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Analysis of the Variation of Thermal Conductivity of Rigid Polyisocyanurate Foam (PIR) in The Context of Aging

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1 Introduction

Change of thermal conductivity over time has been extensively studied for different building thermal insulation materials such as mineral wool, expanded polystyrene foam (EPS), and extruded polystyrene foam (XPS) (Berardi, 2017; Khoukhi *et al.*, 2016). However, the use of rigid polyisocyanurate-polyurethane foam (PIR/PUR) in construction has recently significantly increased due to its excellent mechanical properties and low thermal conductivity (Jin *et al.*, 2014). Tests have shown that the thermal resistance R, ($m^2 \cdot K/W$) of PIR decreases when the ambient temperature drops below 0 *ºC*, reaching a peak when the material temperature is like the indoor air temperature. As PIR is rapidly gaining popularity in the Northern Europe, which has a wide range of ambient air temperatures, it is important to investigate its thermal properties under operating conditions, and to predict the influence of temperature and aging effects on the thermal properties of buildings insulated with PIR.

2 Research Methodology

For this experimental study, three different PIR specimens with the dimensions of 300x300 *mm*, thicknesses 30 and 50 *mm* were prepared: first with a factory-made composite non-diffusion facing; second sealed with a diffusion-tight film from all sides; third has its coating removed. Prior to thermal treatment, the value of the thermal conductivity of each sample is measured using FOX 314 Heat Flow Meter. Two tests are performed in parallel: first - successive effects of temperature on specimens; second - measuring different specimens at different temperature environments, to determine certain temperature impact on thermal conductivity.

3 Results and Discussion

When using a successive thermal treatment procedure (Figure 1), all types of specimens show a significant increase in thermal conductivity after heating at 70 *°C,* because of intense diffusion of gas out of the material pores into the surrounding environment. It can be noticed, that when the same specimens are kept at a lower positive temperature, the increase in the thermal conductivity is insignificant, while for specimens with facing it is close to linear. This indicates that the emission of gas into the environment at this stage is largely dependent on their movement from the inner layers of the material to the superficial layers. The thermal conductivity of the uncoated samples ceases to increase earlier than that of the coated samples, and it depends on the diffusion possibilities, which are limited by the facings. Analysing changes in the thermal conductivity after particular aging procedure, 50 *mm* thick specimens showed that temperatures 70 *°C* and 50 *°C* has the greatest influence (thermal conductivity increases by 8-9 *%*, and 11 *%* when facing is removed).

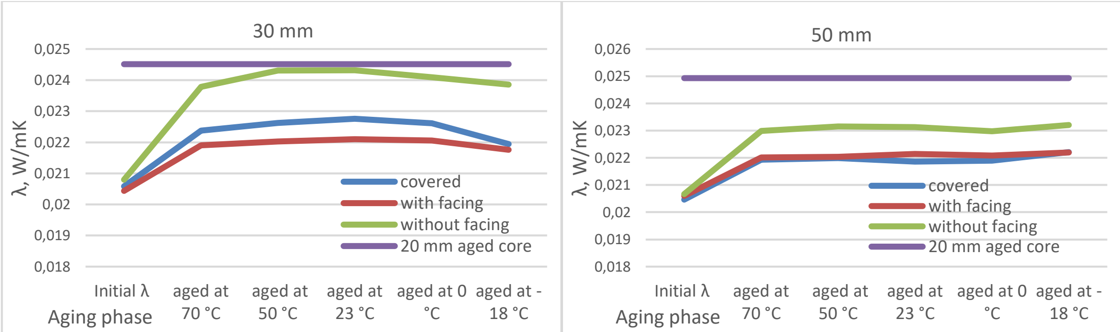

Figure 1. Variation of average thermal conductivity coefficient of 30- and 50-*mm* thick samples during successive aging.

Examination of 30 *mm* thick specimens showed that in all three cases aging at 70 *°C* had the greatest influence (up to 10-15 *%*) on their thermal conductivity. The influence of 50 *°C* on the thermal conductivity of the 30 *mm* samples with facings is smaller (only 3-4 *%*), while that of the samples without facings was slightly higher – 7 *%*. Exposure to negative temperatures (-18 *°C*) does not alter the thermal insulation properties of all specimens.

4 Conclusions

- The standard methodology to determine the declared value of PIR thermal conductivity does not meet the conditions of use of products coated with diffusion tight facings and must be adjusted providing aging and measurement of the specimens with such facings.
- Experiments showed that the 21 days aging at high temperature is enough for the settling down of thermal conductivity. After storage at negative temperatures, the thermal conductivity of the material does not change under standard conditions.
- The removal of the coating results in up to 8 *%* greater change in thermal conductivity after exposure to high temperatures, compared to specimens coated with diffusion tight facings. The application of diffusion tight film to the sides of the specimens does not affect the change in thermal conductivity of the specimens after aging.

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