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Performance Based Fire Safety Design: Risk Perceptions and Communication

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Fire safety design, be it in a performance or a prescriptive regulatory environment, is effectively an exercise in risk management intended to achieve an acceptable level of risk of fire. The acceptable level of risk would normally be set directly or indirectly by regulation; however, whether any risk is deemed acceptable is more complicated issue. This is made clear in *Acceptable Risk*¹, where Fischhoff and his co-authors explain that by simply targeting numerical acceptable levels of risk is not the key to any successful regulation. Alternatively, they argue that a successful regulation is one that addresses the many facets of the risk, resolving questions such as: Is the regulation practical? Is it logical? Is it compatible with the existing institutions? Is it politically acceptable? For more on these and how they apply to performance-based fire safety, see [LINK](#).

Almost twenty years after the publication of *Acceptable Risk*, Fischhoff revisited such regulatory challenges in his paper *Risk Perception and Communication Unplugged: Twenty Years of Process*.² He proposes that the struggles in developing and promulgating successful regulation are universal and adds that too few recognize this “universality.” He offers the reasons:

“Although learning from the experience of others is appealing..., it may be difficult. One possible obstacle is being too isolated to realize that others have faced the same tasks. A second is being too headstrong to admit that help is needed. A third is not having a chance to observe others’ learning process. As a result, newcomers may be condemned to repeat it.”

Analogous to the seven criteria presented in *Acceptable Risk*, Fischhoff’s new paper identifies common developmental stages associated with risk management and regulations.

These stages eerily echo many performance-based fire safety design (PBD) implementation challenges, at least in the United States. As fire engineers work worldwide to gain recognition

and validation of their discipline, they would be wise to heed where they stand among these stages. Based in large part on the author's practical experience and observations, with insightful excerpts from Fischhoff's paper, these universal stages are discussed in light of the current state of PBD in the United States.

Stage 1. All we have to do is get the numbers right.

"There is concern that the data, tools, and methods are lacking."

Before the first 1996 International Conference on Performance-based Codes and Fire Safety Design Methods³, and thanks to contributions from engineers and scientists world-wide, several PBD tools, numerous worthwhile data sets had been developed for those practicing PBD. *The National Fire Protection Association (NFPA)* offered⁴⁵ risk-based approaches, and in 1988, the SFPE published the first edition of SFPE Handbook⁶ with tools and data useful for PBD.

Thanks to researchers worldwide, the numbers are getting "more right" every year. The sixth edition of the the SFPE Handbook is expected to be published sometime in 2022. With the advent of faster and cheaper computers and the development of more user-friendly tools, computational fluid dynamic modeling has almost become the norm in PBD, delivering improved accuracy. But it is unlikely we are finished with this stage.⁷ Better fire and smoke spread model input data (design fire assumptions) and human behavior models (a highly stochastic phenomenon) are needed. Although we have 30+ years of available performance based fire safety data and tools to draw from, this developmental stage may never be truly seen to completion.

Stage 2. All we have to do is tell them the numbers

"When risk managers discover that they have not been trusted...a natural response is to hand over the numbers. How good a story those numbers tell depends on how well the first stage has been mastered."

The 2nd stage suggests that PBD be transparent. The SFPE has made efforts to push transparency through publications on PBD. Among them is the SFPE Code Official's Guide to Performance-Based Design Review⁸ (Guide). Per the Guide, early engagement with the authorities having jurisdiction (AHJ) or their representatives is highly recommended. As part of the engagement, it is important the "numbers", assumptions and inputs be shared with the AHJ. Some important numbers in many PBDs include heat release rate, soot yield, heat of combustion, visibility limits, and occupant characteristics. Many of us have worked through this stage and understood that a basis of design report is a good vehicle to provide such information. Such a report can tell the story, provide the key numbers, and ideally be shared with AHJ before formal start of any analysis.

Stage 3. All we have to do is explain what we mean by the numbers

“When the numbers do not speak for themselves, explaining them is an obvious next step. Those who attempt such... face significant... problems, including a largely unprepared audience. Clearly communicating any number is a complicated task.”

At least in the U.S., building fire safety design, particularly PBD, is not performed in a vacuum. Often a peer reviewer (a prepared audience) and an AHJ (sometimes a less prepared audience) are involved. For this reason, clarity in communication of the numbers is important. For example, giving simple “single point” numerical results may not always communicate the problem or the solution very well. For guidance in reporting results in a PBD, the Guide recommends a way to put results in context:

“The design report describes the final design, documents the engineering analysis used to determine the final design, and identifies the bounding conditions for the analysis.”

Another way of reading the phrase: “*identifies bounding conditions,*” is: “*at what point, does the design fail?*”⁹ This is recognized in *NFPA 101 The Life Safety Code*¹⁰ where as part of its PBD process, it has formalized eight potential fire scenarios to consider. The eighth scenario requires that one or more fire safety design features fail. In case single point results are inadequate, this exercise is one way to provide reviewers a much better appreciation of what the numbers, the results, mean.

Stage 4. All we have to do is show them that they’ve accepted similar risks in the past

“risk comparisons, in which an unfamiliar risk is contrasted with a more common one, individuals...use their response to the familiar situation as a guide...in the new one.”

In the U.S., the most popular method used to justify PBD is based on the principle of equivalency to the prescriptive code.¹¹ The majority of such PBDs are efforts in showing that the design equals the intent of a prescriptive code section. For example, if more exit width is provided than required prescriptively, yet the maximum allowed exit travel distance to an exit is exceeded, a PBD can show that the flow of occupants through the exit width is just as efficient, the occupants can exit equally as fast and therefore the design might be equal that of the prescriptive code. In this case, the fire engineer shows the AHJ that “since they have accepted this risk in the past, they should do so now.”^a This approach, embraced in many parts of the US, has been a great value for PBD, yet may not work 100% of the time, which leads us to Stage 5.

Stage 5. All we have to do is show them that it’s a good deal for them

“People need information about both the risks and the benefits of any activity that might affect them.... Explicitly showing the cumulative benefits of a protective measure may enhance its attractiveness.”

^a Outside the United States, other examples of this step are evident. The early Australian efforts in performance-based codes suggest comparing the risk consequences in terms of equivalent risk to life (ERL) or Fire Cost Expectation (FCE) to a deemed to satisfy or prescriptive design.

Benefits of PBD are often clear to the stakeholders on the design team. However, to the AHJ, PBD be perceived as adding uncertainty, thereby increasing the real or perceived risk.

It is for this reason that often, in the United States, any PBD needs to consider a level of safety that equals *or exceeds* that level of safety intended by the prescriptive code. In the previous example, a building's prescriptive exit travel distance exceeds the code allowed maximum, but because the egress widths provided are in excess of the prescriptive requirements, equivalent egress times are predicted. However, this "equality" may be inadequate to address the AHJ's concerns and uncertainties of the predictions. Often, this has meant that one or more additional safety features may be necessary in order to truly show it is "a good deal for the AHJ." This concept of providing "more" than equivalent is not completely irrational. To the AHJ, the process can allay concerns regarding the seen and unforeseen uncertainties and accommodate their perceptions of risk.

Stage 6. All we have to do is treat them nice

"Getting the content of a communication right requires a significant analytical and empirical effort...(the AHJ) may ask how trustworthy the communication and communicator seem to be. The ignorant smiles of PR types are a good tool for digging oneself into a hole".

Much is written about soft skills: the skills of communication and empathy versus the counterpart set of hard skills or technical proficiency. But some believe that the weaknesses in PBD lies not only in the technical realm but also in the realm of trust: in the trust of the tools, in the trust of the analyst or fire engineer, or in the trust of the construction and maintenance processes.

In *A Risk-Informed Performance-Based Approach to Building Regulation*,¹² Meacham writes:

"...for regulators and enforcement officials, performance-based (fire safety design) approaches are often met with skepticism and concern, as the desired performance is not always well defined and agreed."

Where the number of fire engineers practicing PBD are limited, and where the number of professionals in AHJ roles are more limited, respect and trust are required. Fortunately, the SFPE provides support for these stakeholders with regional, local SFPE Chapters. The SFPE Chapters host regular meetings which provide opportunities for practitioners and the AHJ to meet, present and discuss challenges in a low-pressure environment. At the meetings these would-be partners can exchange ideas and opinions outside of the context of a project, where trust can be gained.

Stage 7. All we have to do is make them partners

"lay people often...master technical material when sufficiently motivated. Unfortunately...the motivation often comes from a feeling of having been wronged. If passions become inflamed...then all sides will be tempted to focus on data supporting their prejudices."

There are still many jurisdictions that might not include enough engineers or design professionals on staff qualified to review PBDs. This should not absolve the design engineer from engaging with the AHJ with an aim to create a partnership. Early communication, can lead to partnership. Partnership can lead to resolving PBD challenges together, as players on the same team rather than opposing players on different teams.

A key tenet of the *SFPE Code Official's Guide to Performance-Based Design Review Guide* is that the process needs to involve all the stakeholders of the design, including the AHJ:

"The owner, designer, and code official should work together as a team with a common goal of a successful project"

Whenever this author finds AHJs who can contribute like team members, PBDs are more welcome and their process of review and approval more easily managed.

Stage 8. All we have to do is all of the above

"Risk communication has to be taken seriously. A...network of...respectful relationships may offer the best hope of reaching agreements.

The developmental stages of successful risk management, successful fire regulations, and successful PBDs require above all, fact-based evidence: data, methods, tools and results. But, implementation and promulgation of PBD will suffer if wide spread communication is not also valued. There is need for communication in many different arenas of the design and construction industry. PBD succeeds when the regulatory umbrella under which it operates is developed and executed in concert with all of its partners, from architects to manufacturers to authorities having jurisdiction. The *1998 Pacific Rim Conference and Second International Conference on Performance-Based Codes and Fire Safety Design Methods* brought fire engineers, fire scientists together with AHJs, architects, and code development professionals. It was an early step in the right direction for bringing large contingents of key partners together. For future fire engineering conferences, symposia, and similar meetings we should make it a priority to bring more of our partners together.

References

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³ *Proceedings of the First International Conference on Performance-based Codes and Fire Safety Design Methods, Ottawa, Canada*, Society of Fire Protection Engineers, 1996.

⁴ *NFPA 550 Guide to the Fire Safety Concepts Tree*, National Fire Protection Association, 1986.

⁵ *NFPA 101A, Guide on Alternative Approaches to Life Safety*, National Fire Protection Association, 1988.

⁶ *SFPE Handbook of Fire Protection Engineering*, Society of Fire Protection Engineers and National Fire Protection Association, 1988.

⁷ Hurley, M. and Rosenbaum, E., *Performance Based Fire Safety Design*, Society of Fire Protection Engineers, 2015.

⁸ *SFPE Code Official's Guide to Performance-Based Design Review*, Society of Fire Protection Engineers, 2004.

⁹ Personal communications per a conversation with Joe McElvaney, retired fire protection engineer (AHJ) from the City of Phoenix Arizona,

¹⁰ *NFPA 101 Life Safety Code, Chapter 5 Performance Based Option*, National Fire Protection Association, 2018.

¹¹ *International Building Code, 2018, Section 104.11*, International Code Council, 2018.

¹² Meacham, B., *A Risk-Informed Performance-Based Approach to Building Regulation*, Journal of Risk Research 13(7), September 2010.