Toward a fire protection planning approach II: some considerations in implementing the life safety design assessment procedure

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PREFACE

Systematic approaches to the fire protection planning of buildings are not new. Dissatisfactions with aspects of the customary building code approach have led to the proposal at various times of a number of philosophic approaches intended to complement or supplant traditional procedures, but these have seldom addressed themselves intimately to the building designer and the design process.

The life safety design assessment procedure discussed here was conceived as a practical working tool that would be simple for designers to use and as an aid to common sense and plain thinking in designing for fire safety. The initial steps taken to develop that tool are described. Although certain weaknesses preclude further development of the approach in its present form, a possible way around this difficulty is thought to lie in the concept of a fundamental set of "attributes" that underlie, and characterize the effectiveness of, the techniques utilized by fire protection designers.

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TOWARD A FIRE PROTECTION PLANNING APPROACH - II. SOME CONSIDERATIONS IN IMPLEMENTING THE LIFE SAFETY DESIGN ASSESSMENT PROCEDURE

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During development of the philosophic foundation discussed by Quirouette,[1] thought was also given to how the approach, as then conceived, might be developed into a practical working tool. The philosophy itself was subsequently further developed and modified, so there is no longer an exact correspondence between the current versions of the working and philosophic approaches. This report is intended simply as a record of thoughts developed and work done on the working approach.

The working approach, which will be termed the life safety design assessment procedure, was intended to be simple in use, an aid to common sense and plain thinking about designing for fire safety. Certain weaknesses preclude further development of the approach in its present form, but there is a possible way around this difficulty.

DESCRIPTION OF THE PROCEDURE

The heart of the procedure is a table derived from one originally drawn up by Quirouette (Figure 1). The fundamental tools of fire protection practice are listed in a column at the left of the table, expressed in forms that make them as basic and independent of each other as possible. The list is open to improvement. These basic concepts will be referred to as principles. Any realistic building fire safety design must necessarily combine several of the principles. Such a workable combination will be referred to as a system. This is the only usage of the word that will be employed in this report.

This original table, identified as "Form B", was intended to be used for life safety assessment. Other versions of the form were to have been used for assessing protection of other values, e.g., property. The various types of hazards, which in the life safety context are Fire and Smoke, were considered separately using two different renderings of Form B. The use of the tables will be illustrated by reference to Case Study No. 1 which as Quirouette has explained pertains to a high-rise apartment building of a specific configuration.

The empty columns in the table are assigned to all those typical areas or spaces in the building where people may be when a fire occurs, e.g., an apartment suite (specifically, the one on fire), spaces elsewhere on the fire floor, spaces elsewhere in the building generally, shafts intended for circulation, and so on.

The columns (building spaces) and the rows (fire protection principles) together create an array or matrix of small boxes. The intended mode of use of the array was to determine, by asking the question at the foot of the table, whether each principle "contributed" to the life safety of the occupants of each typical area or space, thus filling the boxes with affirmatives (YES) and negatives (NO). The basis of these answers was to be informed judgement, supported to the maximum possible extent by explicit technical knowledge. Using a series of such tables sequentially, each time considering sets of first one, then two, then three and so on, principles combined into a system, and each time completing all the answers, one was to be directed toward systems which constituted workable life safety designs.

THE MEANING OF LIFE SAFETY

One could surmise that an ideal goal of life safety design would be to prevent the loss of even one life annually by fire in Canada, in all buildings, under all imaginable circumstances, regardless of cost. Practically, it must be admitted that in some circumstances there is no conceivable way to forestall the loss of a life. Besides, there undoubtedly exists some limit of toleration to the expenditures needed to avert life losses. With regret, one concedes that society cannot afford to protect its members against all imaginable circumstances.

A practical goal may be thought of as optimal building fire protection -- the most economic form of fire protection capable of providing an appropriate degree of safety to the occupants of a building if there is a fire. This redefinition still evades the real question, because the meaning of an "appropriate" degree of safety is not made clear. To discover it, one would be forced to re-ask the old questions. How safe is safe? How safe is safe enough? What does society expect? What will society accept? What is a knowledgeable risk? What is a reasonable precaution? The answers to these questions have yet to be discovered.

For the time being, to provide motivation and an objective for the study, the following hierarchy of life safety goals is put forward. Occupants should be protected in place if possible, but failing this it should be ensured that if anyone is called upon to leave the fire location or the building, he or she can do so in an orderly unhurried manner, which we term evacuation. It is not desirable that any occupant should be subjected to the need to escape -- that is, to depart in undue haste because of imminent peril. It is not tolerable that any occupant should ever have to rely entirely upon external aid under extremely desperate circumstances -- that is, upon rescue.

EXECUTING THE PROCEDURE FOR SMOKE HAZARDS

These considerations prompted replacement of the question asked in Form B (i.e., whether a principle contributed to life safety) by the more positive one of whether the principle or system under consideration was potentially capable, without further additions, of providing an appropriate degree of safety. In addition, the range of possible answers was extended by the use of a question mark as a qualifier, thus giving NO (no promise of capability), NO? (dubious promise), YES? (possible promise) and YES (definite promise).

The amended table (Figure 2) has been completed to show the results of the operations which will now be explained. Case No. 1 -- high-rise residential -- is under study, and the sub-case specifically examined is that of fire occurring in one of the apartment suites. For the moment, only the smoke hazards are considered. The significance of the labels of the various occupied spaces must also be explained. "Suite" is the fire suite. "Floor" is all the rest of the fire floor, excluding the fire suite. "Building" is all the rest of the building excluding the fire floor. Each space is thus exclusive of the lower-scaled spaces to its left in the table, except that "shaft" does not fit into this relationship and perhaps should have been placed separate from the others.

Figure 2 was used to apply the question about potential sufficiency to those systems that comprised only a single one of the fourteen basic principles. The answers were filled in very quickly simply by inspection. The intuitive judgements so made are of course open to challenge, although the situations are so clearcut that any group of fire technology specialists would probably experience little difficulty in reaching agreement on the correct answers to be entered into the decision matrix. The reasoning behind their judgements, which at this stage might amount to only a simple sentence or two for each entry in the array, could be written down and preserved, a process which will be termed documentation.

The conclusion to be drawn from Figure 2 is that no single fire protection feature, used entirely alone, can provide effective protection against the hazard of smoke for any person anywhere in the building. The logical next step in seeking superior performance is to examine systems comprising two of the fourteen basic principles. There is a very large number of such two-level systems, and the strict logic of the procedure imposes the considerable task of assessing them all because there is so far no rationale for deciding which are the most promising prospective combinations. For the exploratory purpose of this study it was decided to examine only those two-level systems comprising sprinklers as one of the two principles. The results of this examination are presented in Figure 3.

Once again, these relatively simple systems do not suffice to provide an appropriate degree of safety to all the occupants of the building. Once again, documentation could have been prepared to explain the reasoning behind each decision.

In preparing to examine systems comprising three principles, the problem again arises that there is a very large number of such systems. Even if all those not including sprinklers were temporarily disregarded, the task of evaluating the remainder would still be formidable. For the present purpose, guidance for further simplification was obtained from Figure 3, where it can be seen that there is potentially some promise in systems that combine sprinklers with some form of smoke movement control. The choice was made to investigate only the three-level systems that contain both these principles.

This method of choosing indicates a possible method of simplifying the task of preparing documentation for all the possible combinations of fourteen principles taken severally at a time, exceeding three hundred thousand in number. Each successive table might be used as one step in a sequential search procedure which would direct the user toward the most promising systems, thus providing relevant results as quickly as possible. The functional imperatives of a given occupancy or a particular building design might provide additional constraints which would reduce the area to be swept by the search procedure. The difficulty of this otherwise attractive simplification is that many paths which appear unsatisfactory in low-level tables might eventually produce effective and economic systems as additional principles were added. In addition, the original predetermined choice of design parameters would be perpetuated, whereas a wider-ranging procedure might suggest viable alternative design imperatives. Over-simplification of the procedure can thus result in the adoption of suboptimal systems.

The three-level systems shown in Figure 4 all appear to promise some potential effectiveness in providing protection against smoke hazards to persons other than those in the suite where the fire originated. The exploratory study was not carried beyond this level, but it is evident that from here on reasoned argument for each decision, and documentation, would be essential to guide each successive choice of path in the search procedure.

EXECUTING THE PROCEDURE FOR FIRE HAZARDS

The analogous table for analysis of the hazard of direct exposure to fire is somewhat smaller (Figure 5) because two exclusively smoke-related principles have been dropped. In the present case, the principles listed in the table, and the question asked, refer only to spread of fire within the building. As before, the decisions for this one-level table were entered into the array very rapidly on the basis of intuitive judgements.

It again appears that no single principle used alone provides appropriate protection. This time, however, there are a few qualified answers in the top line (e.g., "maybe yes") that suggest the next step in the search procedure might well be two-level systems incorporating sprinklers as one of the two principles. Following this more promising direction as a short cut leads to a two-level array (Figure 6) that offers many more promising further directions than did the corresponding smoke table. The rows containing the greatest aggregate promise values presumably indicate the most favourable directions, but there is no clearcut choice. However, circulation routes (which can also be used for egress) are one of the functional imperatives of conventional building, so the choice was made (Figure 7) to examine three-level systems combining sprinklers and routes of egress with any one other principle.

In this new decision array there are two quite promising systems, indicated by arrows. In particular, it looks as though systems having sprinklers and egress routes plus alarm systems may be potentially sufficient to assure safety of all occupants of the building against the hazard of direct exposure to fire originating in a suite. The decisions are of course still only snap judgements; if documentation had been prepared the accompanying reasoned assessments might very likely have resulted in a different, and perhaps less promising, line-up of definite or qualified affirmatives and negatives.

COMBINING THE SMOKE AND FIRE SYSTEMS

The fire protection design finally adopted must be capable of achieving all the objectives specified by both the smoke and fire analyses. When the two systems comprise the same or nearly the same list of principles, but with differing intensities, it is mainly a matter of ensuring that all those principles are present in the final design and that each is applied at the highest intensity called for by either of the two systems. This process is analogous to that of meeting the most restrictive requirements in conventional code-type design.

On the other hand, when the line-ups of principles in the two systems are dissimilar, the synthetical line of attack just mentioned could lead to overdesign or redundancy in the fire protection plan, because principles called for by only one system may in fact be performing also some functions which are served by entirely different principles required by the other system. The concept of equating fire hazard attributes and fire protection principle attributes, proposed by Quirouette, could be applied with considerable effect here, to determine which principles are performing like functions and thus lead to optimization of the synthesized design.

THE SIGNIFICANCE OF DOCUMENTATION

The primary purpose of the documentation process is to force reasoned assessment of the arguments for and against each decision, invoking at the same time at least some awareness of the goals of the fire protection design and the hazards and factors involved. These implicit considerations, which Quirouette subsequently made much more explicit by his introduction of the concept of attributes, could be expressed in questions such as "What are the hazards to which a person in this (currently being considered) space is exposed?", "What are his true needs in terms of fire protection?", "What are the qualities (i.e., attributes) that this or that principle can contribute to provide protection against the hazards?" Documentation tends to promote common-sense thinking based on factual information rather than emotion. It can also promote awareness of areas where information is deficient or lacking.

THE INTENSITY PROFILE OF A SYSTEM

Projecting a little further the decision array manipulations discussed earlier, one can visualize the outcome as being, perhaps, that for a given building sufficient safety is provided by a particular five-level system comprising a certain set of principles.

This would be a misleadingly oversimplified statement, because any or all of the principles involved might be capable of being applied with a range of degrees of determinedness (intensity), some of which would fall below the degree needed for effective performance. For example, simply to mention the principle "fire resistance" ignores the fact that this principle can be applied with intensities ranging from 15 or 20 minutes exposure to the standard fire test, at the low end, to 8 or even 16 hours at the high end. For any given purpose, all intensities of application below a certain level (say 2 hours) will fail to provide the desired performance, while intensities at or above that level will provide the desired performance or better.

Evidently each principle must be applied with an intensity commensurate with the hazard against which it provides protection. Any lesser intensity will be unacceptable from the life safety point of view; any higher level (even if overdesigned or excessively costly) will be acceptable because one is sure of achieving at least the desired degree of safety. (Each principle, of course, possesses one or more attributes, each of which contributes protection against one or more different types of hazards. Effective protection against a given hazard is the sum-total result of partial protection provided separately by several principles possessing a common attribute relevant to that hazard. One can perceive other ways in which principles interact to provide superior levels of protection. Thus the remarks about intensities made earlier in this and in the preceding paragraph should be modified to recognize that ultimately it is the total intensity with which a given attribute must be applied that determines the needed intensities of the contributing principles.)

Suppose that the intensities with which each principle can be applied can be quantified in some manner on an arbitrarily defined scale running from one to ten. Any particular fire protection system can then be represented by a bar chart (Figure 8) in which each bar represents one of the constituent principles of the system and the length of the bar represents the intensity with which that principle is applied in the system. Every system will have a unique chart: its intensity profile.

The results of the assessment and documentation process can thus be summarized in profile form. Profiles can be constructed for generalized systems, producing something akin to a building code, or for specific building design proposals.

PRACTICAL USES OF THE PROCEDURE

Some possible applications of the intensity profile idea have been explored and will now be discussed. It is assumed that for a particular generalized building occupancy and configuration all the workable systems have been identified, the appropriate intensities have been assessed for the constituent principles of each system, and all the documentation has been prepared. The result is a vast library of profiles, which can be sorted and matched endlessly according to any needs that arise. The library constitutes a building code containing all the acceptable fire safety designs for the chosen occupancy and configuration. Profiles of all the unacceptable designs (which necessarily have been examined and rejected during the assessment procedure) could also be filed, in this or another library.

Possible Applications

1. The two profiles shown in Figure 9 obviously came from the same shelf in the library. Both systems have already been through the entire assessment procedure and have been judged sufficient. However, it will be seen that the top principle, whatever it may be, is applied with less intensity in the second system, while the bottom principle is applied more intensely. This means that the outlined area at the top has been exchanged against the shaded area at the bottom.

To the extent that the two systems provide comparable protection, this is a true tradeoff. In practice, one may be an optimal system, providing just enough protection, while the other provides more than is essential. The building designer, knowing that both have passed the assessment test, has the freedom to choose whichever of these -- or their near relatives -- is more economic or suitable for his proposed building.

2. In the same situation as above, the designer may have constructed the profile for his own proposed fire safety design, and found that it does not appear anywhere in the library, but that the two shown in

Figure 9 most nearly match his own. The documentation for the two near matches then provides him with a sound basis for asessing what changes (if any) may be necessary in his proposal.

3. The two systems whose profiles are shown in Figure 10 are again almost look-alikes, except that in the second profile one principle has been omitted (sprinklers) and another, unspecified, substituted for it. Since both systems are assumed to have been subjected to the assessment procedure, and since both have been judged sufficient, Figure 10 represents another type of tradeoff.

4. There are many differences between the two systems shown in Figure 11 -- they come from entirely different shelves in the library of profiles -- so they are not really quite comparable. A designer might find, however, that one or the other offered worthwhile economies and he might choose to modify his design accordingly. This, too, is a type of tradeoff, but, more important, the designer is consciously using the library as a fruitful and comprehensive source of design initiatives.

5. Innovative designs, resembling nothing ever previously constructed, often pose problems for fire and code officials because they appear to incorporate many contraventions of conventionally accepted codified design principles. Lacking precedent, and lacking a coherent organized body of knowledge about fire safety, officials tend to impose conservative and restrictive requirements on the innovative design. Suggestions that these impositions sometimes seem completely arbitrary imply faults, not in the officials, but in the code-making and regulating process itself and in the support services provided for the officials.

The intent of Figure 12 is to show that the documentation associated with the library of profiles can be used by both sides, the designer or owner and the officials, as a common base of knowledge for resolving differences about the fire safety of innovative designs. It is supposed that a profile of the proposed innovative design has been constructed, using the library documentation as a procedural guide, and that the library has been searched for the judged-effective profile that most closely matches the proposed one. Any deviations between the two profiles then become clearly evident, and the consequences of the deviations can be discussed unequivocally in the light of the documentation of the library profile.

SYSTEMS SUBJECT TO STATISTICAL FAILURE

Most fire protection principles are at least slightly susceptible to random failure when called upon to perform, whether through poor design, careless installation, faulty maintenance, human error or pure bad luck (which we call chance). A sufficiently safe system then can become a potentially unsafe one, by reason of the failure of one principle to perform as expected.

The implications of such situations are sometimes deliberately overlooked, as when excessive concessions or unlimited tradeoffs are allowed when a building is fully sprinklered. On the other hand, it is unrealistic to attempt to design on a completely statistical basis, using the various methods of probabilistic analysis of fire safety, because much of the necessary statistical data base of such analyses is essentially unavailable.

A philosophic approach will now be presented which, although ingenuous, is a satisfactory vehicle for rigorous appraisal of random-failure situations.

Take the case of a six-level system incorporating sprinklers in which, for one reason or another, the sprinklers fail to perform as expected. The system is then, in effect, degraded to a five-level system (Figure 13) whose profile can be matched against those in the library. The documentation belonging to the matches might show that the profile still represented a system capable of achieving the desired degree of safety, but one would expect the more usual result to be that the best-matching profile had previously been assessed as insufficient.

The question then arises -- and this must be a policy decision -- given the objective of saving all lives, and given that in a statistically known proportion of fire incidents the sprinklers will fail to perform as expected, is one willing to accept the reduced degree of safety of the five-level system on those few occasions when the sprinklers may fail? In other words, what diminished objective may one reasonably set for the diminished system?

SUGGESTED POLICIES FOR LIFE SAFETY

A possible rationale for establishing diminished objectives follows the safety hierarchy mentioned earlier: protect-in-place/evacuate/escape/rescue, each offering a greater likelihood of life loss to those involved.

Given the objective of protecting everyone in place (Figure 14), then part failure of one principle, or more serious failure of one or more principles, or failure of the entire life safety system, progressively expose more and more people to progressively greater hazard, escalating them downward in the safety hierarchy.

It is suggested that the basic policy should be that acceptable profiles must be such that no type of partial failure can subject large numbers of people to the levels of peril represented by escape or rescue conditions. A number of prohibited consequences can then be identified (barred in the Figure). Small numbers of people, such as those in one apartment suite, could conceivably be allowed to be subjected to escape or rescue circumstances, but there must be full awareness that such a decision implies the policy commitment that those lives will potentially be placed in serious risk whenever a statistical failure occurs in one or another principle. This then gives rise to a prohibited objective (circle in the Figure). Prohibited objectives should be limited to those cases where it must be realistically admitted that effective protection is technically or economically not feasible.

ADVANTAGES OF THE LIFE SAFETY DESIGN ASSESSMENT PROCEDURE

For code writers

- aids in identifying every usable combination of fire protection principles
- encourages use of knowledge and reasoned assessment in making decisions about which combinations provide an acceptable level of life safety
- promotes conscious awareness of the true objectives of life safety regulation
- promotes conscious awareness of where knowledge is lacking and what knowledge is lacking
- encourages permanent record, ("documentation") of the reasoning behind each decision and each choice.

For designers and building officials

- provides a card-index or library function (the profiles) to aid in comparing proposed designs with systems known to afford an acceptable or superior level of safety
- by reference to the documentation, promotes rational and informed negotiation over design proposals which differ from any accepted system
- aids in the identification and assessment of so-called tradeoffs.

WEAKNESSES OF THE LIFE SAFETY DESIGN ASSESSMENT PROCEDURE

This procedure has been presented as a stagewise process. The presentation has been largely conceptual rather than concrete, describing what each stage is intended to do rather than how it would actually work in practice. The links between stages have been handled in a similarly facile fashion. Further, structures needed to incorporate the attribute concept into the procedure have been alluded to but not developed.

The dominant weakness of the procedure as described is the seemingly inescapable necessity to systematically perform assessments on all principle-intensity profiles for all typical building configurations in all occupancies. The task is not merely formidably large; it is impossible. Perhaps, if a start were made, valid short-cuts might gradually be discerned or ways found for applying results obtained for one configuration or occupancy to another, but these are by no means certain.

INCORPORATING THE ATTRIBUTE CONCEPT

The attribute concept seems to offer a way out of this dilemma.

(1) It seems almost certain that generalized rules could be devised for constructing the attribute-intensity profile required by a specific design proposal for any particular combination of occupancy and building configuration.

(2) It seems almost certain that rules could be devised for constructing the sum-total attribute profile of any proposed fire safety system.

(3) It seems probable that the results of 1 and 2 could be expressed on a common basis. The assessment procedure would then be simply one of comparing these two attribute profiles and varying the occupancy/configuration conditions and the fire safety design until the profiles matched.

(4) A more attractive and simpler procedure would be available if generalized rules could be devised for constructing principle-intensity profiles that satisfy the required attribute profile -- that is, the inverse of process 2 mentioned above.

(5) Process 2 would necessitate development of rules for weighting the contribution of each principle in a system to each element of the attribute profile. Each weighting factor would presumably depend on what other principles were present in the system and the intensities with which they were applied.

(6) Process 4 would call for rules by which a required attribute-intensity profile could be decomposed to yield all the possible principle-intensity profiles capable of satisfying the attribute requirements; knowledge of the weighting factors would still be necessary.

If these operations could be computer-programmed, as appears likely, an effective design tool would result: the designer could readily insert his own constraints and could vary his design requirements at will, obtaining as output a limited range of solutions highly relevant to his needs. The possibility of conflict with regulatory officials is still present in execution of the initial step (1) of determining the attribute-intensity requirements of a specific design proposal.

DEFINING RESEARCH AND STUDY NEEDS

The numbered processes above identify areas where research or study would be needed for developing these modified procedures. The development task would be less formidable than that for the original procedure because generalized rules are sought rather than a library of individual assessments and because the task is broken down into several largely independent areas which could be tackled separately. Further, the original judgement and documentation process, which was highly detailed and factual and might well have had to have a committee-type treatment, has been replaced by discrete subtasks of a more abstract character amenable to analytic treatment by technical specialists. The research effort required would thus be far less extensive, and the task could be tackled piecewise over a long period and yet yield definite results while still incomplete.

The comments on the practical employment of the attribute concept largely echo those of Quirouette. They are still entirely conceptual, but provide a good guide to establishing a detailed schedule of research and study needs. Some of the most important needs are as follows:

Identify the protective attribute requirements imposed by the hazards to which building occupants may be subjected;

find out how to quantify attribute intensity requirements, probably in relation to the type of space the occupant is in and the building configuration;

identify, and learn how to quantify, the attribute contributions of fire protection principles of varying intensities;

discover how to weigh the attribute contributions of the several principles in a system so as to determine the net effective attribute profile of the entire system.

Each of these is small enough and specific enough to tackle comfortably, yet each is a vital part of developing the modified assessment procedure.

CONCLUDING REMARKS

The attribute concept gives promise that it can be worked up into an effective design tool. The first step toward this end would be to define the elements of a research and study program to develop the tool. Existing programs could then possibly accommodate some of these elements without major shifts in resources, giving a sustained low-level output on this project without the need to dedicate any manpower exclusively to it.

Reference

1. Quirouette, R.L. Toward a Fire Protection Planning Approach. I. Concepts and Development. DBR Internal Report No. 418, May 1975.

FIRE PROTECTION ANALYSIS

FORM

B

Hazard characteristic under consideration is

CASE STUDY #

MEASURE/PRINCIPLE									
Sprinklers									
Compartmentation									
Fire-resistive Construction									
Flame spread									
Pressurization of space									
Limitation of Fire load									
Non-Combustible Construction									
Smoke Control Measures									
Alternative egress route design									
Area of refuge Concept									
Detection & Alarm Systems									
Communication Systems									
Education & Administrative Plans									
Security Systems									

← AREAS CONSIDERED →

Y/N — Does the measure/principle contribute to the life safety of the occupants?

Figure 1 Basic Form B - Fire Protection Analysis

FIRE PROTECTION ANALYSIS

FORM

B

HAZARD CHARACTERISTIC
UNDER EXAMINATION IS

S M O K E

CASE STUDY # 1

Fire Starts in a Suite

L O C A T I O N   O F   O C C U P A N T

P R I N C I P L E	SUITE	SHAFT	FLOOR	ENTIRE BUILDING	OTHER BUILDINGS
Sprinkler and Automatic Extinguishment (whole building)	no	no	no	no?	
Smoke Barriers	no	no	no	no	
Control of Pressure Differentials	no	no	no	no	
Fire Resistance	no	no	no	no	
Flame Spread of Finish	no	no	no	no	
SDC of Finish	no	no	no	no	
Reduction of Fire Load (Contents)	no	no	no	no	
Reduction of Fire Load (Construction)	no	no	no	no	
Provision of One or More Egress Routes	no	no	no	no	
Area of Refuge Concept	no	no	no	no	
Detection Systems	no	no	no	no	
Alarm and Communications Systems	no	no	no	no	
Tactical Control of Evacuation Behaviour	no	no	no	no	
Fire Fighting (First Aid and Professional)	no	no	no	no	

S Y S T E M S
C O M P R I S I N G
- SINGLE -
P R I N C I P L E S

YES/NO - Is the principle or combination potentially sufficient to assure the safety of occupants of the selected space?

Figure 2

FIRE PROTECTION ANALYSIS

FORM

B

HAZARD CHARACTERISTIC
UNDER EXAMINATION IS

SMOKE

CASE STUDY # 1

Fire Starts in a Suite

LOCATION OF OCCUPANT

PRINCIPLE	SUITE	SHAFT	FLOOR	ENTIRE BUILDING	OTHER BUILDINGS
Sprinkler and Automatic Extinguishment (whole building)	- common to all -				
Smoke Barriers	no	no	no?	yes?	
Control of Pressure Differentials	no	no	yes	yes	
Fire Resistance	no	no	no	no	
Flame Spread of Finish	no	no	no	no	
SDC of Finish	no	no	no	no	
Reduction of Fire Load (Contents)	no	no	no	no	
Reduction of Fire Load (Construction)	no	no	no	no	
Provision of One or More Egress Routes	no	no	no	no	
Area of Refuge Concept	no	no	no	no	
Detection Systems	no	no	no	no	
Alarm and Communications Systems	no	no	no	no	
Tactical Control of Evacuation Behaviour	no	no	no	no	
Fire Fighting (First Aid and Professional)	no	no	no	no	

SYSTEMS COMPRISING **2** PRINCIPLES

YES/NO - Is the principle or combination potentially sufficient to assure the safety of occupants of the selected space?

Figure 3

FIRE PROTECTION ANALYSIS

FORM

B

HAZARD CHARACTERISTIC
UNDER EXAMINATION IS

SMOKE

CASE STUDY # 1

Fire Starts in a Suite

LOCATION OF OCCUPANT

PRINCIPLE	SUITE	SHAFT	FLOOR	ENTIRE BUILDING	OTHER BUILDINGS
Sprinkler and Automatic Extinguishment (whole building)	- common to all -				
Smoke Barriers	no	yes	yes	yes	
Control of Pressure Differentials	- common to all -				
Fire Resistance	no	yes	yes	yes	
Flame Spread of Finish	no	yes	yes	yes	
SDC of Finish	no	yes	yes	yes	
Reduction of Fire Load (Contents)	no	yes	yes	yes	
Reduction of Fire Load (Construction)	no	yes	yes	yes	
Provision of One or More Egress Routes	no	yes	yes	yes	
Area of Refuge Concept	no	yes	yes	yes	
Detection Systems	no	yes	yes	yes	
Alarm and Communications Systems	no	yes	yes	yes	
Tactical Control of Evacuation Behaviour	no	yes	yes	yes	
Fire Fighting (First Aid and Professional)	no	yes	yes	yes	

SYSTEMS COMPRISING **3** PRINCIPLES

YES/NO - Is the principle or combination potentially sufficient to assure the safety of occupants of the selected space?

Figure 4

FIRE PROTECTION ANALYSIS

FORM

B

HAZARD CHARACTERISTIC
UNDER EXAMINATION IS

F I R E

CASE STUDY # 1

Fire Starts in a Suite

LOCATION OF OCCUPANT

PRINCIPLE	SUITE	SHAFT	FLOOR	ENTIRE BUILDING	OTHER BUILDINGS
Sprinkler and Automatic Extinguishment (whole building)	no	no	no?	yes?	
Fire barriers	no	no	no	no	
Fire Resistance	no	no	no	no	
Flame Spread of Finish	no	no	no	no	
Reduction of Fire Load (Contents)	no	no	no	no	
Reduction of Fire Load (Construction)	no	no	no	no	
Provision of One or More Egress Routes	no	no	no	no?	
Area of Refuge Concept	no	no	no	no	
Detection Systems	no	no	no	no	
Alarm and Communications Systems	no	no	no	no	
Tactical Control of Evacuation Behaviour	no	no	no	no	
Fire Fighting (First Aid and Professional)	no	no	no	no	

SYSTEMS COMPRISING - SINGLE - PRINCIPLES

YES/NO - Is the principle or combination potentially sufficient to assure the safety of occupants of the selected space?

Figure 5

FIRE PROTECTION ANALYSIS

FORM

B

HAZARD CHARACTERISTIC UNDER EXAMINATION IS

F I R E

CASE STUDY # 1

Fire Starts in a Suite

L O C A T I O N   O F   O C C U P A N T

P R I N C I P L E	SUITE	SHAFT	FLOOR	ENTIRE BUILDING	OTHER BUILDINGS
Sprinkler and Automatic Extinguishment (whole building)		- common to all -			
Fire barriers	no	no	no	yes?	
Fire Resistance	no	no	no	yes?	
Flame Spread of Finish	no	no	no?	no?	
Reduction of Fire Load (Contents)	no	no	no?	yes?	
Reduction of Fire Load (Construction)	no	no	no?	yes?	
Provision of One or More Egress Routes	no	no?	no?	yes?	
Area of Refuge Concept	no	no?	no?	yes?	
Detection Systems	no	no	no	yes?	
Alarm and Communications Systems	no	no	no	yes?	
Tactical Control of Evacuation Behaviour	no	no	no?	yes?	
Fire Fighting (First Aid and Professional)	no	no	no	yes?	

S Y S T E M S
C O M P R I S I N G
2
P R I N C I P L E S

YES/NO - Is the principle or combination potentially sufficient to assure the safety of occupants of the selected space?

Figure 6

FIRE PROTECTION ANALYSIS

FORM

B

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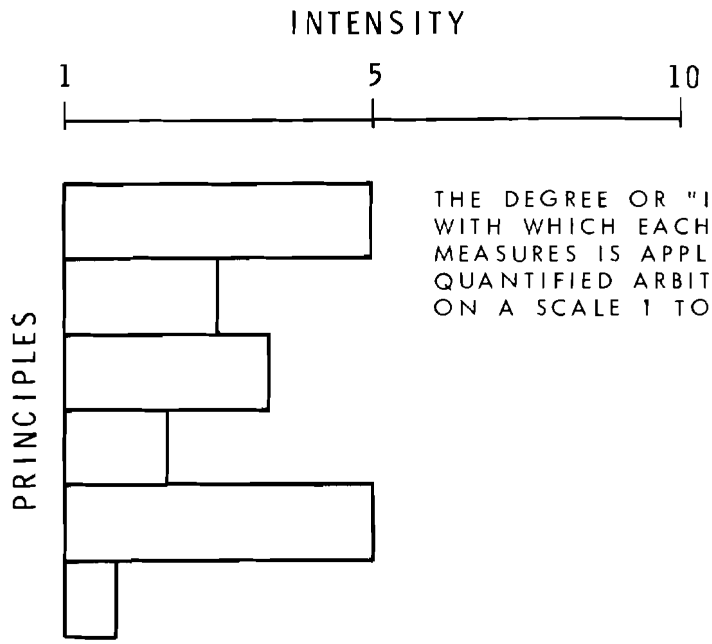
Reduction of Fire Load (Construction)	no	no	yes?	yes?	
Provision of One or More Egress Routes		- common to all -			
Area of Refuge Concept	no	no?	no?	yes?	
Detection Systems	no	no?	no?	yes?	
Alarm and Communications Systems	yes?	yes?	yes?	yes?	←
Tactical Control of Evacuation Behaviour	no	yes?	yes?	yes?	←
Fire Fighting (First Aid and Professional)	no	no	no	yes?	

S Y S T E M S
C O M P R I S I N G
3
P R I N C I P L E S

YES/NO - Is the principle or combination potentially sufficient to assure the safety of occupants of the selected space?

Figure 7



THE DEGREE OR "INTENSITY" WITH WHICH EACH OF THE MEASURES IS APPLIED IS QUANTIFIED ARBITRARILY ON A SCALE 1 TO 10.

FIGURE 8

THE (PROFILE/KEY/MATRIX) OF A COMBINATION OF SIX MEASURES WHICH MEETS OR EXCEEDS THE CHOSEN DEGREE OF SAFETY

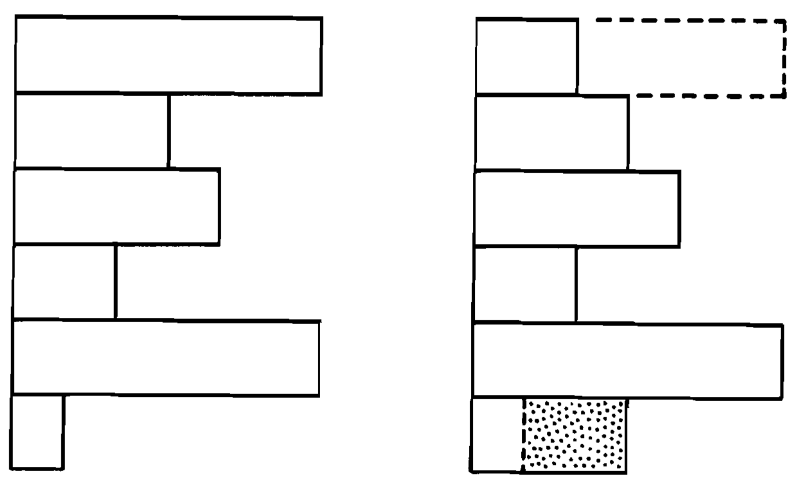


FIGURE 9

TRADEOFFS - 1, Balancing "Intensities"

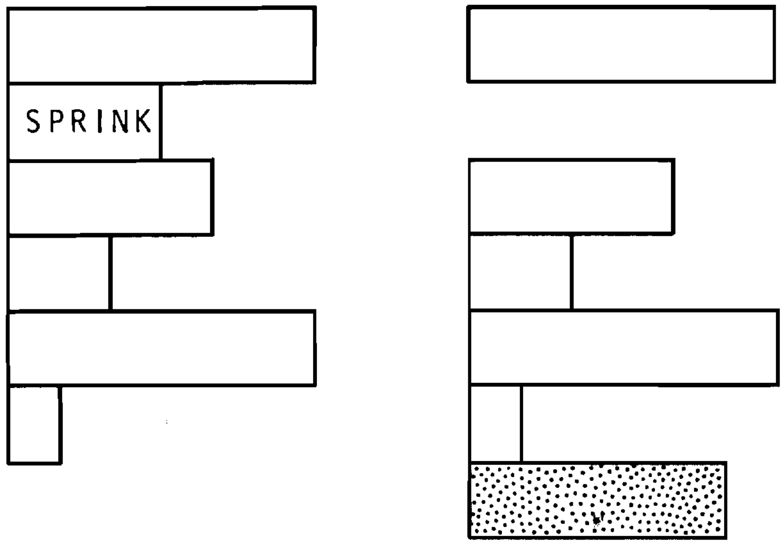


FIGURE 10

TRADEOFFS - 2, Substitution of Principles

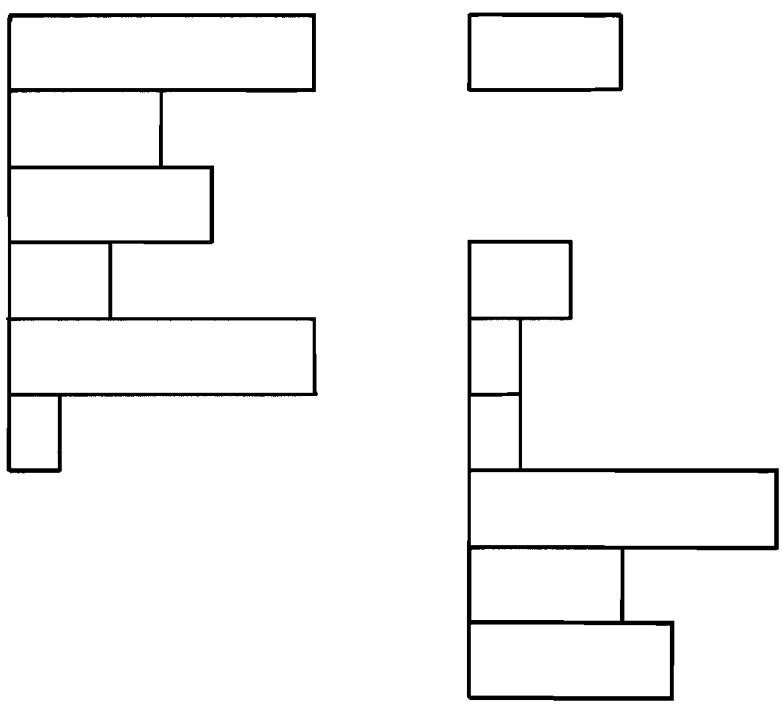


FIGURE 11

TRADEOFFS - 3, Differences of Design

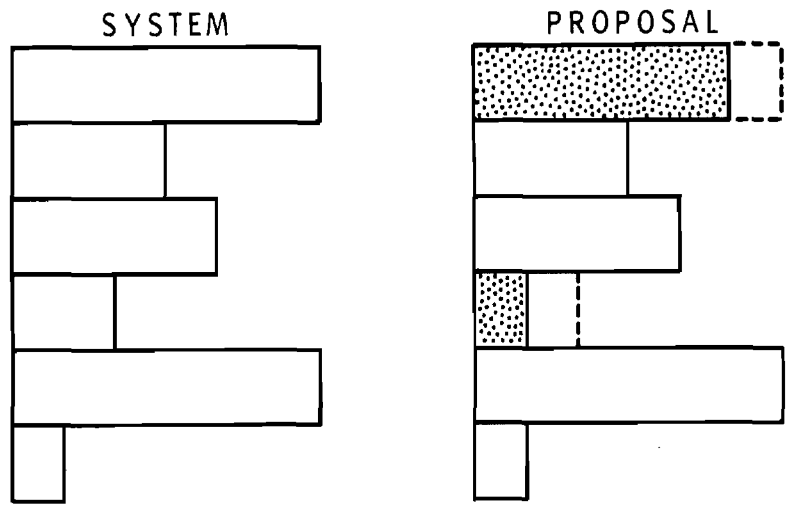


FIGURE 12

GETTING APPROVAL, A Basis for Negotiations

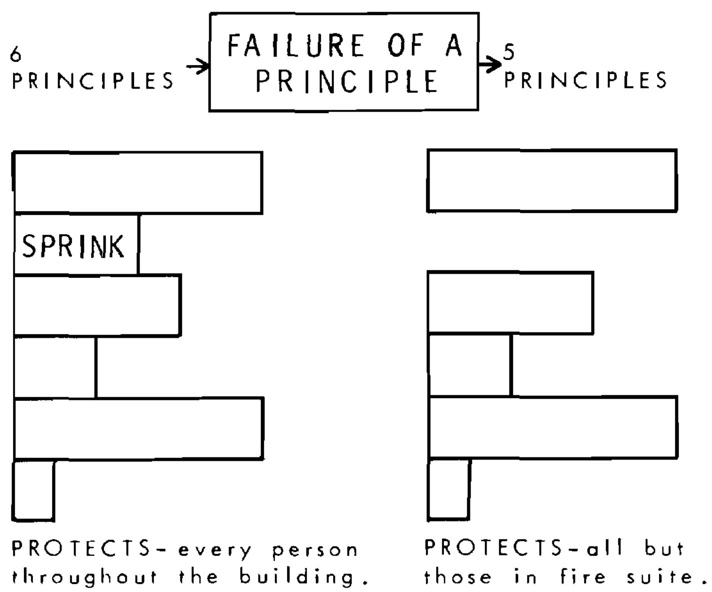


FIGURE 13

A POSSIBLE RATIONALE FOR ASSESSING SYSTEMS WHICH CONTAIN PRINCIPLES HAVING A STATISTICAL CHANCE OF FAILURE

	LOCATION OF PERSON HAZARDED		
FAILURE	FIRE SUITE	FIRE FLOOR	ELSEWHERE IN BLDG
NIL (System OK)	Protect in place	Protect in place	Protect in place
PARTIAL (part or full failure of one principle)	Evacuation	Protect in place	Protect in place
More serious	Escape	Evacuation	Protect in place
Very serious	Rescue	~~Escape~~	Evacuation
		~~Rescue~~	~~Escape~~
			~~Rescue~~

FIGURE 14

POLICY REGARDING ALLOWABLE CONSEQUENCES OF STATISTICAL FAILURE TO PERFORM AS EXPECTED