SCHULTE & ASSOCIATES
Building Code Consultants
880D Forest Avenue
Evanston, IL 60202
fpeschulte@aol.com
504/220-7475

AN ANALYSIS OF THE APPLICATION OF THE FIRE DYNAMICS SIMULATOR TO SPRINKLER/ROOF VENT INTERACTION WITH "GANGED" VENT OPERATION

The paper titled "***Analysis of the Performance of Ganged Operation of Smoke and Heat Vents with Sprinklers and Draft Curtains***" published by Hughes Associates, Inc. (HAI) dated February 18, 2008 reviews research conducted by HAI on the use of the concept of "ganged" roof vent operation in buildings which are protected by standard spray sprinklers. The research on the use of this concept utilizes Version 4 of the Fire Dynamics Simulator (FDS) to conclude that the "ganged" operation of roof vents will not affect the capability of a sprinkler system to control **and extinguish a fire**.

(**Note:** NFPA 13 specifically states that sprinkler systems protecting high-piled storage (which are designed per NFPA 13 requirements) are capable of both controlling and extinguishing a fire "***without supplemental fire department activity***" within 30 minutes of ignition.)

The following are excerpts which address the application of the Fire Dynamics Simulator, Version 4, contained in a report titled ***"Report of the Technical Investigation of The Station Nightclub Fire***" dated June 2005. This report was written by William Grosshandler, Nelson Bryner and Daniel Madrzykowski and published by the Fire Research Division of the Building and Fire Research Laboratory of the National Institute of Standards and Technology (NIST).

> "*Predicting sprinkler activation and suppression and the influence of fire fighting activities on the spread of the fire is another aspect of the problem that can be done today only at the grossest level of precision.*" (Page xxvi, NCSTAR 2, Volume 1)

"*Real-scale platform area mockup experiments were conducted to characterize the fire growth and spread in the early stage of the fire. Approximately 20 % of the nightclub was reconstructed in real scale with polyurethane foam covered walls, a drummer's alcove, a raised platform, carpeting, and wood paneling. . . Data collected on fire spread (gas temperatures, heat fluxes, and gas concentrations)* [from the real-scale platform area mockup experiments] *allow the performance of the computer fire model to be assessed. The degree to which the computer fire model is able to mimic the fire growth for this real-scale mockup is indicative of the quality of the simulation of the fire in The Station presented in Chapter 5, within the limitations of uncertain materials and imprecise dimensions for the actual nightclub.*" (Page 4-26, NCSTAR 2, Volume 1)

"*Computer simulation has been demonstrated to be credible, when properly applied, as a tool to help fill in critical details of a fire incident and to demonstrate the value of alternative building designs and fire safety measures[1-14].*" (Page 5-1, NCSTAR 2, Volume 1)

"*The NIST Fire Dynamics Simulator is a computational fluid dynamics (CFD) model of fire-driven fluid flow. It solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally driven flow with an emphasis on smoke and heat transport from fires [17]. Version 1 was publicly released in February 2000. The predictions performed here were made with the public pre-release version 4 of the model. Version 4 includes several new features, including multi-blocking, which were critical in performing the full nightclub simulations*." (Page 5-1, NCSTAR 2, Volume 1)

"*The choice of computational grid size influenced the selection of the appropriate values for the initial conditions, boundary conditions and material properties, including the size and energy of the ignition source, heat transfer at the boundaries, and burning properties of the fuel. With all other inputs kept constant, doubling the grid size did not lead to the fast growing fires seen in the video or mock-up experiments; halving the grid size led to a fire growth rate that was faster than the evidence (and a single run-time of 10 days). Hence the simulations could not be shown to be grid size independent. This confirmed that if the mock-up experiments and mock-up simulations were to be used to develop input parameters for the full nightclub computer simulation, then the computational grid size needed to be consistent between the two simulation cases. With the grid size selected at 100 mm, the mock-up simulation computational domain required 319,000 grid cells. Approximately 17 hours were required to generate a 200 second simulation of a mock-up experiment. The FDS input parameters could be adjusted to the 100 mm grid by comparing the simulation results with the measured results from the full-scale mock-up experiments. The FDS inputs, described later in this section, were then applied to the full nightclub simulation, with the WPRI video serving as a source of comparison*." (Page 5-4, NCSTAR 2, Volume 1)

"*The comparison of the sprinkler activation times from the sprinklered mock-up experiment and the FDS simulation of that experiment are given in Table 5-4. In FDS, the activation time of the first sprinkler was the result of adjusting the RTI in the simulation until the times were similar. The RTI that provided the best match, 16 $m^{1/2}$ $s^{1/2}$ (32.6 $ft^{1/2}$ $s^{1/2}$), was used as the RTI for the remaining sprinklers in both the mock-up and the full nightclub simulation. The order of sprinkler activation, and the number of sprinklers activated, were the same in the simulation and the experiment. The times to activation differed by no more than 6 seconds.*" (Page 5-19, NCSTAR 2, Volume 1)

"*In both cases FDS under predicts the temperatures near the ceiling.*" (Page 5-24, NCSTAR 2, Volume 1)

"*The temperature, heat flux, and the oxygen volume fraction comparisons show reasonable agreement between the experiments and the model in terms of both trends and range.*" (Page 5-26, NCSTAR 2, Volume 1)

"*The full-scale mockup results were used to compare against the FDS simulations to validate the implementation of the data in the model, and to determine the model's capabilities for this fire incident. Further, the sprinklered mock-up results were used to develop a means to model the sprinkler in the full nightclub simulation.*" (Page 5-33, NCSTAR 2, Volume 1)

From the excerpts above, along with a comparison of the sprinkler operating times in the large-scale tests performed in the research on the interaction of sprinklers and roof vents funded by the National Fire Protection Research Foundation (NFPRF) in 1997/1998 and the HAI model simulation, it appears that HAI use of the FDS to predict sprinkler operating times after the first sprinkler activation is questionable. **Prior to accepting the HAI research as valid, the issue of whether the FDS was properly utilized by HAI in their research should be addressed by HAI and the Smoke and Heat Vent Task Group.**

* * * * *