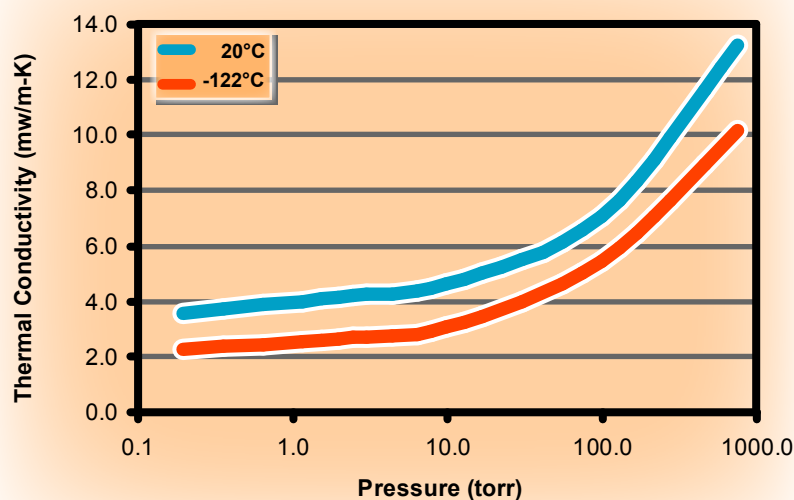


RADIATION CONTRIBUTION

Generally, even thin aerogels (e.g. 1cm) can provide enough infrared (IR) absorption to be treated as “optically thick”. Therefore, the radiative thermal conductivity of porous materials is considered as a local phenomenon within the bulk solid that can be described in the following equation (A):

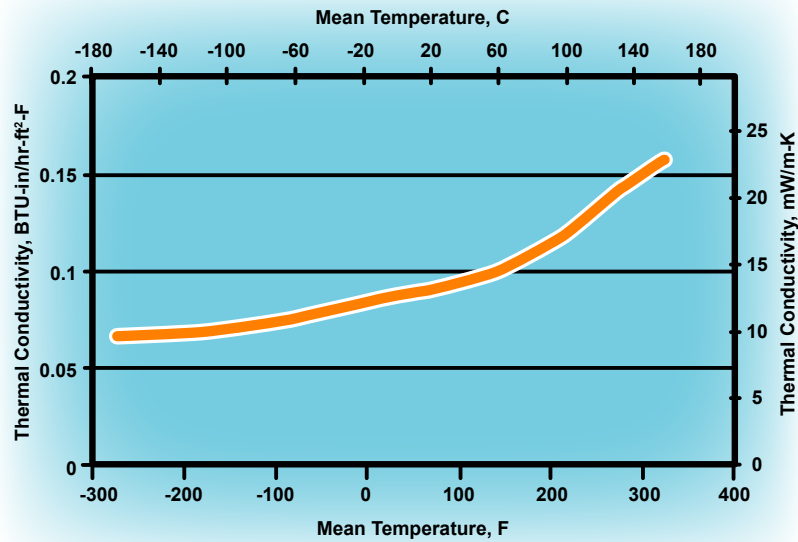
$$k_r = \frac{16 \sigma n^2 T_r^3}{3 \rho e(T_r)} \quad (A)$$

where σ is the Stefan–Boltzmann constant, n is the mean refractive index (for low-density insulation, n is close to 1), T_r is the radiative temperature calculated from the boundary temperature T_1 and T_2 as $T_r^3 = (1/4)(T_1^2 + T_2^2)(T_1 + T_2)$, ρ is the density, and the product $e \cdot \rho = E$ is the extinction coefficient, which is equal $1/l_{\text{photon}}$, where l_{photon} is the photon mean free path. In optically thick insulation, the photon mean free path is very small compared to the thickness of the specimen. Note that the temperature-dependent specific extinction coefficient $e(T_r)$ is derived from the spectral averaging known as the Rosseland mean. According to equation (A), the radiative thermal conductivity would be significantly more dependent on the temperature than solid thermal conductivity (described previously), but gives little contribution to the total thermal conductivity at ambient temperature. The radiative contribution to the overall thermal conductivity of aerogels is only moderately important at ambient temperatures down to cryogenic temperatures (see graph below), but increases considerably at high temperature.



Aspen Aerogels has developed a number of aerogel products that are doped with infrared radiation (IR) “opacifiers”. These materials are either effective IR photon scatterers (based on the principal of Mie scattering) or absorbers in the infrared region. The latter absorb IR radiation photons emitting from a hot surface and re-radiate them isotropically in all directions. This is a very effective mechanism at frustrating heat flow toward the cold side of an insulation system. The graphs below show the relative thermal conductivity values of a non-opacified silica aerogel blanket composite (Cryogel™) and a related material that is opacified with a strong IR absorber (Spaceloft™) from cryogenic to 160°C mean temperature (average temperature between hot and cold sides). The non-opacified material has a thermal conductivity that rises rapidly above 100°C, while the opacified material has a shallower slope. The Pyrogel® materials also contain opacifiers that suppress the transmission of IR through the material in high temperature insulation applications.

Cryogel™



Spaceloft™

