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Thermal characterization of high-performance insulation – not always an easy task.

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High-performance insulations (HPI) have outstanding thermal properties to minimize heat transfer for a specific application. The term "high performance" is a relative rating; because, whether an insulating property, i.e. the thermal conductivity or thermal transmittance, is significantly lower than those of conventional insulating materials or systems depend on conditions of use. Applications fields for thermal insulations are the energy, building, industry and transport sector, but also in space and aviation industry.

The total effective thermal conductivity of HPI depends on the contributions of the heat transfer via the solid skeleton of the porous insulation material, of the radiative heat transfer and of the gas molecules with in the porous structure. For a given operating temperature, the effective thermal conductivity derives a minimum depending on the density and the infrared-optically extinction properties of the insulation material. Examples for HPI with outstanding low thermal conductivity values will be presented and resulting difficulties related with the measurement praxis discussed.

In more detail thermal conductivity measurements on multi-layer insulations (MLI) with extremely anisotropic thermal transfer properties using the stationary guarded-hot-plate method will be presented. Whereas in the direction perpendicular to the layers the heat flow is extremely low, the use of metallic layers to suppress thermal radiation leads to undesirable parasitic heat losses parallel to the layers of the MLI systems. An evaluation method is presented to correct for these lateral heat losses. Another challenge is the reliable determination of the thermal conductivity of aerogels. Due to their special combination of nanostructure and high porosity, aerogels are key materials for HPI. Experimentally derived thermal conductivity values are more or less influenced by the experimental set-up and the experimental conditions and have to be carefully discussed. Here, results of a round robin test performed for a PU-aerogel (polyurethane) were presented. It is shown that correcting for the atmospheric pressure to which the sample was exposed during the measurement results in more accurate values of the thermal conductivity. In some cases, significantly differences in the results were observed between steady-state and transient methods. Finally, studies to better understand the heat transfer in self-evacuating cryo-insulations are presented. The challenge here was to determine local thermal conductivity values at low temperatures and defined atmospheres to specify the influence of the condensing gas on the effective thermal conductivity.