An Egress Analysis of the Smoke Alarm Sensitivity Study

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Test results from the NIST 2008 Smoke Alarm Sensitivity study were used in an egress analysis to examine the effects of pre-movement time, travel speeds through smoke, and tenability to heat and toxic gas exposures on occupant survivability given different smoke alarm installations. The analysis considered both the location and type of smoke alarms. Smoke alarm locations considered included installations that meet the requirements in the current National Fire Alarm code NFPA 72, and a single alarm in the single-level home test structure. Alarm times from commercially-available photoelectric, ionization, and dual photoelectric/ionization alarms were used in the analysis to examine the effects of smoke alarm type on the predicted survivability for a given egress scenario. Egress scenarios considered a single occupant located in, or remote from, the room of fire origin, and multiple occupants located throughout the home. Pre-movement time is represented as a frequency distribution to cover a range in occupant delay to the initial smoke alarm activation. Travel speed throughout the structure is modeled as a function of the optical density of the smoke from experimental results reported in the research literature. Toxic gas and heat exposures are computed using the International Standards Organization (ISO) Standard 13571 equations for fractional effective dose. The fractional effective dose at incapacitation is represented by a frequency distribution as suggested in the Standard. The frequency distributions of both the pre-movement time and incapacitating fractional effective dose allow for a summation of probabilities into a single effectiveness value. Thus, the relative effectiveness of smoke alarm types or installation requirements can be compared over a large number of scenarios. Properties of the pre-movement and incapacitation distribution functions can be modified to examine relative effectiveness skewed to more vulnerable populations (those slower to react and/or those more sensitive to exposures). This methodology is an alternative to imposing a safety factor on a singular required safe egress time in order to gain some un-quantified margin of safety.