AN APPROACH TO ENHANCING THE VALUE OF PROFESSIONAL JUDGMENT IN THE DERIVATION OF PERFORMANCE CRITERIA

by

Harold E. Nelson
Center for Fire Research
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Washington, DC 20234

Proceeding of the 3rd ASTM/CIB/RILEM Symposium on the Performance Concept in Building, in Lisbon-March 29-31 - April 1-2, 1982.

An Approach to Enhancing the Value of Professional Judgment in the Derivation of Performance Criteria

by

Harold E. Nelson
Center for Fire Research
National Bureau of Standards

Abstract

The Center for Fire Research of the U.S. National Bureau of Standards has developed an evaluation system for determining the risk to life from fire in health care facilities. The system was based on a cyclical approach designed to enhance the judgmental decisions of engineering professionals. The focus of the approach was on achieving consensus regarding the impact of each variable on life safety and ensuring that all aspects of safety were simultaneously satisfied. The use of this system in field investigations as well as computer applications is also discussed.

Résumé

Le Centre de Recherche Incendie du Bureau National des Standards E.U. a développé un système d'évaluation en vue de déterminer les risques pour la vie causés par l'incendie dans les centres de soins. Le système a été établi à partir d'une approche cyclique des jugements emis par des ingénieurs de métier, le but étant d'arriver à un consensus relatif à l'impact de chaque variable sur le niveau de sécurité vie, et d'assurer que tous les aspects de sécurité aient été traités simultanément. L'utilisation pratique de ce système sur le terrain et ses applications informatiques sont ici également présentés.

The objective of this paper is to present the concepts used, the lessons learned and the potentials envisioned as a result of the development of the Fire Safety Evaluation System for Health Care Facilities by the Center for Fire Research at the U.S. National Bureau of Standards. The paper also mentions subsequent work on extending this approach to different occupancies and to other problem areas. The evaluation system is a grading system developed through the consensus of experts. The development of consensus in this case differed from many of the traditional approaches due to the use of a hierarchical system of separate consensus groups. Furthermore, the development and proofing procedures involved separately focused consensus judgments with feedback cycles that returned to the evaluators the impact of the focused judgments.

The term "Fire Safety Evaluation System" as used in the Center for Fire Research has become a generic term defining grading systems designed to determine the relative level of overall fire safety of existing or proposed facilities. Comparison is made with the fire safety level that would exist in a hypothetical facility that exactly matched the requirements of an explicit regulation. The specific evaluation system used as the basis of discussion in this paper is the Fire Safety Evaluation System for Health Care Facilities. References in this paper to "evaluation system" or "the system" refer to the Fire Safety Evaluation System for Health Care Facilities [1]. This evaluation system is specifically designed to evaluate health care facilities. The system compares the level of safety of the measured facility to that prescribed for such a facility by the Life Safety Code (NFPA 101-1981)[2].

Figure 1 shows Tables 4 and 5 from the evaluation system. These are the tables most critical to the evaluation and most important to the objective of this paper. Any person wishing to undertake test application of the full system is advised to obtain references 1 and 2. The part of the evaluation system represented by the Tables in Figure 1 attempts to describe the universe of common building factors that determine fire safety. For practical considerations, however, those factors that relate to building utilities, furniture, and emergency procedures are handled elsewhere in the overall evaluation system.

Given the above limitations, Table 4 is then considered as a reasonable description of the controllable building parameters that determine the difference in fire safety of one health care facility as compared to another. The levels of the parameters in Table 4 represent the levels of performance that are currently recognized by U.S. codes and regulations, or exist in the real world but are either below the minimum or as (in the case of smoke control) above any currently required level. A major effort has been made to stay with the recognized levels to enable the use of the evaluation system by the current professional cadre of regulatory authorities reviewing plans or inspecting buildings.

The parameter values in Table 4 shown for each level are dimensionless numbers developed through consensus and are designed to be reasonably comparative in relative value in both the evaluation of the levels within a single parameter and the relative evaluations of individual levels from different parameters. In general, negative numbers represent an item detrimental to life safety and positive numbers represent items additive to life safety.

The parameter values of a measured facility are determined using Table 4. The results are then transferred to Table 5. Table 5 evaluates the importance of each parameter to the fire safety objectives of fire containment, extinguishment, and people movement (including refuge). The use of the shaded entries prevents application of some parameters to some objectives. This approach avoids the over dependence on any single parameter and insures a degree of redundancy as expected in the Life Safety Code and most other regulations. Once the values are transferred to Table 5 the columns are added and a profile of four scores are obtained.

A set of mandatory minimum values for the first three objectives that must be met in order to satisfy the requirement of equivalency were derived by using the evaluation system to measure the referenced Life Safety Code as though it were the description of an actual building. These values varied according to the size and age of facility. For example, a new multi-story facility requires minimum scores of 14 for containment, 8 for extinguishment, and 9 for people movement. Not shown in this presentation but available through references 1 and 2, are adjustment measurements made on the fourth parameter, general safety. These adjustments raise or lower the level of that requirement according to the degree of disability of the patients and the level of nursing staff provided.

By this evaluation system any facility that has a profile of scores in Table 5 that all equal or exceed the profile of scores for a similar building under the Life Safety Code is considered as equivalent to the

Life Safety Code. Any building that fails in one or more is considered as not being demonstrated as equivalent by this system.

The validity of the evaluation system approach rests primarily on the three factors of:

a. the completeness of the universe of parameters and parameter levels that form Table 4;

b. the appropriateness of the relative parameter values assigned in Table 4; and

c. the relationships established in Table 5.

The system was developed and the above problems attacked using four different groups of technically qualified persons. Individual groups entered the process at various stages of development but continued to participate from that point until the essential conclusion of the project, the adoption of the Fire Safety Evaluation System as an appendix in the 1981 Life Safety Code. The four groups are described below.

a. Project Staff. The project staff proposed the parameters, the variable levels of the parameters (but not the value of these levels) and the "redundant" fire safety objectives that constitute the column headings in Table 5. The basic tools to achieve this consisted of a detailed analysis of the requirements of the Life Safety Code, and an event-logic evaluation of the fire safety methodologies available using references such as the National Fire Protection Association decision tree [3]. A study by the staff of the relationship of the requirements of the Code to the fire safety functions related to that requirement is presented in [1]. The prime product was a form very similar to that which now constitutes Table 4 in Figure 1 except that no parametric values were included.

b. NBS Delphi Panel. A Delphi panel consisting of the best qualified persons in the Center for Fire Research was then assigned the task of critiquing the parameters as presented by the staff and determining if all the parameters that were relevant to each of the redundant fire safety objectives in Table 5 of Figure 1 were included. They also provided the initial estimates of the relative parameter values. The mechanism involved a cyclic delphi approach where individuals privately made their best estimates of the parameter values. Each member of the panel made his estimates first in terms of the general, or overall, impact on the stated objective of fire safety in health care facilities equivalent to that prescribed by the Life Safety Code. Each member of the delphi panel also made three additional similar appraisals focusing on the specific, redundant fire safety objectives of containment, extinguishment and people movement. The process was cycled several times following traditional delphi concepts and eventually brought to initial resolution in panel sessions to reach a consensus among the experts. The values for general impact were then used for the initial version of Table 4. The relative values developed by the appraisal of the three redundant objectives was used to develop Table 5. The basic methodology used to develop Table 5 was to eliminate from consideration those parameters where the evaluation of the redundant factor showed little or no variation in impact between the highest and lowest rated level for a given parameter.

c. Peer Consultant Group. The Peer consultant group consisted of recognized authorities in fire safety, health care, and standards and regulation. The prime assignment of the Peer consultant group was to review, in terms of total fire safety performance, the levels of safety allowable by the evaluation system relative to that which would be required by prescriptive compliance to the Life Safety Code. The techniques developed through these meetings are felt to be the most important new contribution to judgment enhancement from this effort and will be discussed further.

d. NFPA Task Group. At a point in the development of the system, it was formally submitted to the National Fire Protection Association Committee on Safety to Life as a proposed addition to the 1981 Life Safety Code. The responsible subcommittee of that organization set up a special task group to review this system. That task group was essentially a replication of the peer consultant group. It also provided special expertise in assuring that the parameter levels reflected the current technological base and intended meanings of the Life Safety Code.

The above four groups worked in a cyclic feedback system. Each problem or question raised was recycled through all four groups until a broad based consensus was reached that the system truly measured equivalency to the level of safety inherent in explicit compliance with the Life Safety Code.

A number of tools were used to provide data to prove the system including field tests, voluntary completion of the forms by facility administrators and engineers, and exercising of the system by fire authorities. All of these were useful, however they tended to present cases in which the level of safety was either so clearly poor or conversely so obviously good that the ability of the system to delineate those buildings that were marginal was not being evaluated. To attack this problem, a computer sorting program was developed. The initial form of this program is reported in [1]. This program is capable of presenting all of the possible satisfactory solutions for any building evaluation that fails to satisfy all four fire safety objectives. Since there are between 300-500 million possible permutations of Table 4, the computer program is arranged so that the user can set logical limits and produce only those feasible solutions that represent corrective actions requiring minimum change. Normally this process reduced the search for alternatives to less than 1,000. The staff then selected those strategies that represented the least demanding (from a fire safety performance view) acceptable solutions. In most cases, this reduced the number of strategies for examination to 10 or less. The residual critical cases were then presented to the Peer Advisory Group and the NFPA Task Group. The method of presentation was as shown in Figure 2. The left hand column of Figure 2 represents the parameter requirements specified for the particular class of buildings by the Life Safety Code. The right hand column represents the comparative set of performance requirements produced by the evaluation system for the case being presented to the Peer Advisory Group. The group then attempted to answer the two following questions.

a. Which of the two solutions produces the higher probability of freedom from fire harm for a patient over the life of his/her stay in a health care facility?

b. Would safety be enhanced if the evaluation system solution were revised to eliminate (trade-off) all of those features that exceeded the minimum requirements of the Life Safety Code in return for upgrading to the minimum required by the Life Safety Code of all those features that were less stringent than the requirements of the Code?

The response to these two questions consistently brought out the strengths and weaknesses in the solution. The second question tended to eliminate habitual or precedential preference to the Code.

The vast number of possible parameters prevented such an examination of every conceivable alternative that could be produced by the evaluation system. The process however was repeated through each of the questionable solutions derived through conditions found in the field surveys, occurring in the sample evaluation system submitted, or raised by any member of the review groups or any other source. The result was the development of a level of confidence in the consistency and validity of the products derived to produce a consensus of commitment to the validity and credibility of the system by the collected advisory groups.

In application, the system has demonstrated an ability to drastically reduce the cost of upgrading existing facilities to meet minimum levels of fire safety by allowing increased flexibility in design, and by developing additional options more suitable to operating management. The favorable nature of these attributes has led to additional applications in other types of construction.

As the result of the level of interest in using this approach in other areas the following brief protocol has been proposed as a guide to chosing problems amenable to solution by consensus evaluation systems such as the Fire Safety Evaluation Systems.

a. The data on methods available to attack the problem involve degrees of uncertainty that preclude solution through traditional analytical methods. This type of consensus approach should be considered inappropriate in any case where its possible to apply basic principles of physics and chemistry, established deterministic engineering procedures, or statistical analysis from a sufficient data base. However, where the preceding are not sufficiently complete to provide the needed answer, an evaluation system approach should be considered, with all available data used to increase the insight and competence of the participants.

b. The problem at hand involves complex interactions that have a potentially identifiable universe of parameters and the parameters have potentially identifiable levels of performance. The evaluation system appears to work best where the universe of the overall problem can be conveniently broken down into between 8 and 20 parameters and these individual parameters generally have at least three levels of performance.

c. The necessary degree of resolution of uncertainty is potentially within the limits of consensus by experts enhanced by the best available data. It must be expected that there will be a degree of variation even in the use of identical terms by experts. If mathematical precision to close tolerance is necessary, this approach is inappropriate. If however, the objective is to improve methods such as current codes and regulations that in themselves are produced by judgment, the evaluation system approach can both enhance the use of that judgment and bring those making the judgments to a finer level of appreciation and concensus in their efforts.

d. The necessary experts exist and will participate. This process is only as good as the talents of the participants. While the number of participants in any group appears to best function with 10 to 20 participants, the quality of the participants is significantly more important than the number. It is essential that participation in any of the judgment groups should be based on professional qualities rather than his/her position per se.

e. Working conservative solutions as opposed to predictive models will meet the needs. Evaluation systems must in all cases of dispute reach consensus by moving towards the safe or conservative position. The end result will be a system in which error is to the safety of the individual. As such, it should always over perform rather than be an exact model.

f. Project direction involves one or more persons with broad knowledge in critical aspects of the problem. While functional knowledge of operations research, delphi approaches, and other data organizational and analysis means are important, the development team must include a strong background in the type of occupancy or facility being evaluated and the technology of the objective of the evaluation (e.g., fire safety, accident prevention, security, etc.).

In summary, it is felt that the Fire Safety Evaluation System, similar to other grading systems that have appeared around the world in recent years, opens up new approaches to rational and sensible approaches to meeting the safety needs of the public. For the specific objectives of this conference it is felt that the approach of developing a focused consensus on the individual values of the safeguards, followed by a reasonably exhaustive analysis of their impact on overall performance, presents an additional mechanism useful towards the enhancement of judgment decisions.

References

1. Nelson, H.E. and Shibe, A.J., A System for Fire Safety Evaluation of Health Care Facilities, NBSIR 78-1551-1, National Bureau of Standards, Washington, D.C., 1980.

2. Life Safety Code, NFPA 101-1981, National Fire Protection Association, Quincy, Massachusetts, U.S.A., 1981.

3. Firesafety Concepts Tree, National Fire Protection Association, Quincy, Massachusetts, U.S.A., 1980.

Table 4. SAFETY PARAMETERS VALUES							
PARAMETERS	PARAMETERS VALUES						
1. CONSTRUCTION	COMBUSTIBLE				NONCOMBUSTIBLE		
	WOOD FRAME		ORDINARY				
FLOOR OF ZONE	UNPROTECTED	PROTECTED	UNPROTECTED	PROTECTED	UNPROTECTED	PROTECTED	FIRE RESIST.
FIRST	-2	0	-2	0	0	1	2
SECOND	-7	-2	-4	-2	-2	1	4
THIRD	-9	-7	-9	-7	-7	2	4
4TH & ABOVE	-13	-7	-13	-7	-9	-7	4

PARAMETERS	PARAMETERS VALUES				
2. INTERIOR FINISH (Corr. & Exit)	CLASS C	CLASS B	CLASS A		
	-5	0	3		
3. INTERIOR FINISH (Rooms)	CLASS C	CLASS B	CLASS A		
	-3	1	3		
4. CORRIDOR PARTITIONS/WALLS	NONE OR INCOMPLETE	<1/3 HR	≥1/3 HR <1.0 HR	≥1.0 HR	
	-10 (0)*	0	1 (0)*	2 (0)*	
5. DOORS TO CORRIDOR	NO DOOR	<20 MIN FR	≥20 MIN FR	≥20 MIN FR & AUTO CLOS	
	-10	0	1 (0)***	2 (0)***	
6. ZONE DIMENSIONS	DEAD END MORE THAN 100'	DEAD END 30'-100'	NO DEAD ENDS >30' & ZONE LENGTH IS: >150'	100'-150'	<100'
	-6 (0)**	-4 (0)**	-2	0	1
7. VERTICAL OPENINGS	OPEN 4 OR MORE FLOORS	OPEN 2 OR 3 FLOORS	ENCLOSED WITH INDICATED FIRE RESIST: <1 HR	≥1 HR <2 HR	≥2 HR
	-14	-10	0	2 (0)*	3 (0)*
8. HAZARDOUS AREAS	DOUBLE DEFICIENCY: IN ZONE	OUTSIDE ZONE	SINGLE DEFICIENCY: IN ZONE	IN ADJACENT ZONE	NO DEFICIENCIES
	-11	-5	-6	-2	0
9. SMOKE CONTROL	NO CONTROL	SMOKE PARTITION	MECH. ASSISTED SYSTEMS: BY ZONE	BY CORRIDOR	
	-5 (0)***	0	3	4	
10. EMERGENCY MOVEMENT ROUTES	<2 ROUTES	MULTIPLE ROUTES: DEFICIENT CAPACITY	W/O HORIZONTAL EXITS	HORIZONTAL EXIT(S)	DIRECT EXIT(S)
	-8	-2	0	3	5
11. MANUAL FIRE ALARM	NO MANUAL FIRE ALARM		MANUAL FIRE ALARM: W/O F.D. CONN.	W/ F.D. CONN.	
	-4		1	2	
12. SMOKE DETECTION & ALARM	NONE	CORRIDOR ONLY	ROOMS ONLY	CORRIDOR & HABIT. SPACE	TOTAL ZONE
	0	2	3	4	5
13. AUTOMATIC SPRINKLERS	NONE	CORRIDOR	CORRIDOR & HABIT. SPACE	TOTAL BLDG.	
	0	2 (0)**	8	10	

NOTE: *Use 0 when item 5 is -10
**Use 0 when item 10 is -8
***Use 0 in zone with less than 31 patients in existing buildings

*Use 0 when item 1 is based on first floor zone or on an unprotected type of construction
**Use 0 when item 1 is based on an unprotected type of construction
***Use 0 when item 4 is -10

Figure 1. (Part 1 of 2) Table 4. Fire Safety Evaluation System for Health Care Facilities

Table 5. INDIVIDUAL SAFETY EVALUATIONS				
SAFETY PARAMETERS	CONTAINMENT SAFETY (S_1)	EXTINGUISHMENT SAFETY (S_2)	PEOPLE MOVEMENT SAFETY (S_3)	GENERAL SAFETY (S_G)
1. CONSTRUCTION				
2. INTERIOR FINISH (Corr. & Exit)				
3. INTERIOR FINISH (Rooms)				
4. CORRIDOR PARTITIONS/WALLS				
5. DOORS TO CORRIDOR				
6. ZONE DIMENSIONS				
7. VERTICAL OPENINGS				
8. HAZARDOUS AREAS				
9. SMOKE CONTROL				
10. EMERGENCY MOVEMENT ROUTES				
11. MANUAL FIRE ALARM				
12. SMOKE DETECTION & ALARM				
13. AUTOMATIC SPRINKLERS			÷ 2 =	
TOTAL VALUE	S_1 =	S_2 =	S_3 =	S_G =

Figure 1. (Part 2 of 2) Table 5. Fire Safety Evaluation System for Health Care Facilities

SAFETY PARAMETER	Life Safety Code (Multi-story-new)		Alternative From Evaluation System	
	Score	Requirement	Score	Requirement
1. Construction	4	≥ 2 HR Fire Resistive	2	≥1 HR Fire resistive
2. Interior Finish (Corr. & Exit)	3	Class A (Flame Spread) ≤ 25	3	(Same)
3. Interior Finish	1	Class B (Flame Spread) ≤ 75	- 3	Class C (Flame Spread ≤ 200)
4. Corridor Partitions/Walls	2	≥1 HR Fire Resistance	0	< 20 MIN. Fire Resistance
5. Doors to Corridor	1	≥ 20 Min. Fire Resistance	0	< 20 Min. Fire Resistance
6. Zone Dimensions	0	100 - 150 Ft. (33 - 50 M)	- 2	> 150 Ft. (> 50 M)
7. Vertical Openings	3	2 - HR Enclosure	0	Non Combustible Enclosure
8. Hazardous Areas	0	None	0	(Same)
9. Smoke Control	0	Smoke Partitions	3	Mechanical Assisted by zone
10. Emergency	0	Multiple Routes	- 2	Deficient Capacity
11. Manual Fire Alarm	2	Fire Alarm Connected To Fire Dept.	- 4	No Manual Fire Alarm
12. Smoke Detection	2	Corridors Only	0	None
13. Automatic Sprinklers	0	None	8	Corridors & Habitable Spaces

Figure 2. Comparative Presentation of Alternative (typical)