INSULATION FACTS #61

NAIMA
North American Insulation Manufacturers Association

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Facts About the Performance of Reflective Bubble Pack Insulations in Duct System Applications

Information from NAIMA

In this issue we analyze and discuss performance claims of reflective (bubble pack) insulations when used to insulate air duct systems and how they fit in the model codes that govern these applications.

Reflective bubble pack insulations have been on the market since at least the early 1980s. Originally designed and marketed for use in residential building cavities, they are being promoted in some HVAC duct insulation applications.

Table 1 (on page 2) is a matrix of model mechanical code requirements and the performance characteristics of reflective bubble pack products compared to like fiber glass products. After reviewing this table, one can only conclude that the reflective bubble pack products do not meet the International Mechanical Code (IMC). Since all other model codes incorporate similar if not more stringent requirements, it is unlikely that the reflective bubble pack insulations meet any of the model mechanical codes. The text that follows provides more detailed information about the performance of these products.

SINCE ALL OTHER MODEL CODES INCORPORATE SIMILAR IF NOT MORE STRINGENT REQUIREMENTS, IT IS UNLIKELY THAT THE REFLECTIVE BUBBLE PACK INSULATIONS MEET ANY OF THE MODEL MECHANICAL CODES.

Thermal Performance

A sufficient body of testing data has been developed to quantify the thermal performance of reflective insulations. The data was developed using accepted[1] ASTM test methods such as ASTM C 518 or ASTM C 177 for materials and ASTM C 236 or ASTM C 976 for building envelope insulation systems.

Chapter 25 of the 2001 ASHRAE Fundamentals Handbook contains accepted and authoritative information on the application of reflective insulations. This Chapter shows that the thermal performance of reflective bubble pack insulations is highly dependent upon having low-emittance facing materials and the presence of a perfectly sealed air space in the construction where they are used. Under the specific conditions — with heat flow down and a 3-1/2″ sealed air space — R-values of up to 10 can be achieved for building wall systems.

[1] ASHRAE 90.1-99, ASHRAE 90.2-93, ICC Building and Energy Codes, Model Mechanical Codes

Table 1

ICC Mechanical Code Section 604	Property	Code Requirements	Test Method	Product Performance	
				Bubble Pack	Fiber Glass
604.2	Exposed Surface Temperature	Maximum exposed surface temperature 120° F.	Not defined in code. ASHRAE equations used to compute following values. See Note 1.	Using an emissivity of 0.05, any duct air temperature over 135° F. will result in bottom of duct failure when product used as duct wrap.	1-1/2" duct wrap with emissivity of 0.20 allows over 180° F. duct air temperature.
604.3	Surface Burning Characteristics See Note 2.	Flame Spread (FS) not more than 25, Smoke Developed (SD) not more than 50.	ASTM E 84	FS - 20, SD - 30.	FS -25 or less SD - 50 or less.
604.3	Hot Surface Performance	250° F. minimum test temperature.	ASTM C 411	Claim pass but limit product to 180°F. maximum service temperature.	All products pass at 250° F. without limitations.
604.4	Thermal Barrier - See Note 3.	Refers to IBC Sect.2603.4 which requires separation of product from interior of building by 0.5" gypsum board or equivalent unless product passes large-scale test (Sect. 2603.7).	Large-scale tests such as FM 4880, UL 1040, or UL 1715	Model code research reports require thermal barrier be used for exposed insulation in crawl spaces. Failed independent UL 1715 test.	Fiber glass is not a plastic foam but products pass both ASTM E 84 and large-scale tests.
604.7	Identification	Insulation shall be marked at max. 36" intervals with: Name of manufacturer, thermal resistance (R-value), flame spread and smoke developed indices.	N/A	No evidence of marking on material being sold at retail outlets even though literature suggesting air duct applications was on display.	All duct insulation products so marked.
604.7	R-value Determination	R-values shall be based on insulation only, excluding air films, vapor retarders or other duct components and shall be based on tested C-values at 75°F. mean temperature.	ASTM C 518 or ASTM C 177	All claims include air films, dead air spaces, and surface emissivity in calculated R-values. Insulation only value is approximately R-1.1.	Duct wrap R-values based on installation @ 25% compression of insulation. Duct liner values based on nominal thickness.
604.13	Durability of Internal Insulation	Materials used as internal insulation and exposed to the airstream shall be durable.	UL 181 (Erosion Test)	No application instructions or claims for meeting this requirement given in available literature.	All liners tested at 2-1/2 times rated velocity using well defined installation details.

1) Assumed duct located in occupied space such as a basement with an ambient temperature of 75° F.
2) ASTM E 84 warns that products which melt and drip and require artificial support present unique problems and require careful interpretation of results. Alternative means such as large-scale testing procedures may be necessary to fully evaluate these materials. See text for further discussion.
3) While the bubble pack products may not be considered to be foamed plastics, they behave in a similar manner. This is obvioiusly true when the installation details in model code research reports require the products to be covered with gypsum board.

However, the R-value can be reduced by as much as 85% if:

- The heat flow direction changes
- The emissivity of the facing is degraded
- The air space is less than 3-1/2″
- The air space is not thoroughly sealed

All of these changes can come into play when considering insulating air ducts and the application procedures recommended by the reflective manufacturers.

Manufacturers of reflective bubble pack insulations have claimed R-values for 5/16″ thick duct wrap as high as 5.6. Independent testing of some manufacturers' products has shown that the actual R-value is approximately 1.1 when the product is tested in accordance with ASTM C 518. This method has been required for reporting R-value data on insulation products for use on residential HVAC ducts currently listed by the Federal Trade Commission.

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So why is there a difference in stated and actual performance?

Many marketers of reflective bubble pack insulations make generalized efficiency and performance claims based on very specific test configurations performed in "lab" conditions. The critical installation details required are not easily achieved in an air duct application. The claimed R-values are for the total construction including inside and outside film coefficients and sealed air spaces. These test conditions are normally not even reported by the reflective bubble pack marketers.

Surface Emissivity Value

The emissivity value of the surface plays an important roll in the insulation performance of reflective bubble pack insulations. The manufacturers always base their data sheet claims on new materials that have a bright foil surface with an average emissivity of 0.05. But, normal deterioration due to aging, dust accumulation, surface oxidation, or exposure to polluted environments will increase the emissivity to over 0.2, which, in turn, decreases the thermal performance. The presence of light condensation can increase the surface emissivity to 0.30.

ASHRAE Chapter 25 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. In addition, surface oxidation, dust accumulation, condensation, and other factors that change the condition of the low-emittance surface can reduce the thermal effectiveness of these insulation systems.*" This is the reason the model codes require the insulation R-value alone to be reported.

Dead Air Space

Typical installation instructions from the reflective bubble pack manufacturers discuss the value of "dead air space" in thermal performance. In actual application, heat transfer across an air space involves conduction, convection and radiation and is usually reported as one combined value. However, in order for these dead air spaces to be effective, they must be sealed to prevent any air movement. The manufacturer's installation instructions suggest the use of strips of their product on specified centers as spacers to create a dead air space (usually not more than 5/16″ thick, instead of the 3-1/2″ tested) but provide no detail on sealing these spaces. 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 to accomplish, especially since the application procedures make no mention of sealing the duct system before insulating. Additionally, even in sealed air spaces, the R-value is substantially reduced when the temperature difference between the surfaces is increased compared to the laboratory test conditions. This will be true in most HVAC applications.

In conclusion, air spaces created according to the manufacturer's installation instructions probably are of questionable benefit in actual practice. Additionally, installation instructions to create these air spaces apparently are being ignored in field applications.

Further, for the above reasons, the model mechanical codes do not permit the claims for dead air spaces or surface emissivity to be used. In the end, the only R-value that is applicable is the R-1.1 measured by ASTM C 518 or C 177.

Fire Safety

There are other issues to consider when deciding whether reflective bubble pack insulation is appropriate for HVAC applications. One important consideration is fire safety. While most building codes list ASTM E 84 (Steiner tunnel) as the primary test standard for determining fire safety, the nature of these plastic bubble packs requires a more careful analysis. ASTM E 84 warns: "*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 during 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.*"

Reflective bubble pack insulations are stiff enough to be self-supporting for an E 84 test. When tested in this manner instead of with artificial support by a nationally recognized laboratory, flame spread indices in excess of 300 were measured.

The Federal Trade Commission (FTC) ruled that manufacturers of foam plastic materials can not use only ASTM E 84 to characterize the fire performance of their materials. Other tests like the corner wall test (UL 1715/UBC 8-2) should also be used.

When these types of materials are evaluated in the corner wall test, they often will provide sufficient fuel when exposed to a low energy fire to cause a flash-over situation. Samples of reflective bubble pack insulation were tested in the UL 1715 corner wall test by a nationally recognized laboratory. The results were flash-over fire

Table 2

Sound Absorption Coefficients at Octave Band Center Frequencies							
Thk.	125	250	500	1000	2000	4000	NRC
Flexible Fiber Glass (1)							
1/2″	.02	.07	.18	.37	.52	.67	.30
1″	.04	.19	.35	.55	.69	.72	.45
Reflective Bubble Pack (2)							
5/16″	.05	.03	.04	.13	.51	.21	.20

1) Minimum performance values as listed in ASTM C 1071
2) Manufacturer published data

conditions within 2-1/2 minutes. These results should cast serious doubts about the fitness for use of reflective bubble pack insulations for any exposed application.

Reflective Bubble Pack Insulation as a Duct Liner

Recently, some reflective bubble pack manufacturers have developed literature suggesting their product is also suitable for use as a duct liner. While the literature makes no claims for thermal performance, a comment appearing in a trade publication suggests that the product has an R-value of 1.1. Table 2 shows the acoustical performance in relation to the performance of fiber glass duct liners. As the table shows, there is very little real acoustical value offered by the reflective bubble pack product, which is not surprising given its closed cell construction.

> It is clear that the reflective bubble pack insulations are deficient in many if not all of these categories.

Detailed application information did not appear in the literature, nor were any test results provided indicating the product is durable when exposed to the airstream.

Without any further data, concerns about the long term durability of the product in this application as well as questions about combustibility performance as required by NFPA 90 A should be considered. Additionally, NFPA 90 A and most model mechanical codes require duct liners to withstand 250° F. internal air temperatures. Published data for reflective bubble pack products show the upper temperature limit to be 180° F. Given these limitations, it is difficult to understand why this product would be chosen as a viable duct liner.

Summary

Duct coverings and linings require more stringent properties than normally associated with envelope insulations. Fire safety is of highest importance as these products are a component of the mechanical system that is capable of creating fire situations, which should not be spread by the duct system.

Insulation performance is important as well. The covering or lining should be adequate to prevent burns, maintain surface temperatures above the ambient dew point to prevent condensation in cooling situations and provide good acoustical performance when used as a duct liner. None of these parameters should change substantially with age from published performance claims to allow the designer to select materials that will perform for the life of the structure.

It is clear that the reflective bubble pack insulations are deficient in many if not all of these categories.

Fiber glass products have a long history of performing these functions well and without decreasing performance as they age. Be sure when selecting a new product that it will measure up to those that have been successfully used for many decades.

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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Printed on Recycled Paper

PUB. NO. AH135 10/01