System for Fire Safety Evaluation of Health Care Facilities

The Fire Safety Evaluation System (FSES) for Health Care Facilities [1] was the first of a series of FSES documents covering a variety of types of occupancies including apartment buildings [2], prisons and jails [3], office and laboratory buildings [4], overnight accommodations in National Parks [5], and board and care facilities [6]. These have provided means for meeting or exceeding the level of safety prescribed by the applicable code while providing the designer with a wide range of cost saving and functional options.

The FSES's have been adopted into building codes and similar regulations and have been institutionalized by the establishment of a special technical committee of the National Fire Protection Association (NFPA) charged with the responsibility for Alternative Methods for Life Safety in Buildings. This committee maintains NFPA Standard 101A [8] in support of the FSES's, thereby ensuring that each FSES remains current and an appropriate reflection of the changing safety levels prescribed by building codes and regulations. This description, however, focuses on the FSES for Health Care Facilities, as a representative sample of the complete series.

The FSES for Health Care Facilities was part of a broad fire safety effort sponsored by the Department of Health and Human Service in response to an important need to develop a means for meeting the fire safety objectives of prescribed codes without necessarily being in explicit compliance with the code. In the 1960s, with the birth of the Medicare and Medicaid programs, Congress prescribed conformance with the requirements of the Life Safety Code, National Fire Protection Association Standard 101, in all nursing homes and hospitals receiving funds under those programs. A nation-wide inspection and enforcement program was established to ensure compliance. Most, if not all, inspected facilities were found to be in some degree of non-compliance with the specific requirements of the Life Safety Code. A significant number were closed as a result. Others undertook correction programs. Many, including some of the Nation's largest and most prestigious hospitals, were declared to fail this safety standard.

The FSES for Health Care Facilities was developed to discover alternate solutions, delivering at least an equivalent level of safety as compared to that produced by exact compliance with the detailed prescriptions of the Life Safety Code. In the case of one large hospital complex, the use of the FSES reduced the cost of compliance from an estimated $30 million to $60 million to less than $2 million. Equally important, the development of alternative approaches allowed the improvements to be made without interruption of hospital services.

The FSES is a grading system designed to determine the overall level of fire safety of an existing or proposed facility in comparison with a hypothetical facility that exactly matched each requirement of the Life Safety Code. The enclosed figure shows Table 4 and 5 of the FSES for Health Care Facilities. These two tables are the most critical to the evaluation. These tables describe most of the universe of common building factors that determine fire safety, such as type of construction, partitioning and finishes, hazardous activities, fire detection and suppression, and fire alarm systems. For practical considerations, however, factors relating to building utilities, furniture, and emergency procedures are handled elsewhere in the FSES.

The levels of parameter values in Table 4 represent the levels of performance that exist in the real world of health care facilities. Some are those required by the code, while others have either more or less impact on safety than the code requirements.

The values assigned to each level are dimensionless, developed through consensus and designed to be comparative in relative value in both the evaluation of the levels within a parameter and between parameters. The specific values for each element in a parameter were developed by iteration through three separate Delphi panels. The base scale of measurement was established by these panels with the directive that the most powerful safeguard was assigned a score of 10, and an element that neither added to or detracted from safety was score 0. Using this scale, all other elements were scored with negative numbers representing an element detrimental to life safety and positive numbers representing elements additive to life safety.

Computer analysis was used to evaluate all possible permutations. The overall safety of the resulting solutions was then evaluated by the Delphi groups. The iterative process of adjusting parameter element values and appraising the resultant level of safety continued until all of the panels concurred that all solutions indicating a level of fire safety that equaled or exceeded the level provided by rigid conformance with the letter of the code did deliver that indicated level of safety.

TABLE 4. SAFETY PARAMETERS VALUES

PARAMETERS	PARAMETERS VALUES						
1 CONSTRUCTION	COMBUSTIBLE				NONCOMBUSTIBLE		
	WOOD FRAME		ORDINARY				
FLOOR OR ZONE	UNPROTECTED	PROTECTED	UNPROTECTED	PROTECTED	UNPROTECTED	PROTECTED	FIRE RESIST.
FIRST	-2	0	-2	0	0	2	2
SECOND	-7	-2	-4	-2	-2	2	4
THIRD	-9	-7	-9	-7	-7	2	4
4^{TH} & ABOVE	-13	-7	-13	-7	-9	-7	4
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	<1/2 HR	≥1/2 TO 1 HR	≥1HR			
	-10(0)*	0	1(0)*	2(0)*			
5 DOORS TO CORRIDORS	NO DOOR	<20 MIN FR	≥20 MIN FR	≥20 MIN FR AND 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 0R 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		SINGLE DEFICIENCY		NO DEFICIENCIES		
	IN ZONE	OUTSIDE ZONE	IN ZONE	OUTSIDE ZONE			
	-11	-5	-6	-2	0		
9 SMOKE CONTROL	NO CONTROL	SMOKE PARTITIONS		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 EXITS		DIRECT EXITS
	-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	CORRIODR & 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 on 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

Fig. 1a. Illustration of the FSES rating system (Part 1).

The parameter values established in Table 4 are transferred to Table 5. Table 5 evaluates the importance of each parameter to the fire safety sub-objectives of fire containment, extinguishment, and people movement. This approach avoids the overdependence on any single parameter and ensures a degree of redundancy as expected as part of the overall fire safety of a facility.

The scoring derived from Table 5 is compared with the score developed by the previously mentioned hypothetical facility. If the score of the facility under evaluation equals or exceeds that of the hypothetical facility in all sub-objectives, the facility is deemed to be in conformance with the objectives of the Life Safety Code.

The validity of the FSES rests primarily on:

a. the completeness of the universe of parameters and parameter factors in Table 4;

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

c. the relationships established in Table 5.

The details of how this validity was achieved are contained in reference [1]. An informative discussion of the relevance of the approach to validity is available in Nelson's paper *An Approach to Enhancing the Value of Professional Judgement in the Determination of Performance Criteria* [7].

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=

Fig. 1b. Illustration of the FSES rating system (Part 2).

The FSES for Health Care Facilities was adopted by the National Fire Protection Association as part of the 1981 edition of the Life Safety Code. It provided a recognized means of developing alternative approaches to determine compliance with the code in that and later editions of the Life Safety Code.

Subsequently, the Life Safety Code adopted FSES's developed by NBS/NIST covering Detention and Correctional Occupancies (i.e., prisons and jails), Board and Care Occupancies, and Office Occupancies. In 1995 the National Fire Protection Association created a new document NFPA 101A, *Guide on Alternative*

Approaches to Life Safety [8] to gather and contain the FSES's in a single publication and place them in the care of a single technical committee. Harold Nelson was the initial chair of this committee, and upon his retirement the chair was given to David Stroup, also of NIST.

The FSES's have stood the test of time and are now a regular part of life safety design in many buildings. They have both improved safety and reduced costs. In the NIST study *Benefits and Costs of Research: A Case Study of the Fire Safety Evaluation System* by Chapman and Weber [9], an estimated savings of almost $1 billion up to 1995 was credited to the FSES for Health Care Facilities. Unmeasured but significant savings have also been achieved by the other FSES's.

In the early 1980's Chapman and his colleagues [10] extended the work of Nelson's team by the development of a cost optimizer computer program enabling the user to determine the best cost acceptable alternatives to achieving equivalent safety with the Life Safety Code requirements for Health Care Facilities. In 1994 this work was used to develop the computer program *ALARM 1.0, Decision Support Software for Cost-Effective Compliance with Fire Safety Codes* [11].

Nelson retired from NIST in 1992 but continues actively as a consultant in fire safety matters. Nelson's honors include the Department of Commerce Silver and Gold Medals; Federal Research Laboratory Consortium Special Award for Technology Transfer; Society of Fire Protection Engineers, Harold E. Nelson Professional Service Award (inaugural awardee); Standards Medal of the National Fire Protection Association; and the Kawaoe Metal of the International Association for Fire Safety Science for lifetime contributions to fire safety science.

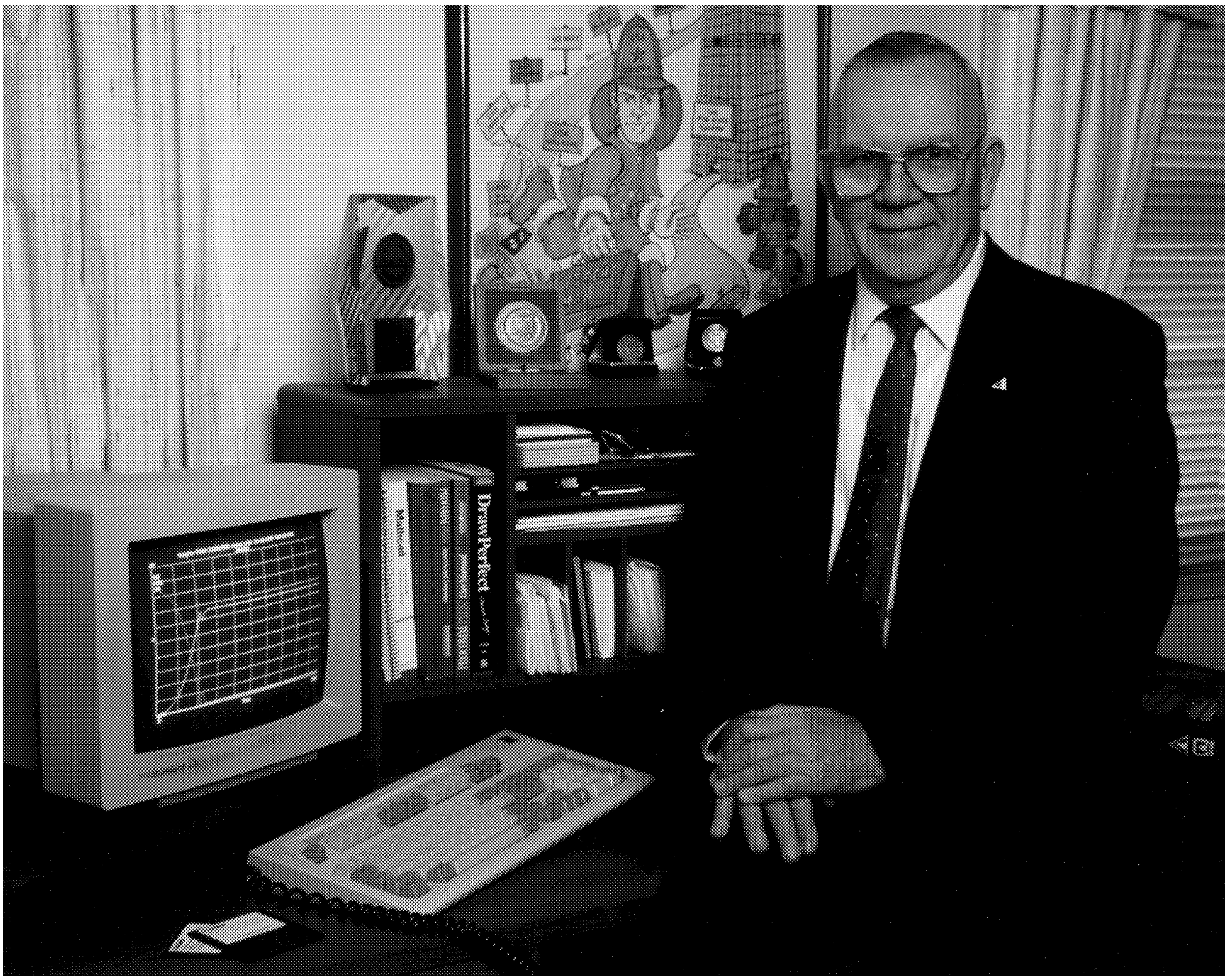

Fig. 2. Harold Nelson.

In the long term, the principal importance of the fire safety evaluation systems lies not only in the specific objective of delivering safety with lower cost and greater design flexibility, but also in the demonstration that a total performance approach to fire safety is feasible.

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