History of R-value and Polyisocyanurate Insulation in the Roofing Industry

Webster's Dictionary defines R-value as a measure of resistance to the flow of heat through a given thickness of a material (such as insulation) with higher numbers indicating better insulating properties.

The standardized measures of resistance to heat transfer were first recommended in 1945 by Everett Shuman, Director of Penn State's Building Research Institute. R-values were later widely applied to industrial and residential insulating materials and helped consumers make more energy-efficient choices.

In the early days, the R-value for most insulation products was determined by using ASTM C518, the Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, published in 1963. In this method, a specimen is placed between a hot and a cold plate, and the heat flow created by the well-defined temperature difference is measured with a heat flux sensor. R-values published using ASTM C158 are representative of the test specimen's R-value at the time of testing.

In the late 1970s, polyurethane foams became popular in the housing market for insulation due to their higher R-values compared to traditional products. Initially, these R-values were measured using ASTM C518 tests conducted immediately after manufacturing, resulting in high reported values. However, it was later discovered that the thermal conductivity of many closed-cell foam insulation products changes over time as production gases diffuse out of the foam and atmospheric gases diffuse in, lowering the R-value. This discrepancy prompted the development of improved testing methods for foam insulation.

In the late 1990s, Oak Ridge National Laboratory in conjunction with the National Roofing Contractors Association (NRCA) and the Polyisocyanurate Insulation Manufacturers Association (PIMA) started efforts that would address this discrepancy in R-value. They conducted research to help develop a new methodology to predict the change in R-value of foam insulation over time. This new methodology was referred to as Long Term Thermal Resistance (LTTR).

In 1995, ASTM International first published LTTR test method ASTM C1303. This test method covers a procedure for predicting the LTTR of unfaced or permeably faced

rigid gas-filled closed-cell foam insulations. This test reduces the insulation's thickness to accelerate aging under controlled laboratory conditions. Then, periodic measurements of the insulation are performed to observe the effects of aging. This new test method provided a more accurate measurement of R-value over the life cycle of the foam insulation.

In 1998, the Standards Council of Canada and Underwriters Laboratories of Canada were the first to published CAN/ULC-S770 which is based on Oak Ridge National Laboratory's research and ASTM C1303 and provides R-value data based on a 15-year time-weighted average.

Finally, in 2003 the Polyisocyanurate Insulation Manufacturers Association (PIMA) started reporting LTTR-values using a third-party certification program. This certification program, known as PIMA Quality-Mark^{CM}, used Canada's CAN/ULC-S770 and the United States' ASTM C1289 for determining the LTTR-value of polyisocyanurate insulation. Both test methods employ a technique called "slicing and scaling" to advance the aging process and provide a relevant and consistent prediction of a product's thermal resistance after 5 years. This 5-year value corresponds closely to the average thermal resistance over a 15-year service life.

In the world of insulation, R-value and LTTR-value are not the same. While both measure the thermal resistance of the insulation, LTTR-value gives a more accurate measurement of the insulating properties over the insulation's life cycle. Polyisocyanurate is the only insulation product on the market to publish certified LTTR values.