

Insulation Quality and Compliance Assessments— Field Inspections for Insulation

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Code and Federal rules:

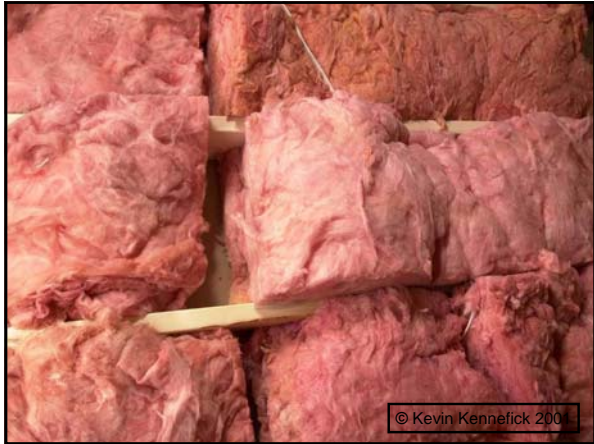
- IECC: Insulation products shall be
 - “...installed in accordance with the manufacturer’s installation instructions....”
- FTC “Home Insulation Rule” (16 CFR 460) requires label on product:
 - “To get the marked R-value, it is essential that this insulation be installed properly.”
- Current codes have embedded assumptions that all insulation is installed correctly

Typical Manufacturer Recommendations:

- Loft to full rated thickness
- Completely fill framing cavity
 - Top to bottom, side to side
- Cut to fit neatly around all obstructions
 - No voids or gaps
 - Split and/or fitted tightly around wiring and other services
- This is industry standard practice, right?

More Typical...

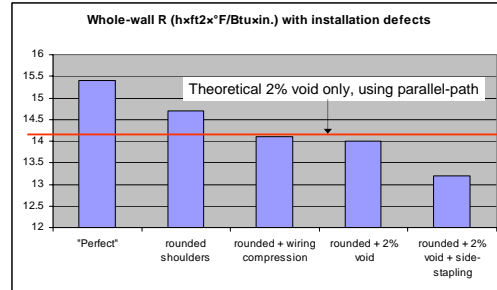






How bad is it?

- Christian, J.E. et al* from hot box tests (2x6 24oc):



* Proceedings of Thermal Performance of the Exterior Envelopes of Buildings VII

Insulation Inspections

- Adopted into home energy ratings standards in 2006
- Field assessment of insulation quality:
 - Three installation Grades: I, II, and III, based on installation defects
 - Other details, framing, compression
- Provide specific modeling guidance
 - Based on results of field assessment

Criteria for Developing

- Can be fairly applied to all types of cavity insulation
- Categorical—not detailed modeling
 - Because we don't have good analytical tools
 - Because inadequate time during inspections for large-scale program implementation
- Performance modeling as worst case within each "bin"
- Default if not inspected = worst case

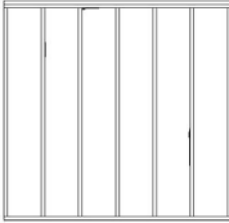
How Code Relates to Ratings

- Performance Analysis:
 - Home energy ratings and performance path 2004/2006 IECC have nearly identical standard design home
- Inspection procedures adopted in ratings because of perceived problem:
 - Performance modeling was not representative of field conditions
- Could consider similar provisions in code

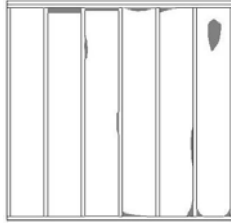
Assessment: Grade I

- Installed according to manufacturers instructions
 - Mentioned above
- Minimal exterior sheathing visible through gaps in the material, minimal compression
- Incomplete fill or compression of up to 30% of intended thickness
 - Covering to up to 2% of the area

Boundary condition: "Grade I"



- **Gaps** clear through insulation– minimal

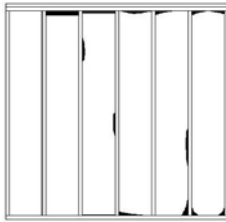


- **Compression** or incomplete fill: <2% of area, compressed by <30% of intended thickness

Assessment: Grade II

- Moderate to frequent defects:
- Gaps/spaces clear through the insulation amounting to up to 2% of total surface area covered by the insulation and/or:
- Incomplete fill or compression of up to **30%** of intended thickness
 - Covering to up to 10% of the area

Boundary condition: "Grade II"



- **Gaps** clear through insulation: <2%

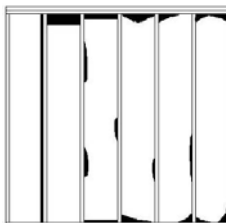


- **Compression** or incomplete fill: <10% of area, compressed by <30% of intended thickness

Assessment: Grade III

- Gaps and voids amounting to less than 5% percent of the total surface area
- In cases that are worse than "Grade III":
 - Measure missing areas, treat as uninsulated
- If entire surface is compressed
 - Insulation R-value according to manufacturer (or defaults) for whole assembly

Boundary condition for "Grade III"



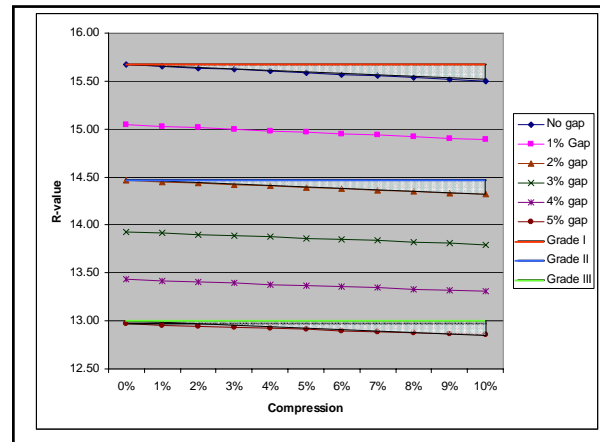
- **Gaps** – clear through insulation: <5%

Performance modeling:

- I: Two parallel paths
 - Cavity + framing(Default framing factors are specified for walls, ceilings, floors for all cases)
- II and III: Three parallel paths
 - II: cavity + framing + 2% empty cavity
 - III: cavity + framing + 5% empty cavity

R and Uo: 2x6, R-19, Grade II

Component R (h×ft ² ×°F/Btu), (unless noted)	Framing	Cavity	Gap
Inside air film	0.68	0.68	0.68
1/2" Gypsum wall board	0.45	0.45	0.45
Cavity	6.88	17.7	1.03
Sheathing (typ)	1.00	1.00	1.00
Outside air film	0.17	0.17	0.17
R total	9.01	19.83	3.16
Relative area	0.22	0.76	0.02
UA (Btu/ h×°F)	0.024	0.038	0.006
U_o (Btu/ h×ft²×°F)	0.069		
R_o	14.5		



Conditions for *Wall* Insulation

- For “Grade I” or “Grade II” rating:
- Must be enclosed on all six sides
 - Sheathing wrap is accepted
- Must be in substantial contact with the sheathing material on at least one side of the cavity
 - Interior or exterior

Additional for Ceilings

- For “Grade I” rating
 - Must be in complete contact with the surface it is intended to insulate
 - Must have eave baffles
- Inspectors need to note whether the framing is covered, and by how much
 - Model cavity insulation separately from continuous insulation



Additional for Floors:

- Must be in complete contact with the surface it is intended to insulate, for “Grade I” rating
- Bottom may be open **IF** in enclosed, unconditioned basement or vented crawlspace
 - **Over garage, or outdoors does need bottom enclosure**

Potential Savings (G-III to G-I)

City, State	Orlando, FL	Dallas, TX	Topeka, KS	Boston, MA	Minneapolis, MN
IECC Climate	2	3	4	5	6
Annual Gas savings: Therms	10	52	133	142	182
Annual electricity savings: (kWh)	87	90	negligible	negligible	negligible
Net annual energy cost savings	\$ 24	\$ 87	\$ 200	\$ 213	\$ 273
Present value of energy savings	\$ 272	\$ 998	\$ 2,288	\$ 2,443	\$ 3,131

Based on:

- 2700 s.f. home
- \$1.50/therm, \$0.10/kWh
- 6438 s.f. insulated surfaces
- \$0.10-\$0.20/square foot for upgrade
 - Cost: \$644 - \$1288
- Even if savings are overestimated x2, still cost effective in zones 4-6

Shortcomings

- Procedure can't be used for closed-cavity applications
- Subjective, even with visual cues
- Doesn't address density of loose-fill applications
- Users may assume modeling represents true performance

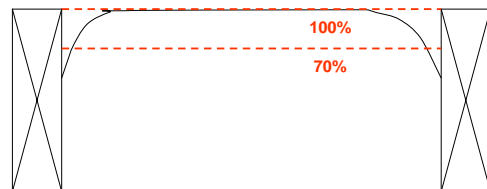
Conclusions

- Need more research on real impacts
 - *In situ* tests such as coheat measurements
- Current codes have embedded assumptions that all insulation is installed correctly ... NOT
- Consider adoption in codes? Options:
 - Adopt "as is" for performance method
 - Simply require Grade I and inspection, or
 - Assume II or III performance for prescriptive

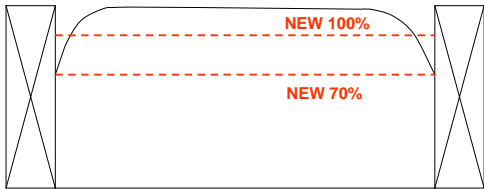
Incomplete Fill / Compression

- Two choices
 - Select thickness of insulation that meets grade level across assembly
 - Select lower grade

Select thickness of insulation that meets grade level across assembly



Select thickness of insulation that meets grade level across assembly



Select thickness of insulation that meets grade level across assembly

