

THE INFLUENCE OF TEMPERATURE HUMIDITY AND DENSITY CHANGES ON THE THERMAL CONDUCTIVITY COEFFICIENT OF THERMAL INSULATION MATERIALS

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Scope

One of the biggest challenges in the building sector is considered worldwide to be the reduction of energy consumption caused by building envelopes, as well as finding appropriate resources and materials. Those are vital in a sustainable development regime. The use of insulating materials is often one of the most basic elements in buildings that aim to reduce such consumption.

There are many advantages that necessitate the adoption and installation of thermal insulation layers, as this contributes to achieving indoor comfort conditions, but at the same time protects the building envelope from thermal stresses. These material products have prevailed due to their usefulness and the advantages they offer

The performance of thermal insulation depends on the thermal conductivity of the materials and the ability to maintain thermal characteristics for a specified period. In practice, the thermal conductivity given in the relevant manuals refers to a constant value under normal temperature and dry conditions. However, when placed in their positions in the building envelope, thermal insulation materials are exposed to different levels of temperature and humidity depending on the prevailing conditions. This can lead to a difference in their thermal performance from that predicted under standard conditions.

Methodology

A total of six thermal insulation materials, Expanded Polystyrene (EPS), Extruded Polystyrene (XPS), Rock Wool, Polyurethane (PUR), Vacuum Insulated Panels (VIPs) and Aerogel, have been selected to be examined. In summary, the research methodology is as follows:

- Data collection regarding the correlations of the thermal conductivity coefficient, for the thermal insulation materials under consideration, with changes in temperature, humidity and density.
- Determination of the thermal conductivity coefficient λ [(W/m²·K)] of thermal insulation materials and creating graphs in function of changes in temperature, humidity and density.

Results And Discussion

Ultimately, temperature, moisture content and density depending on the relationships used and the influencing factors are the most basic aspects that affect, among other things, the thermal properties of thermal insulation materials. For the most part, the graphs demonstrate the linear functions of the thermal conductivity coefficients of materials, to an increase in both the temperature and humidity affecting the materials, as well as their density.

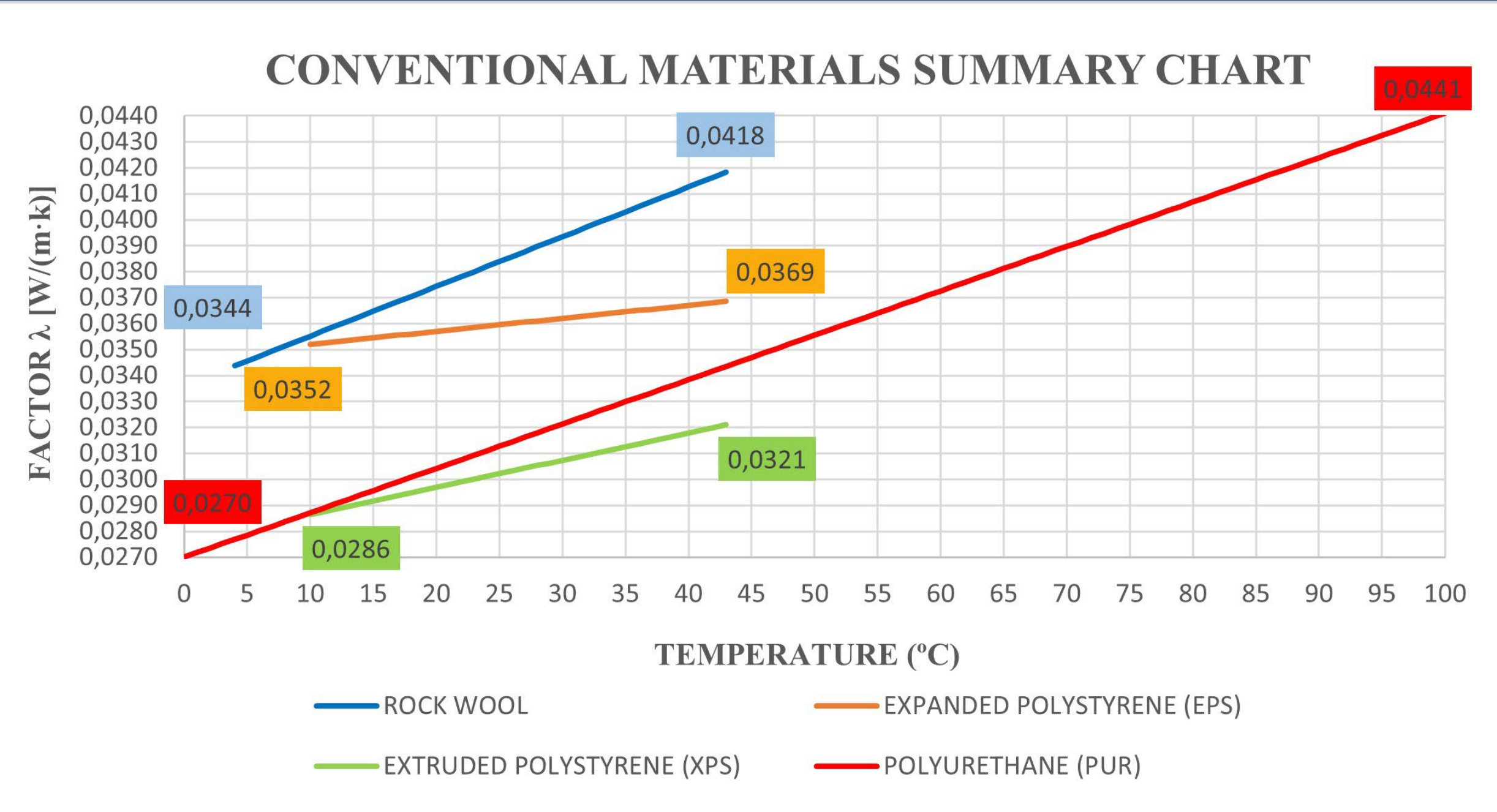


FIGURE 1: Summary graph of the effect of temperature on the thermal conductivity coefficients of conventional materials.

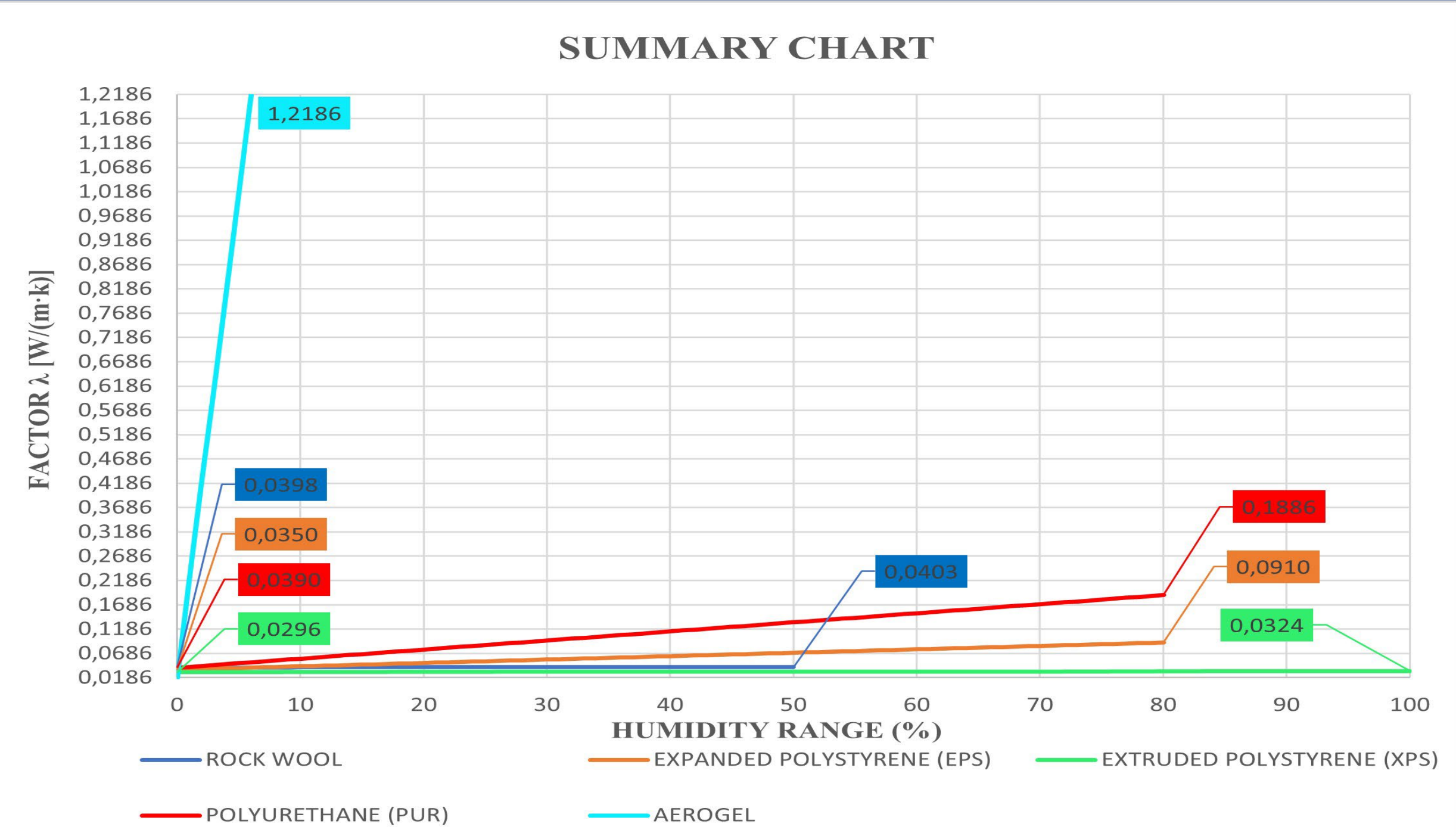


FIGURE 3: Summary graph of the effect of humidity on thermal conductivity coefficients.

In all three cases of influencing parameters, temperature, humidity and density, the values of the coefficient λ were selected individually for each category of materials (conventional and advanced) considering the thermophysical properties of each.

Depending on the relationships used and the influencing factors, each material tends to react differently. However, in simple terms, it can be stated that insulating materials are sensitive to temperature and moisture content in relation to their thermal properties, while depending on the composition and type of material, the density shows several differences in their performance.

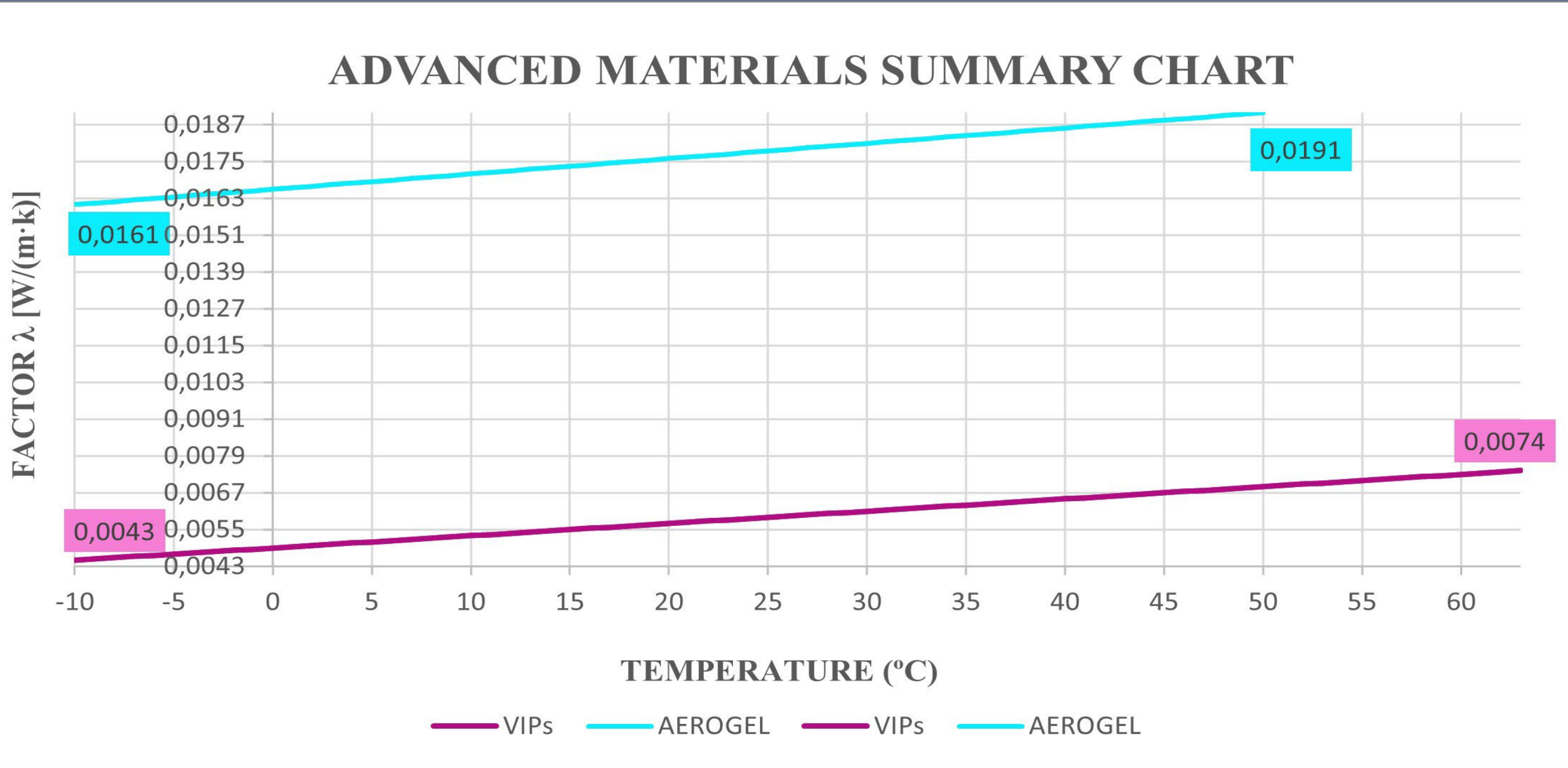


FIGURE 2: Summary graph of the effect of temperature on the thermal conductivity coefficients of advanced materials.

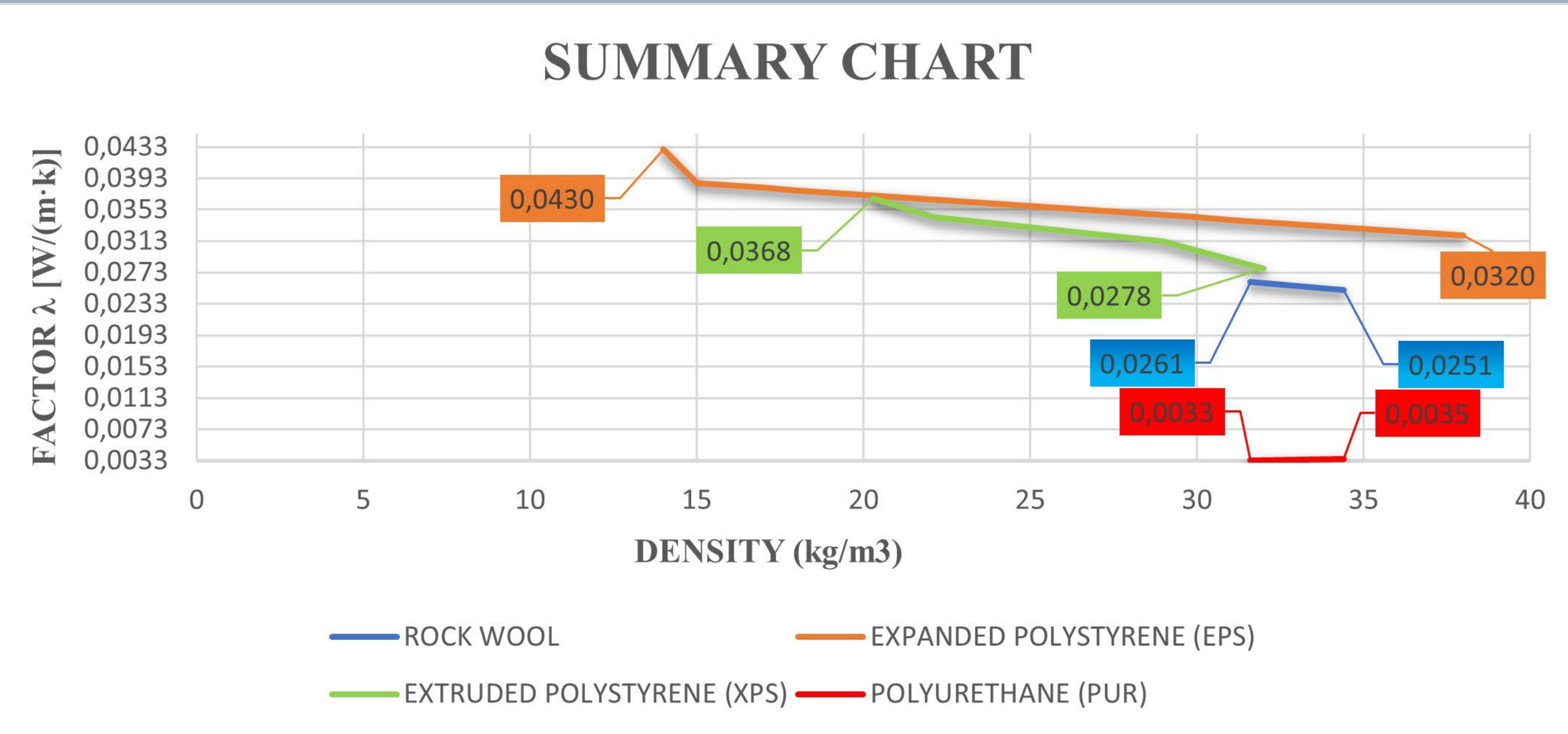


FIGURE 4: Summary graph of the effect of density on thermal conductivity coefficients.

Conclusion

The needs of both building structures and the people who uses them change over time, as do the prevailing conditions that affect thermal insulation materials.

The technical instructions that we have as a guide at the given time cover for a reasonable period, the properties of thermal insulation materials and their response to the shells that will be used.

In any case, a proper understanding of the relationships between the thermal conductivity coefficients of materials and the factors influencing their thermal properties, is a fundamental principle for their determination and response in building structures. Most published studies prove everything mentioned in this paper, however, the methods used for the calculations refer to indicative values measured under ideal laboratory conditions.

Advanced insulating materials are now a reality in a wide range of constructions. However, there are substantial shortcomings in the analysis of their thermal behavior.

With the increased importance of energy saving nowadays, the reduction of the energy produced and its release inside and outside the building structures, more complex calculations need to be considered in the future. In further research, the thermal properties of thermal insulation materials could be analyzed in their actual performance in an insulated structure.

References

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