Product Information Bulletin

365

Improper Test Methodology, Inaccurate Conclusions

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BULLETIN NO.	365
ISSUED:	February 28, 2019
REPLACES:	NEW

Improper Test Methodology, Inaccurate Conclusions

Abstract:
Recent marketing publications from Soprema Inc. suggest that expanded polystyrene (EPS) insulation is a primary cause of wrinkling experienced in SBS-modified bitumen roof membrane systems. The Soprema publications reference two RDH Building Science testing programs noted below. However, the science behind the RDH test programs does not support the assertions made by Soprema.

The initial RDH test program cited was described in a paper presented at the 15th Canadian Conference on Building Science and Technology[1] (CCBST paper). This test program subjected roof test assemblies to a hot temperature exposure of 90 to ~105 °C despite the fact that the published maximum service temperature for EPS insulation is 75 °C. In addition, a number of test conditions used for the test program are not typical of end use applications:

1) No thermal gradient through the insulation in the roof assemblies.
2) Discontinuous support for EPS insulation and plywood substrate at the center of the test assembly.
3) No support provided for the extreme hot temperature exposure selected.

The CCBST paper recognized test protocol deficiencies stating: "Areas for further investigation include: exposure of the roof specimens to more realistic conditions including arrangements with a temperature gradient, evaluation of other common insulations in conventional roofs such as polyisocyanurate insulation, and examination of potential methods to protect temperature sensitive insulation layers from extreme temperatures such as using multiple types of insulation within the roof assembly."

An RDH follow up test program described in a paper presented at the 33rd RCI International Convention and Trade Show[2] (RCI paper) addressed one technical flaw. The RDH "custom-built chamber" was modified such that the roof test assembly was subjected to a thermal gradient where air circulated under the roof test assembly in the climate chamber was maintained at ~22°C room temperature, while the space above the roof test assembly was cooled to -15°C or heated to ~90°C. Other technical flaws, including temperature exposure and test assembly set up, were repeated in the follow up test program.

Despite the disadvantages the unfavorable test conditions presented, RDH state in the conclusion section of the RCI paper that "Overall, the findings of this work have not confirmed that EPS movement is the cause of wrinkles observed in the field." Another key RDH observation is also found in the last paragraph of the RCI paper which states: "It is also important to note that this investigation looked at only one potential cause, and that field investigations performed after this testing was completed have also pointed towards other contributing or causal factors such as quality of the installation, method of insulation and membrane securement, and climate."

It is worth noting that researchers from the National Research Council of Canada (NRCC) are currently evaluating all of these potential contributing factors to wrinkling in SBS-modified bitumen roof membrane systems in their ongoing collaborative research work with the Canadian Roofing Contractors Association (CRCA).

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[1] Tatara, Jun and Ricketts, Lorne, RDH Building Science, Impact of Heating and cooling of Expanded Polystyrene and Stone Wool Insulations on Conventional Roof Performance, 15th Canadian Conference on Building Science and Technology, Vancouver, BC, November 2017.
[2] Tatara, Jun and Ricketts, Lorne, Impact of Insulation Dimensional Stability on Conventional Roof Performance, 33rd RCI International Convention and Trade Show, Houston, TX, March 2018.

It is clear that the RDH test programs do not support Soprema marketing claims identifying EPS insulation as the sole cause of wrinkling in SBS-modified bitumen roof membrane systems. The remainder of this bulletin provides a more detail review of the technical flaws noted above that should be considered when reviewing conclusions offered in Soprema marketing publications.

Coefficient of Thermal Expansion versus Dimensional Stability:

The first point that must be understood when discussing the roof test programs reported in the RDH papers is that two distinct material properties, coefficient of thermal expansion and dimensional stability, caused the EPS insulation dimensional changes noted. Coefficient of thermal expansion is an inherent property of all materials which expand when heated and contract when cooled and is typically expressed in units of in/in/°F or mm/mm/°C to indicate change from the original dimension based upon a homogeneous temperature change in the material. Dimensional expansion or contraction as a result of the coefficient of thermal expansion property is reversible.

Dimensional stability is a characteristic value of materials expressed in % change in volume and/or specific dimension. The laboratory test typically used for thermal insulation specifications exposes a material to constant high or low temperature conditions for a specified period of time. Dimensional changes as a result of the dimensional stability property are often confused with changes due to coefficient of thermal expansion. It is also worth noting that for both properties dimensional change is based upon full thickness heating or cooling, an exposure that does not occur in roof insulation applications where there would always be a thermal gradient through the thickness of the insulation.

15th Canadian Conference on Building Science and Technology (CCBST paper)

The following summary provides more detail regarding the flaws noted previously in the test protocol used by RDH Building Science in the test program described in the CCBST paper:

1. RDH indicated it selected a worst-case scenario temperature exposure for the test program. The roof assemblies tested were exposed to cold (-15 °C) and hot (90~105 °C) temperatures measured at the center (core) of the insulation in an RDH custom-built climate chamber. This raises several issues:
   a. CAN/ULC-S701.1, the National Standard of Canada for EPS insulation, clearly states in scope section 1.2 that EPS insulation is "….intended for use as thermal insulation in building construction and other applications for temperatures ranging from -54 to +75 °C." Clearly the RDH hot exposure was beyond the published maximum use temperature for EPS insulation.
   b. RDH indicated the hot temperature exposure of 90 to ~105 °C was selected based upon RDH data from a 4-year monitoring period on a roof in Chilliwack, BC where in a "typical" year the cap sheet temperature of a black SBS membrane was observed to be above 80 °C for approximately 5 hours. The worst case scenario RDH selected for the test program subjected the roof test assemblies in a heat chamber (oven) to three cycles of temperatures 15 to ~30 °C above S701.1 maximum use temperature and 10 to ~25 °C above the maximum temperature taken from a four year monitoring period on a Chilliwack roof.
   c. The temperature exposures noted for the test program reflect temperatures measured at the core of the insulation – i.e., at the center of the insulation thickness – along the joint between the insulation sections. The report notes that surface temperatures were likely higher than those recorded. This would be especially true near the heat sources and may account for the localized shrinkage seen on the top surface in the EPS insulation photos in the report.
2. The RDH test program was based upon an unrealistic scenario with an insulated roof assembly exposed to conditions within the RDH "custom-built climate chamber" that exposed roof test assemblies to cold/hot temperatures on all sides. Since an insulated roof assembly would be subject to a temperature differential across the thickness, this exposure is not representative of any type of in-service conditions. ***The purpose of insulation, in both hot and cold climates, is to slow the rate of heat transfer from the warm side of an enclosure to the cooler side.*** In other words, RDH reported test results in a technical paper purported to investigate possible issues causing wrinkling of in situ SBS-modified bitumen roof membrane systems based upon unrealistic exposure conditions.

3. The substrate on which the roof system components were assembled was sections of plywood assembled over a wood frame platform that allowed circulation of heated or cooled air around all sides of the assembly. The roof test assembly was purposely split into two separate sections with a gap in the plywood substrate and the self-adhered vapor barrier attached to it located at the center of the test assembly perpendicular to the length of the test assembly. In addition, there was also a continuous joint in the insulation layer at the gap in the plywood substrate. This joint separated the test assembly into two separate halves with the top protection board and roof membrane installed continuously over the insulation joint. The substrate with adhered vapor barrier is intended to provide continuous support and attachment for the insulation in an in situ installation.
4. RDH noted the insulation gap in the EPS roof specimens widened as expected when the insulation temperature lowered to -15 °C and narrowed as the insulation temperature increased until approximately 80 °C. [**NOTE 1:** This initial dimensional change would reflect change as a result of coefficient of thermal expansion.] Above the 80 °C exposure the gap widened at a significant rate. [**NOTE 2:** Shrinkage at temperatures above 80 °C reflects dimensional stability when exposed to full thickness temperature exposure well above the CAN/ULC-S701.1 maximum service temperature.]

   EPS insulation, a thermoplastic material, will begin to soften and plasticize when exposed to a heat source at temperatures at least 15 to ~30 °C above the published maximum service temperature. This test program confirmed findings from previous RDH[3] research. As stated in the CCBST paper, "…EPS insulation typically expands up to approximately 80 °C and experiences a rapid permanent shrinkage above 80 °C." In other words, previous RDH research supports the published maximum service temperature for EPS insulation and the worst-case scenario temperature exposure of 90 to ~105 °C for this test program simply confirmed the RDH expected EPS insulation behavior.
5. Pictures in the CCBST paper clearly identify the effect of extreme hot temperature exposure with localized distortion of EPS insulation near the heat source (infrared lamps). It is worth noting that the hot temperature exposure also affected the SBS roof membrane and the 4.8 mm thick protection board which behaves similar to thermoplastics at hot temperatures. SBS acts like natural rubber at room temperature, but becomes soft and plastic when heated. It would be expected that the 90 to ~105 °C temperature exposure also softened and plasticized the SBS components over the EPS insulation especially near the heat source.

RDH state in the conclusion section of the CCBST paper: "Areas for further investigation include: exposure of the roof specimens to more realistic conditions including arrangements with a temperature gradient, evaluation of other common insulations in conventional roofs such as polyisocyanurate insulation, and examination of potential methods to protect temperature sensitive insulation layers from extreme temperatures such as using multiple types of insulation within the roof assembly."

33rd RCI International Convention and Trade Show (RCI paper)

The RDH paper presented at the RCI conference in Houston, TX provided test results from a follow up test program that addressed one area for future investigation identified in the CCBST paper. In this follow up test program the RDH "custom-built chamber" was modified such that the roof test assembly was subjected to a thermal gradient so that air circulated under the roof test assembly in the climate chamber was maintained at ~22°C temperature to represent the interior exposure, while the space above the roof test assembly was cooled to -15°C or heated to ~90°C.

The following summary highlights flaws in the test protocol used by RDH Building Science in the test program described in the RCI paper:

1. The roof test assemblies were constructed in the same configuration as reported in the CCBST paper. In other words, the same gap in the plywood substrate/self-adhered vapor barrier with a

[3] Bowden, A., Ricketts, L., & Finch, G., Dimensional Stability of Rigid Board Insulation Products, 2015.

continuous joint between the EPS insulation sections at the center of the test assembly perpendicular to the length of the test assembly was incorporated into these test set ups as well. Temperatures were recorded within the test assembly at the SBS membrane surface, at the top surface of the insulation, at the center of the insulation, under the insulation and under the test assembly. Minimum and maximum temperatures were measured at the SBS surface. EPS insulation roof assemblies were subjected to three heating cycles where the maximum ~90°C temperature was held for four hours.

2. Once the roof specimen was allowed to cool down to 22°C after the heating cycles, it was disassembled to make visual and physical observations. Upon visual inspection, no ridging or wrinkling of the SBS roof membrane was observed. Permanent shrinkage of EPS insulation was only observed at the joint between insulation boards **close to the top of the assembly** where the insulation experienced temperatures of ~90 °C. As noted previously, the CAN/ULC-S701.1 service temperature range for EPS insulation is -54 to +75 °C thus the temperature exposure was ~15 °C above published maximum service temperature.
3. Additional information provided in the RCI paper regarding the Chilliwack, BC monitoring program noted previously was a statement that as roof temperature is largely dependent on solar heating of the roof surface, the measured roof temperature at the Chilliwack study building would be similar to other roofs with the same membrane reflectance (i.e., roofs with black cap sheet as per Chilliwack). As well, RDH noted that "latitude, ambient air temperature, wind, shading by neighboring buildings, and cloud cover may impact the temperature of other comparable roofs." NBC 2015, Appendix C climate data indicates that Chilliwack, BC is located in Climate Zone 4, the warmest Climate Zone in Canada. The Chilliwack reference data for roof temperature may not represent expected exposure conditions for the majority of commercial roof systems across Canada.

RDH state in the conclusion section of the RCI paper that "Overall, the findings of this work have not confirmed that EPS movement is the cause of wrinkles observed in the field." This is a pretty strong indication that the assumptions made by Soprema are not supported by the RDH test programs.

Conclusions:

The above summary confirms that test programs exposing EPS insulation to extreme temperatures of 90 to ~105 °C versus EPS insulation published maximum service temperature of 75 °C have not been shown to be valid in a technical review of wrinkling in SBS-modified bitumen roof membrane systems. In other words, the RDH test programs do not support specific Soprema marketing claims identifying EPS insulation as the sole cause of wrinkling in SBS-modified bitumen roof membrane systems.

Another key observation by RDH in the last paragraph of the RCI paper states "It is also important to note that this investigation looked at only one potential cause, and that field investigations performed after this testing was completed have also pointed towards other contributing or causal factors such as quality of the installation, method of insulation and membrane securement, and climate."

It is worth noting that researchers from the National Research Council of Canada (NRCC) are currently evaluating all of these potential contributing factors to wrinkling in SBS-modified bitumen roof membrane systems in their ongoing collaborative research work with the Canadian Roofing Contractors Association (CRCA).

Plasti-Fab has always supported and welcomed the opportunity to participate in science-based research that works toward resolving building science issues.