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Fire Safety Evaluation System for Office/Laboratory Buildings

H. E. Nelson

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Fire Research
Gaithersburg, MD 20899

November 1986

Sponsored by:
National Aeronautics and Space Administration
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TABLE OF CONTENTS

	Page
Abstract	1
1. INTRODUCTION	1
2. DEVELOPMENT PROCESS AND RATIONAL	3
3. ADDITIONAL ANALYTICAL GUIDANCE	7
4. CONCLUDING REMARKS	9
5. ACKNOWLEDGEMENTS	11
6. REFERENCES	12
APPENDIX A. NBS REPORTS ON PREVIOUS SYSTEMS	13
APPENDIX B. FIRE SAFETY EVALUATION SYSTEM FOR OFFICE/LABORATORY BUILDINGS	14

FIRE SAFETY EVALUATION SYSTEM FOR NASA OFFICE/LABORATORY BUILDINGS

H.E. Nelson

Abstract

A fire safety evaluation system for office/laboratory buildings is developed. The system is a life safety grading system. The system scores building construction, hazardous areas, vertical openings, sprinklers, detectors, alarms, interior finish, smoke control, exit systems, compartmentation, and emergency preparedness.

Keywords: risk assessment, fire safety evaluation system, office buildings, laboratories.

1. INTRODUCTION

This project was undertaken at the request of the National Aeronautics and Space Administration (NASA). NASA requested assistance from the Center for Fire Research (CFR) of the National Bureau of Standards (NBS) in the development of a method to appraise the relative level of life safety from fire in existing NASA office or combination office/laboratory buildings. NASA desires means of comparing fire-safe conditions in office and combination office/laboratory buildings with NASA safety objectives and criteria.

NASA uses the Life Safety Code (National Fire Protection Association Standards No. 101) as modified by internal NASA design and safety publications as its stated criteria. The existing building inventory and the operational needs and functions of NASA, however, frequently conflict with the explicit application of the NASA criteria. This results in a need to consider alternative solutions that involve deviations from the established NASA criteria and a need to determine the safety suitability of these alternatives. The responsibility for determining the impact of a deviation or alternative approach on NASA safety objectives rests with the NASA Division of Safety.

NBS recommended a two-phase program. Phase I has been completed. This is the report of that phase. Phase I consisted of the development of an evaluation system through the combined professional judgment of fire safety experts from NASA and NBS. The project has involved close coordination between NASA and NBS. In the process, NASA maintained all decision authority on the level of safety appropriate for NASA. NBS concentrated on the technical measurement of the relative level of risk in existing buildings or design proposals to the given NASA objectives.

2. DEVELOPMENT PROCESS AND RATIONAL

Phase I consisted of seven individual activities as follows:

1. Site visits
2. Establishment of parameters and variables for an evaluation system
3. Initial evaluation of relative impact of parameters and variables
4. NASA professional peer evaluation
5. NASA field evaluation
6. Iterations
7. Report

NBS fire protection engineers visited the Lewis, Johnson, and Langley centers. These visits were made in the company of NASA safety representatives. Office and combination office and laboratory and other buildings were reviewed at each site. The basic types of deficiencies, problems, and needs were identified. In general, the following overall conclusions were reached:

a. Most NASA buildings are of a substantial construction in terms of framing and floor construction.

b. Most are relatively low rise (1 to 4 stories). The exceptions are generally office buildings that do not contain laboratories.

c. Open stairways that could allow the rapid propagation of smoke are common in many of the lower rise buildings.

d. Many of the buildings have a variety of laboratories having a wide range of potential fire hazards. Most of the laboratories have doors opening directly on the paths of travel that would be used by persons attempting to leave the building in time of emergency.

e. Most buildings have manual fire alarms that report directly to a facility fire department.

f. Relatively few of the buildings visited have early warning alarms, and sprinkler protection is generally present only in cases of combustible construction or critical operations such as essential computer facilities.

g. Most of the occupants of the buildings have general familiarity with the entire building or at least all possible exit routes that might be of importance to them.

Following the site visits, discussions with the project leadership concluded that the primary scope of the project was safety to life considerations for occupants of these buildings in case of fire. It was also decided that the basic standard of performance would be that presently delivered by explicit compliance with NASA standards. It was also understood that any evaluation system developed should be capable of having its criteria changed by NASA if NASA should desire to adjust its standards.

CFR has previously developed a series of fire safety evaluation systems involving buildings with varying degrees of similarity to the NASA facilities. Appendix A is a list of NBS reports describing these previous systems. The titles of these reports describe the types of buildings involved. These reports also include detailed discussions of the theory and concepts inherent in such evaluation systems.

The background of the past experience in previous fire safety evaluation systems, the data derived from the visits to the field, and other logic tools such as event logic trees and comparison matrices were used by CFR throughout the project. A general outline of the parameters and variables and information on initial relationships based on both past experience and technical judgment was prepared by the CFR staff members.

The 13 parameters used to measure fire safety (see Table 1 of the Fire Safety Evaluation Worksheet in Appendix B) were developed by the CFR staff. This was done by reviewing the Life Safety Code and the NASA safety and design manuals. The 13 parameters match the principal headings of the fire safety requirements for office type occupancies in the Code and NASA manuals. These 13 parameters, along with the brief list of other considerations contained on the face page of the worksheet, encompass all the fire requirements and criteria specified by NASA for office and combination office-laboratory buildings. Similarly, the variable elements of each parameter were selected to match the levels of parameter performance in the Life Safety Code, in NASA criteria, or in actual or probable use in NASA buildings. The evaluation systems previously developed by CFR (see Appendix A) were extensively used as a guide in this phase of the project.

The initial assignment of relative point values for the individual variables was done by the CFR staff using past systems, the character of NASA buildings, and professional judgement as the basis.

In each case (parameters, variable elements, and assigned values) the initial proposition presented by the CFR staff was used as the basis for examination and testing in the subsequent phases of the project.

A meeting was then held with NASA fire safety representatives from NASA Headquarters, and the Lewis, Johnson, Goddard, and Langley centers. Two-days of discussion were held and proposed interrelationships were reviewed. A preliminary fire safety evaluation system evolved from that meeting.

CFR staff members then developed a trial fire safety evaluation system based on approaches agreed to at the joint meeting. The mandatory requirement values listed in Table 3 of the worksheet (Appendix B) were developed at this time. This was done by using the trial evaluation system to evaluate a hypothetical building that actually conformed with NASA criteria. The scores obtained became the values used for Table 3. In addition, a computer sorting program to study potential outputs was developed and a copy of this program was provided to the Lewis Center. The trial fire safety evaluation system was circulated for review and testing through the NASA fire protection and safety offices.

After an extended period of field testing, an additional meeting was convened with NASA fire safety representatives. The comments developed from the NASA field trials were reviewed. An adjusted fire safety evaluation system was developed. An exercise similar to that described by Nelson in his paper "An Approach to Enhancing the Value of Professional Judgment in the Determination of Performance Criteria" [1] was used to compare potential results obtainable from the evaluation system against NASA objectives. At the close of this session a consensus was reached on a satisfactory evaluation system.

3. ADDITIONAL ANALYTICAL GUIDANCE

The range of occupancies and sizes of buildings constituting the NASA inventory indicated a need to provide specific guidance to users for estimating certain values in Table 1 of the Fire Safety Evaluation System.

The following is an explanation of that guidance:

a. Segregation of Hazards (Item 2)

(1) The mixed occupancy nature of many of the NASA buildings makes it important to identify which laboratories and similar special purpose spaces actually present a hazard in the building and the

extent or level of that hazard. In order to make this evaluation, it is necessary to predict both (a) the likelihood that "flashover" will occur in that space and (b) the total potential fire severity in that space. "Flashover" refers to the full involvement of all combustibles within a compartment and is here assumed to correspond to an upper gas layer temperature exceeding about 1000°F. Figure 1 of the evaluation system (see Appendix B) contains both a graph and a formula to assist in estimating total potential fire severity. The later provides a means of estimating the time period before a standardized (severe) fire test exposure in a laboratory space will cause failure of the main structural components and is based on a correlation developed by Law [2] between the intensity and duration of fires in compartments and the standard fire endurance test exposure.

(2) Figure 2 of the evaluation system (see Appendix B) provides a means of estimating the amount of energy that would be necessary to produce flashover in a space. This figure is based on a simple flashover prediction formula developed by Thomas [3]. Figures 1 and 2 are used by the investigator to estimate the potential impact of fire in laboratories and other work spaces.

(3) Figure 4 of the evaluation system (see Appendix B) provides a means of estimating the potential maximum energy level produced by varying arrangements of furniture and other common fuels. This will allow the investigator to make an appraisal of the likely

level of energy in a preflashover fire. The data in figure 4 have been abstracted from several sources, predominantly those by Babrauskas [4] and Alpert and Ward [5].

b. Corridor/Room Separation (Item 12)

The evaluation system specifies a point value charge of 0 to -6 for incomplete corridor/room separations. This is the only element in the evaluation system with a range rather than a specific number. Figure 5 of the evaluation system is designed to assist the investigator in estimating the number to assign to this element. This figure uses a smoke flow or leakage formula developed by Nelson [6] to estimate the amount of time it would take for smoke flowing from a fully involved room through a limited opening area into a large size corridor. Caution is important in using this formula since it assumes that the leakage area is close enough to the ceiling of the corridor so that entrainment is not a significant factor.

4. CONCLUDING REMARKS

Appendix B is the fire safety evaluation system jointly developed by NBS and NASA. This system provides a reasonable measurement of comparative fire safety based on current NASA criteria. If NASA criteria is changed, the system can be adjusted to relate to the new criteria.

Since this conclusion was based upon the experience and judgment of personnel from both NBS and NASA fire safety staffs, it is suggested that the use of the evaluation system be under the oversight and direction of the NASA fire and safety staff organization.

5. ACKNOWLEDGEMENTS

The development of the Fire Safety Evaluation System for NASA Office/Laboratory Buildings was possible only because of the cooperation and contribution of NASA professionals. We are particularly grateful to Mr. Jack R. Colegrove for both technical and administrative leadership. Of critical importance was the team of NASA expertise that Mr. Colegrove assembled to critique and test the system as it developed. The NASA experts that served on that team were:

Jack R. Colegrove	Lewis Research Center
Leven B. Gray	Nasa Headquarters
John C. Garrison, Jr	NASA Headquarters
Joseph H. Letourneau	Goddard Space Flight Center
Ronald L. Long	Kennedy Space Center
Matthew B. Cole	Johnson Space Center
Jackie W. Holloway	Langley Research Center

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[3] Thomas, P.H., Testing Products and Materials for Their Contribution to Flashover in Rooms, Fire and Materials, 5, pp. 103-111, 1981.

[4] Babrauskas, V., Upholstered Furniture Room Fire Measurements, Comparison with Furniture Calorimeter Data and Flashover Predictions, Journal of Fire Sciences, Vol. 2, No. 1, 5-19, Jan/Feb 1984.

[5] Alpert, R.L. and Ward, E.J., Evaluating Unsprinklered Fire Hazards, SFPE Technology Report 83-2, Society of Fire Protection Engineers, Boston, MA, 1983, 103-111, 1981.

[6] Nelson, H.E., "Fireform" - A Computerized Collection of Convenient Fire Safety Computations, NBS Report, NBSIR 86-3308, National Bureau of Standards, Gaithersburg, MD, 1986.

APPENDIX A. NBS REPORTS ON PREVIOUS FIRE SAFETY EVALUATION SYSTEMS

A Firesafety Evaluation System for Health Care Facilities, NBS Report NBSIR 79-1551-1, 1980.

A System for Fire Safety Evaluation for Multifamily Housing, NBS Report NBSIR 82-2562, 1982.

A Fire Safety Equivalency System for National Park Service Overnight Accommodations, NBS Report NBSIR 84-2896, 1984.

A Fire Safety Evaluation System for Board and Care Homes, NBS Report NBSIR 83-2659, 1983.

The Development of a Fire Safety Evaluation System for Detention and Correctional Occupancies, NBS Report NBSIR 84-2976, 1984.

APPENDIX B

FIRE SAFETY EVALUATION SYSTEM
FOR
OFFICE/LABORATORY BUILDINGS

Fire Safety Evaluation Worksheet for Office/Laboratory Buildings

Facility Identification ______________________________

Evaluator ______________________________ Date ______________

First complete Table 1 on page 2. Continue with Table 2 on page 3 and Tables 3 and 4 on page 4. Then return to this page to obtain the Equivalency Conclusions:

TURN TO NEXT PAGE

PART E. EQUIVALENCY CONCLUSIONS

Complete Tables 1–4 before doing this part.

1. ( ) All of the checks in Table 4 are in the "yes" column. The level of fire safety is at least equivalent to that prescribed for general purpose buildings.*
2. ( ) One or more of the checks in Table 4 are in the "no" column. The level of fire safety is not shown by this system to be equivalent to the life safety requirements prescribed by NASA for general purpose buildings.

*The equivalency covered by this worksheet includes the majority of considerations involved by NASA. There are however, a few considerations that are not evaluated by this method. These must be separately considered. These additional considerations are covered below.

Facility Fire Safety Requirements Worksheet

Considerations	Met	Not Met	Not Applic.
A. Building utilities conform to the requirements of Paragraph 7–1 of the Life Safety Code.			
B. The air conditioning, heating, and ventilating systems conform with Paragraph 7–2 of the Life Safety Code.			
C. Elevator installations are made in accordance with the requirements of Paragraph 7–4 of the Life Safety Code.			
D. Rubbish chutes, incinerators, and laundry chutes are installed in accordance with Paragraph 7–5 of the Life Safety Code.			

Fire Safety Evaluation System for Office/Laboratory Buildings

DETERMINE SAFETY PARAMETER VALUES – USE TABLE 1
Select and circle the safety value for each parameter in Table 1 that best describes the conditions in the facility. Choose only one value for each of the 13 parameters. If two or more values appear to apply, choose the one with the lowest point value.

Table 1. Safety Parameters

SAFETY PARAMETERS / PARAMETER VALUES

1. Construction	Combustible				Noncombustible		
	Wood frame		Ordinary			Prot.	Fire
	Unprot.	1 hr.	Unprot.	1 hr.	Unprot.	(1 hr.)	resistive
1 story	−1	0	−1	0	0	0	0
2 stories	−4	0	−2	0	−4	2	2
3 story	−12	0	−6	0	−6	2	2
4–5 stories	−12	0	−12	0	−12	2	2
6 stories or more	NP	−6	NP	0	NP	0	2

2. Segregation of hazards	Expose exit system		Segregated from exit routes		None or no deficiencies
	Dbl. def.	Single def.	Dbl. def.	Single def.	
	−7	−4	−4	0	0

3. Vertical openings	Open (or incomplete enclosure)				Enclosed	
	Connects 5 or more floors	4 flrs.	3 flrs.	2 flrs.	< 30 min.	30 min.–1 hr
	−10	−7	−4	−2	−1(0)[A]	0

4. Sprinklers	None	Corridors only	All but corr. s and lobbies		Total Bldg.	
			Std.	Fast	Std.	Fast
	0	0	4	6	10	12

5. Manual fire fighting appliances	None	Fire Ext.s only	Standpipes only		Standpipes & ext.s	
			≤3 sty.	≥4 sty.	≤3 sty.	≥4 sty.
	0	1	0	1	1	2

6. Manual fire alarm system	None	w/o fire dept. notification	w/fire dept. notification	
			off–station	on–station
	0	1	1	2

7. Smoke detection & alarm	None	Corridors or special haz.	Rooms	Zone	Total Bldg.
	0	1	2	4	5

8. Interior finish	Flame spread ratings [B]					
exit routes	< 75 ≤200		> 25 ≤75		≤25	
rooms suites	> 75 ≤200	≤75	>75 ≤200	≤ 75	> 25 ≤200	≤ 25
	−3	−1	0	1	1	2

9. Smoke control	None	Smoke partitions	
		Passive	Active
	0	3	4

10. Exit access	Max. dead end		No dead end > 50ft. & travel is:			
	<75'>100'	< 50' ≥ 75'	> 200'[C]	100'–200'[C]	50–100'	≤ 50'
	−2[D]	−1[D]	−1	0	1	3

11. Exit system	Single	Multiple routes		Direct exits
		Deficient	≥ 2	
	−6	−2	0	5

12. Corridor/room separation (Compartmentation)	Separation exists and level of protection is:						No separation
	Incomp.	Smoke resistive [E]		> 20 min. [E]		1 hr or more [E]	
		w/o door closers	w/door closers	w/o door closers	w/door closers	w/door closer	
	−6 to 0	0	1(2)[F]	1	2(3)[F]	3(4)[F]	0

13. Emergency prepardness	Unfamiliar occupants		Familiar staff	
	None	Coordinated	None	Coordinated
	−2	0	0	1

A. Use 0 if building is 1 level

B. Consider flame spread rating to be 25 in any sprinkler protected spaces.

C. Increase 200–300 if parameter 4 is 10 or more.

D. Use 0 if parameter 11 is −6.

E. Rate separation 20 min.(or actual if greater) if parameter 4 is 10 or more.
- Smoke resisting if parameter is based on unprotected const.

F. Use ( ) if separation between rooms also meets criteria.

PART B. COMPUTE INDIVIDUAL SAFETY EVALUATIONS - USE TABLE 2.

1. Transfer each of the 13 circled safety parameter values on Table 1 to every unshaded block in the line with the corresponding safety parameter in Table 2. Where the block is indicated (÷2) enter only one-half the value shown in Table 1.

2. Add the four columns, keeping in mind that any negative numbers deduct.

3. Transfer the resulting values for S_1, S_2, and S_3 on page 4 of this worksheet.

Table 2. Individual Safety Evaluation

SAFETY PARAMETER	FIRE CONTROL (S_1)	EGRESS PROVIDED (S_2)	GENERAL FIRE SAFETY PROVIDED (S_3)
1. Construction			
2. Hazardous areas			
3. Vertical openings	÷2		
4. Sprinklers		÷2	
5. Manual fire fighting equipment			
6. Manual fire alarm system	÷2		
7. Smoke detection and alarm	÷2		
8. Interior finish	÷2		
9. Smoke control		÷2	
10. Exit access			
11. Exit system			
12. Corridor separation	÷2	÷2	
13. Emergency prepardness			
Total	S_1 =	S_2 =	S_3 =

PART C. DETERMINE MANDATORY REQUIREMENTS – USE TABLE 3.

Transfer the circled values from Table 3 to the blanks marked S_a, S_b, S_c, and S_d in Table 4.

Table 3. Mandatory Requirements

Building Height	Control Requirement (S_a)	Egress Requirement (S_b)	General Fire Safety Requirement (S_c)
1–5 Story	2	2	3
≥ 6 Story	11	4	9

PART D. EQUIVALENCY EVALUATION

1. Perform the indicated subtractions in Table 4. Enter the differences in the appropriate answer blocks.
2. For each row check "YES" if the value in the answer block is zero or greater. Check "NO" if the value in the answer block is a negative number.

Table 4. Equivalency Evaluation

		YES	NO
Control provided (S_1) minus Required Control (S_a) ≥ 0	S_1 ☐ − S_a ☐ = ☐		
Egress Provided (S_2) minus Required Egress (S_b) ≥ 0	S_2 ☐ − S_b ☐ = ☐		
General Fire Safety (S_3) minus General Fire Safety (S_c) ≥ 0	S_3 ☐ − S_c ☐ = ☐		

Return to page 1 of this form

GLOSSARY FOR EVALUATING A OFFICE/LABORATORY BUILDING

This glossary is provided to assist in completing the Fire Safety Evaluation Worksheets for office and combined office/laboratory buildings. The instructions for completing the worksheet are included in the worksheet itself. They are not repeated in this glossary. This glossary provides expanded discussion and definitions for the various items in the worksheet to assist the user when questions of definition or interpretation arise. To the maximum extent possible, the glossary does not repeat the definitions already existing in the Life Safety Code or NASA Manuals.

Areas of Application

The entire building can be evaluated on a single worksheet. The building may, however, be zoned with each zone considered separately or in any convenient grouping of zones. The choice of zoning is normally based on the approach that produces the most functional or economical results. The criteria for zoning facilities is as follows:

a. Zoning must be such as to divide the building into units that consist of one or more complete fire/smoke zones. A fire/smoke zone is a portion of a building that is separated from all other portions of the building by building construction having at least 1-hour fire resistance and/or smoke partitions conforming to the requirements of section 6-3 of the Life Safety Code for smoke barriers of at least 20-minute fire resistance. Any vertical openings (shafts, stairs, etc.) involved must also provide 1-hour separation (except that stair doors may be 45-minute, Class C doors). In facilities completely protected by automatic sprinkler protection, the above fire resistance requirements do not apply. The elements separating one zone from another, however, must be of sound, smoke resisting construction. Doors in zone separations must be either self-closing or equipped with automatic closers operated by smoke detectors.

b. Zones may be either adjacent to each other (e.g., separate wings or building sections) or above each other (e.g., floors or groups of floors).

c. Each zone containing business (e.g., office or laboratory) space must be evaluated using this system with the following adjustments:

   (1) Charges for Parameter 2, Hazardous Areas, apply to any hazardous area in the zone being evaluated and to any hazardous areas in zones adjacent to or below the zone being evaluated.

   (2) Where zones are located above each other, the value assigned to Parameter 1, Construction in each zone, is based on the highest story used for regular human occupancy in that "stack of zones", and the type of construction of that "stack of zones".

(3) The assignment of values for Parameters 5, Manual Fire Fighting Appliances; 6, Manual Alarms; 11, Exit Systems; and 10, Exit Access, does not consider conditions in unoccupied spaces in other zones when such are not involved in any egress paths.

(4) The evaluation of Parameter 11, Exit Systems, includes those portions of any exit route that serves the zone being evaluated. Any exposures or deficiencies pertaining to any part of the exit route must be taken into account in the evaluation of the zone.

d. Zones that do not involve regular human occupancy are evaluated the same as those with regular human occupancy with the following variations:

(1) Any such zone may be omitted from the numerical evaluation if all of the following conditions are met:

a. The zone is not involved in the exit route from any space with regular human occupancy.

b. The zone conforms to the Life Safety Code requirements applicable to its use.

(2) Alternatively, such zones may be evaluated using this system provided any additional egress capabilities and arrangements appropriate to the specific use of the space are provided.

<u>Maintenance</u>

All protection systems, requirements, arrangements, and procedures must be maintained in a dependable operating condition and a sufficient state of readiness, and used in such a manner that the intended safety function or hazard constraint is not impaired. Otherwise, they receive no credit in the evaluation.

<u>Safety Parameter Table (General Discussion)</u>

The safety parameters are a measure of those building factors that bear upon or contribute to the safety of those persons who may be in the building at the time of a fire.

Each of the safety parameters is to be analyzed, and the safety value for each parameter that best describes the condition in the building is to be identified. Only one value for each of the parameters is to be chosen. If two or more appear to apply, the one with the lowest point value is used.

1. Construction

Construction types are classified in accordance with the definitions of NASA standards.

The requirements of NASA standards for "interior partitions enclosing stairways or other openings through floors" are not to be considered in the construction classification. These floor openings and their protection are separately evaluated under safety parameter 3, Vertical Openings.

Where the facility includes additions or connected structures of different construction the rating and classification of the structure is based on (a) separate buildings if a one-hour or greater fire resistive separation exists between the portions of the building and/or (b) the lower safety parameter point score involved if such a separation does not exist.

2. Segregation of Hazards

The assignment of charges for unsegregated hazards areas is a four-step process.

Step 1. Identify Hazardous Areas. A hazardous area is any space or compartment that contains a storage or other activity that is not a part of normal office space arrangements and possesses the potential of producing a fully involved fire.

Step 2. Determine the Level of Hazard. There are two levels of hazard as follows:

a. Structurally Endangering. A hazardous occupancy with sufficient potential fire severity to defeat the basic structure integrity of the building framing as defined in Parameter 1 (Figure 1 for determining approximate potential fire severity).

Example: For a room 20 feet by 30 feet by 8 feet high with a (window) opening 3 feet wide by 4 feet high, 3000 pounds of ordinary fuel can produce a fire severity of approximately 95 minutes. If the fire resistance of the hazardous area enclosure is less than 95 minutes, the hazardous area is classed as structurally endangering.

b. Not Structurally Endangering. A hazardous occupancy with sufficient fire potential to build to full involvement (flashover) and present a danger of propagating through openings or wall partitions but not possessing sufficient total potential to endanger the structural framing or floor decking as defined in Parameter 1. (See Figure 2 for assistance in estimating the fire size needed to flashover a room.

Also see Figure 4 for assistance in estimating the unit fire potential of various combustible contents.)

Example: For the same room as in the previous example, flashover is expected if the burning rate of the most combustible fuel array exceeds about 2000 Btu/sec. In such case the area is classed as a hazardous area.

Step 3. Determine the Fire Protection Provided. The parameter value for hazardous areas is based on the presence or absence of the fire protection necessary to control or confine the hazard. Two different types of fire protection are considered. The first consists of automatic sprinklers or other appropriate extinguishing system covering the entire hazard.* The second is a complete fire enclosure having sufficient fire resistance to contain the potential fire severity of the hazardous area. This includes (a) the separation of the hazardous area from any structural framing members, (b) partitions separating the hazardous area from all other spaces, and (c) fire-resistant doors sufficient to exceed the potential of the fire load involved. Any hazardous space that has either of these protection systems is classified as having single protection.

Step 4. Determine Degree of Deficiency and Assign Parameter Values. The parameter value is finally determined on the basis of the degree of deficiency that the hazardous area has in terms of the level of protection needed.

Figure 3 provides a matrix type table to assist in determining degree of deficiency to be assessed.

In some situations, the building will contain more than one hazardous area with the same or with differing levels of deficiency. The charge is based on the single most serious charge for hazardous area found.

Open Plan Office Space

A sprinkler-protected open plan office space is not considered as a hazardous space.

An unsprinklered open plan office space is not considered as a hazardous space unless it involves such a collection of fuel that flashover is likely to occur. This can be estimated in the following manner:

---

*The credit for sprinklers is not to be given unless the hazardous area is separated from the rest of human occupancy or the egress route by reasonably smoke resisting partitions and doors.

a. Appraise the largest fuel concentrations. A fuel concentration is a collection of combustible materials (desks, files, or other material or items) that is separated from other fuel concentrations by a clear space that is 2 feet wide or 1/2 the height of the collection, whichever is greater. Floor covering is not considered in this estimate.

b. Burning rate is based on the best available data. If test data is available use that data, if not see Figure 4 for assistance. If data is not available and Figure 4 is not sufficient, burning rate is based on 125 Btu per sec. per sq. ft. of actual fuel-covered floor space for typical desk modules (based on wooden desks, ignore space occupied by metal desks or metal file cabinets). For open shelf storage or similar piled or stacked concentrations of combustible materials, estimate 100 Btu per sec. per sq. ft. of covered floor space for each foot of height of combustible material. Double the above figures for the portion of the fuel assembly that is foam plastic.

c. Based on the estimated burning rate, appraise the flashover potential. Use figure 2 to do this.

d. If flashover is shown as a potential, use figure 1 to appraise severity.

e. If flashover is shown as a potential, classify the space as a hazardous area and assign charges as appropriate.

3. <u>Vertical Openings</u>

These values apply to vertical openings and penetrations including exit stairways, ramps, and any other vertical exits, pipeshafts, ventilation shafts, duct penetrations, and laundry and incinerator chutes. The charge for vertical openings is based on the presence or lack of enclosure and the fire resistance of the enclosure if present.

A vertical opening or penetration is classified as open if it is (a) unenclosed; (b) enclosed but has doorways (or similar portals) that are without doors; (c) enclosed but has unprotected openings other than doorways; and (d) enclosed with cloth, paper or similar materials without any sustained fire stopping capabilities.

4. <u>Sprinkler Protection</u>

Where an automatic sprinkler is installed, either total or partial building coverage, the system is in accordance with the requirements of NFPA Standard No. 13, Installation of Sprinkler Systems.

To receive credit for protection the sprinkler system must be equipped with an automatic alarm initiating device that will activate the building manual fire alarm system or otherwise sound an alarm sufficiently audible to be heard in all occupied areas.

To receive credit for "Total Building" sprinkler protection, the entire building must be provided with sprinkler coverage and must cover all zones of the building.

5. Manual Fire Fighting Appliances

Portable fire extinguishers are credited if the installation meets the requirements of "Standard for the Installation of Portable Fire Extinguishers", NFPA 10.

Standpipe and hose system are credited if they are in accordance with "Standard for the Installation of Standpipe and Hose Systems", NFPA 14.

6. Manual Fire Alarm

a. None. There is no manual fire alarm system, or if the system is incomplete and does not meet the requirements necessary for a higher scored category.

b. W/O F.D. Notif. There is a manual fire alarm system which meets the requirements of Life Safety Code Section 7-6.

c. W/ F.D. Notif. There is a manual fire alarm system which complies with the requirements of b, above, and, in addition, automatically transmits a signal to the NASA or other fire department which is committed to serve the area in which the building is located, through a direct connection, an approved central station, or through other means acceptable to NASA.

7. Smoke Detection and Alarm

All references to detectors herein refer to smoke detectors. No credit is given for heat detectors in habitable spaces except as specifically noted below. Heat detectors can be credited in uninhabitable spaces where ambient temperature can be expected to exceed 120 degrees Fahrenheit or fall below 0 degree Fahrenheit, as long as separation from inhabited spaces has at least 20 minutes fire resistance.

To meet the requirements for smoke detector coverage, the spaces must be provided with smoke detectors installed in accordance with NFPA 72 E, Automatic Fire Detectors.

Only those detectors whose activation will sound the alarm throughout the zone of origin are to be credited in this parameter.

If the building is evaluated by zones as defined under "Areas of Application", the evaluation is based solely on detection within the zone.

8. Interior Finish

Classification of interior finish is based on the flame spread rating of the interior finish tested in accordance with ASTM Standard E 84, Tunnel Test. The requirements apply to wall and ceiling finish materials as described in section 6-5 of the Life Safety Code.

No consideration is included in the safety parameter value for any finish with a flame spread rating greater than 200 or for any material not rationally measured by the ASTM E 84 test. Such materials include foam plastics, asphalt impregnated paper, and/or materials which melt, drip or delaminate, or those capable of inducing extreme rates of fire growth and rapid flashover. In any case where these materials are involved, the resultant risk is considered beyond the capacity of this evaluation system and will require individual appraisal.

Any interior finish having a flame spread of 200 or less that is protected by automatic sprinklers is evaluated as having a flame spread of $\geq$ 25.

9. Smoke Control

Smoke control definitions are as follows:

a. No Control. There are no smoke barriers or horizontal exits to a separated fire/smoke zone on the floor and no mechanical assisted smoke control systems serve the floor.

b. Smoke Barriers. Smoke barriers consist of installations conforming to the requirements of Section 6-3 of the Life Safety Code.

    1. Passive. The smoke control system is passive if it consists of continuous vertical and/or horizontal membranes designed to restrict the movement of smoke. Passive smoke barriers may or may not have a fire resistance rating and may have protected openings.

    2. Active. The smoke control system is active if it has a tested engineering smoke control system that will obstruct the leakage of smoke between compartments or zones.

10. Exit Access

Exit access is a measurement of the travel distance from the room to the outside or to an enclosed interior stairway or other exit (i.e., horizontal exit), or through a smoke barrier, whichever is shorter.

The charge for dead end access is made when any corridor affords access in only one direction to a required exit. The calculation of the distance to determine the level of charge is the measurement from the centerline of the doorway exiting the office/suite to the nearest point where a person has a choice of two directions or routes of egress.

If dead end distances exceed 100 ft., a separate analysis must be made to evaluate the potential of flashover of any spaces that could block egress from the dead end and of the potential rate of smoke filling of the egress system involved. If the safe time is shorter than the expected egress time the evaluation should be discontinued unless a corrective action is specified.

11. Exit System

Exit systems are the paths of travel from a room to the outside of any of the types and arrangements described in Chapter 5 of the Life Safety Code.

a. Single Route. A single route exists when occupants on any floor do not have either a direct exit or multiple routes as defined in b, below.

b. Multiple Routes. Multiple routes exist when the occupants on a floor have a choice of two separate exit routes to the outside of the permissible types listed in Chapter 27 of the Life Safety Code.

    Deficient. An exit route is deficient if it fails to meet any of applicable criteria in Chapter 5 of the Life Safety Code including capacity. An exit route is deficient if a vertical opening interconnects with an exit route.

c. Direct Exits. To be credited with direct exits, each room must have within that unit a door that opens to the exterior at grade level or onto an exterior balcony with direct access to an exterior exit or smoke proof stair. Where such openings are directly onto grade in a location where any person egressing can move directly away from the building without further exposure, the credit for direct exit is applicable even if there are not other exit routes from the space.

12. Corridor/Room Separation

The values assigned in the Corridor/Room Separation parameter, are based on the quality of separation between room and the corridor.

a. Incomplete. The separation is judged as incomplete if the wall to the corridor has unprotected openings (no door, louvers, gaps, or transfer grills) between floor and the ceiling. If openings exist above the ceiling level, the separation is considered complete if the ceiling in the room is a complete membrane. In this case, the separation rating is based on the level of resistance to smoke flow or fire resistance involved in wall/ceiling system.

The score imposed for incomplete separation is based on the potential time that at least the lower 5 ft. of corridor could be expected to remain free of smoke if a fully involved fire occurs in an exposing room. This is dependent on the amount of leakage area from the most leaky exposing room and the size of the corridor (see Figure 5). The scores are as follows:

Safe Time	Score
≤ 2 min	-6
> 2 but ≤ 4 min	-4
> 4 but ≤ 8 min	-2
> 8 min ≤ 16 min	0
> 16 min	Complete Separation

b. Complete Separation. If the separation is not judged to be incomplete based on the above criteria, the separation is considered to be complete.

c. No Separation. There is no separation if the floor or the smoke zone is not subdivided (there is no corridor leading to an exit).

Discussion on credit for door closers "smoke resistive" vs "> 20 min", "1 hr", footnote F of Table 1.

13. Emergency Preparedness

a. Coordinated. Building or Zone occupants are classified as "Coordinated" if a majority of the occupants have taken part in scenario oriented fire exit drills. The scenarios are based on the hazardous conditions that may develop during a fire in the facility. The occupants must also be familiar with the fire safety procedures described in NASA Safety Manual, Volume 9, Chapter 8.

b. None. Building or Zone occupants are classified as "None" if the occupants do not meet all the requirements for "Coordinated".

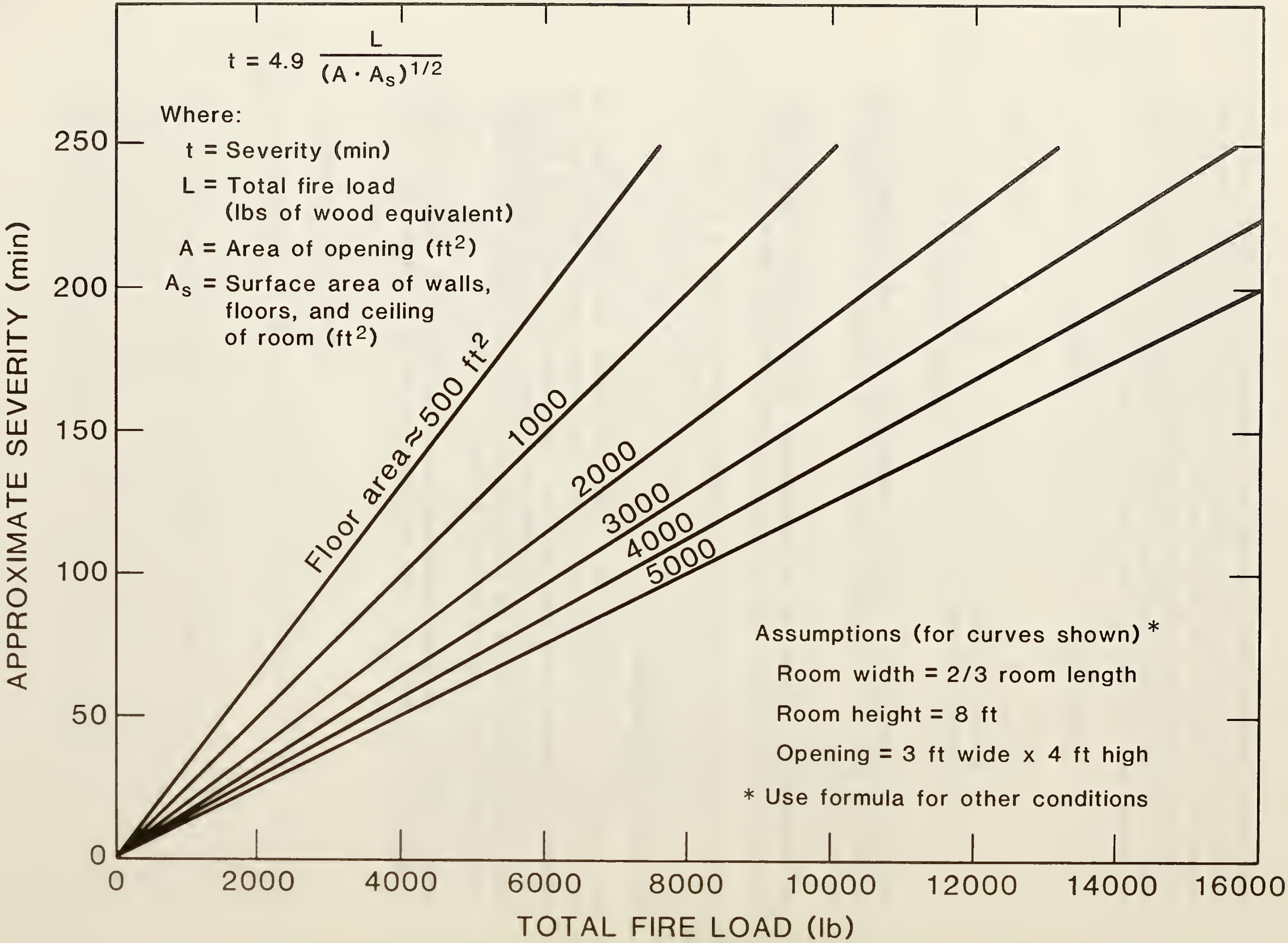

Figure 1. Approximate Fire Severity

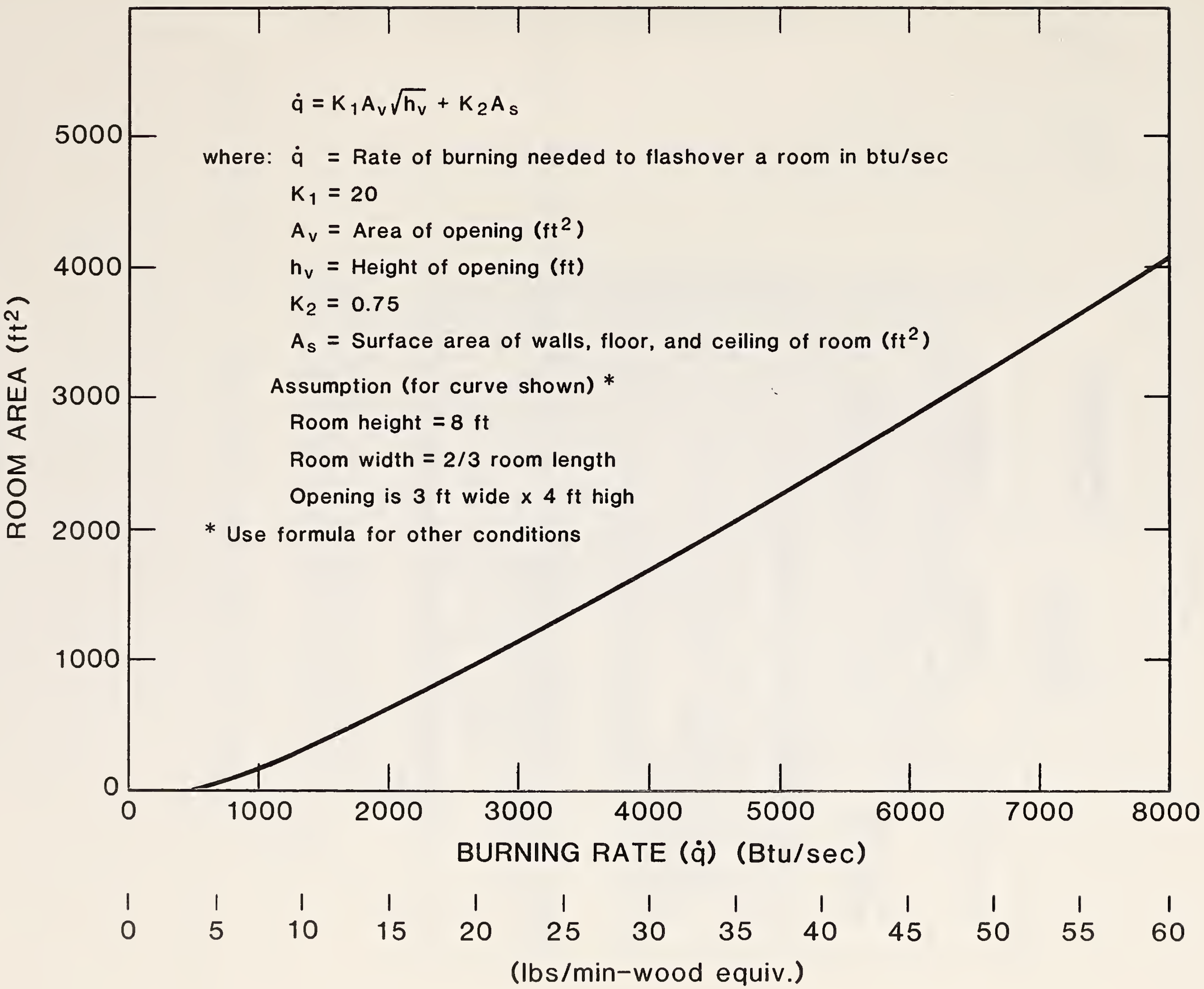

Figure 2. Approximate Flashover Energy

	NOT STRUCTURALLY ENDANGERING	STRUCTURALLY ENDANGERING
NO PROTECTION	SINGLE DEFICIENCY	DOUBLE DEFICIENCY
SPRINKLER PROTECTION		SINGLE DEFICIENCY
FIRE RESISTIVE ENCLOSURE*	NO DEFICIENCY	
SPRINKLERED & FIRE RESISTIVE ENCLOSURE		

*Complete Enclosure Having Sufficient Fire Resistance to Contain the Potential Fire Severity of the Hazardous Area.

Figure 3. Segregation of Hazards - Degree of Deficiency

SOME TYPICAL PEAK RATES OF HEAT RELEASE

BTU/SEC/ SQ. FT. OF FLOOR AREA	GROWTH RATE	POTENTIAL FUEL
1.5	S	FIRE RETARDED TREATED MATTRESS (INCLUDING NORMAL BEDDING)
15*	M	LIGHT WEIGHT TYPE C UPHOLSTERED FURNITURE**
35*	S	MODERATE WEIGHT TYPE C UPHOLSTERED FURNITURE**
35	F	MAIL BAGS (FULL) STORED 5 FEET HIGH
50*	M	COTTON/POLYESTER INNERSPRING MATTRESS (INCLUDING BEDDING)
60*	M	LIGHT WEIGHT TYPE B UPHOLSTERED FURNITURE**
60*	S	MEDIUM WEIGHT TYPE C UPHOLSTERED FURNITURE**
65	VF	METHYL ALCOHOL POOL FIRE
70*	S	HEAVY WEIGHT TYPE C UPHOLSTERED FURNITURE**
80*	F	POLYURETHANE INNERSPRING MATTRESS (INCLUDING BEDDING)
90*	M	MODERATE WEIGHT TYPE B UPHOLSTERED FURNITURE**
125	M	WOODEN PALLETS 1-1/2 FEET HIGH
145*	M	MEDIUM WEIGHT TYPE B UPHOLSTERED FURNITURE**
150*	F	LIGHT WEIGHT TYPE A UPHOLSTERED FURNITURE**
150	F	EMPTY CARTONS 15 FEET HIGH
175*	M	HEAVY WEIGHT TYPE B UPHOLSTERED FURNITURE**
175	F	DIESEL OIL POOL FIRE (>ABOUT 3 FT. DIA.)
175	VF	CARTONS CONTAINING POLYETHYLENE BOTTLES 15 FEET HIGH
220*	F	MODERATE WEIGHT TYPE A UPHOLSTERED FURNITURE**
225*	F	PARTICLE BOARD WARDROBE/CHEST OF DRAWERS
290	VF	GASOLINE POOL FIRE (>ABOUT 3 FT. DIA.)
340*	VF	THIN PLYWOOD WARDROBE WITH FIRE RETARDANT PAINT ON ALL SURFACES (50IN. X 24IN. X 72IN. HIGH)
350	F	WOODEN PALLETS 5 FEET HIGH
360*	F	MEDIUM WEIGHT TYPE A UPHOLSTERED FURNITURE**
450*	F	HEAVY WEIGHT TYPE A UPHOLSTERED FURNITURE**
600*	VF	THIN PLYWOOD WARDROBE (50IN. X 24IN. X 72IN. HIGH)

FIGURE 4 (PART 1 OF 2) - SOME TYPICAL PEAK RATES OF HEAT RELEASE

NOTES:

* Peak rates of heat release were of short duration. These fuels typically showed a rapid rise to the peak and a corresponding rapid decline. In each case the fuel package tested consisted of a single item.

** The classification system used to describe upholstered furniture is as follows:

Light weight = Less than about 5 lbs. per square foot of floor area. A typical 6-foot long couch would weigh under 75 lbs.

Moderate weight = About 5-10 lbs. per square foot of floor area. A typical 6-foot long couch would weigh between 75 and 150 lbs.

Medium weight = About 10-15 lbs. per square foot of floor area. A typical 6-foot long couch would weigh between 150 and 300 lbs.

Heavy weight = More than about 15 lbs. per square foot of floor area. A typical 6-foot long couch would weigh over 300 lbs.

Type A = Furniture with untreated or lightly treated foam plastic padding and nylon or other melting fabric.

Type B = Furniture with untreated or lightly treated foam plastic padding or with nylon or other melting fabric but not having both.

Type C = Furniture with cotton or well treated foam plastic padding and having cotton or other fabric that resists melting.

The estimated heat release rates are based on furniture having simple lines. For ornate or convoluted shapes increase the indicated rates by up to 50% based on elaborateness.

GROWTH RATES

S = Slow. Burning rate in the range of a t-squared fire that reaches 1000 btu/sec in 600 seconds.

M = Moderate. Burning rate in the range of a t-squared fire that reaches 1000 btu/sec in 300 seconds.

F = Fast. Burning rate in the range of a t-squared fire that reaches 1000 but/sec in 150 seconds.

VF = Very Fast. Burning rate in the range of a t-squared fire that reaches 1000 btu/sec in 75 seconds.

FIGURE 4 (PART 2 OF 2) - SOME TYPICAL PEAK RATES OF HEAT RELEASE

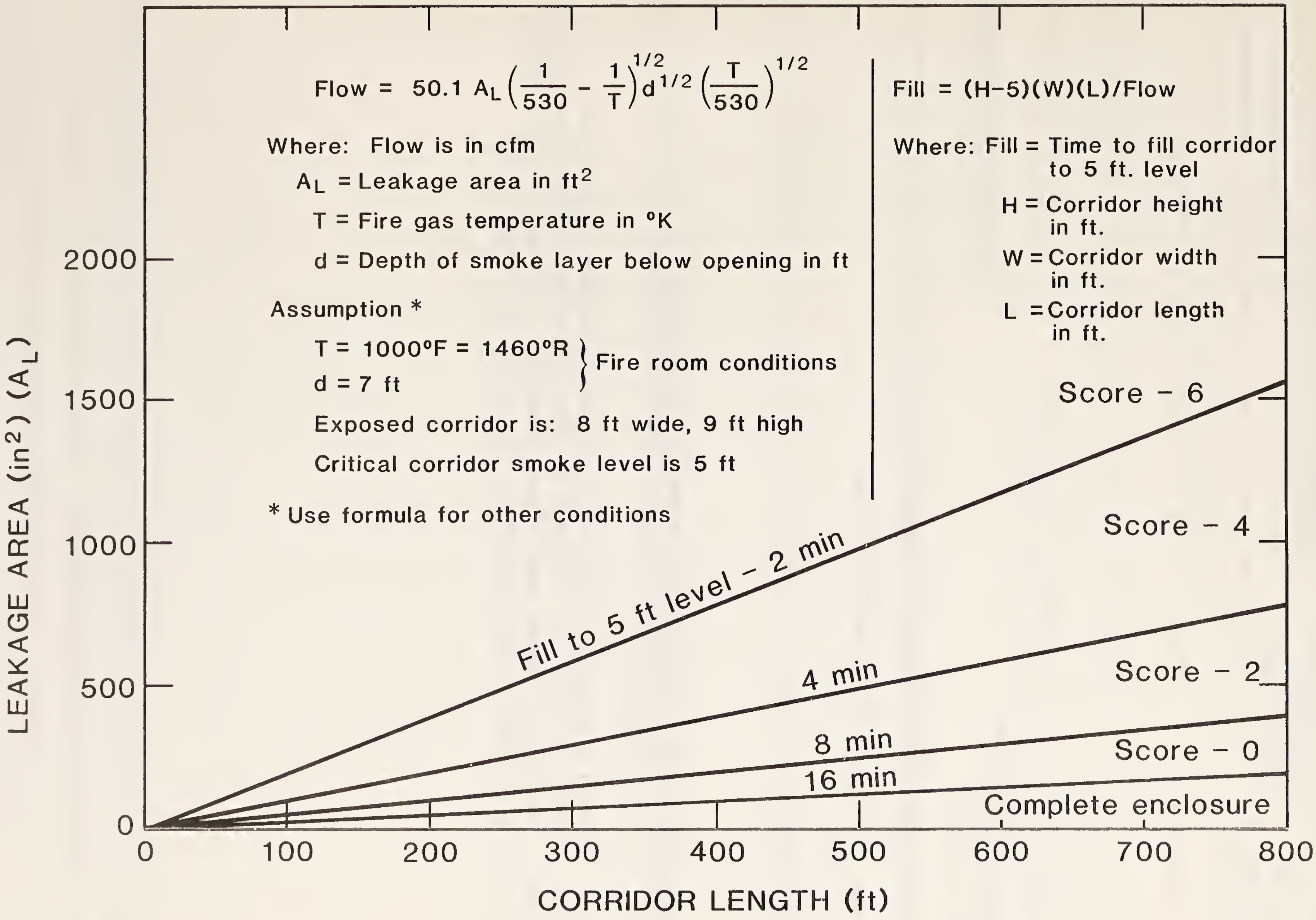

Figure 5. Approximate Time to Smoke Impact

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

A fire safety evaluation system for office/laboratory buildings is developed. The system is a life safety grading system. The system scores building construction, hazardous areas, vertical openings, sprinklers, detectors, alarms, interior finish, smoke control, exit systems, compartmentation, and emergency preparedness.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

fire safety evaluation system; laboratories; office buildings; risk assessment

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