermocouples
Heat Flux Transducer
Moisture Measuring Devices

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY
Comparison of Weekly Heat Fluxes (Cooling) - 4” Garden vs Growing Media

- **Weeks (starting 06/13/2008)**

- **Total Heat Flux (Btu/ft²/week) - Cooling**
  - 0
  - 200
  - 400
  - 600
  - 800
  - 1,000
  - 1,200
  - 1,400

- **4 in Garden**
- **Growing Media**

- **Legend**
Effect of mass on building loads using DOE 2.1E simulations

![Graph](image)

- Atlanta Light
- Atlanta Mass

Steady state R-value

Total Loads [MBTU]
Calculation of DBMS (dynamic benefit of massive systems)

Total loads for house with R-18 massive walls
Calculation of DBMS (Dynamic benefit of massive systems)

Total loads for house with R-18 massive walls

DBMS
Closing summary

- R-value allows comparison of ALL insulations under ALL conditions
- Many other energy savings features are not (and should not) be included in R-value
Understanding R-values

Comments and Questions???