A Modern Evaluation of the Thermal Resistances of Air Spaces

Hamed H. Saber and David W. Yarbrough

The determination of thermal resistances for enclosed air spaces including those with one or more low emittance surfaces has advanced from one-dimensional heat transfer between large parallel planes to three-dimensional heat flow in a wide variety of physical configurations. The key elements in this advancement are the use of computational fluid dynamics to evaluate the heat flux for conduction-convection coupled with the solution for radiation that includes all surfaces bounding the region of interest.

The computational system that has been developed can be used to evaluate infiltration, imperfect installation, internal defects in multilayer systems in addition to the conventional rectangular regions. The computational program has been used to examine the impact of aspect ratio, angle of inclination, and internal partitions for surface emittances from 0 to 1, temperatures that cover the expected range for building envelopes in a variety of climates, and air gap sizes up to 200 mm.

The computational system has been validated against laboratory test data including the classical data set from the U.S. National Bureau of Standards for the thermal resistance of air spaces that has been the basis for handbook values for reflective air spaces for five decades. Selected results and comparisons obtained with this modern computational tool will be discussed.