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FIRE MODELING ON TRIAL:
THE BEYLER DEPOSITION (SUMMARY)

The following are excerpts from the Society of Fire Protection Engineers (SFPE) Canon of Ethics:

> *"**Preamble**. . . .Accordingly, the services provided by fire protection engineers require honesty, impartiality, fairness and equity, and must be dedicated to the protection and enhancement of the public safety, health and welfare; and the environment. In the practice of their profession, fire protection engineers must maintain and constantly improve their competence and perform under a standard of professional behavior which requires adherence to the highest principles of ethical conduct with balanced regard for the interests of the public, clients, employers, colleagues, and the profession.. . ."*
>
> SFPE Canon of Ethics

"***Fundamental Principles.*** *Fire protection engineers uphold and advance the honor and integrity of their profession by: . . . Being honest and impartial, and serving with fidelity the public, their employers, and clients. . . "*

SFPE Canon of Ethics

"***Canon 6.*** *Fire protection engineers shall be honest and truthful in presenting data and estimates, professional opinions and conclusions, and in their public statements dealing with professional matters . . . "*

SFPE Canon of Ethics

ATTACHMENT 1

BEYLER/COOPER PAPER (PAPER 21) EXCERPT
FEBRUARY, 1999

The following excerpt is from a paper titled **"**Interaction of Sprinklers with Smoke and Heat Vents" authored by Craig L. Beyler and Leonard Y. Cooper dated February, 1999. (Note that this paper is also referred to as **Paper 21**.)

> ". . . . 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. . . ."
>
> Craig L. Beyler and Leonard Y. Cooper, February 1999

ATTACHMENT 2

McGRATTAN STATEMENTS
MODEL VALIDATION

The following are Dr. Kevin McGrattan's comments regarding the "validation" of the Fire Dynamics Simulator used for the purposes of predicting the activation times of sprinklers. These comments were posted on the **FDS/Smokeview Bulletin Board** on **February 17, 2009** by Dr. McGrattan.

> "The purpose of the FDS Validation Guide is to present comparisons of FDS predictions against full-scale measurements. . .there is no consensus metric in fire protection engineering by which a model is considered validated or not for a particular application. . . We make the source code available for those who want to check the model themselves, or publish their results in the open literature.
>
> Dr. Kevin McGrattan, Building and Fire Research Laboratory (BFRL), National Institute of Standards and Technology (NIST), February 17, 2009

"... 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."

Dr. Kevin McGrattan, Building and Fire Research Laboratory (BFRL), National Institute of Standards and Technology (NIST), February 17, 2009

“This information tells us something about the reproducibility of large scale sprinkler experiments. . . 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. . .But I hope you understand that I simply cannot make a blanket statement like “FDS is validated for predicting multiple sprinkler activations.”

Dr. Kevin McGrattan, Building and Fire Research Laboratory (BFRL), National Institute of Standards and Technology (NIST), February 17, 2009

ATTACHMENT 3

EXPERT REPORT EXCERPTS
DR. CRAIG BEYLER DEPOSITION
IAN DAVID McAUSLIN, et al v.
GRINNELL CORPORATION, et al
NEW ORLEANS DISTRIBUTION CENTER FIRE
(McFRUGAL'S WAREHOUSE)

The following are excerpts from Dr. Craig Beyler's expert report in the litigation arising from the fire at McFrugal's Warehouse in New Orleans. This litigation is referred to as Ian David McAuslin, et al v. Grinnell Corporation, et al.

"In a recent study sponsored by the NFPA Research Foundation, LES3D was used to predict the interaction between sprinklers and heptane spray fires. The sprinkler activation times predicted by LES3D compared well against the heptane spray fire experiments done at Underwriters Laboratories for the same study. First ring sprinkler activation times were predicted to within about 15 percent, and second ring sprinklers activation times were predicted to within about 25 percent. Predictions of the total number of sprinklers activated by the spray fires were generally very good with most predictions within 25 percent with greater deviations in three of the 21 tests. " (Page 16)

Dr. Craig Beyler-Expert Report, Ian David McAuslin, et al v. Grinnell Corporation, et al, Spring 1999

"You and Kung (1984) and Kung, You and Spalding (1986) showed that the plumes and ceiling jets resulting from rack fires can be described using formulations presented in Beyler (1986) for simpler beds. This means that a simple representation of the burning racks as a simple surface at the top of the rack is a valid means of specifying the fire for use in performing calculations of the interaction of rack fire plumes/ceiling with the sprinkler spray." (Page 17)

"For this study, the data in Beyler (1977b) were used for this purpose. The mean drop size, initial velocity, and water flow rate are dependent on the sprinkler pressure and orifice diameter. The experiments (Beyler, 1977b) used for establishing the parameters were 12.7 mm (½ inch) sprinklers flowing at 114 lpm (30 gpm). The median size was not reported in that work and a value of 1 mm was used based on the work of You (1986)." (Pages 25 and 26)

Dr. Craig Beyler-Expert Report, Ian David McAuslin, et al v. Grinnell Corporation, et al, Spring 1999

"The standard clearance fire caused activation of four sprinklers over a period of 100 to 350 seconds. The MacFrugal's NODC clearance resulted in a fire that activated nearly 70 sprinklers during the simulation and clearly did not control the fire." (Page 41)

"The modeling results provided in this report confirm that the excessive ceiling clearance in the NODC sprinkler design caused the failure of the sprinkler system." (Page 44)

"The graphs on this page indicate the estimated operating times of sprinklers for a fire in a Class II commodity which is three tiers high with top of storage to ceiling clearances of 10 feet and 50 feet." (Page 62)

Dr. Craig Beyler-Expert Report, Ian David McAuslin, et al v. Grinnell Corporation, et al, Spring 1999

"The graph for the 10 feet clearance indicates that the first operating sprinkler will activate in approximately 100 seconds and that the fire will be controlled by a total 4 operating sprinklers." (Page 62)

"The graph for the 50 feet clearance indicates that the first operating sprinkler will activate in approximately 215 second and that the fire will not be controlled and will continue to grow." (Page 62)

Dr. Craig Beyler-Expert Report, Ian David McAuslin, et al v. Grinnell Corporation, et al, Spring 1999

ATTACHMENT 4

DEPOSITION EXCERPTS
DR. CRAIG BEYLER DEPOSITION
IAN DAVID McAUSLIN, et al v.
GRINNELL CORPORATION, et al
NEW ORLEANS DISTRIBUTION CENTER FIRE
(McFRUGAL'S WAREHOUSE)

The following are excerpts from Dr. Beyler's deposition on **May 12, 1999:**

Page 418

Q. **If I understood your response, the model does not include or can't determine what goes on within the rack itself.** Is that correct? Did I repeat what you had stated earlier accurately?

A. You may have, but I'll make a comment on it, not because you mis-characterized it, but because I made it clear to me that I didn't describe it very well.

Q. Okay.

A. **The computational domain does not include the racks themselves. That does not mean that we aren't predicting or otherwise know what's going on within the racks, but that is done as a sub-model as opposed to being a part of the - - fluid mechanics domain. What has been done is the fluid mechanics domain starts at the top of the racks up to the ceiling, of course. We predict using the LES model how much water arrives at the top of the racks and we use other models to establish, one, how the fire grows within the racks, and to, what the effect of that water is. So they are - - they are modeled, but they are not modeled in the fluid dynamical part of the LES 3D.**

(Continued Next Page)

(Continued From Previous Page)

Q. Which portions are they modeled in and what sub-programs or models are those two phenomenon?

A. **Those sub-models are a fire growth model that's described subsequently in the report as well as the effect of water is. There's a sub-model for that that we added for that.** Both of those are - - We'll talk about them in detail, I'm sure. **Both of those come out of work done at Factory Mutual.**

Q. **And the effect of the size of the flue does have an effect or is part of that equation, is it not?**

A. The - -

Q. **If you change the flue size, it will change the outcome?**

A. **The testing that was done that supports those sub-models were with the standard six-inch flue spaces and, yes, there is a - - there is an effect of flue space width on, you know, the air flow through the commodity.**

Page 423, Line 3

Q. Let's mark that as 34 then. And let the record reflect the correction to Exhibit 34. **Now, with respect to the Yao and Chan articles, your purpose was to discuss RDD and ADD?**

A. Yes. **Basically the modeling approach that we adopted that I just described in terms of dealing with the domain only above the commodity is the same approach that's inherent in the ADD-RDD or RDD-ADD concept that Factory Mutual has been using** I'm going to say a couple of decades, but I'm not absolutely sure, in terms of how they have conducted experimental programs to understand the interaction of sprinklers and fires. They in fact have reduced it, I don't mean reduced in the sense of diminish, but reduced it that is, **developed it to the point where it's actually a standard type of a test that they use to establish the commodity classification of some commodity that may not have been tested previously or for whatever reason they have some doubt as to how it's expected to burn. So the intention of including these here is simply to indicate that this is not an approach without precedent.** It is the underlying basis for a whole body of research that Factory Mutual has done over the years. **And obviously if the prior references we talked about, You and Kung and Kung, You and Spaulding, if those weren't true they wouldn't be doing it. But in fact, they have been and have been successful.**

Page 430, Line 21

Q. Okay. Now we pick up the first - - **Is this, on page 19, the first of the algorithms that were imported into the program. Is that what that is at the top of page 19?**

A. Yeah. **What we're doing in this part is describing how we're going to model the commodities in terms of surface areas and then we'll go on in the subsequent page to burning rate per unit areas and then subsequently into flame spread rates, which are the things that are needed to - - that's the fire growth model. And, you know, which are coming out, as we're seeing here, as out of data in correlations of data provided by various authors at Factory Mutual.**

Page 450, Line 1

Q. And then explain the significance, the role of Exhibit 42.

A. Sure. Bert did experiments in which he looked at a range of sprinklers and looked at the drop size distributions that were produced and correlated those drop size distributions. This is a report of that work. **And you will find that equation 13 is included in Bert Yu's work as a means of correlating the mean droplet diameter to the flow rate and we are using this correlation. So as the flow rate from the sprinkler diminishes, as more sprinklers are activated, not only does the flow rate change, which we have produced in our modeling input, but also the mean droplet size changes, and that is also reflected through the use of this correlation developed by Bert Yu in Exhibit 42.**

Page 490, Line 14

Q. Would you be able to model that by use of a different program or do you have to make a qualitative decision, non-quantitative decision as to the effect of the water discharged by the sprinklers in the rack?

A. I mean the substance of the meaty, you know, the meaty part, **the central portion of this, our report, are the modifications that we made to LES to allow the modeling of the effect of sprinkler sprays on the burning of the commodities.** We added that, we used that. What we did would be - - is applicable to ceiling sprinkler systems, and as indicated yesterday and again today, that I don't know how to expand that to in-rack sprinklers.

The following are excerpts from Dr. Beyler's deposition on **June 23, 1999**:

Page 1345, Line 24

Q. Okay. I thought it was clear from the content what we were referring to, and if there are multiple reports, I readily stand corrected. But I thought it was clear it was the report that you and Mr. Trelles worked on . **Where there more than one report that you worked on for the AAMA?**

A. **The review paper that I did with Mr. Cooper was also funded by that organization.**

Page 1352, Line 25

Q. Did you, in your review of the inventory, and by you, **I am referring to the imperial you, determine whether or not any aerosols or flammable liquids were present in the warehouse?**

A. **Don't know.**

Q. Do you recall whether anyone else that was part of the Lloyd's team made that determination or came to that conclusion or did that identification?

A. **Don't know.**

Q. Did you receive any documents from Mr. Mazarat that would indicate whether or not there were aerosols present in the warehouse?

A. **Don't remember.** I mean we have reviewed the materials I got from him. I don't remember what those are. We could review any of those that were made exhibits, but I don't remember as I sit here.

Q. **Your understanding is, to the extent that there were aerosols present within the warehouse, that was contrary to the variance? Is that correct?**

A. **Yes.**

Page 1359

Q. Okay. Multi-row. **That is you had that configuration and the same design for the overhead as was at the warehouse, that the overhead, if it was ten feet or less above the top of storage, would control that fire?** Is that correct?

A. **That's what the modeling indicated.**

Q. **That's what the model indicates.**

A. Yes.

Q. Okay.

A. **That is the prediction.**

Page 1397, Line 20

Q. This is still a point where I am a little bit confused and I need you to assist me if you would. **Are the fire growth rate and suppression algorithms used in your model based upon tests and experiments done on double row racks or multi-row racks?**

A. The two configurations of tests that were used in the testing, as I best remember them, some were arrays of four racks, two by two. Typically the calorimetry tests are done in that geometry. And then there are other tests that are a double row rack. That is, the one dimension being longer that the other.

Q. That partially answers my question. Let's split it in half.

A. Okay.

Q. **For the suppression algorithms, - -**

A. Yes.

Q. **- - does it use double row racks or multi-row racks?**

A. **Those are tests, and I think those were Bert Hughes' tests that are a two by two array.**

Page 1412, Line 10

Q. We talked about this a little bit earlier. Going back to the model. **What is the proper, in your mind, or in your opinion, method for validating computer fire models?** Let me restate it again. All right. Do you understand the question, sir?

A. I'm going to review it again, but I think I do. Obviously validation of a computer model is involved in both assurance that the code does what you think it does and that the model that's implemented compares - - involves comparison with data. You used the word "proper" and I'm not sure I can define for you what "proper" is. That is, I'm not sure I could give you a definition of "proper" versus "improper" validation. Not a word I would have picked, but, you know, you did.

Q. What word would you pick? **Is there a correct method for validating a model, computer model?**

A. **There's not a well established protocol per se. There are some - there are some, you know, general ideas, which I think I have tried to indicate in my answer already; that is, comparison, the idea of the validation by comparison of data**, you know, doing things - - doing checks on calcs to see that they do what you intend them to do. **But I don't think there's a prescription that, you know, this is the proper method. There are certainly - - there's information around as to the process, but I don't know what I could identify this is a proper one and this is an improper one.**

Page 1414, Line 15

Q. Okay. **The model, the LES3D model encompasses or takes into account pre-wetting.** Is that correct? Or does it?

A. **The water does flow on to commodities and the water density does affect the burning rate. Those are the ways in which the model includes - - includes, you know, water application. It doesn't accumulate water on surfaces or anything of that sort.**

Page 1425, Line 11

Q. **Had Mr. McGrattan, et all disclosed what their margin of error or error rate is with respect to the LES3D program? At least as of the margin that you used?**

A. **I think the published papers, you know, that are cited in the report include comparisons with data that are illustrative of the margins of error** and I think I we talked about some of those last time.

Q. Okay. **And with respect to the inclusion of additional suppression algorithms that were proprietary or have been asserted to be proprietary to Hughes & Associates, have they been subjected to review for determination of how they affect rate of error?**

A. **As I indicated last time, the models that we used, the models aren't proprietary. It's the source code. And, of course, the models that were used are in the open literature and have comparisons available, data versus - -**

Q. You said models. I was referring to algorithms. Were you using them - -

A. Algorithms are an implementation of a model.

Q. Okay.

A. **And so I mean you have the question there of does the source code do what you want it to do, and that's error checking, which was done. And then there's the question of given the - - you know, a correct implementation of the model, how well does that model do relative to data. Those comparisons of model to available experimental data are included in the references we cited, which I believe are all exhibits to my deposition. I mean they exist.**

Page 1426, Line 24

Q. In the model, the **suppression algorithm** decreases the rate of heat release over time?

A. **The heat release rate is reduced by the application of water.**

Analysis: In the paper titled "***Interaction of Sprinklers with Smoke and Heat Vents***" dated **February 1999**, Dr. Beyler states that the fire model is unable to predict sprinkler activation times "*beyond the first sprinkler activation*".

Practically simultaneously **(late 1998/early 1999)**, Dr. Beyler develops his expert's report in the McFrugal's Warehouse litigation utilizing the LES3D fire model to predict the activation times of multiple sprinklers, the number of sprinklers which will operate and the effects of sprinkler spray discharge on the fire. In sworn testimony, Dr. Beyler asserts that these capabilities of the fire model have been "validated".

In **2008/2009**, Dr. Beyler is unable to provide any documentation that the Fire Dynamics Simulator is capable of accurately predicting the activation times of multiple sprinklers and the number of sprinklers which will activate.

It is an accepted fact in the fire protection field in 2010 that the ability to predict the effects of sprinkler spray discharge on a fire is outside of the capabilities of the Fire Dynamics Simulator.

If Dr. Beyler is unable to provide documentation that the capability of the Fire Dynamics Simulator to predict the activation times of multiple sprinklers and the number of sprinklers which will operate has been "validated" in **2008/2009**, Dr. Beyler's assertion in sworn testimony that these capabilities had been "validated" in **1999** was obviously in error.

If the Fire Dynamics Simulator is not capable of predicting the effects of sprinkler spray discharge on a fire in **2010**, then Dr. Beyler's assertion in sworn testimony that the LES3D fire model was capable of performing this task in 1999 was also obviously in error.

Based upon the above, there seems to be only two conclusions which can be reached. Either Dr. Beyler is not the renowned expert in fire modeling that he is considered to be or Dr. Beyler deliberately provided false sworn testimony in the McFrugal's Warehouse litigation.