B80 The Application of NIST's Fire Dynamics Simulator to Tenability Analysis and Fire Death Investigations

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The goal of this presentation is to demonstrate to the forensic community the features of FDS (Fire Dynamics Simulator) that can be applied to hazard analysis and potentially to ongoing fire death investigations.

Hazard analysis with regard to fires involves estimation of the effects of a specified fire, usually by measurement of the toxic components in thermally produced smoke and gases. Of particular importance in such analyses are the conditions for tenability, or the ability to occupy a fire prior to incapacitation and/or death. Human tenability characteristics include: elevated temperature (65°C at a layer height of 1.5 m), smoke obscuration (OD ³ m –1 at a layer height of 1.5 m), convected heat (Purser hyperthermia equation), and toxic gases (fractional incapacitating dose from Purser for CO, HCN, O2, and CO2).

Several fire modeling programs, beginning with HAZARD I (the first comprehensive application of fire modeling in the world), quantify hazards to occupants of burning buildings through a combination of expert judgment and calculations. The aim of HAZARD I was to be able to calculate the development of hazardous conditions over time, calculate the time needed by occupants to escape under those conditions, and estimate the resulting loss of life based on assumed occupant behavior and tenability criteria. Applications of fire modeling include a wide range of problem sets from single-family dwellings to industrial conditions such as control rooms at electrical power plants. Such programs provide fire protection engineers with an invaluable tool for predicting the consequences of fires in order to improve public fire safety, strategies for reducing fire losses including building design and arrangement, detection technology, and fire safety education.

While the benefits of quantitative hazard analysis with regard to product assessment, fire prevention, and cost savings are widely recognized, few have considered the potential of applying such models to actual fire death investigations. Here, the possible applications of fire modeling programs are explored, specifically the National Institute of Standards and Technology's Fire Dynamics Simulator, to ongoing fire death investigation cases.

Fire Dynamics Simulator consists of two programs, FDS and Smokeview. FDS is a computational fluid dynamics (CFD) model that solves a form of the Navier-Stokes equations and is appropriate for lowspeed, thermally driven flows of smoke and hot gases generated in a fire. It predicts smoke and/or air flow movement caused by fire, wind, ventilation systems, etc. Smokeview visualizes FDS computed data by animating time dependent particle flow, 2D slice contours and surface boundary contours.

FDS is frequently applied to issues of fire spread and development. However, the features of this program applicable to hazard analysis and tenability appear to be less frequently used. The application of this modeling program to hazard analysis (specifically carbon monoxide levels) will be demonstrated and applications to fire death investigations will be discussed. This will be done with specific reference to a case study where FDS was used to corroborate a witness' timeline based on observing CO levels produced by the model.

The parts per million of carbon monoxide can be visualized in Smokeview for any particular coordinate within the modeled structure by specifying a carbon monoxide slice file in the data. If the structure is properly modeled to reflect known specifications from an actual structure fire, the slice file data can provide insight into the CO intake experienced by occupants of that structure. In a recent arson case, for example, it was crucial to be able to verify a witness' timeline of events in order to include or exclude this witness as a suspect in the arson that resulted in the deaths of 3 individuals. The medical examiner was able to provide blood carboxyhemoglobin levels of the deceased individuals. This data, in conjunction with the modeled CO levels, provided investigators with an estimate of how long the individuals occupied the structure in order to sustain the observed carboxyhemoglobin levels.

Note that great care should be taken when using information from a modeled fire to verify witnessed events to such a specific degree. The success of the model depends largely on the expertise of the user, and improperly modeled fires (that is, those that do not sufficiently resemble the actual fire) can provide misleading results. Moreover, even when used by the most experienced engineers, fires are exceptionally difficult to replicate and predict. However, this example demonstrates the potential for fire investigators and engineers to work together to help solve death investigation cases by using state-of-the-art fire modeling programs. While it should not be considered an accurate and widely applicable technique at this time, the potential and the success of the application of FDS to fire death investigations could likely increase as more engineers become proficient at using fire modeling techniques, and modeling programs become increasingly accurate.

Forensic Science, Fire Modeling, Tenability