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## VALIDATION? WE DON'T NEED NO STINKING VALIDATION! FIRE SCIENCE?

By Richard Schulte

On Jul 8, 11:00 am, Stephen Olenick . . .wrote [on the FDS/Smokeview Bulletin Board]:

*“ . . . Fire dynamics are governed by the laws of science. If FDS and other computer fire models are appropriate for design, it is appropriate for use in fire investigation and reconstruction. Regardless of whether it's pre- or post-fire, the fire dynamics are the same. . .the judge took the stance that computer fire modeling is inappropriate for fire investigation and reconstruction as a whole.”*

*“ . . .the judge took the stance that computer fire modeling is inappropriate for fire investigation and reconstruction as a whole.”*

The NIST Fire Dynamics Simulator (FDS) development team responded to Olenick's post with the following posted on the FDS/Smokeview Bulletin Board at 11:08 am on Jul 8:

*“In my opinion, fire modeling and fire science are inseparable. The most important results of fire science are incorporated in our models. . .A model is nothing more than a calculation method, and to say that "fire models" are not generally accepted in fire investigation is akin to saying that science has no role in that practice. . . This blanket dismissal, based largely on one person's opinion, sends the wrong message.”*

*“ . . .to say that "fire models" are not generally accepted in fire investigation is akin to saying that science has no role in that practice. . .”*

In the summer of 2006, the AAMA Smoke Vent Task Group announced that new research on the interaction of sprinklers and smoke/heat vents would be conducted using fire modeling. The announcement includes the following excerpt:

*“To concretely demonstrate the value of S&HV in terms of property protection, occupant safety, firefighter safety, and firefighter effectiveness, AAMA’s Smoke Vent Task Group (SVTG) has inked a contract with Hughes and Associates to conduct Large Eddy Simulation (LES) and Computational Fluid Dynamics (CFD) studies in cooperation with the University of Maryland and the National Institute of Standards and Technology. Test results will provide data for an optimized S&HV design approach suitable for inclusion in Chapter 8 of NFPA 204, “Guide for Smoke and Heat Venting,” or in model building codes.”*

The results of Hughes Associates’ fire modeling study of the interaction of sprinklers and smoke/heat vents were published in a report titled “*Analysis of the Performance of Ganged Operation of Smoke and Heat Vents with Sprinklers and Draft Curtains*” dated February 18, 2008. Of particular interest to this discussion are excerpts on the issue of model “validation” contained in the Hughes Associates’ report. The discussion of the “validation” issue is included in section 3.1 of the report, pages 30 to 32. (I know what you’re thinking—the discussion on the “validation” of the model must be really detailed if it’s almost 2 pages in length.) Excerpts from section 3.1 in the Hughes Associates’ report include the following:

*“As was indicated above, the reason for choosing the  $t^2$  growth rate of  $1.78 \text{ kW/s}^2$  ( $0.157 \text{ BTU/s/ft}^2$ ) was to facilitate comparisons with the results of the tests reported in [McGrattan, Hamins, & Stroup, 1998]. . . The average of the first sprinkler activation times reported in Table 5 for these runs is 70.0 s. The*

*sprinkler performance results for the heptane tests from [McGrattan, Hamins, & Stroup, 1998] are reported in Table 6. Only burner positions E and F correspond to the burner being centered on four sprinklers. The average of the first sprinkler activation times reported in Table 5 for these two cases is 70.5 s. The difference between these tests and the current study is 0.7%. For Runs 4 – 12, an average of 19 sprinklers operated. From Table 6, an average of 21 sprinklers operated with the heptane burner tests II-9 and II-10. The difference is 9.5%. . . The comparisons presented in the section are of suitably low percent differences to conclude that the validation exercise is a success.”*

I know what you’re thinking—the discussion on the “validation” of the model must be really detailed if it’s almost 2 pages in length.

In a paper titled “*Interaction of Sprinklers with Smoke and Heat Vents*” authored by Craig Beyler and Leonard Cooper dated February 1999, Beyler/Cooper also addressed the capability of the fire model used with the experiments referred to in section 3.1 of the February 18, 2008 report. The following is an excerpt from the Beyler/Cooper paper:

*“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.”*

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Further, in deposition testimony on June 21, 1999 (page 1195) in the *Ian McAuslin, et al v. Grinnell Corporation, et al* litigation, Dr. Beyler had this to say about the heptane spray burner tests in the experiments referred to in section 3.1 of the Hughes’ fire modeling report on the interaction between sprinklers and smoke/heat vents:

*“Well, I mean you are correct in observing the difference in number of sprinklers operated in the heptane spray fire . . . However, we understand those tests to be not the most relevant ones. That is, they aren’t real commodities. You don’t have real exting - - there is no extinguishment, there’s no suppression. Now, the fire is what the fire is. The more important test with regard to interaction of - - of the totality of the interaction of smoke, smoke and heat vents with draft curtains - - smoke and heat vents with draft curtains and sprinklers are the commodity tests. They’re more realistic as you quickly understand. . .”*

In short, Hughes Associates' discussion of the "validation" of the fire model used in the study of the interaction of sprinklers and roof vents in 2008 is contradicted by Dr. Beyler's statements made in February 1999 and in sworn deposition testimony on June 21, 1999. Obviously, nine years intervened between Beyler's statements in 1999 and Hughes Associates' statement on "validation" of the model in 2008, however, it should be noted that all three statements refer to the same heptane spray tests conducted in 1997/1998. The statement in February 1999 refers to the Industrial Fire Simulator, which was essentially Version 1.0 of the Fire Dynamics Simulator, while Beyler utilized the LES3D model in his work in the McAuslin v. Grinnell Corporation litigation. The fire model used in the Hughes' research conducted between 2006 and 2008 was Version 4 of the Fire Dynamics Simulator.

*"However, we understand those [heptane spray] tests to be not the most relevant ones. That is, they aren't real commodities. You don't have real exting - - there is no extinguishment, there's no suppression. Now, the fire is what the fire is. The more important test with regard to interaction . . . are the commodity tests. They're more realistic as you quickly understand. . ."*

While it is possible that improvements in the fire models in the intervening 9 years resulted in improved prediction capabilities with respect to sprinkler activation times and number of sprinklers activated, no one in the field has yet to come forward to state that this is the case since 2008, not even colleagues of Dr. Beyler, Phil DiNenno or Dr. Jason Floyd. When the question regarding the "validation" of the FDS was posed to the NIST FDS development team on the FDS/Smokeview Bulletin Board, Dr. Kevin McGrattan responded as follows on 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. . .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 feel that an open discussion of model strengths and weaknesses is healthy, and we do everything we can to promote it.*

**[Editor's Note:** In my opinion, this last statement in the preceding paragraph is incorrect. It appears to me that there is a genuine fear about discussing anything controversial on the FDS/Smokeview Bulletin Board. The fear is that those who express viewpoints other than those which conform to the viewpoints of the NIST FDS development team will be ostracized or "ex-communicated".]

*. . . 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. . .*

*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). . . 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."*

*“ . . . But I hope you understand that I simply cannot make a blanket statement like “FDS is validated for predicting multiple sprinkler activations.”*

Not to pile on or anything, but an article published in the April 2008 issue of *Industrial Fire Journal* authored by Dr. Alan Beard raised further questions about the capability of fire models to produce reliable and accurate predictions. Dr. Beard's article titled "*Reliability of Computer Models in Fire Safety Design*" calls into question the reliability of computer models used in the fire protection field. Excerpts from this article include the following:

*"This concern covers all kinds of models, including computational fluid dynamics [CFD] models. Concerns centre around the degree to which such models may or may not have the potential to represent the real world reasonably accurately and the ways in which such models may be used and results interpreted."*

*"Whether or not a model may be reliably used as part of fire safety decision-making depends not only upon the conceptual and numerical assumptions in the model itself but also upon how it is used and how the results are interpreted. Using models as part of decision-making may be dangerous."*

In another article on the subject titled "*Computer Models and the Limitations in Safety Design*" dated January 1, 2009 and published on the *Industrial Fire Journal* website, Dr. Beard once again expresses caution on the use of output from computer fire models. Excerpts from this article include the following:

*". . . The point was that it is generally not difficult to run a computer-based model and get results, given the availability of packages today. However the implication was that it is very difficult to employ a model so that it makes a genuinely valuable contribution to real-world decision-making, rather than leading to inaccuracy and inappropriate interpretation."*

*"Different users may produce quite different results, even when using the same probabilistic model and applying it to the same case."*

*"A similar point may be made about deterministic models; different users may produce very different results when applying the same model to the same case."*

*"A similar point may be made about deterministic models; different users may produce very different results when applying the same model to the same case."*

*“Errors may result from mistakes in the software. There is also the possibility that the physical system which is being modelled may enter a condition which the software is not suitable for; this may relate to lack of realism of the theoretical and numerical assumptions made in the model.”*

*“It is necessary to assume a questioning attitude to experimental results as well as to theoretical predictions.”*

*“It is usually assumed that hardware is very reliable and the possibility of a computer making a mistake because of its hardware has been generally ignored, at least by those who are not in the field of computer science.”*

*“It is necessary to assume a questioning attitude to experimental results as well as to theoretical predictions.”*

Based upon the above, who do you agree with, Stephen Olenick and Dr. Kevin McGrattan or the judge? . . . It also appears to me that the judge knows what he’s talking about when it comes to the use of fire modeling in his courtroom.

## **Conclusion**

Based upon the above, who do you agree with, Stephen Olenick and Dr. Kevin McGrattan or the judge? It looks like there is more than just a single person who has expressed reservations about how fire models are being utilized in the fire protection field. It also appears to me that the judge knows what he’s talking about when it comes to the use of fire modeling in his courtroom.

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