CARLISLE
SPRAY FOAM INSULATION

Long Term-Thermal Performance of Spray Applied Foam Insulation

Background

The thermal resistance of a material has been proven to vary depending on a variety of factors such as moisture present within the material,[1] air movement across the surface or through a material, temperatures at which the material is exposed or mean temperature.[2,3] In addition, as blowing agents were introduced to replace air in certain types of insulations to increase thermal performance the gradual release of these blowing agents over time resulted in a gradual lowering of thermal performance or time.[4] Due to these factors, standards have been developed to provide standardized methodologies of testing so that stakeholders and consumers can compare the effectiveness of various insulation materials and products within a category of insulations and make informed choices when selecting products. Standards are developed by committee through consensus and overseen by bodies such as Underwriters Laboratories Canada (ULC), ASTM International, Canadian General Standards Board (CGSB), and others. With respect to Spray Foam insulation in the Canadian market, harm is being caused by confusion and uninformed commentary about the science of thermal performance in the category. This has led to misunderstanding and misinterpretation of the strict requirements set out by the standardized test methods manufacturers are required to adhere to.

Purpose

This paper sets out to provide insight into Canadian standards and their intent, with a particular focus on the effects of time on thermal resistance of medium density closed-cell spray foam insulations, historical data using older technologies. The paper will also discuss how newer technology in spray foam is outperforming its predecessors and competitors.

Standards

Standards exist in every manner which affects our daily lives more than one can imagine. Examples are life safety standards as they pertain to fire resistive materials or structural standards. Others are performance standards which control heat loss through windows and opaque walls for materials such as glass, framing, and insulation materials. Standards improve quality of life, keep Canadians safe and help allow people to make informed decisions when selecting a product with apple-to-apple comparisons. ULC Standards is a federal Crown corporation that oversees Canada's National Standards System and is accredited as Standards Development Organization by the Standards Council of Canada (SCC). In Canada, standards are developed through consensus, and subjected to public review, prior to publication.[5] These material standards promote safety and allow Canadians to make more informed choices.

Standards Committees consist of various stakeholders within a particular industry including but not limited to, testing facilities, manufacturers, governing material bodies, researchers, and persons with an area of expertise in a specific area.

Standards are regularly updated with each edition being formally approved by the ULC Standards Committees and then published for purchase and use. Standards are intended to be used for conformity assessment. Every material standard begins with a scope to explain its use, purpose and intention in relation to which materials are to be tested. For example, concrete has its own standards which would not apply to a standard for testing wood. Similarly, mineral fibre insulation standards list physical properties that do not apply to foamed plastic insulation and vice versa. One example of is that the compressive strength of foamed plastics is exceptionally high compared to a semi-rigid mineral fibre board insulation, and the status allowing the use, and comparison, of foamed plastic in areas which require high compressive strength such as below grade, under slab, and areas of high traffic. The scope is important and sets the expectations to stakeholders in a given industry to allow for accurate testing and reporting of materials.

1. EPS Industry Alliance, EPS Insulation Advancements & Technology Innovations Technical Bulletin EPS Below Grade Series 103, 15-Year In-Situ Research Shows EPS Outperforms XPS in R-value Retention.
2. Graham, M., R-value concerns, Professional Roofing, May 2010
3. Schumacher, C., Ricketts, L., Finch, G., Straube, J., The Effect of Temperature on Insulation Performance: Considerations for Optimizing Wall and Roof Designs, RDH Engineering, May 2016
4. Duncan, R.S., Thermal Aging of Medium-Density Closed-Cell SPF, Spray Foam Alliance (SPFA), October 2019
5. https://canada.ul.com/ulcstandards/about-ulc-standards/importanceofstandards/

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The CAN/ULC-S770-18 standard was developed to address thermal performance of foamed plastic insulations with captive blowing agents. Studies, dating back to the 1990s, were beginning to demonstrate that some foamed plastics produced lower than stated R-values after some time had passed. This led experts to believe a thermal drift was occurring resulting in thermal performance being lower than initially measured and claimed. In order to protect consumers, the standard set out to account for this thermal drift and ensure they receive a material with the correct thermal resistance. Several studies occurred and stakeholders developed what is today's Long-term Thermal Resistance (LTTR). The scope additionally defines which materials this standardized, and approved, test method is for. Mineral fibre insulation is not subjected to the CAN/ULC-S770-18 LTTR test methodology because its R-value, in a laboratory, is the same in 5 years as it is today.

Standards, like S770-18, vary in their scope to reflect the use and application of the material in question and therefore have methodologies that reflect these uses and applications.

For example, in the CAN/ULC-S702 standard for Mineral Fibre Insulations, there are no compressive resistance requirements for batt or blanket. If the mineral fibre insulation is bent around a pipe with a specific Outer Diameter (OD) and recovers or does not rupture it is deemed a batt and thus except from compressive resistance testing or reporting. If the material does rupture it is subjected to a test where the board or semi-rigid board is cut to 32" in length and spans a distance of 30". If the material sags more than 0.5" it is classified as semi-rigid and if not, then it is a rigid mineral fibre. Compressive resistance must be tested to these semi-rigid and rigid board types.

Another example is the CAN/ULC-S712 which is for half pound, open cell spray foam insulation. There is a requirement to test the R-value as initial (between 4 and 14 days after spray) and again at day 90. If the material ages and loses more than 5% of the original R-value, then the 90 day aged R-value is to be reported.

In a similar way the CAN/ULC-S770-18 has already mentioned is the Standard test Method for determination of Long Term Thermal Resistance (LTTR) of closed cell foam insulations. This standard defines within its scope under Section 1.4 that the LTTR procedure applies to foam insulations that vary over 3% in a 180 day period, The standard reads as follows:

1.4. This test procedure is applicable to cellular plastic insulation manufactured to retain a gas or mixture of gases, other than air, for a period longer than 180 days. If the thermal resistivity of a product changes by more than 3% over this 180 day period, this test procedure shall be applied. This procedure specifiers reference time, sampling and testing requirements and is based on ASTM standard test method ASTM C1303 to determine LTTR for closed-cell foams such as extruded polystyrene, sprayed polyurethane, and polyisocyanurate.

Therefore, the standard does not apply to foam insulations where the thermal resistance varies by less than 3%. Until recently, all foam insulations did vary more than 3% over 180 days and therefore the LTTR test methodology applied to all insulations tested. However, Carlisle conducted extensive research and testing to manufacture a product that is very dimensionally stable. As a result, and as the paper will show that Carlisle SealTite One spray foam insulation is the first in the industry to have a stable thermal performance. Carlisle is not choosing to declare Design R-value of R6.5 at 2", this is a matter of fact given that CAN/ULC-S770-18, per the scope 1.4, does not apply to SealTite One spray foam insulation.

Time

Studies as early as the 1960s show the passage of time can negatively affect the thermal performance of a material which relies on an inert gas.[6] This was referred to by several names such as Thermal Drift, Aging, or Long-term Thermal Resistance. These inert gases are what provided foamed plastic insulations their superior thermal performance over older fibre insulation technologies whose technology relies solely on retaining air to produce their R-values. This drift in R-value is due to gases such as Hydrofluorocarbon (HFC) and Pentane diffusing out of the foam's polymer matrix where it is replaced with air, made up of N_2, O_2, and H_2O. Air's thermal conductivity is greater than HFC or Pentane and thus a lower R-value.

6. Norton, F.J., "Thermal Conductivity and Life of Polymer Foams," Journal of Cellular Plastics, Jan 1967, pp. 23-37.

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Later studies show third generation blowing agents HFC can lose R-value over a period of time.[7,8] Canada led the North American market with the development of CAN/ULC-S770-18 Long-Term Thermal-Resistance (LTTR), developed in 1998, based on evidence from the David Yarbrough studies with National Research Council of Canada (NRC) which is a method of thin slicing foam to allow a more rapid escape of the blowing agent over a shorter period of time to predict the material's 5 year, stable R-value. The committees involved developed a mathematical formula to predict the LTTR based on actual 5 year old aged samples of foam. The R-value at 5 years had stabilized and no further thermal drift was occurring.

The same study investigated four (4) manufacturer's 180 day aged foam with skins intact on the substrate to that of their same product, merely a different sample, with skins intact on the substrate aged in laboratory conditions for 5 years. Sample sizes were small with 2 of the manufacturers dropping only 5% from 180 days to 5 years with R values of others dropping significantly by 10% to 18% and the overall average being 11%.

This study provides valuable information to determine that, overall, an industry such as spray foam should be looking at longer aged values. It also shows not all foams are created equally.

Carlisle Testing

Carlisle prides itself for being a forward thinking company that continues to innovate and raise the bar of the industry in terms of product quality. We encourage others to do the same. When developing our 4th generation HFO blowing agents we set out to make a foam that can withstand the harsh Canadian climate from the very inception of SealTite One starting with Dimensional Stability. The foam is currently the most stable on the market when tested to ASTM D2126 to the requirements set in CAN/ULC-S705.1 for 28 days in the environmental chambers.

Property		CAN/ULC-S705.1 Requirements	Metric Value (Imperial)	Test
Dimensional Stability	At -20°C	-2/+5	< 0.5	ASTM 2126
	At 80°C	-2/+8	< 0.5	
	At 70°C, 97% + 3% RH	-2/+14	< 7.0	

This means that Carlisle SealTite One will remain adhered to the substrate without delamination. Our White Paper The Material Compatibility Between Spray Foam Insualation and Henry Blueskin SA, highlights SealTite One's superior adhesion and stability.

Another example of Carlisle innovation is the shelf life of spray foam resin which is commonly 6 months with some manufacturer claims of 9 months. With no Canadian standards or guielines, the shelf life is set to the satisfaction of the manufacturer. Carlisle's internal testing of resin at 1 year after blending showed no signs of weaked dimensional stability, rise time, cream time or yield of foam. These results allowed Carlisle, the first in Canada, to offer a 12 month shelf life to its spray foam, SealTite One and a clear indication of a stable product.

As stated earlier in this White Paper, the clear intent of the CAN/ULC-S770-18 standard is it only applies to insulations which drop significantly in R-value over a 180 day period. Carlisle was confident that its SealTite One foam exhibited a stable R value and with that in mind, set out to determine if SealTite One foam insulation needed to comply to that standard or not. Under careful watch by third party witness a batch of SealTite One was produced in the Fall of 2021, approximately 1 year since its release date. Random drums selection of A-Component pMDI and random drums of SealTite One resin were selected by the third party witness after the batching of resin. Drums were sealed, signed and shipped to Canada for spraying. The drums were

7. Wilkes, Yarbrough, Nelson, and Booth. 2003. "Aging of Polyurethane Foam insulation in Simulated Refrigerator Panels – Four-Year Results with Third generation Blowing Agents,"
8. The Earth Technologies forum, April 22-24 and Duncan. 2019. "Thermal Aging of Medium-Density Closed-Cell SPF Project Report"

unsealed under the witness of a third party laboratory located in Canada and sprayed onto HDPE boards per the requirements of CAN/ULC-S705.1 sample preparation. Shortly after the spray foam sample boards were cured the laboratory witness signed and dated the samples to ensure proper chain of custody before shippment to their laboratory the next shipping day.

Key physical properties were tested such as dimensional stability, water vapour permeance, and core density to ensure the newly sprayed samples met the original materials tested in 2020.

Foam sample boards were removed from their HDPE boards as per the requirements of CAN/ULC-S770-18 and tested at day 1 and day 180. The results are recorded in the third party laboratory report, signed by two authorized lab personnel and sent to a third party evaluation body for final reporting.

SealTite One results are already noted within the Evaluation Report ER-39311-03 Rv1 are the following:

R-value Day 1: R6.5/inch *R-value Day 180: R6.5/inch*

Carlisle continued to test beyond the standards requirements and tested again after Year 1.

R-value Day 365: R6.5/inch

The results show that SealTite One's R-value did not drop by more than 3% in the 180 day period but rather a 0% change in R-value with no substrates at ambient laboratory temperature. Carlisle's SealTite One performs at R6.5 per inch at a 2.0" thickness when tested to the scope of CAN/ULC-S770-18.

Conclusion

Over the past 24 years the CAN/ULC S770-18 standard has been the benchmark for testing spray foam insulation with significant thermal drift. However, until now, no manufacturer has been able to pass the rigorous requirements to be exempt from this standard, exceeding the challenge of maintaining thermal performance over time. Carlisle set out to create a product with superior thermal stability that not only meets but exceeds Canadian standards. Through extensive testing and third party validation, SealTite One has become the first spray foam in Canada to achieve a stable R-value of 6.5 per inch. This achievement, backed by the National Building Code of Canada, ULC Standards for Spray Applied Polyurethane Foam Insulation, and the most thorough ULC evaluation process has demonstrated the evolution of spray foam technology and establishes a new standard of quality for Canadian consumers. The milestone is celebrated as a turning point in the industry and Carlisle hopes to see competitors rise to the challenge, pushing the boundaries to exceed the standards for the benefit of the entire market.

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