Product Information Bulletin

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Facts About Thermal Resistance of Reflective Insulation

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Reflective insulation materials have been on the market since at least the early 1980s. Two common types currently being marketed consist of either a moulded expanded polystyrene (EPS) insulation board that is faced with reflective foil or a bubble pack core material faced with reflective foil.

Canadian Construction Materials Centre (CCMC) has published evaluation listings for a number of EPS insulations manufactured with a reflective foil facer. In Canada, evaluation of EPS insulation with a reflective foil facer is based upon compliance with the National Standard of Canada for EPS insulation, CAN/ULC-S701, ***Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering***. The thermal recognized resistance value for listed products complying with CAN/ULC-S701, type 1 is RSI-0.65 $m^2\cdot°C/W$ for a 25-mm thickness (R-3.75 $ft^2\cdot hr\cdot°F/BTU\cdot in$).

General requirements and physical properties for foil-faced insulation used as a reflective insulation are addressed in ASTM C1224, ***Standard Specification for Reflective Insulation for Building Applications.*** ASTM C1224 clearly states in the scope section that: "***Reflective insulations derive their thermal performance from surfaces with an emittance of 0.1 or less, facing enclosed air spaces.***" Emissivity is the value given to materials based on the ratio of heat emitted compared to a perfect black body, on a scale from zero to one. A black body would have an emittance of 1 and a perfect reflector would have a value of 0.

ASTM C1224 includes requirements that the thermal performance of reflective insulation shall be determined as part of an assembly in accordance with ASTM Test Method C1363, ***Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus***. ASTM C1224 is not a referenced material standard in Canadian or US model codes.

National Building Code of Canada 2010 (NBC 2010) does not recognize reflective insulation on its own as an acceptable insulation material and addresses it as follows:

- NBC 2010, Footnote 4 to Table A-9.36.2.4.(1)D., ***Thermal Resistance Values of Common Building Materials***, states:

  Reflective insulation material may contribute a thermal property value depending on its location and installation within an assembly. Where a value is obtained through evaluation carried out in accordance with Clause 9.36.2.2.(4)(b), it may be included in the calculation of the thermal resistance or transmittance of the specific assembly.
- NBC 2010, Sentence 9.36.2.2.(4) states the following:

  The effective thermal resistance of opaque building assemblies shall be determined from
  a) calculations conforming to Article 9.36.2.4., or
  b) laboratory tests performed in accordance with ASTM C1363, "Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus," using an indoor air temperature of 21±1°C and an outdoor air temperature of -35±1°C.

2012 Ontario Building Code, MMA Supplementary Standard SB-12, ***Energy Efficiency for Housing***, states the following in Sentence 2.1.1.1.(5): "***Reflective surfaces of insulating materials shall not be considered in calculating the thermal resistance of building assemblies.***"

Thermal Performance

Since reflective insulation is not prescriptively addressed by the NBC 2010 (i.e., ASTM C1224 is not a referenced standard in NBC 2010), some reflective insulation manufacturers have sought CCMC evaluations to develop test data to quantify the thermal performance of reflective insulations using ASTM C1363 as specified in the NBC 2010. CCMC has evaluated wall systems incorporating reflective insulation.

The basis for one CCMC evaluation is testing of wall assemblies incorporating reflective insulation with sealed airspaces over plywood using ASTM C1363 in accordance with NBC 2010, Clause 9.36.2.2.(4)(b). The results of this testing were then used to validate a mathematical model simulating actual proposed wall systems – e.g., reflective insulation installed on the face of a 200-mm (8") concrete wall with a furred 19 mm (¾") or 38 mm (1 ½") air space with sealed gypsum board on the interior side. The **Conditions and Limitations** section in the evaluation report for the products addressed in the report include the following:

- Thermal resistance values provided in the evaluation report are valid only if there are no construction imperfections, no condensation in the cavity, and no dust on the reflective surface of the insulation.
- The air space in front of the reflective surface must be sealed at the interior finish to prevent any air exchange between the furred air space and the interior space and at the perimeter of the wall, around outlets, etc.
- All ends and edges of the gypsum board must occur over furring members or joints must be taped with 50-mm (2") wide aluminum tape.

Previous research by the National Research Council of Canada (NRCC) indicates that about 14% of the thermal resistance for these types of wall assemblies is attributable to radiation heat transfer as a result of the low emissivity of the foil surfaces. NRCC research also indicates that if the emissivity of the surfaces of the foil-faced sheet material were to be changed to 0.9 from 0.04, the thermal resistance of the airspaces and furring assembly with low emissivity reflective material would decrease by about 50%, mainly due to the increase in heat transfer by radiation.

The thermal performance of reflective insulation with air spaces was also discussed in an article in **Home Builder** magazine written by *M.C. Swinton,* a research officer in the Building Performance Laboratory of the Institute for Research in Construction/Na*tional* Research Council Canada. The article entitled ***Radiant Barriers and Reflective Insulation***, highlights the fact that the thermal performance of reflective insulations is dependent upon having low-emittance facing materials in combination with a perfectly sealed air space in the construction.

Canada Housing and Mortgage Corporation (CMHC) also published a Research Highlight entitled, ***Comparison of Under-Floor Insulation Systems*** (Technical Series 04-127) in October 2004. This CMHC research highlight evaluated the thermal resistance of a double-layer bubble pack with an intermediate foil layer in an under-floor application and found it to be RSI-0.40 (R-2.27).

So, why is there a difference between stated thermal resistances of reflective insulation versus actual reflective insulation performance? There are several reasons:

1. Many marketers of reflective insulations make generalized efficiency and performance claims based on very specific test configurations performed in “lab” conditions.
2. The critical installation details used for tested assemblies are not easily achieved in an actual application.
3. Claimed thermal resistance values are typically for the total wall assembly including thermal resistance of inside and outside air films and sealed air spaces.

The above test conditions are normally not even reported by reflective insulation marketers.

Surface Emissivity Value

As noted above, the emissivity value of the foil surface plays an important role in the thermal resistance of reflective insulation. Reflective insulation manufacturers typically base their product performance claims on new materials with a bright foil surface. However, normal deterioration due to aging, dust accumulation, surface oxidation or exposure to polluted environments can increase the surface emissivity, which, in turn, decreases the thermal performance. The presence of light condensation will also increase the surface emissivity substantially.

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.*” For these reasons, CCMC product evaluation listings recognize the thermal resistance of the insulation material alone. When the contribution of the reflective surface is recognized in an evaluation report, a complete description of the tested building system is provided.

Dead Air Space

Typical installation instructions from reflective insulation 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 with reflective insulation, they must be sealed to prevent any air movement. Creating a true, leak-free uniform sealed air space in an end-use application is very difficult to accomplish.