Blind versus Open Fire Model Validation: Issues, Pros & Cons

Deytec, Inc.
Nuclear Engineering Services

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Abstract

Two international projects that examined the issue of blind (a priori) versus open (a posteriori) fire model validations, the Dalmarnock Round Robin Project and the International Collaborative Fire Model Project, have initiated a discussion in the international fire science community on the pros and cons of blind versus open fire model validations. These discussions are documented in this report and analyzed further to assist the fire science community specify a course of action for its development. The compilation and analysis of comments on the issue of open versus blind fire model validation show that although several concerns were raised against the adoption of blind fire model validations, the issues can be addressed in a standard. It is recommended that a standard be developed to phase in the use of blind fire validations, along with open validations, in performance-based designs to achieve a higher degree of confidence in the predictive capability of the models. Third party validation can address the issue of the possible bias introduced in fire model validations by providing an independent assessment and determination of the model errors. This will add credibility to performance-based regulatory systems. A policy that accounts for the given technical limitations should be developed to guide the proper evolution of performance-based fire protection regulatory systems worldwide. The policy and standard can be revised as experience with blind validations is gained, and the technical limitations of current fire models are overcome.

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Executive Summary

There have been two international projects that examined the issue of blind (a priori) versus open (a posteriori) fire model validations:

1. Dalmarnock Round Robin Project; and
2. International Collaborative Fire Model Project (ICFMP).

The Dalmarnock Round Robin and ICFMP projects have initiated a discussion in the international fire science community on the pros and cons of blind versus open fire model validations. These discussions are documented in this report and analyzed further to assist the fire science community specify a course of action for its development. The report presents all the views expressed on the topic in terms of the pros and cons, and examines the issues raised to allow for discussion in the fire science community.

The compilation and analysis of comments on the issue of open versus blind fire model validation show that although several concerns were raised against the adoption of blind fire model validations, the issues can be addressed in a standard.

The comments were broad and went beyond the specific topic to issues regarding the validity of the models and the performance-based regulatory standards for fire protection adopted in many countries. Some commenters went as far as to state that fire model predictions are not reliable and should not be used, that deletions of useful fire protection features were being justified by computer models, and that practitioners are blindly using model results as the truth (reification). They argue that if fire science is at an infancy, why trust results at this point? There is an apparent need to inject confidence in the performance-based regulatory systems for fire protection worldwide. Some practitioners even expressed skepticism given the many sources of uncertainty in performance-based design, model error, user effects, and sensitivity to unknown parameters.

It is recommended that a standard be developed to phase in the use of blind fire validations in performance-based designs to achieve a higher degree of confidence in the predictive capability of models. The goal should be to set safety factors in fire safety designs commensurate with the predictive capabilities of the models. This will establish a robust and conservative methodology and prevent the misuse of fire models. It will also add credibility to performance-based regulatory systems worldwide.

It is recommended that an international standard be developed to:

1. Establish a process to ensure that blind calculations are used to establish model errors that are used to establish safety margins in fire safety analysis;
2. Examine and include "third party validation" as an option for establishing true model errors.

Third party validation can address the issue of the possible bias introduced in fire model validations by providing an independent assessment and determination of the model errors. Third party validation can also be used to provide validations as newer versions of a particular fire model are released.

It is necessary to globally harmonize definitions for verification and validation, and the methods for verification and validation (V&V). In order to achieve this, a consensus on the measurement methods for parameters needed as input to fire models and values for parameters input to fire models is needed.

It is suggested that standards established in other industries (where model accuracy is important for safety) such as the medical field be reviewed in the development of the standard for fire model validation. For example, the Food and Drug Administration (FDA) quality control requirements for medical software and models are very complex, and require expert documented and non developer validation and verification. The many lessons and experiences of the medical industry can be examined as they evolved from where the fire science community is today to a robust regulatory regime. Strict quality control requirements are recommended for the development and validation of fire models, especially given the rudimentary stages of their development, expanding application in fire safety engineering, and lack of confidence in the methods expressed by some stakeholders.

Although a stricter regulatory regime for performance-based fire protection is needed to establish confidence, a phased approach that includes the use of both open and blind validations is suggested as fire science matures. Blind validations have definitive benefits as well as open validations. It is also important to present all information to practitioners on model errors, sensitivity analysis, and implementation of code options as these areas are also of concern. A policy that accounts for the given technical limitations should be developed to guide the proper evolution of performance-based fire protection design. The policy and standard can be revised as experience with blind validations is gained, and the technical limitations of current fire models are overcome.

Acronyms and Initialisms

FDA	Food and Drug Administration
FSE	Fire Safety Engineering
GRS	Gesellschaft fur Anlagenund Reaktorsicherheit mbH
HRR	Heat Release Rate
IAFSS	International Association of Fire Safety Science
ICFMP	International Collaborative Fire Model Project
ISO	International Standards Organization
NIST	National Institute of Science and Technology
SC	Subcommittee
TC	Technical Committee
WG	Working Group
USNRC	U.S. Nuclear Regulatory Commission
V&V	Verification and Validation

1 Introduction

This document was developed by Deytec, Inc. utilizing its own resources as a service to the scientific community. It summarizes and discusses the issues, pros, and cons of blind (a priori) versus open (a posteriori) fire model validations that were raised in various international forums and blogs. Specifically, comments posted in the forum of the International Association of Fire Safety Science in 2008, 2009, and 2011; and in the blog of the BRE Centre for Fire Safety Engineering, University of Edinburgh in 2009 have been included in this report.

The objective of this report is to present all the views expressed on the topic in terms of the pros and cons, and examine the issues raised to allow for discussion in the fire science community. It also provides a conclusion and recommends a course of action. The discussions and recommendations are primarily of the author but also include ideas and suggestions provided in the comments.

There have been two international projects that examined the issue of blind versus open fire model validations:

3. Dalmarnock Round Robin Project (Rein, 2009)
4. International Collaborative Fire Model Project (Rowekamp, 2008; and Dey, 2010)

Another project was conducted by the International Building Council (CIB) during the late 1990s, and the results showed considerable differences in results predicted by different users for the same specified case. As a consequence of the poor showing of model use found in that study, the report and its findings were not made widely available.

Dalmarnock Round Robin Project

The 2006 Dalmarnock Fire Tests conducted in a high-rise building were used to look into the issue of blind and open fire model validation. An international study of fire modeling was conducted prior to Dalmarnock Fire Test One (Rein, 2009). The philosophy behind the tests was to provide measurements in a realistic fire scenario with very high instrumentation density (more than 450 sensors were installed in a 3.50 m by 4.75 m by 2.45 m compartment). Each of the seven participating teams independently simulated the test scenario a priori using a common detailed description. Comparison of the modeling results shows a large scatter and considerable disparity among the predictions and between predictions and experimental measurements.

The differences between a priori and a posteriori modeling become patent when comparing the round-robin results with the work conducted after the Dalmarnock data was publicly disseminated. Subsequent studies (Jahn et al. 2007, Jahn et al. 2008 and Lazaro et al. 2008) show that it is possible to conduct a posteriori fire simulations that reproduce the general fire behavior to a satisfactory level. This was achieved due to the availability of experimental data of the real behavior for reference, allowing for iterations until an adequate input file was found.

International Collaborative Fire Model Project

The International Collaborative Fire Model Project (ICFMP) was co-sponsored by the U.S. Nuclear Regulatory Commission (USNRC) and Gesellschaft fur Anlagenund Reaktorsicherheit (GRS) mbH, and conducted from 1999 to 2008. The ICFMP project was designed with two objectives:

1. To examine the modeling of the physics involved in several nuclear power plant scenarios in current state-of-the-art fire models, and to develop their capabilities and limitations for modeling such scenarios; and
2. To develop the predictive accuracy of the models (model error) for important parameters in nuclear plant fire safety analysis.

The ICFMP project consisted of five international benchmark exercises in which nuclear safety research organizations from five countries (Germany, UK, France, Finland, and USA) attempted to validate fire models. Typically, seven organizations from the five countries exercised their respective fire models in the benchmark exercises. The fire models exercised were zone, lumped-parameter, and computational fluid dynamic (CFD) fire models. Empirical fire correlations were also evaluated. The 1st international benchmark exercise included a hypothetical exercise for fire scenarios in nuclear plants for which experimental data did not exist. The 2nd, 3rd, 4th, and 5th international benchmark exercises consisted of tests simulating nuclear plant fire scenarios. Full-scale compartment fire experiments were conducted by the USNRC at the National Institute of Standards & Technology (NIST) for ICFMP Benchmark Exercise No. 3 to simulate a cable room with various types of cables in different configurations. Gesellschaft fur Anlagenund Reaktorsicherheit (GRS) in Germany conducted tests for ICFMP Benchmark Exercise No. 4 to simulate intense fire scenarios in a compartment, and ICFMP Benchmark Exercise No. 5 to simulate pool fires and cable flame spread.

The V&V process in the ICFMP project was very beneficial in many respects. The benchmark exercises allowed different models to be analyzed and compared against each another and experimental data for a wide range of scenarios in nuclear power plants. The comparisons of the trends between codes and experimental data allowed an examination of the modeling of the physics of the scenarios. The capabilities and limitations were derived from such comparisons and analysis.

In order to determine model predictive errors that would be widely accepted, the ICFMP project was established by the parties to conduct blind (a priori) benchmark exercises, i.e. participants would conduct and submit results of their respective fire model calculations based on a specification of the exercise prior to the release of experimental data and learning of the results from other participants. Great efforts were expended to develop the specification of the benchmark exercises in sufficient detail to minimize the variance in the input parameter values used to conduct the blind calculations. The goal of the blind exercises was to provide participants a process in which they could establish the true predictive errors of their models in an international forum. These results could then be used by the respective organizations for application.

The ICFMP attempted to conduct blind exercises but faced two categories of issues in the process:

1. Lack of agreement among participants on the measurements and data needed as input to the fire models being exercised;
2. Lack of an established formal procedure for the submission and collection of blind calculations from the participants.

The main three input parameters that were issues in the ICFMP V&V process were: (1) heat release rate (HRR); (2) radiative fraction of heat from fire; and (3) thermal parameters of the compartment boundary. These input parameters also have the greatest effect on output parameters of interest in nuclear power plant fire safety analysis. Although attempts were made at measuring and specifying these parameters for the benchmark exercises, there was disagreement among participants as to the correct values to be used as input for the fire models.

Since there was no agreement on these inputs to the models, participants changed their calculations based on modified values of input parameters they believed to be correct after the experimental results were released to participants. Blind fire model predictions had been submitted to a central contact, but the submission and collection of blind calculations was informal due to the lack of an international standard and the collegial nature of the collaborative project. In the end, it was up to participants to declare which calculations were open or blind.

The model errors derived for output parameters was significantly different (up to 55% differences in model error) among participant calculations using the same fire model, or using models with the same degree of sophistication. Therefore, it is concluded that the ICFMP benchmark exercises were not successful as blind validation exercises. However, the development of the V&V process provided experience in the conduct of such blind exercises and the issues that provided a challenge. These issues could be addressed and the V&V process can be improved. A discussion of the technical findings and lessons learned from the ICFMP can be found in Rowekamp, 2008, Dey, 2009 and Dey, 2010.

The Dalmarnock Round Robin and ICFMP projects described above have initiated a discussion in the international fire science community on the pros and cons of blind versus open fire model validations. These discussions are documented in this report and analyzed further to assist the fire science community specify a course of action for its development. A few papers have been published on the topic, including those for the two projects discussed above, and those by Alan Beard.

The results of the ICFMP projects were presented by the author to WG 7, "Assessment, Verification and Validation of Calculation Methods in FSE" of ISO TC 92 SC 4, "Fire Safety Engineering" in 2009 and 2011 at their meetings in Lancaster, Pennsylvania, and Paris, France. This report will be presented to WG 7 in October, 2011 in Ottawa, Canada. The issue of blind versus open fire model validations is presently under consideration by WG 7 (Brein, 2011).

2 Definitions

When making comparisons of fire model results to experimental measurements, there are two general approaches that can be followed: a priori (aka blind) and a posteriori (aka open). In a priori simulations, the modeler knows only a description of the experimental scenario, but has no access to the experimental measurements of the parameters for which predictions the models are being tested. Thus the modeler will be providing a true forecast of the quantities of interest. In a posteriori simulations, before the simulation is run the modeler knows not only the experimental scenario but also the experimental measurements of the parameters for which predictions the models are being tested. Most fire model validations in fire safety engineering have been conducted a posteriori.

3 Summary of Comments and Discussion

3.1 Pros of Blind Validations

3.1.1 Eliminates natural bias

The main advantage of blind simulations is that it eliminates the natural bias in the validations that can occur in open calculations conducted by developers, owners, or users of the computer fire models. As indicated above, both the Dalmarnock Round Robin Project and the International Collaborative Fire Model Project demonstrated that this natural bias can and does occur. Only a priori simulations are free of the possible bias that could be introduced by prior knowledge of the experimental measurements of parameters for which predictions the models are being tested. The extent and importance of this natural bias in fire safety engineering is currently under study by different research groups.

3.1.2 Provides high degree of confidence in predictive capability

Blind validations provide a high degree of confidence in the predictive capability of the models to users and regulators by truly establishing the errors in the predictions. Blind validations lead to a robust and conservative methodology.

Several stakeholders have stated that fire model predictions are not reliable and should not be used, that deletions of useful fire protection features were being justified by computer models, and that practitioners are blindly using model results as the truth (reification). They argue that if fire science is at an infancy, why trust results at this point? There is an apparent need to inject confidence in performance-based regulatory systems for fire protection. Blind validations will increase the degree of confidence in the performance-based regulatory systems being used worldwide.

3.1.3 Establishes confidence in setting safety factors

Knowing the true predictive capability of the models allows a designer to establish safety factors for the designs with confidence. Current fire models provide reliable predictions for many parameters that are good enough to be applied towards engineering problems if a robust and conservative methodology is defined. A prerequisite for this methodology is that it applies appropriate safety factors. An important point is that 'real world' fire engineering applications most frequently simulate events for which real behavior had not been (and will never be) measured (Beard, 2009). These simulations are a priori simulation, not a posteriori. However, most fire model validations in fire engineering have been conducted a posteriori. Therefore, it is necessary to have a priori comparisons of fire modeling for setting safety factors in designs. Otherwise, unsafe fire protection designs will result.

3.1.4 Reveals areas where fire models are not "credible"

A major advantage and need for blind validations is that they reveal areas where fire models are "primitive" and not "credible." Experts agree that some predictive tools in fire models are still "primitive" and should not be relied upon in fire safety decision making, e.g., for flame spread. However, there are open validation studies and databases that show these types of predictions in a favorable light resulting in their use by many practitioners. This leads to unsafe designs and increases the risk of fires to the public.

The use of blind validations will reveal the weak areas of fire models and prevent the misuse of fire models.

3.2 Cons of Blind Validations

3.2.1 Newer versions of a model make blind validations obsolete

Issue

One of the major disadvantages cited for blind validations is that when newer versions of a model are released, the blind validations become obsolete. Obsolete validations are of little value to regulatory authorities.

Discussion

The third party validation option can address this issue regarding the conduct of *blind* calculations. As discussed above, the differences between *blind* and *open* results have been studied and documented. Studies have shown that *open* fire simulations can be made to look favorable. This is achieved due to the availability of experimental data, allowing for iterations until an adequate input file is found. Only *blind* simulations are free of the possible bias that could be introduced by prior knowledge of the experimental measurements. Third party validation can address the issue of the possible bias introduced in fire model validations by providing an independent assessment and determination of the model errors.

Third party validation can also be used to provide validations as newer versions of a particular fire model are released. The Food and Drug Administration (FDA) quality control requirements for medical software and models require expert documented and non developer validation and verification. Procedures in the FDA requirements can be examined to establish methods for third party validation for fire models.

3.2.2 Cannot separate user effects

Issue

It has been stated that one cannot separate user effects and input data uncertainty from model error in blind validations. A priori model evaluations lump many sources of uncertainty together. Perhaps this can be viewed as a virtue, but it can also be less enlightening than a posteriori evaluations.

Discussion

User effects are not part of model validation. Model validation checks whether the model can predict results that represent the real world. It is assumed that users of the model will be competent in both blind and open validations. Open validations can also be subject to user effects.

The specifications of the benchmark exercises in the ICFMP were developed with great efforts to include sufficient details about the inputs required for the fire models. The goal was to minimize the uncertainty and debate about input parameters such that the predictive errors of the models could be determined. As evidenced by the specifications of the ICFMP benchmark exercises, the model input data were specified in sufficient detail such that there was minimal reason for "user effects' to affect the model results, i.e. from different analysts making different assumptions about input data. Therefore, it has been shown that the input data uncertainty can be made small and to not affect the model errors determined in blind validations.

3.2.3 Fire experiments cannot be replicated

Issue

Fires are too complex and fire experiments cannot be replicated. Tests are seldom conducted as planned, and there are large experimental uncertainties. Therefore, blind simulations are not possible or useful.

Discussion

The procedures for the ICFMP addressed this issue that experiments cannot be replicated and therefore the fire experimental data has large uncertainties for the purpose of *blind* fire model validations. Of the fifteen tests that were conducted for Benchmark Exercise No. 3 in the ICFMP, four were replicate tests representing the wide range of compartment conditions in the test series for the exercises. It was shown that the compartment conditions were almost duplicated in the replicate tests (Dey, 2009). There was no challenge to the test results from ICFMP participants based on the argument that fire tests can never be conducted to duplicate the same results.

The test series for Benchmark Exercise No. 3 in the ICFMP was very successful in being conducted according to the test plan and specification of the exercise distributed to participants in the *blind* exercise. Also, any minor changes to the test plan prior to the tests were communicated to ICFMP participants as addenda to the specification of the *blind* exercise.

Therefore, it has been shown that tests can be replicated and conducted as planned.

3.2.4 Cannot vary initial conditions and conduct sensitivity analysis

<u>Issue</u>

Blind validations do not allow for variation of initial conditions, grid size (CFD), and other code options. Blind validations also do not allow for the conduct of sensitivity analysis.

<u>Discussion</u>

Analysts are required to make some assumptions about their models for a blind validation, e.g., initial conditions, grid size for CFD and lumped-parameter calculations, and any options available for their specific models. These assumptions are also necessary for engineering calculations. An engineering calculation for a design fire is a blind calculation as experimental data for that particular fire scenario does not exist. Analysts must choose the optimal value for the assumption, e.g., grid size, in a design calculation which the analyst believes is most appropriate and/or practical for the analysis of the fire scenario. This same assumption must be made in a blind validation. Therefore, the assumptions made in a blind validation result in a true test of the predictive capability of the model in design engineering calculations. The safety factor for fire protection systems design will be based on this optimal predictive capability of the model.

Although sensitivity analysis is appropriate in design calculations because the values of input parameters (e.g., thermal properties) in the scenario are unknown and can vary, a blind validation tests the ability of the model to predict conditions given a specific set of input data.

3.2.5 30 years of experimental results will be discarded

<u>Issue</u>

It has been stated that 30 years of experimental results should not be thrown away for blind validations. Some model developers have documented open validations for experiments performed over the past thirty years, including 30 experimental test series. These test data and validations should not be discarded for blind validations.

Discussion

As discussed later in the section on recommendations, open validations can continue to play the role it does at the present when blind validations are introduced in fire model standards. Open validations have some merits, e.g., for sensitivity analysis, that will continue to reveal important information.

The purpose of blind validations is to provide a high degree of confidence to users and regulators in the predictive capability of the models by establishing the true model errors in the predictions. This is done by eliminating the natural bias in the validations that can occur in open calculations conducted by developers, owners, or users of the computer fire models. As indicated above, both the Dalmarnock Round Robin Project and the International Collaborative Fire Model Project demonstrated that this can and does occur. Only a priori simulations are free of the possible bias that could be introduced by prior knowledge of the experimental measurements of parameters for which predictions the models are being tested.

4 Comments on Blind versus Open Fire Model Validations

4.1 Comments Posted in the Forum of the International Association of Fire Safety Science, August 2008

1. Brannigan, V., University of Maryland

From: iafss-bounces@newcastle.edu.au on behalf of Bogdan Dlugogorski [bogdan.dlugogorski@newcastle.edu.au]
Sent: Wednesday, August 27, 2008 4:08 PM
To: iafss@newcastle.edu.au
Subject: IAFSS> Re: Updated Fire Model Survey

Vince Brannigan <firelaw@firelaw.us> 27/08/2008 10:17 pm

My approach is the same as that used in Medicine. Medical ethics prohibits the use of "secret remedies" or Secret surgical techniques. No journal would publish research on, or national regulatory agency approve, a drug without a full disclosure of the ingredients. No physician would prescribe a drug without such disclosure. The FDA quality control requirements for medical software and models are very complex, and require expert documented and non developer validation and verification.

I am simply astonished that any reputable builder or regulator would accept any results produced by a model that had not been fully vetted by third party review. Abolishing the "patent medicine" era of secret remedies was critical to the advancement of Medicine as a profession instead of appearing to be a bunch of self promoting quacks. Perhaps as Fire Engineering matures into a real profession it will see the same advantage in making sure that models are valid and able to be shown to be valid.. Certainly the liability exposure alone should make any private party wince at the use of such models. Both Validation and verification are critical steps.

As the FDA uses the terms:

3.1.2 Verification and Validation

The Quality System regulation is harmonized with /ISO 8402/:1994, which treats "verification" and "validation" as separate and distinct terms. On the other hand, many software engineering journal articles and textbooks use the terms "verification" and "validation" interchangeably, or in some cases refer to software "verification, validation, and testing (VV&T)" as if it is a single concept, with no distinction among the three terms.

Software verification provides objective evidence that the design outputs of a particular phase of the software development life cycle meet all of the specified requirements for that phase. Software verification looks for consistency, completeness, and correctness of the software and its supporting documentation, as it is being developed, and provides support for a subsequent conclusion that software is validated. Software testing is one of many verification activities intended to confirm that software development output meets its input requirements.
Other verification activities include various static and dynamic analyses, code and document inspections, walkthroughs, and other techniques.

Software validation is a part of the design validation for a finished device, but is not separately defined in the Quality System regulation. For purposes of this guidance, FDA considers software validation to be "*confirmation by examination and provision of objective evidence that software specifications conform to user needs and intended uses, and that the particular requirements implemented through software can be consistently fulfilled.*" (http://www.fda.gov/cdrh/comp/guidance/938.html)

In simple terms verification is whether the computer coding is right and validation is whether it means anything in the real world. Both have to be demonstrated. The recent WTC 7 report highlights the failure of the profession and industry in validating the test methods routinely referenced by the models. There are no "trade secrets" in validation.

Vincent Brannigan J.D.
Prof. Emeritus
Department of Fire Protection Engineering U of Maryland College Park

[Posted to IAFSS Forum, August 27, 2008]

2. Olenick, S. E., Combustion Science & Engineering, Inc.

From: Stephen M. Olenick [mailto:solenick@csefire.com]
Sent: Tuesday, August 26, 2008 7:45 AM
To: Dr. Monideep K. Dey
Subject: Re: IAFSS> Updated Fire Model Survey

You are probably right that that needs to be done. Currently, the SFPE has a task group that I participate on that follows the ASTM standard (E1355 I think) on model evaluation. You should consider contacting SFPE and joining the task group. We put out a report every few years on a new model, although with the number of models, it is a daunting task. In terms of the model survey website meshing with your idea, the goal of the model survey is for the developer to fill out a survey. So your concern about developers and owners not being sincere about the limitations may be valid. We do put a topic in the survey on validation references and allow the developer to fill that out, but there likely are times where unfavorable ones or ones conducted by outsiders are not included. Unfortunately, this is a shortcoming of the model survey as the goal is not for the information on the website to be a compilation of my thoughts on each model, but instead a compilation of the developers posted information on their models.

Take care,

Stephen.

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[Posted to IAFSS Forum, August 26, 2008]

3. Dey, M., Deytec, Inc.

From: iafss-bounces@newcastle.edu.au on behalf of Dr. Monideep K. Dey [deytec@frontiernet.net]
Sent: Tuesday, August 26, 2008 10:34 AM
To: 'Stephen M. Olenick'; IAFSS
Subject: Re: IAFSS> Updated Fire Model Survey

Mr. Olenick:

I commend you and CSE in compiling the fire model list. I would like to suggest another task in the interest of the fire science community, i.e. the collection of fire model validation data, specifically the predictive errors of such models. Fire models are starting to be used widely as a result of the push for performance-based fire safety analysis, but I do not believe that there is a true understanding of the predictive capabilities and errors of these models. I would like to propose to the fire science community that a task and an international standard be developed that would outline the procedure for developing fire model validation data. It is very important that such a standard mandate that fire model validation data be developed by a third independent party, because my observation is that model developers, owners, and users are not always sincere about revealing the true limitations and errors of fire models.

I will be glad to participate in the proposed effort, if such an effort is established by the fire science community.

Again thanks for your efforts. Please contact me if you would like to discuss my proposal further.

Monideep K. Dey

[Posted to IAFSS Forum, August 26, 2008]

Dr. Brein:
Dr. Solenick

Thank you for your comments and suggestions to join the SFPE 1355 and ISO TC92 SC 4 activities in the subject area. Yes, I am familiar with these activities. When I worked at the U.S. Nuclear Regulatory Commission (USNRC), we did a survey in the mid-90s of initiatives of performance-based fire safety analysis and included a review of the ISO TC92 SC4 activities (see NUREG-1521). When I was at the USNRC I also initiated the use of ASTM 1355 there for fire model validation. I am glad to hear that these efforts are continuing and may lead to new levels of rigor and quality in fire model verification and validation.

I am certainly not against the use of fire models or any new safety analysis methods, and have been involved in fire model validation since the mid-90s. However, we must ensure that the fire model results are used in the appropriate manner in fire safety decision making. If the model limitations and true predictive errors are not considered in safety decision making, then faulty safety designs result, safety is decreased(as opposed to having used good engineering judgment), and the public interest is not served.

I will contact the ISO and SFPE group to try and contribute to these efforts, but my ability to travel is limited. I have just started my company and funds for travel to these types of activities are limited at this time.

Thanks for your comments. I am elated that you and others in the community share my concerns.

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[Posted to IAFSS Forum, August 28, 2008]

4. Deal, S., Excelsior Fire Engineering

From: iafss-bounces@newcastle.edu.au on behalf of å... .... [eurekaignem@gmail.com]
Sent: Wednesday, August 27, 2008 5:03 PM
To: iafss@newcastle.edu.au
Subject: IAFSS> Updated Fire Model Survey

The question of honesty and integrity is not limited to fire modeling, or to fire technology-science in general. Almost all money-making industries eventually have people willing to slant the truth to their advantage for reputation and money.

There is a fire mafia, no question.

It burns me up to see people lie, manipulate and hide the truth-via-silence. I have seen it in America, in Europe and in South America. Not pervasive, but distinctively present. The best solution I have is exactly what you proposed, and I have mentioned from time to time over the last 7 years, more peer review. Will it happen? Probably not. Reason being...fire risk is usually acceptable. As one consultant put it " my designs probably will not be tested before I am dead..."

scot deal
excelsior fire engineering

[Posted to IAFSS Forum, August 27, 2008]

5. Delichatsios, M., University of Ulster

From: Delichatsios Michael [M.Delichatsios@ulster.ac.uk]
Sent: Wednesday, August 27, 2008 3:04 AM
To: Dr. Monideep K. Dey; IAFSS
Subject: RE: IAFSS> FW: Updated Fire Model Survey

Just some common sense remarks.

Working in fire science and technology for many years and from the vantage point of physics of fire and model application, I would make some trivial comments:

1. All models have limitations and these must be clearly stated by modelers and understood by the users.
2. There are many " good models" to predict the dispersion of gaseous product if the fire size and product yields are known.
3. The difficult is to predict the combustion and interaction with the fuel pyrolysis including smoke , radiation, soot and toxic gases. No reliable and credible models exist for these cases useful for the users.

Moreover, there is no driving force for the general combustion community to develop such models.

I would like also to mention that there is a working group in ISOTC92 dealing with model application and validation.

Best regards

Michael

Michael A. Delichatsios, Professor
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Chair and Head of Fire Dynamics and Materials Lab (FML) University of Ulster
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http://www.firesert.ulster.ac.uk/

[Posted to IAFSS Forum, August 27, 2008]

6. Rein, G., University of Edinburgh

From: iafss-bounces@newcastle.edu.au on behalf of Guillermo Rein [G.Rein@ed.ac.uk]
Sent: Wednesday, August 27, 2008 8:56 AM
To: iafss@newcastle.edu.au
Subject: Re: IAFSS> FW: Updated Fire Model Survey

This is a very interesting and long-due discussion in the community.

I largely agree with Michael's point 3; which means that there is a lot of work and convincing to do in the research arena for fire modelling.

The comment of Dr Dey that "fire model validation data be developed by a third party, because my observation is that model developers, owners, and users are not always sincere about revealing the true limitations and errors" is related to the lack of blind fire validations. A blind or 'a priori' validation is when the modelling is conducted before seeing the experimental results. This is important because the bias introduced into the validation by having the modeller accessed the experimental data before hand could be large and is rarely explored in fire modelling.

In this direction, CIB organized and conducted a large and international blind round-robin for fire models (circa 1999) but the results were not made publicly available. My research group at Edinburgh conducted a round-robin using the 2006 Dalmarnock Fire

Tests (the results are published here http://www.era.lib.ed.ac.uk/handle/1842/2405). And more recently, in 2008, new blind modelling round-robins are being organized by Prof Coppalle in Coria Université de Rouen (some preliminary results will be presented as a poster at the 9th IAFSS, I think). All the results point towards the same direction; that blind validations provide very different results that open validations.

The question of how to address the results from blind validations remains unanswered, and I think it should be an important issue for the fire community.

Cheers
G.

[Posted to IAFSS Forum, August 27, 2008]

4.2 Comments Posted in the Forum of the International Association of Fire Safety Science, August 2009

1. Rein, G., University of Edinburgh

I would be interested in knowing the professional views of those working on fire modelling regarding the difference between 'a priori' and 'a posteriori' simulations.

In my view, only a priori simulations are free of the possible bias that could be introduced by prior knowledge of how the event developed. The magnitude and importance of this bias in fire engineering is currently unknown.

I have put some of my views here:

http://edinburghfireresearch.blogspot.com/2009/08/blind-vs-open-fire-modelling.html

You are welcome to share your views too.

Best Regards,
G.

[Posted to IAFSS Forum, August 27, 2009]

Comments received in response to above post are included in the Section 4.4.

PD: The essence of the discussion applies in general to any kind of modelling provided the real process is complex.

Dr Guillermo Rein
Lecturer in Mechanical Engineering

BRE Centre for Fire Safety Engineering
http://www.eng.ed.ac.uk/~grein

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The University of Edinburgh

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http://edinburghfireresearch.blogspot.com

2. Dey, M., Deytec, Inc.

Dr. Guillermo Rein:

This is an important topic in fire safety engineering which I believe was discussed in a limited manner several months ago in this forum. You are right that the fire science community has thus far been fairly silent on this topic although these models are being used today for fire safety design to protect the public from adverse affects of a fire.

As the project leader and analyst in the International Collaborative Fire Model Project (ICFMP) from 1999 to 2006, I have derived much information and conclusions about blind versus open predictions. The ICFMP project evaluated fire models for nuclear power plant applications through a series of 5 benchmark exercises in which fire models were evaluated for predicting nuclear plant fire scenario experiments through blind and open predictions.

Model developers or owners are generally hesitant to conduct and publish blind predictions. Regulators are more or should be interested in blind predictions to ensure that adequate safety margins are included before making fire safety decisions. The variation between blind and open predictions was large up to 40-50 % for some parameters, and larger for the more difficult predictions. There was much debate to justify the open predictions ranging from the claim that experimental measurements were erroneous to that handbook values for input thermal parameters such as conductivity are better than data derived from specific measurements of material used in the experiments. There was a lot learned from the exercises on the technical issues as well as the policy aspects of deriving true model errors for use in fire safety analysis.

I commend you for raising this topic. I believe the fire safety community should come to a consensus that an international standard be developed that will ensure that true model errors are derived and used in fire safety analysis and decisions. I believe that we owe this to the public we protect.

I will be publishing a paper and report on the technical and policy lessons learned the ICFMP project in the near future and will be glad to share these with you once they are available. The reports of the ICFMP project are available in my company website and can be downloaded.

By the way, I am also a firm believer on the value of fire models in fire safety decision making. We just have a lot of more work to do before we can ensure their correct use.

Thank you for raising this important topic and the opportunity to comment.

Sincerely,

Dr. Monideep K. Dey, President

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Yellow Spring, WV 26865
USA

[Posted to IAFSS Forum, August 28, 2009]

4.3 Comments Posted in the Forum of the International Association of Fire Safety Science, July – August 2011

1. Brannigan, V., University of Maryland

I would suggest that the term "complete safety" when used with fire modeling is akin to the "unsinkable Titanic". Fire models used for code approvals are composed of vast quantities of assumptions and guesswork not to mention outdated science when applied to toxicity. The CCTV was a "performance-based" design. Of course the assumptions it was based on were ludicrous.

Vincent Brannigan
Professor Emeritus
U of Maryland
Department of Fire Protection Engineering

[Posted to IAFSS Forum, July 22, 2011]

2. Rein, G., University of Edinburgh

This is an overarching problem that can be tracked beyond visibility calculations and into fire modelling in general. I call it "excess in degrees of freedom". FDS manuals refer to it as "user effects". It relates to the often encountered situation by FPE who using a state-of-the-art fire model find it difficult to feed consistent input data. This leads to uncertainty in the results. As we reported in the last Fire and Materials [http://www.scribd.com/documents/47947428 and http://hdl.handle.net/1842/4777]:

"Under the current state of the art, there are many ill-defined and uncertain parameters within the models which cannot be rigorously and uniquely determined. Thus, there is plenty of space for uncertainty and doubt to unravel, and for curve fitting and arbitrary parameter value selection to take place"

This is an important topic that the FPE community will continue facing during the incoming decades as engineering tools develop faster than the state of the art knowledge on fire dynamics. At Edinburgh, we are proposing the inclusion of "a priori" validations to the already conducted "a posteriori" validations. More information on this at http://hdl.handle.net/1842/2704 and http://dx.doi.org/10.1016/j.buildenv.2010.11.001

Regards,

G.

[Posted to IAFSS Forum, July 25, 2011]

3. Brannigan, V., University of Maryland

I have explored the more general question of how to use advanced fire engineering in the regulatory process in several papers, most recently at Santander in 2009, The Regulatory Use of Advanced Fire Engineering Techniques.

Vincent M. Brannigan J.D
Professor Emeritus
Department of Fire Protection Engineering
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ABSTRACT

Engineers and fire scientists have worked steadily to improve our understanding of fire. These scientific changes have been incorporated into *performance based design* But Performance based design is largely a Regulatory not a Design innovation. The use of

advanced fire engineering techniques requires a rethinking of the regulatory system to adapt to the unique advantages and disadvantages of the novel techniques. A key finding is that improvements in fire science do not automatically translate into better regulation because the uncertainties involved in the choice of scenarios and outcomes still dominates the process. Movement of products in international trade and a dependence on possibly inadequate performance based standards can only make the situation worse.

One point in this paper may be of value to the discussion:

5.2.4 Reification of Test results

Reification is defined as the fallacy of treating an abstraction being treated as if it is a *real* entity. [[i] (#_edn1)] In the specific case of regulatory fire standards it is the inappropriate treatment of the output of a test as a measurement of the properties of the object in the real world. The Reification fallacy believes the test scores describe an inherent attribute of the design and the test is simply a measure of that attribute, rather than the test score is a calculation based on the test method and assumption about the design. In particular any statement that the ASET or RSET has been measured is reification. Reification in the ASET/RSET environment occurs when the outputs are viewed as real items with fixed meanings rather than technical/social constructs of great uncertainty. If the uncertainty known to the developers is not propagated to the users, the results get reified into claims about the building. For example in the brand new CFPAE Guideline No 19, 2009 on Fire Safety Engineering concerning Evacuation from Buildings [[ii] (#_edn2)] there is no treatment of definition of uncertainty in the ASET/RSET calculations. Instead contains very specific statements:

"*The knowledge of these parameters, with regards to time, allows us to establish the exact moment in which the conditions of the Environment do not guarantee the possibility to evacuate in safe conditions. (ASET time)." And later in dealing with the various variables in pre movement time it states:

"The analysis of all these elements allows the recognition and response time evaluation for each occupant or for group of occupant per enclosure."

The only recognition of any uncertainty is the proposal that the gap between RSET and ASET may represent a margin of safety. However there is no analysis of the range of uncertainty of the RSET and ASET values themselves. The values are treated as real things and reification has
triumphed. All of the vast number of assumptions and cautions and limitations has been forgotten in the pursuit of a *number*.

[i] (#_ednref1) Gould, S. J. (1981). The Mismeasure of Man. New York: W.W. Norton & Co.
[ii] (#_ednref2) CFPA E Guideline No 19, 2009, Fire Safety Engineering Concerning Evacuation from Buildings.

Happy to send this entire paper to anyone on request.

An earlier paper is on the web:

http://www.see.ed.ac.uk/FIRESEAT/files08/02-Brannigan.pdf

Vince Brannigan

[Posted to IAFSS Forum, July 25, 2011]

4. Dey, M., Deytec, Inc.

Dear Colleagues:

This is a very interesting discussion thread. I agree with Guillermo Rein that the discussion shows the uncertainties involved in fire model predictions, including the input data to the models (the two are correlated) as simple models such as correlations are used in the fire computer models because the fire science is not sufficiently developed.

I'd be very cautious by saying results from fire models are conservative or not unless one is totally sure of the uncertainties involved. The reported predictive errors of fire models available in the computer fire model validation data bases, or in the literature, are generally very optimistic given the validations are conducted "a posteriori" (open) and include natural biases of the authors. As recommended by Guillermo Rein and Edinburgh, I also recommend the use of results from "a priori" (blind) validations before setting safety factors in engineering studies. My recommendation is based on my work in the International Collaborative Fire Model Project (ICFMP) which was conducted from 1999 to 2008. See: www.deytecinc.com/FSA22.pdf

I also did some comparisons of CFAST and FDS smoke results with actual data for compartment fires. See: www.deytecinc.com/FSA8.pdf

The comparisons were pretty good, as long as the fires were fully ventilated. The smoke yield constant for the larger fire was not as good as the smaller fire where it was measured.

Regards,

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[Posted to IAFSS Forum, July 28, 2011]

5. Rein, G., University of Edinburgh

To the email from Dr Dey I would like to add that there is a latent but strong opposition in some FPE circles to consider "a priori" studies as a compliment to "a posteriori" validations. I wonder why these views do not reach most of us but are exchanged in closer circles. Maybe this open email list would be a good venue to communicate the most important of those opposing views. I am definitely interested in hearing them and having the opportunity to debate them in the open.

Cheers
G.

[Posted to IAFSS Forum, July 28, 2011]

6. Hurley, M., Society of Fire Protection Engineering

One problem with a priori model evaluations is that they lump many sources of uncertainty together. Perhaps this can be viewed as a virtue, but it can also be less enlightening than a posteriori evaluations.

Uncertainty in model use comes from a variety of sources, e.g., the model itself, the input data that is used, and the model user. Quantifying all these sources of uncertainty can be non-trivial. In lieu of quantifying each source of uncertainty, it would be much easier to conduct an a priori study and conclude that the findings portray all uncertainty associated with using the model.

However, this approach is inelegant. If the uncertainty from the various sources in an a priori study were offsetting, then the user might conclude that the total uncertainty is lower than it really is. Also, any given evaluation is inherently finite in scope - it is limited to a set of conditions - e.g., geometry, fire size, etc. Therefore, the findings of any evaluation are limited to model applications that are similar.

SFPE has published a guide that describes an approach for evaluating a model for a given application. These guidelines recommend treating model verification and validation separately from uncertainty introduced by using the model. For more information, see http://www.fpemag.com/archives/department.asp?issue_id=57&i=493

The guidelines can be obtained from:

https://netforum.avectra.com/eweb/shopping/shopping.aspx?site=sfpe&webcode=shopping&prd_key=345a5b8e-2dde-4a6f-a57d-568113881459.

Respectfully,

Morgan J. Hurley, P.E., FSFPE
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[Posted to IAFSS Forum, July 29, 2011]

7. Brannigen, V., University of Maryland

I would note that the SFPE use of the term Validation may be at odds with the rest of the world's use of the terms.

From the source: "Validation is a check of the physics, i.e., whether the equations are an appropriate description of the fire scenario. Most often, validation takes the form of comparisons with experimental test data. Validation does not mean that a model makes perfect predictions, only that the predictions are good enough for its intended use. The meaning of "good enough" is up to the model user, and to say a model has been validated only means that an end user has decided that the model is sufficiently accurate for a particular application." This a subjective not an objective statement. It would I assure you be inadmissible in court as Ipse Dixit (I say it is so myself). Expertise has to be demonstrated not merely asserted.

The whole point of a priori evaluation of the process is to test whether the modeler has the capability to do what Morgan suggests. If you can't pick a model that will accurately forecast a fire form a known scenario how do we "know that you know what you claim to know?"

I'm not exactly sure what Morgan means by uncertainty in the "model user". Humorous possibilities come to mind.

If there is uncertainty in the measurement of the inputs of a known scenario this is a legitimate criticism of the model process. Inability to accurately measure the input is an indicator that the model is not Valid.

Vincent Brannigan J.D.
Prof. Emeritus
D. Of Fire Protection Engineering
U of Md.

[Posted to IAFSS Forum, July 30, 2011]

8. Brein, D., Karlsruher Institut für Technologie (KIT)

Dear colleagues,

Apart from the original discussion on "visibility criterion" triggered by Victor Shestopal some days ago we now seem to proceed to the more general aspects of the assessment of calculation methods in Fire Safety Engineering.

May I inform you that the International Standards Organisation does some work on the issue within ISO TC92 Fire Safety SC4 Fire Safety Engineering WG7 Assessment, Verification and Validation of calculation methods in FSE, with ISO 16730 published in 2008.

For those, who are not familiar with the work, I attach the FDIS (I am not permitted to submit the standard, but the FDIS contents, text and figures are identical to the standard).

From this document you may learn what the current terms mean in view of
ISO:
- if there are still diverging definitions around, ISO 16730 is an invitation to globally harmonize the definitions of terms used in the assessment of calculation methods for FSE.

The definitions for "assessment", for "verification" and for "validation", respectively, taken from ISO 16730 read as follows:

"3.2
Assessment:
process of determining the degree to which a calculation method is an accurate representation of the real world from the perspective of the intended uses of the calculation method and the degree to which a calculation method implementation accurately represents the developer's conceptual description of the calculation method and the solution to the calculation method.

NOTE:Key processes in the assessment of suitability of a calculation. Method are verification and validation.

3.23
Validation:
process of determining the degree to which a calculation method is an accurate representation of the real world from the perspective of the intended uses of the calculation method.

3.24
Verification
process of determining that a calculation method implementation accurately represents the developer's conceptual description of the calculation method and the solution to the calculation method.

NOTE:The fundamental strategy of verification of computational models is the identification and quantification of error in the computational model and its solution."

The Working Group started with discussion on "a priori" or "blind" versus "a posteriori" or "open" calculations some time ago; the next revision of ISO 16730 is intended to address some findings, in a neutral way as possible, of course. Still there many pros and cons discussed for both approaches in the ISO community. Any views on this within this IAFSS discussion forum will carefully be noted by WG7.

Best regards,

Dieter Brein

(Convenor ISO TC92 SC4 WG7)

[Posted to IAFSS Forum, July 31, 2011]

9. Rein, G., University of Edinburgh

Following the email from Dr Brein, I have changed the subject of this discussion to "a priori vs. a posteriori debate". I am delighted to learn that WG7 Committee is interested in this ongoing debate.

In Aug 2009, I wrote the blog entry "Blind vs Open fire modelling" starting with:

"I always wanted to start a debate on this topic and now think that a better way is using the blog. Three years after The Dalmarnock Fire Tests, the 'a priori' vs. 'a posteriori' debate in is still not too popular in the fire modelling community. The debate seems to be mostly taking place in personal communications and during the peer reviewing of papers.

Unfortunately, not much is happening publicly or at the reach of the fire community as a whole"

See the rest here:
http://edinburghfireresearch.blogspot.com/2009/08/blind-vs-open-fire-modelling.html

I invited the IAFSS email list to join the debate and the blog got comments also from N Ryder, S Desanghere, K McGrattan, M Salley, B Merci, L Iannantuoni and G Manzini.

Maybe it is a good time to repeat the debate. Two years have passed and the open debate is not fully taking place within the IAFSS community.

Cheers
G.
--
Dr Guillermo Rein

Senior Lecturer in Mechanical Engineering http://www.eng.ed.ac.uk/~grein The University of Edinburgh, UK.

[Posted to IAFSS Forum, August 1, 2011]

10. Simenko, P., SimCo Consulting Pty Ltd.

In my work I rely on the following definition of the meaning of words

"verification, validation and accreditation":

1. Source "wikipedia.org/wiki/"

Verification and validation is the process of checking that a product, service, or system meets specifications and that it fulfills its intended purpose.

These are critical components of a quality management system such as ISO 9000. Sometimes preceded with "Independent" (or IV&V) to ensure the validation is performed by a disinterested third party. (en. wikipedia.org/wiki/)

Verification is a Quality control process that is used to evaluate whether or not a product, service, or system complies with regulations, specifications, or conditions imposed at the start of a development phase. Verification can be in development, scale-up, or production. This is often an internal process.

Validation is a Quality assurance process of establishing evidence that provides a high degree of assurance that a product, service, or system accomplishes its intended requirements. This often involves acceptance of fitness for purpose with end users and other product stakeholders.

It is sometimes said that validation can be expressed by the query "Are you building the right thing?"[1] and verification by "Are you building it right?"[2] "Building the right thing" refers back to the user's needs, while "building it right" checks that the specifications are correctly implemented by the system. In some contexts, it is required to have written requirements for both as well as formal procedures or protocols for determining compliance.

2. Source - Systems Engineering Fundamentals; Supplementary Text prepared by The Defense Acquisition University Press, Fort Belvoir, Virginia 22060-5565, January 2001 (pdf file version is available on internet):

13.4 VERIFICATION, VALIDATION, AND ACCREDITATION: How can you trust the model or simulation? Establish confidence in your model or simulation through formal verification, validation, and accreditation (VV&A). VV&A is usually identified with software, but the basic concept applies to hardware as well. Figure 13-2 shows the basic differences between the terms (VV&A).

More specifically:
* Verification is the process of determining that a model implementation accurately represents the developer*s conceptual description and specifications that the model was designed to.
* Validation is the process of determining the manner and degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model, and of establishing the level of confidence that should be placed on this assessment.
* Accreditation is the formal certification that a model or simulation is acceptable for use for a specific purpose. Accreditation is conferred by the organization best positioned to make the judgment that the model or simulation in question is acceptable. That organization may be an operational user, the program office, or a contractor, depending upon the purposes intended.

I would appreciate if any of the IAFSS members have a better definition, or maybe can indicate any shortcomings of the above definitions when applied to fire engineering.

Regards,

Peter Simenko, Fire Engineer
SimCo Consulting Pty Ltd
Melbourne, Australia

[Posted to IAFSS Forum, August 1, 2011]

11. Brannigen, V., University of Maryland

The problem with using non regulatory definitions of Validation is that they fail to take into account both the public interest in the validation exercise and the important dichotomy between "what has to be demonstrated" i.e. the substantive requirement and the "Evidence" used to demonstrate that the goal has been achieved. One of the most sophisticated and intensive efforts in the area of computer software regulation has been the Food and Drug Administration's General Principles of Software Validation; Final Guidance for Industry and FDA Staff:

http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm085371.pdf

This is the software used in life critical medical devices and situations so it is a fair comparison for Fire protection Engineering. In fact fire protection engineering probably involves much greater risk to life that posed by medical software The definition for Validation is clearly stated:

For purposes of this guidance, FDA considers software validation to be "confirmation by examination and provision of objective evidence that software specifications conform to user needs and intended uses, and that the particular requirements implemented through software can be consistently fulfilled."

Four different components of this definition are important:

1) The requirement for Objective evidence. The Subjective opinion of the developer or anyone else for that matter is not in and of itself suitable evidence.
2) "conform to user needs" You have to demonstrate objectively that you conform to user needs, not merely that someone has "signed off"
3) "intended uses" The fact that both user needs and intended uses have to be validated is not an accident.
4) "requirements...consistently fulfilled" requires effective documentation of the verification process

The Document goes on to say:

"Validation activities should be conducted using the basic quality assurance precept of "independence of review." Self-validation is extremely difficult. When possible, an independent evaluation is always better, especially for higher risk applications. Some firms contract out for a third-party independent verification and validation, but this solution may not always be feasible. Another approach is to assign internal staff members that are not involved in a particular design or its implementation, but who have sufficient knowledge to evaluate the project and conduct the verification and validation activities. Smaller firms may need to be creative in how tasks are organized and assigned in order to maintain internal independence of review."

One of the most important issues is Robustness:

"Robustness -- Software testing should demonstrate that a software product behaves correctly when given unexpected, invalid inputs. Methods for identifying a sufficient set of such test cases include Equivalence Class Partitioning, Boundary Value Analysis, and Special Case Identification (Error Guessing). While important and necessary, these techniques do not ensure that all of the most appropriate challenges to a software product have been identified for testing."

http://lib.bioinfo.pl/pmid:1807596/pmid/cit

http://lib.bioinfo.pl/citwww/paper/1807596

These are the bare minimum standards for the regulatory use of software products.

Vincent Brannigan J.D
Professor Emeritus
U of Maryland
Department of Fire Protection Engineering

[Posted to IAFSS Forum, August 1, 2011]

12. Dey, M., Deytec, Inc.

I agree on the 3 sources of predictive errors from fire models, the model itself, input data, and the user. Errors due to the user can be eliminated during the validation process by competent users. Assessing user error in engineering studies can be difficult.

I disagree that blind validations lump all these error sources. The input data can be measured for each validation as in the ICFMP project, and the uncertainty dramatically reduced. The validation is then of the model itself. Input data can be a big source of error in engineering studies though.

I agree that fire model validations are applicable only to a range of similar fire scenarios, as fire applications can vary significantly.

I don't see how open validations solve the issue of "lumping" errors if that was true. Finally, the main point proponents of blind simulations make is to eliminate the natural bias caused by validations conducted by developers or interested practitioners. This issue can also be overcome if open validations are conducted by independent bodies.

Thanks,

Dr. Monideep Dey, President

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[Posted to IAFSS Forum, August 2, 2011]

13. Brannigen, V., University of Maryland

I am still waiting for a clear definition of user error. Dr. Dey states "Errors due to the user can be eliminated during the validation process by competent users. Assessing user error in engineering studies can be difficult."

I think this statement conflates user error in running a model with misuse of the model to generate misleading predictions. Such misuse cannot be cured in "validation."

I am certainly personally familiar with user error when running full scale fire burns, standardized laboratory tests or even riding a bicycle. I even remember dropping decks of punch cards when feeding the IBM 7094. These are all user error But a fire model has none of these characteristics.
A fire model is an algorithm or computer program. It takes input and gives outputs. The model is not sensitive to the user of the model. It's not a pinball machine where you whack the side.

Calling misuse of a model output "predictive error" would be misleading. What an "incompetent" user claims for the model output is not part of the model itself or its validation. Either the output is valid or it is not. Validation testing includes defining clearly the input scenarios over which the model is valid.

But a model which can accept data outside of its range of validation (e.g. provided by an incompetent user) and gives spurious answers that do not reflect reality is not showing "predictive error" that can be lumped with other errors. It is instead a model with a serious validation problem, since it cannot recognize and exclude inappropriate inputs. Data input acceptance outside the range over which a model is valid is a classic validation problem and should not be called user error.

Verification is a test of coding the inputs and outputs. Validation is the relationship of the model to reality.

The reason this issue is important is that if a model is described as valid, it specifically includes a range of inputs over which the validity has been demonstrated, and should normally automatically exclude any use outside that range.

Vincent Brannigan J.D.
Professor Emeritus
University of Maryland
Department of Fire Protection Engineering

[Posted to IAFSS Forum, August 3, 2011]

14. Dey, M., Deytec, Inc.

Vince:

I agree with your analysis and conclusion that user error ("misuse of the model") is outside the scope of the model validation process. We should separate user error from validation of the model.

Thanks,

Dr. Monideep Dey, President

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[Posted to IAFSS Forum, August 3, 2011]

15. Horton, G., URS/Scott Wilson

As someone who uses the outputs from CFD analysis as part of design, my experience is that the outputs of modelling of visibility tend to err on the side of caution i.e. the visibility predicted seems to be lower than experience would suggest is likely.

1st some clarifications,

1. When I say experience I am talking walking around buildings on fire as a fire-fighter, i.e. totally subjective and my own experiences.

2. When I say err on the side of caution I am saying subjectively that the densities of the smoke appears to be unreasonably dense.

3. The modelling is not only driven by technical considerations but also regulatory considerations i.e. in the absence of any specific data the modelling always assumes the smoke sources is polyurethane (which I understand is about as bad as it gets?) and it probably is rate this bad in the average building fire if there is such a thing.

4. Modelling for fire in a design sense is in many cases overly conservative as a result of the input of regulators (understandably so given what is at stake, this is not an attack on them merely an observation of where we are in the UK industry at least).

A constant source of frustration and a practitioner is the use of fire models to derive results that are seen/used as a 'truth' whereas they may represent one or more possible truths. The use of those results often distils down to the absolute worst case results presented as being the defining characteristic in a design, Not always but often and is I believe is down to how we, humans that is, find it difficult to put risk in perspective, i.e. hope we fear flying but will happily drive along the road without a seat belt on or something like that.

I am not sure if this is of any interest to the forum but it is interesting to see the academic, technical perspective about the modelling as a practitioner, and one who at that doesn't actually run the models (well not for a long time anyway) and how this relates to the day to day work of a practising fire engineer.

Glenn Horton BEng (Hons) CEng MIFireE MBEng ASFPE

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[Posted to IAFSS Forum, August 6, 2011]

16. Brannigen, V., University of Maryland

I suspect that some developers of models do the exact opposite, they take the most comfortable assumptions possible and make them the core of the model. E.g., the life safety code assumes only one ignition. That is a pure comfortable assumption used to make the claims of Performance based design "work." But the uncertainties in predicting fires and building performance are still huge. We cannot make long future predictions of the actual fire safety of real buildings. We don't even have an easy method of making sure that the fuel load producing the hypothetical design fire is not exceeded the first day the building goes into operation. Some of the assumptions used for "phased evacuation' border on fantasy. This has been a problem since the original Richardson formulation and no one has solved it. The fact that traditional codes do not do any better is a red herring, since they are policy documents that do not make any claims of scientific accuracy. It is also the case that Technical decisions may not be the most important components of the risk.
Arson or terrorism may be a key risk but is not a professional technical input. It is a policy input expressed in technical terms.

Performance based design is largely a forensic science. Its key market is the legal/regulatory process. Failure to properly integrate policy and technical decision making in the design process contributes both to over claiming the scientific validity of the risk models, and failure to recognize the complementary role of political and technical input in the safety process. It also tends to overstate the design issues and under emphasize the operational issues in a building. We can, within limits make buildings as safe as policy makes want the advances in fire engineering in this area have been enormous. We can also make Buildings cheaper and accept more risk. What is indefensible is over claiming the safety of a design by taking advantage of clever assumptions and known deficiencies in safety criteria. Ultimately society decides what risks it will accept. The goal is transparency in that decision process.

Prof Emeritus Vincent Brannigan
University of Maryland
Department of Fire Protection Engineering

[Posted to IAFSS Forum, August 7, 2011]

17. Simenko, P., SimCo Consulting Pty Ltd.

With Prof Emeritus Vincent Brannigan's comments (which are, however, always interesting and challenging) I have often the feeling that he is trying to push the blame for making the difficult, and admittedly - critical design decisions "what is acceptably fire safe and what is not" to fire engineers.

It then comes to my mind that it was actually the "a priori" decision of the governments to introduce the performance-based concept into the fire regulations - without first providing proper design tools for technical, ethical and to a degree also philosophical support at these decisions.

Without having clear quantifiable design criteria and approved methods to verify the necessary design decisions, any reasonable designer/fire engineer has to structure his approach (i.e. make trade studies) how to demonstrate equivalency with the DTS design solutions. To anybody who thinks how easy this is I would suggest to carefully read the doctoral thesis from Dr. Thomas Lundin (Safety in Case of Fire, The Effect of Changing Regulations, Johan Lundin, 2005).

Bertrand Russell once said: "The greatest challenge to any thinker is stating the problem in a way that will allow a solution." (Bertrand Russell, British author, mathematician, & philosopher (1872 - 1970).

One has also to listen to one of the "greats" in fire engineering, Ms Margaret Law. Margaret Law, in her paper, “The development of fire engineering into a mature discipline,” (Sunderland) makes two relevant comments (taken from my notes from the Sunderland seminar):

1st comment - "Modern engineering design is based on the application of science and engineering principles, using measurement, empiricism and judgment. This is the same in concept as traditional engineering design. The major difference is a recognition that it is better to have explicit assumptions and relationships, so that the design engineer can apply the codes in an intelligent way. In the past, the search for simple solutions has been deflected down the route leading to simple rules and the prescriptive approach. The resultant masking of assumptions means new hazards may not be addressed properly and the available resources may not be used to best effect."

2nd comment "It is reported that Huxley said: “All true science begins with empiricism” and that he went on to say that it only remains true science “in so far as it strives to pass out of the empirical stage.” The same may be said of engineering, but we can also recognize that while science is concerned with the search for truth and knowledge of reality, engineering is more concerned with the search for the satisfactory performance in reality. What is satisfactory is a matter for judgment. Most engineering relationships are developed as aids to judgment and are not conceived as statements of absolute truth. Once this is understood, the use of engineering calculations to assess fire safety will appear more acceptable to non-engineers."

At the end I would suggest that all the governments - that have made the "a-priori" decision to introduce the performance-based approach to fire safety in buildings, could now perform an "a-posteriori" verification (and possibly validation) of their first "a-priori" decision. I bet the results will be positive in engineering terms - the community is getting a better product/service then before with the prescriptive rules.

Regards,

Peter Simenko
Fire Engineer
SimCo Consulting, Melbourne, Australia

[Posted to IAFSS Forum, August 7, 2011]

18. Dey, M., Deytec, Inc.

I agree with Peter Simenko that there is much work to be done for performance-based fire safety design. This lengthy discussion on "visibility criterion," although interesting and useful, illustrates that there needs to be an international consensus and standard to establish the values for input parameters to fire models in performance-based design. As indicated earlier by Dr. Dieter Brein, the convener of WG7 in ISO TC 92 SC4, WG7 has nobly taken on the task to examine validation issues and methods for determining the true predictive errors of fire models. Perhaps the same group, or another in SC 4, can take on the task of establishing an international consensus and harmonizing values of important input parameters needed for fire modeling analysis in performance-based design.

Thanks,

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[Posted to IAFSS Forum, August 16, 2011]

19. Babrauskas, V., Fire Science & Technology Inc.

I'm not so convinced that standardization is the immediate answer. If the state of the art is still sufficiently primitive so that competent persons making a decent effort will get substantively divergent results, I just do not see how ISO, SFPE, etc. can use standardization strategies to ameliorate this. Such strategies would only help if some of the divergence would be due to use of incorrect physical constants, but I truly doubt that this was a significant factor. The second way the societies could help is if the divergences were due to blunders; in that case, educational classes or documents could be helpful. But, again, I sincerely doubt this was a factor with Dalmarnock. In very general terms, I think the ability of our fire models to model flame spread is still highly limited. Thus, in situation where flame spread is a moot point (pool fires, etc.), you can get gloriously good results. Where flame spread is important, divergences will rear their ugly head.

Best regards,

Vytenis (Vyto) Babrauskas, Ph.D.

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[Posted to IAFSS Forum, August 16, 2011]

20. Brannigen, V., University of Maryland

I am traveling so I will limit my comments to two very general points. I am simply astonished by the suggestion that "It then comes to my mind that it was actually the "a priori" decision
of the governments to introduce the performance-based concept into the fire regulations - without first providing proper design tools for technical, ethical and to a degree also philosophical support at these decisions." Performance based design was invented and promoted by fire engineers who repeatedly assured governments they had precisely these design tools. I wrote a whole series of articles on the bizarre assumptions that were used to overcome any opposition. My 1999 IAFSS paper detailing key steps in the process is on the web at: http://fire.nist.gov/bfrlpubs/fire00/PDF/f00159.pdf (Brannigan, V.M., 2000. Fire Scenarios or Scenario Fires? Can Fire Safety Science Provide The Critical Inputs For Performance Based Fire Safety Analyses?, Fire Safety Science 6: 207-218. /IAFSS.FSS.6-207). Our 1996 Interflam paper is at
http://www.fire.nist.gov/bfrlpubs/fire96/PDF/f96056.pdf

The second point is the question of shared responsibility between designer and regulator. I covered this in my Fireseat paper http://www.see.ed.ac.uk/FIRESEAT/files08/02-Brannigan.pdf

There I wrote:

"The worst case is where compliance with the standard fully satisfies the designer's legal responsibility but the inadequate standard produces socially unacceptable design. The result is a "black hole" where disasters can occur and yet no one accepts responsibility. Leading designers and regulators managed to combine to create the Kaprun ski train disaster, but at the end of the day no one actually felt responsible for the overall safety.

The key question is whether compliance with regulatory test methods and standards is actually enough to produce safety or is merely a method of complying with the code."

I am still waiting for the comprehensive report on the performance based design process and philosophy that led to the TVCC fire. What have we learned?

If a code requires a true "level of safety" it is a real performance code cf. the code of Hammurabi. If a code merely specifies an acceptable technical response, however sophisticated that specification e.g., "Tenability", it is still simply a traditional prescriptive code. The
risk of course is that in the complexity of claims of modern performance codes we simply create more hazardous buildings.

Prof. Vincent Brannigan

[Posted to IAFSS Forum, August 16, 2011]

21. Horton, G., URS/Scott Wilson

Isn't this a case of silk purses and sows ears? We have models which are currently sows ears, we want to use them to make silk purses, we just don't know how yet?

Not as eloquent as Mr Babrauskas, but I think it may reflect the current state of fire modelling to a degree. Despite the apparent increasing complexity of our models they are only an approximation of a real world scenario, potentially just one possible reality. But note only a potential reality, not a definite one.

Standardisation of input parameters e.g. soot production rates, will only give an appearance of order but will not quantitatively improve the outputs.

The outputs of our modelling still require a significant amount if interpretation on the part of the engineer applying/receiving the outputs.

Regards

Glenn

[Posted to IAFSS Forum, August 17, 2011]

22. McMurtie, S., Pyroactive

I maybe straying slightly from the specific debate at hand, but I think that the thread is relevant.

Whilst I am certainly not an academic nor do I regard myself in the same league of knowledge as the majority of contributors to these forums, I do find it sad to think that many builders, engineers, certifiers, practitioners and owners are allowed to use these calculations quite often as a cheap justification to get out of / or eliminate traditional deemed to satisfy or proven prescriptive requirements when yet even in our (my) training and education process, our (my) educators still describe fire safety engineering as Bucket Chemistry!

Fire Brigades are needing to publish guidelines to ensure that alternative solutions and fire engineering is used appropriately.

We know that correctly designed sprinkler systems suppress fires, but we allow them to be engineered out of certain buildings by using software calculations that we ourselves describe as 'sows ears" or "bucket chemistry"!

Have we set the ground rules correctly from the start? If the science is still in it's infancy, should a "sows ear" be relied upon in high risk situations? (e.g., any situation where an occupant or fire fighter is exposed to fire).
Are we educating our building certifiers, fire safety measures installers and maintainers appropriately?

I am all for fire engineered solutions in the right context, so please do not take this as a criticism of our trade/profession or anybody's knowledge, but simply an observation from the installers and occupants perspective where sometimes it seems like a bit of a "free for all" depending on your qualifications and grasp of the English language.

Stuart McMurtrie
Post Graduate Diploma - Fire Safety Engineering

[Posted to IAFSS Forum, August 17, 2011]

23. Kip, S., SKIP Consulting Pty Ltd

Hi all,

The issue of who is to 'blame' for introducing performance based codes is a complex one involving a range of historical inputs from GATT agreements to poor maintenance of existing prescriptive codes. For example in Australia at the time of introduction of the performance-based Building Code of Australia (1997), the Australian Building Codes Board stated: "A technical constraint to the performance system is the lack of verification (quantification) methods. These are methods used to determine whether a component reaches the required performance level. A large commitment is needed to rectify this shortcoming. The fact that the code is written in performance terms will encourage more verification methods to be developed."

It seems that the regulators assumed (hoped) that industry would fill in the policy holes and it is true that since the introduction of the performance-based Building code in Australia we have seen significant technical advances; for example in analysis of redundancy, reliability, disabled egress and many others. Certainly our understanding of the strengths, weaknesses and limitations of our prescriptive codes (deemed-to-satisfy provisions in Australia) has increased greatly.

It is also true that the amount of technical 'discretion' given to practitioners by regulators should be inversely proportional to the level of training, competency, auditing and checking required of those practitioners. In my experience this is the area where the majority of work still needs to be done.

Regards,

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[Posted to IAFSS Forum, August 17, 2011]

24. Dey, M., Deytec, Inc.

The round robin using the Dalmarnock tests was useful and important because it demonstrated that fire model inputs can be varied to show models are capable for simulations where experts know they are still "primitive" and not capable. The key issue then is how validations can be conducted to inform non-experts that fire models are unreliable for some simulations.

Thanks,

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[Posted to IAFSS Forum, August 24, 2011]

25. Brannigen, V., University of Maryland

The Titanic's designers complained about those lifeboats that would never be needed on an unsinkable ship. So they put on the bare minimum. Not only were there not enough, the failure to analyze the problem correctly left 400 empty places in the lifeboats they had. I submit that we have no idea, in the real world, if performance designs are conservative or not. The models are just part of the problem. Our confidence in the range of inputs over the lifetime of the building is just as poor. To get performance based codes approved Fire engineers made claims of safety, not merely compliance with codes.

I have raised this issue repeatedly in many forums and have yet to receive a satisfactory answer. I would note that the recent controversies over safe levels of volcanic ash and aircraft engines show exactly the same technical regulatory problem. Engineers can create objects without understanding the hazards, "conning" poorly trained regulators has become an art form, inadequate research is endemic, claims of trade secrets are used to cover up "creative technical accounting" and everything is great until the disaster hits.

But by then the fees have been collected and the practitioners are long gone. Then the finger pointing begins, as in the DEEPWATER HORIZON. The fact that the "Emperor Experts" have no clothes is obvious but far too late. Only sometimes, as in the TITANIC, HINDENBURG, Sprint Fidelis, COMET or the ATR does the disaster occur promptly before the designers move on.

I am happy to send details of all these engineering disasters on request. I teach a whole course in this kind of engineering failure.

There are no easy solutions to this problem but some suggestions are obvious:

1) Failure to fully and publicly investigate a technical disaster simply means that the cover up continues.

2) Any claims of Trade secret in areas of public safety and concern must be considered unethical. Medicine banned any such claims many years ago. All regulatory approvals and the rationale should be public.
3) Regulators must have resources and transparent technical advice equal to the hazard.
4) Professional societies must have organized systems of self criticism rather than simply insider cheer leading. New designs should be published with adequate data for analysis and criticism.
5) Any design that involves a claim that a regulatory requirement is unneeded should be backed by a solid solvent insurance policy against the event which it is claimed will not happen. Such insurance will be cheap if the proof is good. If it's expensive, that tells us something.

There are funding, legal and professional issues in all of these areas, but uncontrolled public experiments on human life are not an acceptable alternative.

Vincent Brannigan
Prof Emeritus
U of Md. Department of Fire Protection Engineering

[Posted to IAFSS Forum, August 26, 2011]

26. Reddaway, L.,

The earlier discussion about visibility, and computer models, has been 'high tech' stuff; and has served to reinforce my view that outputs from computer modelling needs to be treated with great skepticism, despite the lure of believing whatever a computer says.

Professor Brannigan's broader view is so important. Surely, fire safety professionals and fire safety organisations should be constantly pushing those people who ultimately control our building approvals processes to put in place regulatory processes that:
1) do not permit an over-enthusiastic manipulator of computer models to have excessive influence; and
2) include rigorous, independent, skeptical reviews of unusual designs.

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[Posted to IAFSS Forum, August 26, 2011]

27. Kip, S., SKIP Consulting Pty Ltd

To me the discussion seems narrowly focused on issues around the tools of engineering rather than what actually are the roles and responsibilities of an engineer.

In my view good engineering design should be efficient and cost-effective and satisfy the public policy (legal) requirements of the relevant jurisdiction. The best definition of engineering I have come across is the simplest; "Engineering is the practical application of science."

The criticism of fire safety engineering in Australia is mostly centered around unjustified cost-savings (particularly externalisation of those so-called "cost-savings" to other parties), and "reverse engineering" i.e. starting with an unjustified conclusion and using the modelling and technology to prove this.

Unfortunately when a disaster occurs (our most recent example in Australia being the Black Saturday Bushfires where 173 lives were lost), the politicians then look for a solution where "absolute safety" is the goal, regardless of cost (i.e. policy development is focused on consequence at the expense of a reasoned probability analysis). Engineers are often dragged into this policy whirlpool and will try to resist/assist by applying a so called "risk-based approach", however this can be naïve or misplaced. For example, community outrage is highest immediately after an event and it should not be the role of an Engineer to determine acceptable probability or consequence, even though we may be able to calculate or assess one or both of these to determine the risk.

In the area of fire safety engineering, most engineers I know struggle daily with the dilemma of whether you can, or should, reduce or replace one or more systems in a building with other systems that are more cost-effective, or more efficient. An example might be paring back fire-ratings in a low-rise sprinklered building so that those cost savings can be transferred to deal with other issues such as disabled egress or smoke protection (both of which are either poorly dealt with, or not dealt with at all, in our prescriptive building code). I have not yet had a client who was prepared to deal with these important issues as a cost extra to the project and even on a project where the client is informed, altruistic and educated (for example a new public Hospital), we are told that every dollar spent on fire safety is a dollar that could or would otherwise be spent on dealing with other risks such as infection control, security, staffing, equipment etc. The client will sometimes even have data to support that these risks are greater than the risk of fire. Whilst cost-saving should be an admirable engineering outcome if correctly justified and, for example, one of our Government policy documents gives an example of this; "the imposition of unnecessarily strict safety requirements on public transport may push up fares, encouraging people to use cars, where the risks of accidents are greater" (the Victorian Guide to Regulation), I do not believe it is the Engineers role to trade off one risk against another.

When we are trying to do our most difficult task of all, i.e. establish what is “safe enough”, we must deal with our specific issues to the best of our ability, without distraction. In Australia, one of the ways we can help to ensure the communities expectations of us (and the buildings we work
on) are met is to follow the stakeholder consultation process in the International Fire Engineering Guidelines 2005.

I support the views of Professor Brannigan entirely and his comments are a very healthy input to our daily working lives, but I thought it was worth expressing and explaining the difficult job of engineering from a practitioner’s point of view.

Kind regards

Stephen Kip

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[Posted to IAFSS Forum, August 27, 2011]

28. Thorsteinsson, K., Shaw

The building and fire codes could benefit from specific design risk criteria for acceptable level of safety along the lines of the UK HSE regulations for high hazard industries:

- Maximum tolerable risk level, e.g. 10E-4 fatalities/yr (public), 10E-3/yr (employees)
- Broadly acceptable risk level, e.g. 10E-6 fatalities/yr

And in between these two criteria is the ALARP (as low as reasonably practicable) region where all practicable risk mitigation measures must be either implemented or the cost shown to be grossly disproportionate to the benefit.

Kris

[Posted to IAFSS Forum, August 27, 2011]

29. Horton, G., URS/Scott Wilson

Arguably the fire codes already include a consideration of the acceptable levels of deaths and injuries. However, I wonder if the explicit statement of such criteria would be acceptable to the general population?

I wouldn't want to quote the source, but I know the value placed on a human life in terms of economic value is something that is widely discussed behind closed doors in the UK but rarely, if ever, figures in the public debates about fire codes or changes to them.

A classic example in the UK at least, is the ongoing debate about whether to impose sprinklers across the board for new buildings. Currently with a death rate of approx 0.8/100k head of population (source GAIN Newsletter No 26, 2010 all fires including those outside of buildings); the cost of imposing such a requirement would be relatively high and has so far not been perceived to give the benefits to society that the costs might be perceived to demand.

I recall that the perception is that such a change would likely reduce the death and injury rate slightly but would not make a significant impact on overall deaths and injuries. I don't recall of the top of my head what the benefits would be in this context although if I had more time could no doubt trawl through my info and find it, but I think the key point is the at a societal level the cost benefits have not been considered sufficiently beneficial to impose the requirements.

It is interesting to note that when considering death rates/100k there are many countries which from a UK perspective would appear to have a lower level of fire safety than found here and yet they have lower death rates (e.g. Spain and Italy specifically). Whilst on the other hand countries where the imposition of sprinklers is mandated far wider have higher death rates (i.e. USA).

Clearly the correlation between different codes and our perceptions about what is safe or not is a far from simple, clear relationship. This is despite the fact that we are all largely working from the same data, or at the very least largely have access to the same models and data if we are not all using the same information.

Whilst I agree with some of what Vince and others are saying re the engineers, I take the view that there are at least two sides to the story and we are all participants. It is unreasonable to simply blame fire engineers on the design side, when in fact regulators have a major role to play in what is acceptable and accepted. I am aware that in some countries (Australia, UK) that regulatory fire engineering capability matches much of what is found in industry although I would accept that this is not the case everywhere.

It is reasonable to say that the decisions made by regulators are on occasions as dubious as those made by design fire engineers.

JMHO

Glenn

[Posted to IAFSS Forum, August 29, 2011]

4.4 Comments Posted on the Blogspot of the University of Ediburgh

(from http://edinburghfireresearch.blogspot.com/2009/08/blind-vs-open-fire-modelling.html)

1. Rein, G., University of Edinburgh

Blind vs Open fire modeling

I always wanted to start a debate on this topic and now think that a better way is using the blog. Three years after The Dalmarnock Fire Tests, the 'a priori' vs. 'a posteriori' debate is still not too popular in the fire modelling community. The debate seems to be mostly taking place in personal communications and during the peer reviewing of papers. Unfortunately, not much is happening publicly or at the reach of the fire community as a whole.

The problem is the following. When making comparisons of modelling results to experimental measurements, there are two general approaches that can be followed: a priori (aka blind) and a posteriori (aka open). In a priori simulations, the modeller knows only a description of the initial scenario. The modeller has no access to the experimental measurements of the event and thus will be providing a true forecast of the quantities of interest. In a posteriori simulations, before the simulation is run the modeller knows the initial scenario and also how the fire developed (i.e. via the experimental measurements). Most fire model validations in fire engineering have been conducted a posteriori.

Only comparison of a priori and a posteriori simulations of the same event allows one to investigate the possible effect that maybe has been introduced by prior knowledge of how the event developed. The importance of this effect in fire safety engineering is currently an advanced research topic and under study by different research groups.

The 2006 Dalmarnock Fire Tests conducted in a high-rise building were used to look into the problem. An international study of fire modelling was conducted prior to Dalmarnock

Fire Test One. The philosophy behind the tests was to provide measurements in a realistic fire scenario with very high instrumentation density (more than 450 sensors were installed in a 3.50 by 4.75 2.45 m compartment). Each of the seven participating teams independently simulated the test scenario a priori using a common detailed description. Comparison of the modelling results shows a large scatter and considerable disparity among the predictions and between predictions and experimental measurements. These results tend to shock, please and anger the audience in equal parts.

An exception to the relative silence of the fire community are the two magazine articles of Dr. Alan Beard from Heriot-Watt University:

1. Reliability of computer models in fire safety design, April 2008 in the magazine Industrial Fire Journal.
2. Role Models, Aug 2009 in the magazine Fire Risk Management

First note that I disagree with blanket statements like "a predicted result from a model cannot be assumed to be accurate; i.e. to reflect the real world". Our work also shows that fire simulations provides fire features that may be good enough to be applied towards engineering problems if a robust and conservative methodology is defined. A prerequisite for this methodology is that it can use predictions with crude levels of accuracy and that it applies appropriate safety factors. But Dr. Beard has an important point in that 'real world' fire engineering applications are most frequently applied to simulate events which real behaviour had not been (and will never be) measured. These simulations are a priori simulation, not a posteriori. However, most fire model validations in fire engineering have been conducted a posteriori. I certainly agree with Dr. Beard on this one; we need more a priori comparisons of fire modelling and address full model validation. What is the effect of prior knowledge of the fire development? Would the validations provide the same conclusions if conducted a priori? The problem is not unique to fire engineering and any discipline dealing with complex simulations tools should be facing this question. I do not know how other disciplines cope with it.

The differences between a priori and a posteriori modelling become patent when comparing the round-robin results with the work conducted after the Dalmarnock data was publicly disseminated. Subsequent studies (Jahn et al. 2007, Jahn et al. 2008 and Lazaro et al. 2008) show that it is possible to conduct a posteriori fire simulations that reproduce the general fire behaviour to a satisfactory level. This was achieved due to the availability experimental data of the real behaviour for reference, allowing for iterations until an adequate input file was found.

I would like to finish with the same final words I use when presenting the results in conferences and seminars. We, the authors of the Dalmarnock round-robin, are professionals of, and supporters of, fire modelling. We want fire modelling to improve and be developed further. Our daily work goes in that direction.

I am interested in hearing your comments.

Guillermo Rein

[Posted August 20, 2009]

NOTE #1: All the relevant information, book and papers about The Dalmarnock Fire Tests are accessible in open access.

NOTE #2: There are two points about Dalmarnock that need to be emphasised since are often misunderstood. These are:

- The aim of our a priori work was to forecast the test results as accurately as possible, and not to conduct an engineering design with adequate conservative assumptions or safety factors.
- Experimental variability was one of our greatest concerns and that is why the scenario was designed for maximum test reproducibility. The Dalmarnock Fire Test One was benchmarked against a second test to establish the potential experimental variability. Results show that the scatter of the a priori simulations is much larger than the experimental error and the experimental variability together.

NOTE#3: No matter how useful and interesting the results from blind simulations are, only three blind round-robins on fire modelling can be found in the historical records of the discipline. The other two are the 1999 CIB and the 2008 French PROMESIS project. All three round-robins overwhelming agree on the results, but the Dalmarnock one was the first to be publicly communicated and the one providing, by far, the largest instrumentation density.

NOTE #4: I initiated a related discussion on this topic in April 2008 in the FDS forum.

2. Ryder, N. L., Packer Engineering Inc.

As one of the participants in the study and as a frequent user of fire/explosion simulation tools I believe this is a great subject to address and kudos to you Guillermo for bringing it up in a public way for all to benefit.

Random Thoughts on the subject:
I believe that prior to any type of modeling what must be clearly defined is the purpose of running the model as this makes a huge difference in the approach, the accuracy required, the tool utilized, etc. Often this is overlooked and someone runs a model because they believe it is the correct thing to do or because someone has asked them to.

There is no doubt that modeling can provide far more information spatially and temporally about an event than other tools, and often when compared to empirical or scaled predictions they do equally well or better given the same information.

As someone who uses models frequently after an event for reconstruction purposes I find that often the approach that is taken is to use the model for comparative purposes or a "quantitative qualitative" assessment (i.e. given all the same parameters except one how do the model runs compare to each other). In this way you are not relying on a specific value and stating that "this is the answer" but rather using the model to support other evidence or analysis and to provide a range of reasonable answers given an appropriate sensitivity analysis.

In the performance based design world models have become significantly more important and have been shown to be fairly good especially when looking at a design fire, smoke movement, etc. When getting into more detailed issues such as flame spread, structural integrity, etc. a full engineering analysis with safety factors should be done that does not rely solely on the modeling itself. The model should be a tool that is chosen because it best suits a particular need that has been identified in a broader scope of work not as a magic bullet that will provide all of the answers.

The real world is a tough thing to model and fire invariably is one of the more difficult phenomena to model. Even "identical" experiments can generate varying results, yet a model will produce the same result repeatedly given the same inputs. Thus we must recognize the inherent limitations in even the best models.

Whether modeling is done blind or open the simple fact, I believe, is that the approach taken and the manner in which the results are used is the core issue as with any engineering problem and engineered solution.

Unless we are striving towards a black box approach out of which always comes the "right answer" then there is a use for both types of studies.

The larger concern is that modeling will be used in an inappropriate way as the justification for a design/decision and an incident will occur that casts a shadow over fire modeling in general and the progress that has been made technically as well as acceptance will be lost. Here again is why it is important to identify upfront what the model will be used for and whether it is appropriate or not in isolation or what needs to be done in conjunction.

I once heard someone far more knowledgeable than me state "it looks so right it must be right" in reference to some model results, this attitude/mind-set I believe is what can get us into trouble. We must always remember that we are engineers and that inappropriate reliance on a tool, whether it be a model or a screwdriver, is bound to get us in trouble.

[Posted August 20, 2009]

3. Desanghere, S., CSTB

Dear Guillermo, thank you for opening this public debate.

I also strongly disagree with Mr. Beard's sentence "a predicted result from a model cannot be assumed to be accurate". On the contrary, giving accurate results is the ultimate purpose of any model!

We should be careful of the confusion between assumptions (input data) and model predictions (output data). Each model is just a tool which has to be held in good hands, as Mr. Ryder said. I mean the model should be used by a really skilled user. It is obvious that running advanced model doesn't allow you to take place of thinking and having a strong knowledge in fire safety engineering (FSE). Otherwise, it is like driving the formula one of Lewis Hamilton to go shopping and finally say "it is not a good car!" There are much more bad users than bad models.

I think there is a fundamental difference between a priori forecasting any test results as accurately as possible, and conducting an engineering design. These are completely two different worlds. It has no sense to draw conclusions concerning FSE from the Dalmarnock Round Robin study, because this study was not aimed at making engineering design at all. In fact, the robustness of the model is the key factor for engineering design purpose, the accuracy is of secondary interest.

On the other hand, we have to lowly admit that we are not able to predict the evolution of a real fire involving real furniture with a high level of accuracy. This is an extremely difficult task which is going to give us intense research work for a long time! So, to me it is not a shame to get such scattering between predictions when performing an a priori comparison. The question is then what we do with that, can we explain the differences observed?

It makes no doubt that the use of models (from the simplest to the more advanced) has largely contributed to improve our knowledge concerning fire dynamics. Nowadays, modeling is a major link of the scientific approach. So, please do not shoot on the models.

It is very important to make people not specialized in modeling understand the use and limitations of any model. Scattering results like Dalmarnock's ones scare only those who trust than the use of models is like a perfect crystal ball prediction. It is also the role of FSE experts to educate the general public on this point.

[Posted August 21, 2009]

4. Deal, S., Excelsior Fire Engineering

Modelling the structure is usually easy, as far as our worry about introducing a priori uncertainties. The design fire is the rub. I have seen more-than-I-care-to-bear of modeling that charges the customer scores of thousands of (name your denomination), documenting hundreds-of-thousands of (name your denomination) in fire protection equipment, without due diligence as to identifying 'what has to happen to fail the fire protection systems?' Part of engineering, certainly fire engineering, is investigating failure. I don't know what other disciplines do, but structural engineers reference ultimate strength. Too few analyses I see, have shown any sensitivity as to what the fire size need be to reach a building tenability failure point. Publishing a serious-failure-endpoint provides one basis for comparison *across building types*; a valid benchmark for performance-based design. The Dutch government has published acceptance-probabilities on dike failures ten years on. Probabilities of failure-fires are often lower than these Dutch tolerances, yet this Dutch hazard often exposes 1 to 2 orders more souls than the counterpart fire modeling hazard. It is time the fire profession (including AHJ's) take the blinds off and openly discuss sensitivity to fire failure. Besides, identifying a serious fire failure is a relatively easy thing to do with a model.../a priori/.

Respectfully appreciative of the open debate,

[Posted August 28, 2009]

5. McGrattan, K., National Institute of Standards and Technology

Consider these three issues from the developer or regulator point of view:

1. The Dalmarnock exercise was focused on "user effects" -- that is, how different modelers can choose a wide variety of input parameters and then get a wide range of results. It tells us little about whether the math and physics of the models are right. We made the decision in the NRC V&V study (NUREG 1824) to eliminate as much as possible the variations in input parameters model to model to better assess the accuracy of the models themselves. To me, that is what V&V is all about.

2. Blind or "a priori" exercises rarely provide the modelers with enough information about the test. I've never seen a fire experiment conducted that was exactly as specified in the test plan. Practical considerations the day of the experiment usually nullify the usefulness of simulations run prior to the test. This was true of all the attempts during the International Collaborative Fire Modeling Project (ICFMP) whose experiments were included in NUREG 1824.

3. We re-run the NUREG 1824 calcs, plus about 200 other fire tests, each time we release a new "minor" revision of FDS. Those results are the only ones that matter to anyone using that particular version. A "blind" exercise conducted in 2003, like ICFMP BE #3, is of little value for a regulatory authority who is being asked to evaluate a fire modeling analysis with a newer version of the model.

I am not opposed to blind modeling exercises. If the opportunity arises, great, take advantage. But I would hesitate to place a greater value on so-called blind studies over "open" because the vast majority of our validation database is open. We cannot just throw away thirty years of experimental measurements because they no longer provide us with "blind" results.

[Posted September 2, 2009]

6. Salley, M., U.S. Nuclear Regulatory Commission

Please let me jump in and try to explain our logic/thought process: If you charge off doing "Blind Simulations" you make the unvalidated assumption that: 1)The fire models are perfect tools, and, 2) your variance in predictions will be based solely on user's skill/input values. Nothing could be further from the truth. The models are not perfect ~all the reasonable developers recognize this fact. This was the whole key to the NRC and EPRI creating NUREG-1824, (http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1824/) where we asked the question: "How good are the models?" and "Are different models (hand calculations/zone/CFD) better at some things than the other?" (if the only tool you own is a hammer........) NUREG-1824 now provides us with a baseline within the applicable bounding limits. We have a better handle on the "uncertainty" of a model prediction; albeit conservative, or non-conservative. To charge off doing blind predictions with un V&Ved models is like trying to solve 1 equation with 2 unknowns, the model & the modeler. Let me ask you this; if you run a blind calculation and get unacceptable answers, is it the fault of the model, or the modeler?

Likewise, if you get the exact answer, I guess you assume the model & modeler are perfect? One could not compensate for the other? We have a much better grasp on this today. As for the quality (or lack their of) of the modeler, we are working on the users-guide for NPP applications that Jose has peer-reviewed for us. Education will always play a key role in this. I believe a much better approach would be to take the V&V fire models, understand their uncertainties and limitations, then take the completed users guide, educate the users, and only then begin to run the blind calculations. By doing this, in this manner, you would be better able to see where problems/additional work was needed (e.g with the model, modeler, input data, etc).

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[Posted September 2, 2009]

7. Merci, B., University of Ghent

Dear colleagues, I agree that Guillermo raises an extremely important issue. Improved models and modelers are exactly what we, as engineers, should hope and strive for.

Clearly, we are, to my opinion, nowhere near complete trust in blind simulations and we need not be ashamed of this. The same is true in other communities.

I will write this comment, biased towards CFD, as I am most familiar with that area, but I assume many aspects also hold for structural engineering.

I would like to use the international workshop series on turbulent non-premixed flames (TNF, web site: http://public.ca.sandia.gov/TNF/9thWorkshop/TNF9.html) as enlightening example from the combustion community. Over the years, simulation results for a limited set of test cases improved a lot, mainly due to better and better description of the test cases and more stringent choices of computational meshes and model options and constants.

Yet, with every new test case, scatter appears again among results of different groups all over the world. In particular now with the relatively recent break-through of LES, where some aspects appear more sensitive to numerics than in RANS turbulence modelling, there are new issues. Indeed, quality assessment of LES is, after decades of use, now a real focus in the TNF community.

To make my point clear: 1. I do not think it is a shame that we are not at the stage of trustworthy blind fire simulations yet. It is not even possible for well-controlled flames with a well-known fuel and heat release rate, so why would it be possible yet in a far more complex fire. 2. I do not think this should be used as an argument against blind simulations. The point, to me, is that blind simulations should always be done with a sensitivity study of crucial parameters. As cumbersome and time consuming this might be, it is necessary. In that sense, many simulations on an affordable mesh can be more valuable than one 'heroic' simulation on a very fine mesh (although, of course, the mesh must not be too coarse). 3. I think, from a research point of view, a major step forward could be if a workshop series is initiated, focusing on fires that are seemingly simple to simulate (e.g. 'simple' pool fires), to learn from the deviations between several groups and then to move forward to more complex configurations, step by step.

Finally, being where we are, I think it is utterly important to educate as many people as possible. This might, at short term notice, even be more efficient and fruitful than progress in research (which is, beyond any doubt to me, necessary for the long-term development of FSE). Increasing the number of well-educated practitioners will speed up our senses on how sensitive model results can be to certain options/choices.

I hope I have not offended anyone with my comment. All the best,

……….one more thought came across my mind that I would like to throw into the discussion.

Suppose we had perfect numerics, perfect models and perfect model users, then, specifying initial and boundary conditions, there would be a solution. There can still be some randomness in the solution due to numerical round-off, but let us assume this would be small. Then the solution from the model simulations could be considered as the 'reference solution'.

Then: if we had the perfect experimentalist, the best he/she could do is perform many many experiments and after statistical averaging of the results, the 'reference solution' should be obtained.

Now we all know that a developing fire is prone to large differences due to (apparently) details in the real world. So then the question becomes how large the experimental scatter is.

My point is: if a single (or a few) experiment(s) is (are) performed, how do we know how far the measurements deviate from the statistically to be expected 'average' solution? If we are unfortunate, we are far off this average solution and then it is hard to expect that model simulations will get the 'odd' experimental results.

Just to avoid any misunderstandings:

1. I do not intend to say that we are close to using 'model simulation results' as 'reference solutions' in case of fire.
2. I do not intend to say that 'blind simulations' are no good, on the contrary.
3. I do think (see my previous comment on this blog) that it is crucial to have an idea on the sensitivity of model simulation results to (small?) variations in model options, but also to variations in initial and boundary conditions. This is cumbersome, but necessary.
4. I also think that we should try to get funding and time for repeated, seemingly identical experiments, in order to grasp some feeling on how much scatter we can really expect. This is a true challenge for the experimentalists among us, I think.

[Posted September 8, 2009]

8. Iannantuoni, L, Manzini, G., Dept. di Energia, Politecnico di Milano

It is clear, also from comments, that it might not be a debate about which one is the better approach, between a priori and a posteriori simulations, not only because of their different purposes, but also because often it is from the analysis of the differences in results between the two approaches applied to the same case that it is possible to outline better the methodologies to apply with that model in that class of similar cases to achieve more confidence. In fact there is no need to pretend that an unreliable a priori simulation could harm the model nor the user, as good results from a posteriori simulation can not demonstrate the general reliability of the model nor the expertise of the user. Because of the outstanding challenging of fire simulation tasks, comprising the complexity of fire models and the general lack of experimental data, what we think has to be focused mainly is to reach validated tools coupled with correct methodologies to apply that tools. These methodologies should be strengthen by sensitivity analysis, of course, but also from any previous simulation experience, both open or blind, reported with the sufficient amount of information to understand the code behaviour.

[Posted September 24, 2009]

5 Conclusion and Recommendations

The above compilation and analysis of comments on the issue of open versus blind fire model validation show that although several concerns were raised against the adoption of blind fire model validations, the issues can be addressed in a standard.

The comments were broad and went beyond the specific topic to issues regarding the validity of the models and the performance-based regulatory standards for fire protection adopted in many countries. Some commenters went as far as to state that fire model predictions are not reliable and should not be used, that deletions of useful fire protection features were being justified by computer models, and practitioners are blindly using model results as the truth (reification). They argue that if fire science is at an infancy, why trust results at this point? There is an apparent need to inject confidence in the performance-based regulatory systems for fire protection worldwide. Some practitioners even expressed skepticism given the many sources of uncertainty in performance-based design; model error, user effects, and sensitivity to unknown parameters.

It is recommended that a standard be developed to phase in the use of blind fire validations in performance-based designs to achieve a high degree of confidence in the predictive capability of models. The goal should be to set safety factors in fire safety designs commensurate with the predictive capabilities of the models. This will establish a robust and conservative methodology and prevent the misuse of fire models. This will also add credibility to performance-based regulatory systems worldwide.

It is recommended that an international standard be developed to:

3. Establish a process to ensure that blind calculations are used to establish model errors that are used to establish safety margins in safety analysis;
4. Examine and include "third party validation" as an option for establishing true model errors.

Third party validation can address the issue of the possible bias introduced in fire model validations by providing an independent assessment and determination of the model errors. Third party validation can also be used to provide validations as newer versions of a particular fire model are released.

It is necessary to globally harmonize definitions for verification and validation, and the methods for V&V. In order to achieve this, a consensus on the measurement methods for parameters needed as input to fire models and values for parameters input to fire models is needed.

It is suggested that standards established in other industries (where model accuracy is important for safety) such as the medical field be reviewed in the development of the standard for fire model validation. For example, the Food and Drug Administration

(FDA) quality control requirements for medical software and models are very complex, and require expert documented and non developer validation and verification. Many of the lessons and experiences of the medical industry can be examined, as they evolved from where the fire science community is today to a robust regulatory regime. Strict quality control requirements are recommended for the development and validation of fire models, especially given the rudimentary stages of their development, expanding application in fire safety engineering, and lack of confidence in the methods expressed by some stakeholders.

Although a stricter regulatory regime for performance-based fire protection is needed to establish confidence, a phased approach that includes the use of both open and blind validations is suggested as fire science matures. Blind validations have definitive benefits as well as open validations. It is also important to present all information to practitioners on model errors, sensitivity analysis, and implementation of code options as these areas are also of concern. A policy that accounts for the given technical limitations should be developed to guide the proper evolution of performance-based fire protection design. The policy and standard can be revised as experience with blind validations is gained, and the technical limitations of current fire models are overcome.

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