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A Measure of Confidence in Polyisocyanurate Insulation LTTR

An August 2013 article written by Jared Blum, President, Polyisocyanurate Insulation Manufacturers Association (PIMA), highlights a change to the PIMA certification program for declared LTTR.[1] PIMA is suggesting participating member companies certify to a design R-value of R-5.7 per inch beginning January 1, 2014. LTTR design R-value is determined based upon testing using either CAN/ULC-S770[2] or ASTM C1303.[3]

This bulletin will provide background on how "long-term" thermal resistance (LTTR) is determined for products like polyisocyanurate insulation. It will also provide information on how ***actual*** R-value measurements compare against declared LTTR design R-value for polyisocyanurate insulation.

Background:

CAN/ULC-S770 determines the "long-term" thermal resistance (LTTR) of foam plastic insulation manufactured with blowing agents intended to be retained for greater than 180 days. S770 was developed as a National Standard of Canada for testing of cellular foam plastic insulation manufactured with the intent to retain a blowing agent. LTTR is defined in S770 as:

> *The thermal resistance of an insulation product containing a gas or mixture of gases, measured or predicted at standard laboratory conditions, equivalent to the thermal resistance resulting from gas exchange with ambient air after storage for 5 years at these conditions.*

LTTR requirements are included as a mandatory requirement in CAN/ULC-S704[4] as follows:

> *All cellular plastic insulations manufactured with the intent to retain a blowing agent, other than air, for a period longer than 180 days, shall be tested for long term thermal resistance (LTTR) in accordance with CAN/ULC-S770. This thermal resistance shall be the design thermal resistance value for purposes of energy calculations, and for determining compliance with the requirements of this Standard, listed in Table 1, for permeably faced products.*

Table 1 in CAN/ULC-S704 lists the minimum LTTR for a 50-mm product thickness as 1.80 $m^2 \cdot {}^oC/W$ which is equivalent to R-5.2 per inch of thickness.

ASTM C1303, Part A, provides a prescriptive method for determining LTTR which, like S770, is intended for product evaluation, specifications, or product comparisons. C1303 defines "long-term" as:

> *long-term, adj—for the purposes of the Prescriptive Method, long term refers to five years.*

ASTM C1289[5] references CAN/ULC-S770 and ASTM C1303, Part A (using core slices only), as acceptable for determining and reporting values, but does not include minimum LTTR values.

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[1] NRCA Professional Roofing, ***A measure of performance***, Jared O. Blum, PIMA, August 2013.
[2] CAN/ULC-S770-09, ***Standard Test Method for Determination of Long-Term Thermal Resistance of Closed-Cell Insulating Foams***, published by Underwriters Laboratories of Canada.
[3] ASTM C1303-12, ***Standard Test Method for Predicting Long-Term Thermal Resistance of Closed-Cell Foam Insulation***, published by ASTM International.
[4] CAN/ULC-S704-11, ***Standard for Thermal Insulation, Polyurethane and Polyisocyanurate, Boards, Faced,*** published by Underwriters' Laboratories of Canada.
[5] ASTM C1289-13ε1, ***Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board***, published by ASTM International.

It is important to note that the scope statements for both LTTR test methods indicate that they provide a means of "predicting" or "estimating" what the R-value for affected cellular foam plastic insulations would be after five years in laboratory conditions. The five year period was chosen for LTTR as it is expected to predict the 15-year, time-weighted average R-value of an insulation. ***Predicted*** or ***estimated*** LTTR is intended to be compared to ***actual*** R-value measured at a mean temperature of 24 ºC (75 ºF).

Actual Measured R-values:

LTTR claims by polyisocyanurate manufacturers have been disputed by the National Roofing Contractors Association (NRCA) since 1987 when they recommended using R-5.6 as a design R-value for polyisocyanurate roof insulation. Since then, NRCA has attempted to clarify the basis for their recommendations by participating in test programs to establish the ***actual*** R-value. For example, a 2006 article by Mark Graham, NRCA Associate Executive Director of Technical Services, highlighted a test program conducted on 20 aged polyisocyanurate insulation samples.[6] The article states: *"On the basis of this data, a positive bias in the LTTR methodology clearly is apparent—that is, the LTTR methodology appears to overstate a product's actual R-value at five years of relative aging.*"

To further clarify the issue, NRCA participated in another test program reported on in May 2010.[7] The test program again demonstrated that for samples with ages ranging from four to thirteen months, ***actual*** R-values for polyisocyanurate insulation were lower than both the LTTR of R-6.0 per inch currently being certified by PIMA and the new LTTR of R-5.7 per inch suggested by PIMA as of January 1, 2014.

Building Science Corporation (BSC) followed up on the NRCA test program with additional testing published in BSC Information Sheet 502.[8] The figure below from the BSC information sheet highlights the range of R-values from the NRCA test program and the BSC test results. Both test programs measured ***actual*** R-values for polyisocyanurate insulation less than the new LTTR of R-5.7 per inch.

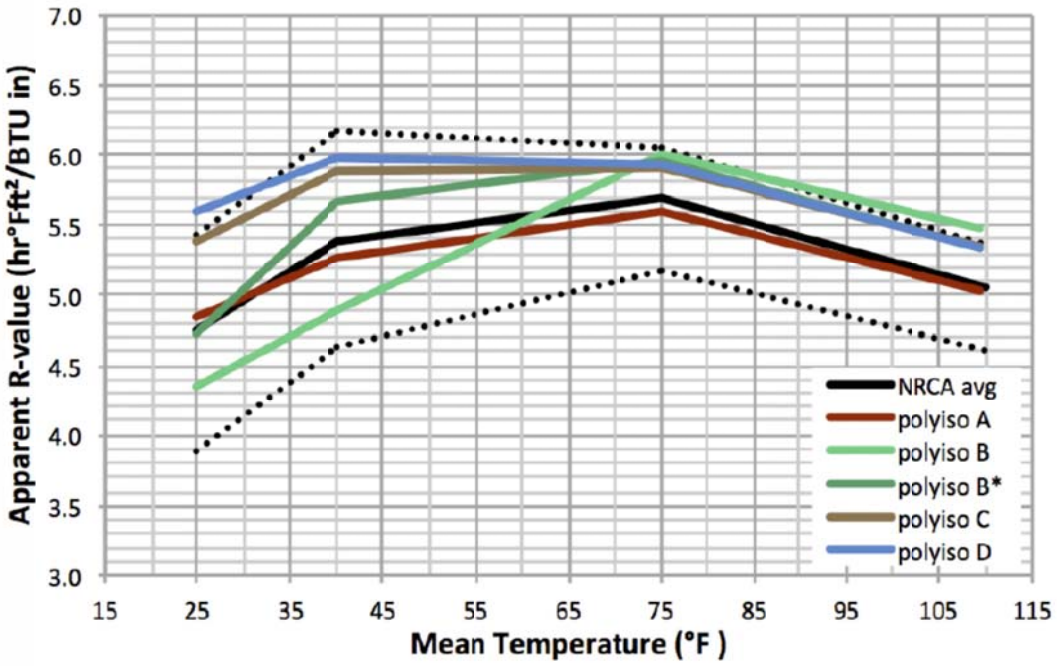

Figure 1 - BSC & NRCA average R-values measured at various mean temperatures for 2 in. samples
Note: The dashed lines indicate the range of R-values measured by NRCA.

[6] NRCA Professional Roofing, Tech Today, ***Research reveals the LTTR method may be over-reporting results***, Mark S. Graham, NRCA, January 2006.
[7] NRCA Professional Roofing, Tech Today, ***R-value Concerns***, Mark S. Graham, NRCA, May 2010.
[8] BSC Information Sheet 502, ***Understanding the Temperature Dependence of R-values for Polyisocyanurate Roof Insulation***, Building Science Corporation, 2012.

Observations:

The Blum article states that the polyisocyanurate industry is taking actions to improve the performance of its products and to identify ways to accurately measure that enhanced performance. However, based upon comparison of published results from ***actual*** R-value tests with the current and proposed PIMA declared LTTR design R-values there is a reality gap.

First of all, it is important to note that the LTTR test methods that PIMA has identified as providing ways to measure enhanced performance are **not new test methods**. The original version of S770 was published in 2003 and was quickly adopted by the polyisocyanurate industry directly into ASTM C1289. However, additional work on the S770 standard including a round robin to define the bias for the test method resulted in an updated version. The current version of CAN/ULC-S770 was published in 2009.

The announcement by PIMA in the Blum article suggesting that member companies adopt lower LTTR values leaves several questions unanswered:

1. Could it be inferred from the reference in the Blum article to "*actions to improve performance*" that additional formulation changes are coming so ***actual*** "measured" R-value after 5 years aging for products on the market as of January 2014 may not be available to verify LTTR predictions?
2. How should designers judge a new lower LTTR that still over-states ***predicted*** R-value based upon published ***actual*** R-value tests conducted by independent test laboratories on polyisocyanurate insulation samples less than 5 years old?
3. Should building designers use a ***design*** R-value of R-5.0 per inch as suggested by NRCA for cold climates[9] when using polyisocyanurate roof insulation?
4. When will the ***predicted*** LTTR declared by polyisocyanurate insulation manufacturers be adjusted to reflect measured ***actual*** R-values?

Conclusion:

One final note to bear in mind when faced with polyisocyanurate insulation LTTR claims is that Plasti-Fab® expanded polystyrene (EPS) insulation is not required to *predict* LTTR values. This is because the closed cell structure of Plasti-Fab EPS insulation is filled with air so it provides constant design thermal resistance for the expected life of the structure.

[9] NRCA Professional Roofing, Tech Today, ***Revised R-Values***, Mark S. Graham, NRCA, December 2010.