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DRAFT
ATTACHMENT

The following are statements addressing the capabilities of fire models to predict the activation times of multiple sprinklers and the effects of sprinkler discharge on fire growth.

Michael Dillon, Dillon Consulting Engineers, Inc.
(204-1 Log #5, December 2009)

> "*The document prematurely and improperly requires and relies upon unproven methods of calculation for the effectiveness of smoke and heat vents in the presence of automatic water-based sprinkler protection systems. It also relies on calculations of questionable accuracy to determine activation times for the vents and the sprinklers.*"

Smoke Vent Task Group Teleconference Minutes
March 24, 2009

> "*The concern remains that if C. Beyler is not willing to support the $100K SVTG Modeling Study, then the study* [referring to the study titled "*Analysis of the Performance of Ganged Operation of Smoke and Heat Vents with Sprinklers and Draft Curtains*"] *is worthless. The members questioned why no other groups, organizations, or Fire Protections Engineers have come forward to defend the FDS program, particularly, Kevin McGratten, from NIST, who wrote the original version of FDS, and has been intimately involved in it since its development. B.Sampson will contact K. McGratten to obtain his thoughts on this.*"

Dr. Kevin McGrattan, Building and Fire Research Laboratory, National Institute of Standards and Technology
(FDS/Smokeview Bulletin Board, February 17, 2009)

> "*The purpose of the FDS Validation Guide is to present comparisons of FDS predictions against full-scale measurements. We work very hard to present the data in a form that enables those who use FDS, or those who are thinking of using it, to decide for themselves if the model is appropriate for a given application. We do not believe that our role is to say whether or not the model is appropriate because we cannot be sure about what the application could potentially be or what the required level of accuracy should be. We prefer that people use their own judgment to decide what is the best tool for the job. That is essentially what you are doing* [referring to Schulte]. *You are making an argument that the model is not sufficiently accurate to predict multiple sprinkler activation. We do not want to make such a statement because we don't know exactly what you intend to use the model for, and furthermore, there is no consensus metric in fire protection engineering by which a model is considered validated or not for a particular application. We prefer to do the technical work in developing the model and quantifying its accuracy as we have done in the Validation Guide. We prefer to leave the decision about validation up to you. We even provide you with this forum by which you and others can discuss the merits of the model for this and other applications. We make the source code available for those who want to check the model themselves, or publish their results in the open literature. We feel that an open discussion of model strengths and weaknesses is healthy, and we do everything we can to promote it.*
>
> *In that spirit, let me point out the second plot in Figure 6.2. Throughout the Validation Guide, there are scatterplots similar to those shown here, except all the other scatterplots have off-diagonal lines that represent the estimated experimental uncertainty. All large scale fire experiments have a considerable amount of uncertainty in the reported heat release rate, environmental conditions, sprinkler characteristics (like droplet size, RTI, etc), and various other parameters that are input into the fire model. Because of the complexity of the experiments and simulations of fires in large warehouse-type facilities, especially those involving multiple sprinkler activations, we do not have a good way (yet) of quantifying the experimental uncertainty. It might be as hard to do that as to predict the experimental results themselves. So rather than try to quantify the experimental uncertainty, we have added the second plot in Figure 6.2. In the UL/NFPRF test series, Phase I, there were 22 experiments, all involving a heptane spray burner and a heat release rate of approximately 4.4 MW. Of those 22 tests, there were three replicate tests (Tests 1 and 8, Tests 4 and 7, and Tests 9 and 10). These were not designed as replicates, but in each case, a vent was either closed for the duration or did not activate, making the two tests essentially the same. The second plot in Fig. 6.2 compares the measured activation times for the sprinklers in one test against the measured activation times in the other (replicate) test. This is only comparing one experiment against another. This has nothing to do with FDS. For example, in Test 8, four sprinklers activated at about 4.5 min after ignition whereas in Test 1, these same four sprinklers activated after about 2 min. There was even a sprinkler that activated after 6 min in Test 8 and after about 2.25 min in Test 1.*

This information tells us something about the reproducibility of large scale sprinkler experiments. It is not an indictment of the testing lab, UL, because this sort of behavior is not surprising for those who do this sort of testing. I observed these experiments, and I noted that following the first activation, there was a considerable effect on the fire because these sprinklers release about 1 gallon of water per second. The burner was placed exactly between four sprinklers [in] *each test, and because there is some variability in the activation temperature of a real sprinkler, there was usually one sprinkler that activated a few seconds before the others, which caused the fire, the plume, and the subsequent activations to trend in a particular direction. FDS has no such bias -- the sprinklers in these calculations were programmed to activate at exactly 74 C (165 F). I suppose that we could build in a random component to the activation temperature to mimic reality, but we worry that this would simply add an additional uncertainty to an already complicated problem. We prefer that the model produce a result that, on average, compares favorably with a number of replicate tests. The fact that FDS sometimes over-predicts and sometimes underpredicts the number of activations is a good thing. Our goal is to predict the total number of activations and the average activation time of each "ring" of sprinklers. We are less concerned about one or two outliers because we know that there is a randomness to this kind of experiment that simply cannot be predicted.*

This kind of information is part of what goes into deciding if the model is appropriate for your purpose. It is my job to provide you with as much information as I can so that you can make an informed judgment. But it is not my place to tell you that the model is right for you. You decide. Ask me questions about the data if something is not clear. But I hope you understand that I simply cannot make a blanket statement like "FDS is validated for predicting multiple sprinkler activations." You have made an argument above that it is not, and you have every right to that opinion."

Dr. Craig Beyler, Hughes Associates, Inc.
(AAMA Smoke and Heat Vent Modeling Plan Summary for the CTC Study Group, March 2007)

"*While FDS formally has fire suppression algorithms, validated predictions of fire suppression remain beyond the capabilities of FDS.*"

Dr. Craig Beyler, Hughes Associates, Inc.
("Interaction of Sprinklers With Smoke and Heat Vents", February 1999)

". . . *While there have been many attempts to model all or part of the interactions of sprinklers and vents, the issues are more complex than can be dealt with using even the most sophisticated modeling methods available today [1999]. The most clear indication of this is the recent NFPRF research project. While modeling of the fluid mechanical aspects of the problem were quite successful in predicting aspects of sprinkler activation in the first heptane spray fire series, the model was unable to predict the corresponding results in the rack storage tests beyond first sprinkler activation*. . . ."