product feature

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ADVANCES IN REFLECTIVE TECHNOLOGY

BACKGROUND

The past decade has seen significant changes and advances in the design, manufacturing, and utilization in North America of reflective insulation and radiant barrier materials. The most prominent change has been the use of metallized aluminum film to provide the reflective material for *enclosed reflective air spaces*. This is closely followed in importance by the use of reflective technology in conjunction with other types of insulation such as cellular plastic or mineral fiber insulations to create "hybrid" insulation assemblies that can economically deliver high thermal resistance values (R-values). These advances result is an expansion of choices available for insulating buildings to reduce the cost of providing comfortable enclosures and while reducing destructive emissions to the atmosphere.

FOIL TO FILM

The use of films metallized with aluminum in place of aluminum foil has resulted in an improved performance of reflective products in the widely recognized and required test for flame spread/smoke developed, ASTM E 84/D2599. E 84 tests on the present generation of reflective products is yielding flame-spread values less than 25 (often designated "Class A"). The flame-spread test on reflective products is one of the evaluations required by the "*Verification Program*" managed by the reflective industry association, RIMA-I.[1]

The RIMA-I verification program includes a review of technical data on product tables and technical bulletins and the basis for the claims. Metallized films, properly protected from reaction with atmospheric oxygen, have slightly higher emittances than polished aluminum foil. The RIMA-I verification program includes a test that verifies the performance of the protective coating protecting the metallized film. The coated metallized films in the market have emittances around 0.05 while foil surfaces are generally around 0.03 on a scale of 0 to 1. The higher emittance for the film products is due to a thin transparent coating that blocks oxygen from contacting the metallized surface. The increase in emittance results in a small decrease in the thermal resistance of the *enclosed reflective air spaces* created by installation of the reflective product in a building construct. **Table 1** contains R-values calculated with effective emittances of 0.03 and 0.05 to show the magnitude of the decrease in thermal resistance. The calculation is based on published hot-box data.[2,3] The R-values in Table 1 are for an average air space temperature of 75°F and a temperature difference across the air space of 10°F. The differences in R-value for the cases listed in Table 1 are tenths of an R-value in most cases. The maximum differences in R-value between enclosed air spaces with effective emittances (E) 0.03 and 0.05 occurs for heat-flow down because thermal radiation in a dominate mode of heat transfer for heat-flow down and thermal radiation is proportional to emittance. The R-values in Table 1 have units $ft^2 \cdot h \cdot °F/Btu$ commonly used in the United States.

TABLE 1. R-VALUE COMPARISON

Heat Flow Direction	Air Space (inches)	R-value E=0.03	E=0.05	R-value difference
Up	0.5	2.17	2.07	0.10
	1.0	2.42	2.30	0.12
	2.0	2.64	2.50	0.14
Horizontal	0.5	2.52	2.39	0.13
	1.0	3.87	3.58	0.29
	2.0	3.76	3.49	0.27
Down	0.5	2.55	2.42	0.13
	1.0	4.58	4.18	0.40
	2.0	7.64	6.59	1.05

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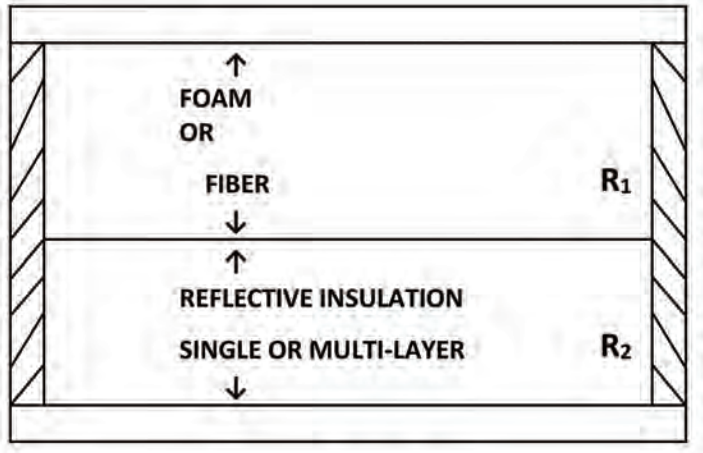

Figure 1: Hybrid Assemble with Additive R-values

The effective emittance (E) combines the emittances of parallel surfaces into a single value.[4] The emittance of non-reflective surfaces such as wood was taken to be 0.90 in the present case.

Hybrid Insulation Assemblies

Increases in required amount of thermal resistances, the march toward zero-energy buildings, and the need to control the cost of construction has promoted the use of combined insulation technologies to create hybrid assemblies with additive R-vales as diagramed in **Figure 1** provides a designer or specifier an opportunity to optimize a building's insulation package with respect to performance and cost. Insulation systems that combine reflective technology with foam insulation or mineral fiber insulation are currently available in the marketplace. An example of an established type of hybrid assemble with a reflective component is pictured in **Figure 2**.

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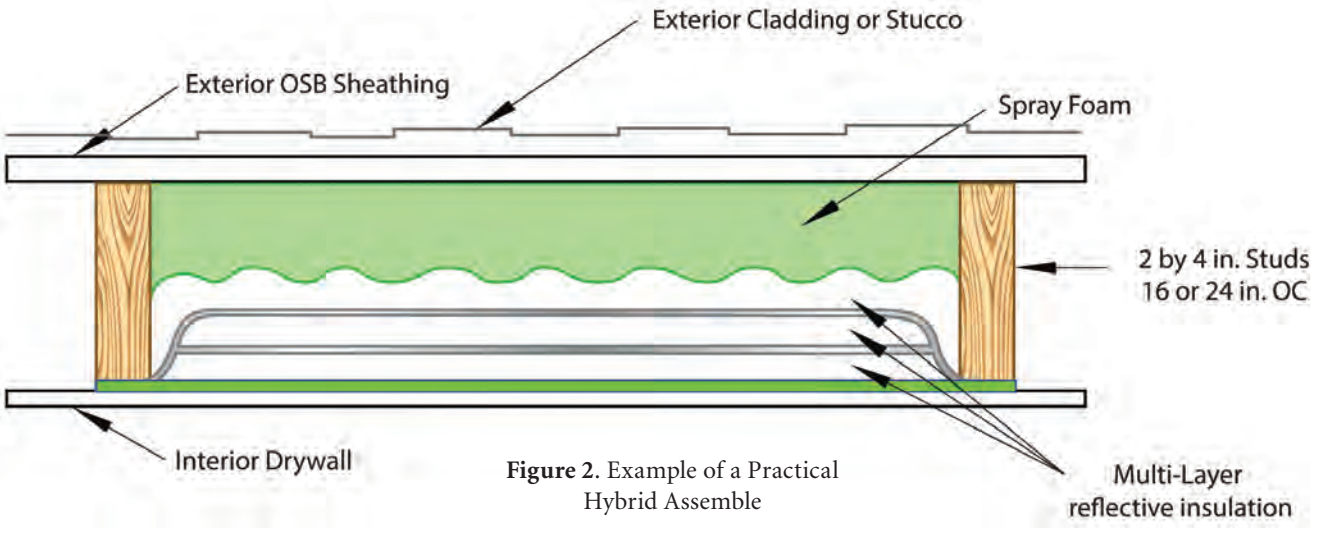

Figure 2. Example of a Practical Hybrid Assemble

R-values in series are additive and the temperature difference across each layer of insulation is a fraction of the total temperature difference across the region containing the hybrid assemble. Figure 3 illustrates this partitioning of the total temperature difference for a specific case with heat flow down across a 3.5-inch air space. The effective emittance of the air space is 0.05. The result for the R-value of the reflective air space was calculated using a published iterative procedure.[5] Hybrid assemblies like that in the **Figure 3** diagram are especially favorable for reflective insulations since the reduced temperature difference across the air space is much less than the overall temperature difference thus reducing the magnitude of natural convection, if any, in the enclosed air space.

The reflective region of a hybrid assemble can be designed to have a single low-emittance surface, can be used to form two enclosed reflective air spaces, or a multi-layer reflective insulation can be installed if space permits. The thermal resistance contributed by the introduction of two, three, or more enclosed reflective air spaces in a region like that shown in Figure 2 significantly increases the reflective contribution to the overall thermal resistance. Large air spaces for example between floor joists provide space for multi-layer reflective surfaces

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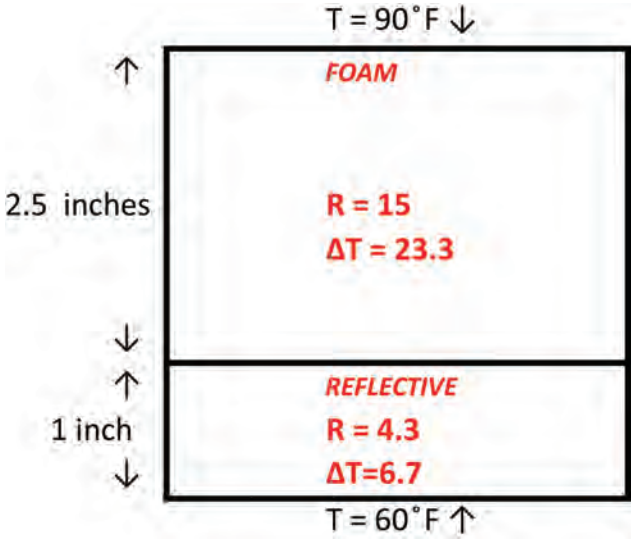

Figure 3. Illustration of Temperature Differences Across a Hybrid Assemble

and creative combinations of insulation technologies. Aluminum foils and metallized films also contribute to the control of water vapor transmission and qualify as air barrier material in many cases thus adding to the versatility of the product type. RB

SUMMARY

Improvements in design, testing, quality control, and verification are contributing to an insulation technology that provides flexibility in specifying materials and systems for insulating the building enclosure.

References

1 RIMA International: www.rimainternational.org

2 Robinson, H.E., F. J. Powell. and R.S. Dill, "The Thermal Insulation Value of Air Spaces", Housing Research Paper 32, U.S. National Bureau of Standards (1954).

3 Desjarlais, Andre O. and David W. Yarbrough, "Prediction of the Thermal Performance of Single and Multi-Airspace Reflective Insulation Materials, ASTM STP 1116, Insulation Materials: Testing and Applications, Second Volume, edited by R. S. Graves and D. C. Wysoci, American Society for Testing and Materials (1991).

4 2017 ASHRAE Handbook – Fundamentals, Chapter 26, Table 3, note "e".

5 Ibid 3