

gaps on reducing the thermal efficiency of insulated walls [77, 78]. In spite of these guidelines for effective thermal resistance in standards, there is not general agreement in the literature that shrinkage reduces the insulating ability of foams. Timm and Smith [75] have made reference to calculations by Barker indicating that shrinkage has little effect on insulating ability of foams.

Since the publication of the Canadian [13] and DOE standards [18] and HUD bulletin [19], studies have been conducted which provide data supporting the guidelines for effective thermal resistance given in these documents. Reliable determinations of heat flow through building envelope components such as walls are made using calibrated or guarded hot box tests. Two of the studies on effective thermal resistance used hot box techniques. In one, the National Research Council, Canada, conducted a study of full scale walls filled with foam [79]. The foam was allowed to shrink in the walls and their thermal resistance was determined. The results indicated that, for example, if the foam shrunk 6 percent, the reduction in the thermal resistance was about 29 percent. In the second study, Tye and Desjarlais [80] measured the resistance of wood-frame cavity walls containing polystyrene boards of varying dimensions (to simulate shrinkage) and found a direct relationship between thermal performance of the wall and air gap around the polystyrene boards. For each 1 percent shrinkage, the reduction in thermal resistance of the insulation was about 5 percent which was comparable to the NRC results. In a related study, McFadden et al. [81] conducted a field test using a small structure having walls insulated with urea-formaldehyde foam. The foam underwent a shrinkage of about 6 percent, which resulted in a measured thermal resistance of the wall which was about 20 percent less than that predicted without shrinkage. The effective thermal resistance of the foam was calculated to be about 29 percent less than the R-value measured in the laboratory.

The U.S. Federal Trade Commission (FTC) reviewed available information concerning shrinkage and its effect on thermal efficiency in 1978 [82]. This review was undertaken by FTC because of concerns over misleading statements in advertisements regarding the R-values of foam insulation. Based on the review, the FTC considered that shrinkage is an inherent characteristic of urea-formaldehyde foam insulation which can significantly reduce the R-value of the insulated area. Consequently, the FTC's insulation advertisement rule requires a disclosure statement on shrinkage or a reduction in the claimed R-value to account for shrinkage, whenever ads for the product mention its R-value [83]. The required disclosure statement is as follows:

"Foam insulation shrinks after it is installed. This shrinkage may significantly reduce the R-value you get."

This statement need not be made if a manufacturer's literature claims a lower R-value than that measured in the laboratory. However, the claimed lower R-value must be based on "reliable scientific proof of the extent of shrinkage and of its effect on R-value [83]."