Building Science Research Summary
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Temperature Dependence of Aged Polyisocyanurate Insulation R-values

Please note that as of 2018, ROXUL® and its product lines have been rebranded to ROCKWOOL™ with its respective product names. For more information regarding a specific product found in the report please visit www.rockwool.com or email contactus@rockwool.com.

Recent studies have shown that the in-service thermal resistance of polyisocyanurate insulation has potential to be impacted by temperature and aging. Generally, the testing has focused on new insulation material or laboratory aged insulation material.

Therefore, a research study was undertaken by ROCKWOOL® Building Science and RDH to measure and compare thermal performance of polyisocyanurate insulation which has been collected from various existing buildings having been exposed to real environmental conditions.

Aged insulation samples have been removed during fall and winter 2014 from buildings located in Canada and the Pacific Northwest of the USA. The description of the samples from these buildings can be found in the table below.

In-service location	N°	Date of installation / manufacture	Thickness (inches)	Facer	Density (kg/m^3)
Building 1	01	1995 to 1996	2 ½	Paper	46.0
Building 1	02	1995 to 1996	2 ½	Paper	38.5
Building 2	03	2006	1	Foil	34.7
Building 2	04	2006	1	Foil	33.7
Building 2	05	2006	1	Crinkle foil	40.1
Roofing shop storage	06	2007 to 2009	2 ½	Paper	32.2
N/A	07	2014	1	Foil	35.4

The thermal conductivity of 12”×12” in-situ insulation samples were measured using a technique based on ASTM C 518-10 “Standard Test Method for steady-state thermal transmission properties by means of the heat flow meter apparatus” and modified by Building Science Consulting Inc. to assess the thermal performance at a range of realistic temperature conditions independently from insulation thickness.

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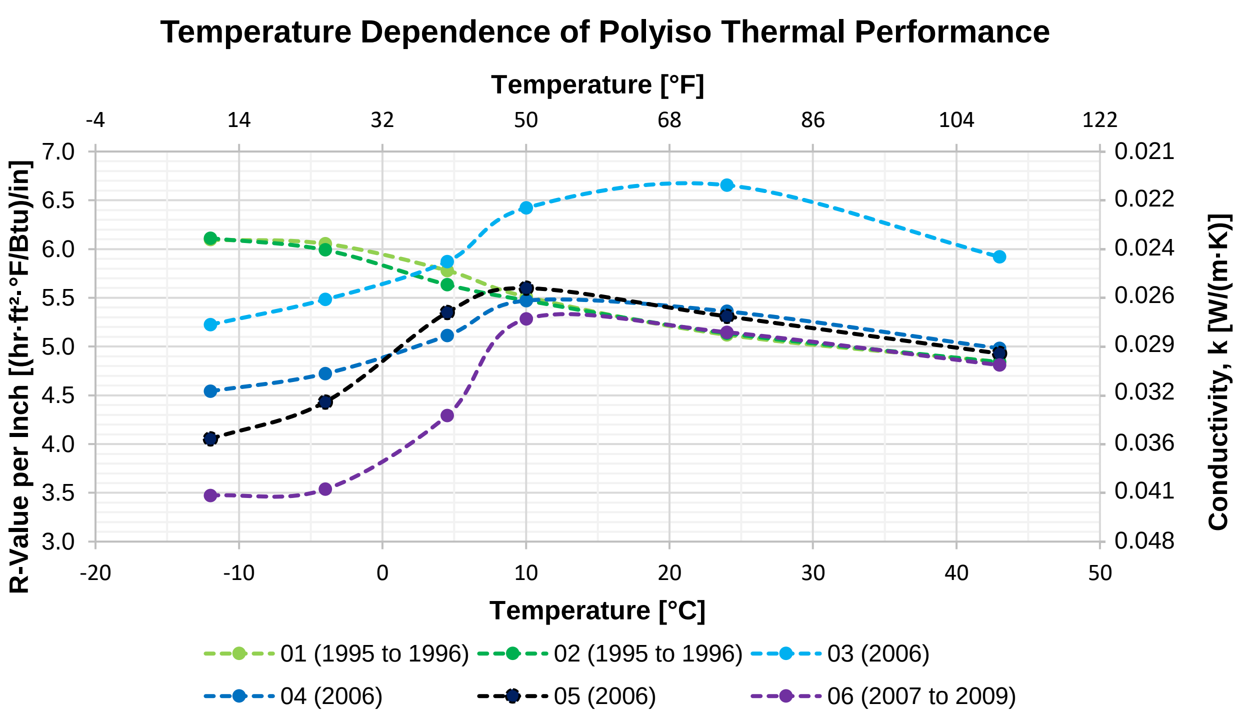
Results of the conductivity measurements

Measurements shown below clearly indicate significant variability in the thermal performance of the removed polyisocyanurate insulation samples, with all samples demonstrating temperature dependent thermal performance. The maximum and minimum R-values per inch are approximately R-3.5 and R-6.6 hr·ft²·°F/Btu respectively, indicating an overall range in performance of approximately R-3 per inch.



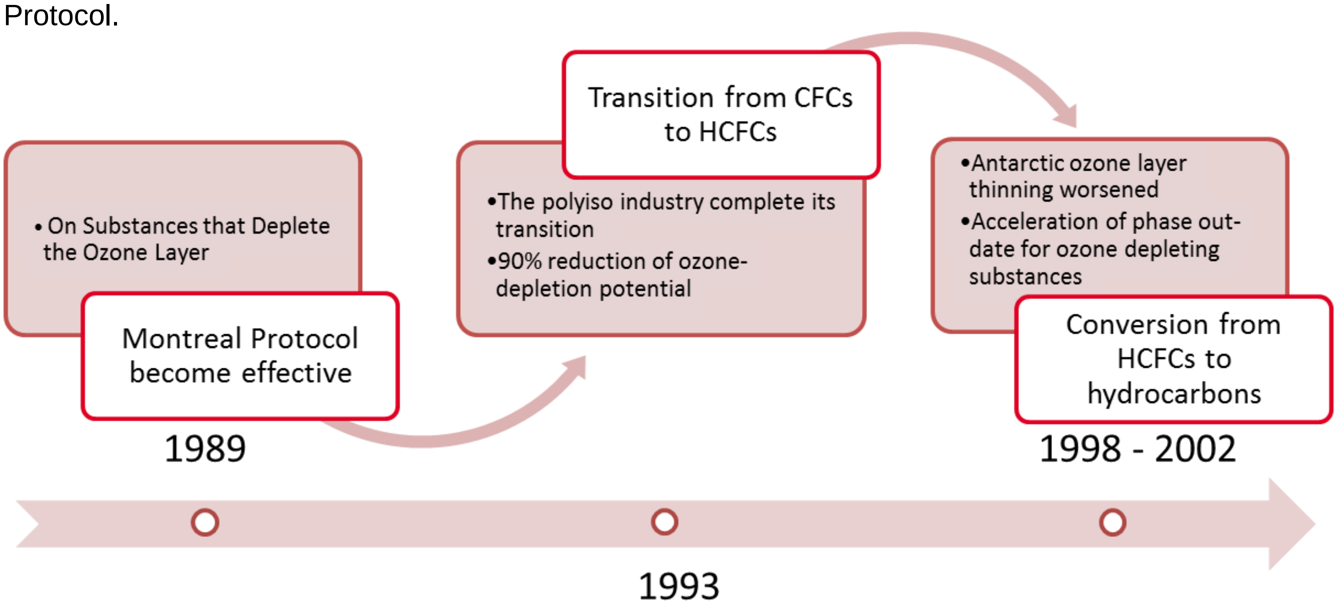
As expected, the measures showed higher R-values per inch at warm temperatures for the recently manufactured insulation samples. In contrast, the older insulation samples were both determined to provide a significantly higher R-value per inch at cold temperatures.

History of blowing agents[1]

From its introduction during the late 1970s, the polyisocyanurate industry used CFC-11 as a blowing agent (CFCs, Chlorofluorocarbons) but increasingly strict environmental regulations gradually limited their use since the Montreal Protocol in 1987 as they were commonly considered to have negative environmental impacts, including depletion of the ozone layer and contribution to climate change.

Therefore, in 1993, the polyisocyanurate industry completed its transition from the use of CFC to HCFC based blowing agents. At the time, HCFC-141b was considered a significant improvement because it represented a 90% reduction in ozone-depletion potential (ODP) but it could only be a temporary substitute as a blowing agent with a zero ozone-depletion potential was needed.

For that reason, from 1998 to 2002, the polyisocyanurate manufacturers finally converted their plants from HCFC to hydrocarbon based blowing agents to reduce the environmental impact, in particular the ozone depletion attributed to these chemicals and meet the ultimate zero ODP goal of the Montreal Protocol.



Evolution of blowing agents used in polyisocyanurate insulation

In order to better understand the various behavior of the removed polyisocyanurate insulation samples and in regards to the evolution of the blowing agents used in the past decades, ROCKWOOL® Building Science commissioned EXOVA to identify which blowing agents were used to manufacture these samples, using a gas chromatography–mass spectrometry (GC-MS) analytical method.

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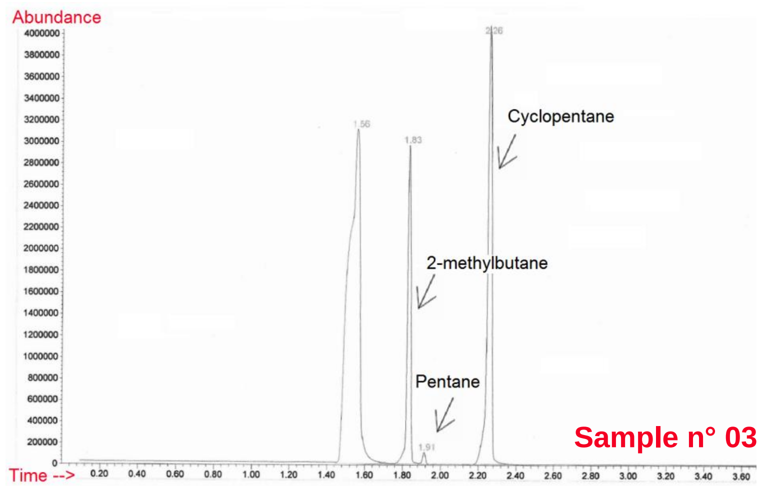
[1] From the article by Lorraine Ross “A blowing agent update - Learn why the change to pentane was made and what it means for polyiso” in the NRDA magazine Professional Roofing

Results of the GC-MS analysis

For samples n°1 and n°2 from 1995-1996, the GC-MC showed a major peak at 1.62 minutes for 1,1-Dichloro-1-fluoroethane (CAS 1717-00-6; HCFC 141b) and traces of other Chlorofluorocarbons (CAS 75-45-6; FC22 and CAS 75-71-8; FC12).

These results brought, as expected, the evidence of HCFC based blowing agents for these two samples.



Then, the DOW samples n°3 and n°7, from 2006 and 2014 respectively and sample n°6 from 2007 – 2009 showed a peak at 1.91 minutes for Pentane (CAS 109-66-0) and peaks of Pentane's isomers at 1.83 minutes for 2-Methylbutane (CAS 78-78-4; Isopentane) and at 2.26 minutes for Cyclopentane (CAS 287-92-3).

Sample n°7, more recent, also showed peaks at 2.06 minutes for 2.2-Dimethylbutane (CAS 75-83-2; Neohexane) and two halocarbons at 2.15 minutes for 1-Chloropropane (CAS 540-54-4) and at 2.82 minutes for 1-Bromopentane (CAS 540-54-4).

These results brought, with a reasonable doubt, the evidence of hydrocarbon based blowing agents in these samples, with halocarbon compounds for the most recent one.

Conclusion

It is theorized that the difference in performance between the newer and older insulation types of polyisocyanurate is due to the use of different blowing agents.

In accordance with the theory, the testing demonstrated that the different thermal behavior at cold temperature of these older samples could be explained by the use of a HCFC based blowing agent which had a good thermal performance but is no longer used. Six more samples are currently being tested and are showing the same trend.

The thermal performances of the blowing agents commonly used today in polyisocyanurate insulation are considered to be more inconsistent but it is a critical research and development focus for the polyisocyanurate manufacturers. Therefore, the blowing agents in polyisocyanurate insulation might evolve and improve quickly in the coming years.