INSULATION FACTS #54

Fire & Thermal Performance of Reflective Insulations in Metal Building Applications

Information from NAIMA

In this issue we analyze and discuss the fire and thermal performance claims of reflective insulations used in metal building systems.

NAIMA
North American Insulation Manufacturers Association

Reflective insulations, designed and marketed for use in residential building cavities, are also being used in some pole barns and metal buildings. Stated thermal and fire performance of these products are not consistent with their actual field applications in metal building construction.

Although manufacturers of reflective insulations have claimed R-values as high as 15, independent testing of some manufacturers' products has shown that the actual R-value is between 1 and 2.[1]

While manufacturers of reflective insulation claim their products meet the code requirement for fire safety, those reflective insulation products produced with plastic cores raise safety concerns because of the way they react to fire test conditions.

Why the Difference in Stated and Actual Performance?

Some marketers of reflective insulations make generalized efficiency and performance claims based on specific test configurations performed in "lab" conditions. But, upon further inspection, one will find that these performance details are not always well defined or are not typical of the installation configuration in a real world metal building application.[2]

Fire Safety

An important consideration when deciding whether reflective insulation is appropriate for metal buildings is fire safety.

Building codes require exposed insulation to have a flame spread index of 25 or less when tested in accordance with ASTM E84. The ASTM E84 Tunnel Test is one of the primary test standards for determining the fire safety of building products.

Because many reflective insulations have a plastic core, the nature of these reflective insulations requires a careful analysis of fire safety claims.

ASTM E84 states: *"Materials that drip, melt, delaminate, draw away from the fire or require artificial support present unique problems and require careful interpretation of the test results. Some of these materials that are assigned a low flame spread index based on this method may exhibit an increasing propensity for generating flame-over conditions*

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Table 1: Fire Test Summary

	ASTM E84[19] Flame Spread Index	UL 1715[20] Room Corner
Reflective 1 (Foil/Foam Core/Foil)	455	FAIL
Reflective 2 (Foil/Bubble Pack/Foil)	310	FAIL
Fiber Glass (R-10 Fiber Glass/PSK Facing)	25	PASS

All tests performed at Omega Point Laboratories

Comparison Guidelines

Look for the following information when comparing insulations for metal buildings:

1. **R-value of the actual product** – not performance claims based on specific tests or for combined construction components.

2. **Performance in "real" world construction applications** – not performance data from applications where the "complete sealing of dead air space" is contingent on achieving thermal performance.

3. **Surfaces where cleanliness is not an issue** – not products that require clean, bright, foil surface (void of dust and dirt typically found on surfaces of all products over time) that can result in significant performance losses.

4. **Third-Party Certifications** – not products that do not validate "performance" claims with third-party certification programs.

during a room fire test with increasing area of exposure of the material and increasing intensity of the fire exposure. The result, therefore, may not be indicative of their performance if evaluated under large-scale test procedures. Alternative means of testing may be necessary to fully evaluate some of these materials."[3]

Reflective insulations are stiff enough to be self-supporting for an ASTM E84 test. When tested in this manner by a nationally recognized laboratory, flame spread indices in excess of 300 were measured. (See Table 1.)

When these types of insulation materials were evaluated in the UL 1715 room corner test, they provide sufficient fuel, when exposed to a low energy fire, to cause a flash over situation. Samples of reflective insulation were tested in the UL 1715 test by a nationally recognized laboratory. The results were flash over fire conditions within 2.5 minutes for both samples tested.[4] (See insert.) These results should cast serious doubts about the fitness for use of reflective insulations for any exposed application.

Thermal Performance Testing

Another important consideration in making an insulation choice is thermal performance. The R-values claimed by manufacturers of reflective insulations are usually for the total construction[5] including inside and outside film coefficients, sheathing materials, interior finishing materials, and the air cavities that are present in the construction. The test conditions or R-value of their actual products are normally not specified.

Over the last ten years, a sufficient body of testing data has been developed to quantify the thermal performance of these reflective insulations. The data was developed using accepted ASTM test methods such as ASTM C518 or ASTM C177 for materials and ASTM C236 or ASTM C976 for insulation systems. These test methods determine the thermal performance of both component materials and construction assemblies. Chapter 25 of the *2001 ASHRAE Fundamentals Handbook*[6] contains accepted and authoritative information on the application of reflective insulations.

Thermal Performance Evaluation

Ideal vs. Actual Situations

The *2001 ASHRAE Handbook of Fundamentals* shows that the thermal performance of reflective insulations is highly dependent upon having low-emittance facing materials and the presence of a smooth, parallel sealed air space where air exchange and movement are inhibited in the construction where they are applied.[7] Under the right conditions – with heat flow down and a 3.5" air space at typical application temperatures of 90°F and an average emittance of .03 – R-values of up to 10 can be achieved.[8] However, the R-value can be 85% lower[9] if:

- The heat flow direction changes
- The emissivity of the facing is degraded
- The air space is less than 3.5"
- The air space is not thoroughly sealed

The *ASHRAE Handbook of Fundamentals* states, "Values for foil insulation products supplied by manufacturers must also be used with caution because they apply only to systems that are identical to the configuration in which the product was tested."[10] Typical installation instructions from reflective insulation manufacturers discuss the value of "dead air space," in thermal performance, but *do not* emphasize that in order to be effective, these dead air spaces must be sealed to prevent any air movement due to convection. Typical installation instructions also depict draping the insulation[11] to achieve dead air spaces, but neglect to state that the draping can result in non-uniform air spaces which impact the thermal performance. In actual application, heat transfer across an air space involves conduction, convection and radiation and is usually reported as one combined value. In sealed air spaces, the R-value is substantially reduced when the temperature between the surfaces is increased.[12] If the air space is not thoroughly sealed, the resistance is also reduced due to convection currents. Having a true, leak-free uniform air space is a nearly impossible situation for most constructions.

Tests of metal building roof assemblies containing reflective insulation products were conducted in a hot box apparatus conforming to ASTM C 1363.[13] The construction of the test assemblies involved draping the reflective insulation material over z-purlins spaced 60" apart. Sheet metal roofing panels were screwed to the purlins to simulate, as closely as possible, the actual construction details typical of a screwed-down metal roof. For summertime conditions (heat flow down) measured overall (air-to-air) R-values averaged 5.9, or ***less than 50%*** of the R-value calculated using the *2001 ASHRAE Handbook of Fundamentals* values. For wintertime conditions, the measured R-value averaged 3.8, or ***25% below*** the calculated value. (See Table 2).

These tests illustrate the importance of accounting for real-world effects when comparing insulation systems for metal buildings.

Surface Emissivity Value

The emissivity value of the surface plays an important role in insulation performance. Data sheets from reflective insulation manufacturers base their claims on new materials that have a bright foil surface. But, normal deterioration due to aging, dust contamination, surface oxidation, or exposure to polluted environments can result in "rapid and severe"[14] performance losses of up to 46% or more over time.[15]

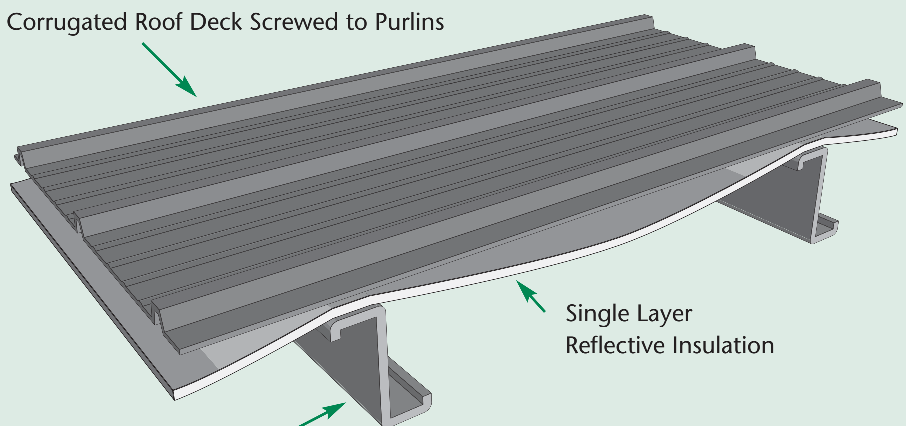
Bright aluminum foil has an average emissivity of 0.05. Once installed, the "brightness" may begin to deteriorate quickly. Minor deterioration can increase the emittance to over 0.2, which, in turn, decreases the thermal resistance. Even the presence of light condensation can increase the surface emittance to 0.30.[16]

Are Reflective Layers The Answer?

Many marketers of reflective insulations claim high thermal performance based on multiple reflective layers. However, *2001 ASHRAE Fundamentals Handbook* warns that the performance of these layers may not be additive.[17]

Table 2: Thermal Resistance

Reflective Insulation System



Component	Thermal Resistance: Summer Conditions Heat Flow Down	Thermal Resistance: Winter Conditions Heat Flow Up
Outside Film[21]	0.25	0.17
Metal Roof Deck	0	0
Sealed Air Space	6.09	2.55
Reflective Insulation, single layer, ε=0.03	1	1
Inside air film, ε=0.05[22]	4.55	1.32
Calculated Construction Total*	11.89	5.04
Measured Value	**5.9**	**3.8**
% of calculated R-Value	**50%**	**75%**

* R-Values shown are for center line heat flow path only and do not account for thermal bridges at the purlins.

Energy Code Compliance

Because the performance of reflective insulation systems depends on specific application conditions, builders may need to use worst-case conditions in order to comply with energy code requirements. There are currently no known third-party programs for certification of reflective insulations. This means builders must rely on the manufacturers' claims.

Summary

Under ideal conditions, the thermal performance of reflective insulation systems can be predicted using Chapter 25 in the *2001 ASHRAE Fundamentals Handbook*. However, if the manufacturers' claims do not reasonably agree with the ASHRAE calculation results, specific R-values can not be assured.[18] In addition, the fire safety characteristics of these products should be carefully evaluated before using them exposed in occupied spaces of buildings.

References

1. Johns Manville test report E436-T-1580 dated 9/30/81, pg. 12.
2. Reflective insulation manufacturer's packaging.
3. 1999 Annual Book of ASTM Standards, vol. 04.07, ASTM E 84-00a, Section x3.7.8, p. 499.
4. Omega Point Laboratories, 2001, UL1715 Fire Test of Interior Finish Materials, Project No. 13220-109410, pg. 3 and Project 13220-109402, pg. 3.
5. Reflective insulation manufacturer's packaging.
6. *2001 ASHRAE Fundamentals Handbook*, Chapter 25.
7. *2001 ASHRAE Fundamentals Handbook*, pg. 23.3.
8. *2001 ASHRAE Fundamentals Handbook*, pg. 25.4.
9. *ibid.*
10. *2001 ASHRAE Fundamentals Handbook*, pg. 25.2.
11. Reflective insulation manufacturer's instructions
12. *The Thermal Performance of Reflective Insulation Materials and Systems with Horizontal Heat Flow:A Parametric Study*, A.O. Desjarlais & R.P. Tye, pg. 279.
13. Johns Manville Test report CHB-03-001 dated 9/05/03.
14. *2001 ASHRAE Fundamentals Handbook*, pg. 25.2.
15. *Contamination of Reflective Foils in Horizontal Applications and the Effect on Thermal Performance,* J.C. Cook, Jr., D.W. Yarbrough, PhD., P.E., K.E. Wilkes, PhD., P.E., VA-89-8-4.
16. *2001 ASHRAE Fundamentals Handbook*, pg. 25.2.
17. *2001 ASHRAE Fundamentals Handbook*, pg. 25.1.
18. *2001 ASHRAE Fundamentals Handbook*, pg. 25.2.
19. Omega Point Laboratories, 2001, ASTM E84-00a Surface Burning Characteristics, Report No. 13220-109417, pg. 3 and Report No. 13220-109405, pg. 3.
20. Omega Point Laboratories, 2001, UL1715 Fire Test of Interior Finish Materials, Project No. 13220-109410, pg. 3 and Project 13220-109402, pg. 3.
21. *2001 ASHRAE Fundamentals Handbook*, pg. 25.2.
22. ibid.

About NAIMA

NAIMA is the association for North American manufacturers of fiber glass, rock wool, and slag wool insulation products. Its role is to promote energy efficiency and environmental preservation through the use of fiber glass, rock wool, and slag wool insulation, and to encourage the safe production and use of these materials.

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Large Scale Fire Testing of Metal Building Insulations

UL 1715 Room Corner Test • Omega Point Laboratories[23]

Reflective Insulation Sample #1 (Foil / Foam Core / Foil)

When two types of reflective insulation materials were evaluated in the UL 1715 Room Corner Test, they provided sufficient fuel when exposed to a low energy fire to cause a flash over situation.

In this example, two samples of reflective insulation and one fiber glass insulation sample were tested in the UL 1715 Room Corner Test by Omega Point Laboratories. The results were flash over fire conditions for these reflective insulations in less than 2.5 minutes for both samples tested.

Fire Test Summary: UL 1715 Room Corner

Reflective Insulation Sample #1 (Foil/Foam Core/Foil)	FAIL
Reflective Insulation Sample #2 (Foil/Bubble Pack/Foil)	FAIL
Fiber Glass Metal Building Insulation (R-10 Fiber Glass/PSK Facing)	PASS

Reflective Insulation Sample #2 (Foil / Bubble Pack / Foil)

For copies of the test reports, contact:

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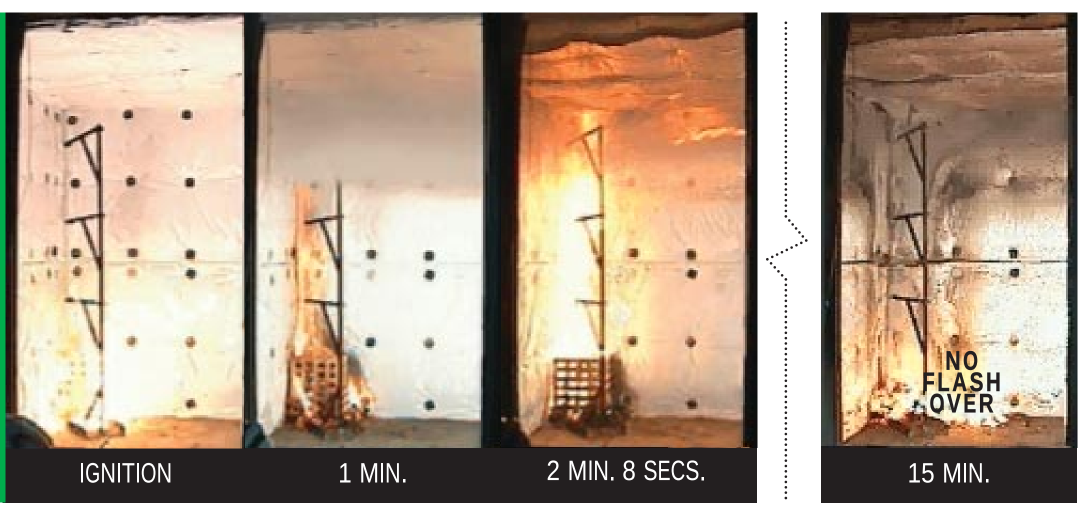
Fiber Glass Metal Building Insulation (R-10 Fiber Glass / PSK Facing)



Start of test. **time line not to scale**

* Times rounded to nearest second.

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Surface Burning Characteristics of Metal Building Insulations

ASTM E84 Tunnel Test • Omega Point Laboratories[24]

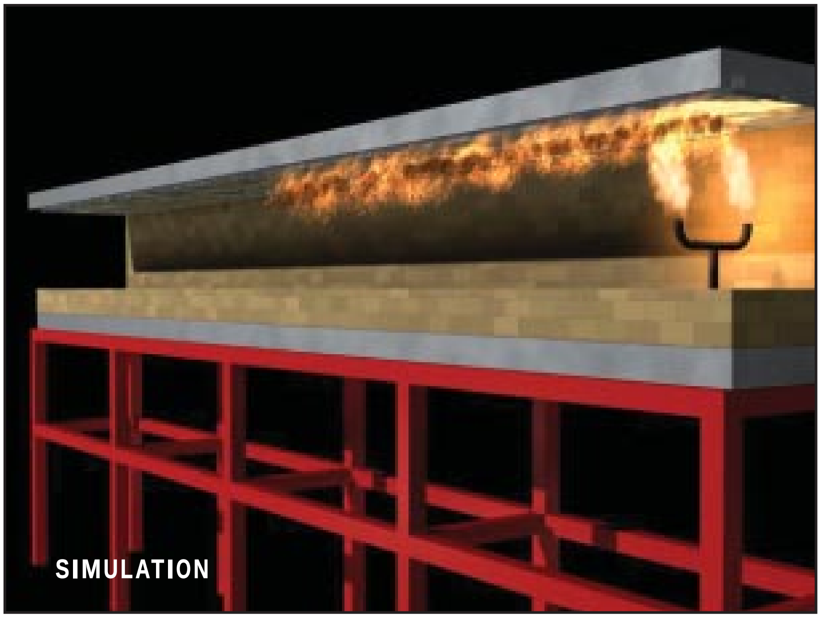

Photo #1: The Tunnel Test is the primary standard for determining the fire safety of building products. ASTM E84 states: "Materials that drip, melt, delaminate, draw away from the fire or require artificial support present unique problems and require careful interpretation of the test results. Some of these are assigned a low flame index based on this method and may exhibit an increasing propensity for generating flame-over conditions…alternative means of testing may be necessary to fully evaluate some of these materials."[26]

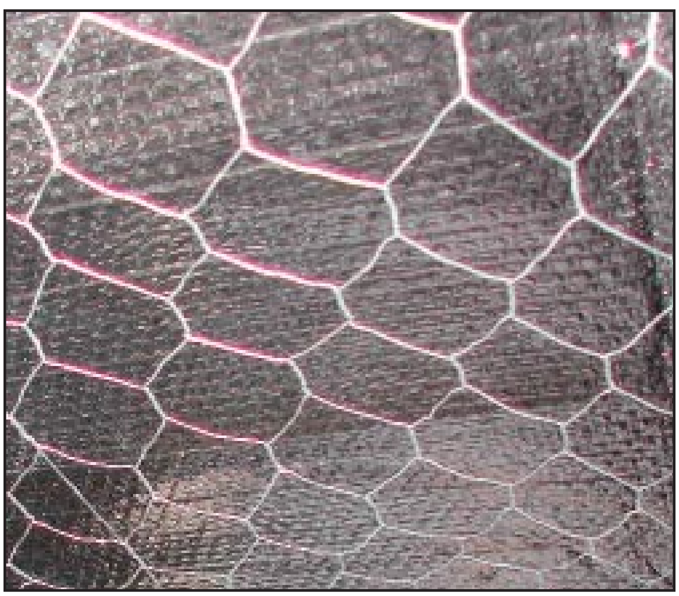

Photo #2: Manufacturers of reflective insulations state their products meet a flame spread index of 25 per ASTM E84. When the products tested were supported on poultry netting they met code requirements for flame spread. However, when tested without the poultry netting, they failed to meet code requirements.

Building codes require exposed insulation to have a flame spread index of 25 or less when tested in accordance with ASTM E84 – or the Tunnel Test. ASTM E84 is the primary test for determining the fire safety of building products. Although ASTM E84 allows reflective insulations[25] to be tested with support, this is not how they are used in metal buildings. Reflective insulations are stiff enough to be used without support and should be tested as self-supporting products in the ASTM E84 test. When tested without support by Omega Point Laboratories, flame spread indices in excess of 300 were measured for the two reflective insulations with plastic cores.

Insulation	ASTM E84 Flame Spread Index	
	With Poultry Netting Support	Without Poultry Netting Support
Reflective #1 (Foil/Foam Core/Foil)	25	455
Reflective #2 (Foil/Bubble Pack/Foil)	20	310
Fiber Glass Insulation	N/A	25

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Photo #3: Reflective insulations are installed in metal buildings without a support structure such as poultry netting. These products are self-supporting and should be tested for their flame spread performance without additional support.

REFERENCES:

23 Omega Point Laboratories, 2001, UL1715 Fire Test of Interior Finish Materials, Project No. 13220-109410 and Project 13220-109402.

24 Omega Point Laboratories, 2001, ASTM E84-00a Surface Burning Characteristics, Report No. 13220-109417 and Report No. 13220-109405.

25 Reflective insulations are defined here as products with a plastic center of bubble pack material sandwiched between two sheets of aluminum or with a center of foam-like plastic material with at least one side aluminum covered.

26 "1999 Annual Book of ASTM Standards," vol. 04.07, ASTM E84-00a, Section X3.7.8, p. 499.