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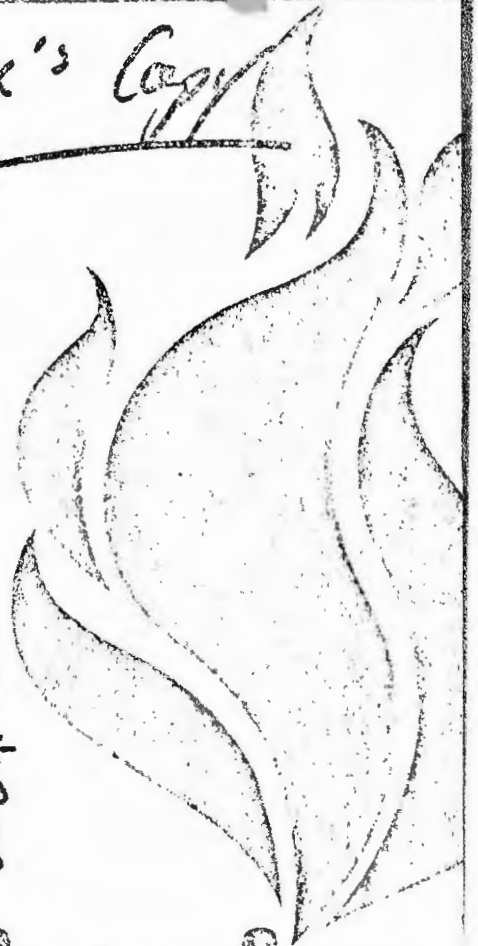

life safety from fire

A GUIDE FOR HOUSING THE ELDERLY

PROPERTY OF NFPA
NATIONAL ACADEMY FOR FIRE PREVENTION & CONTROL
U.S. FIRE ADMINISTRATION
WASHINGTON, D.C. 20472

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U.S. DEPARTMENT OF HOUSING
AND URBAN DEVELOPMENT
FEDERAL HOUSING ADMINISTRATION
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STATE INSURANCE COMMISSIONER

AN APPROACH TO LIFE SAFETY

Before the problem of life safety from fire can be approached, two kinds of understanding must be gained: an understanding of the nature of fire, and an understanding of the occupant, his limitations, and his performance in time of fire. The first half of this report explores fire, the occupant, and the reaction time; it then puts all three together to determine an approach, or a philosophy, for life safety. This is not "background", rather it is the substance from which all life safety decisions are made.

RESPONSIBILITY: Direct placement of responsibility for life loss has always been avoided. Traditional approaches to reporting the cause of death ("burns", "asphyxiation", etc.) may be literally accurate, but they do not single out the actual cause, or the person or group responsible for that death. If cause of death were specified as . . .

. . . undetected fire – detector failure – contractor did not inspect
. . . wedged or propped fire doors – by kitchen staff
. . . poor housekeeping – owner neglect
. . . excessive distance to exit – architect accepted building code requirements designed for average person . . .

. . . the responsibility – and the remedies – would be implicit in the statement of cause.

EXPENDABILITY: What criteria can be used to evaluate life safety decisions?. One such tool is expendability. To use the tool, one question is asked of every decision: "How many lives may be expended as a result of this decision"? The answer to this question provides an effective means for evaluating life safety decisions well before the fact of the fire.

These concepts, outlined here in the overview, are the framework on which this report is built. They will be [illegible] illustrated and applied in the text and

THE COMPROMISE: 100% life safety from fire can only be a theoretical ideal. Even if it were possible to place every occupant in a totally fire-resistant compartment with no ignition, no combustible contents, instantaneous detection, and unlimited escape routes, it would be neither functionally nor economically feasible to build the compartment.

By implication, this means that every life safety decision must compromise the ideal; not every link in the chain of life safety can carry the highest priority nor even all the weight it "should" in the ideal situation.

What is needed is an approach, or philosophy, which recognizes the compromise and which "buys the most life safety for the money"

THE PHILOSOPHY: A philosophy, or an integrated approach to life safety, is needed for each occupancy type. This philosophy:

- recognizes the importance of the occupant and his characteristics.
- examines each link in the life safety chain, and determines its importance for that occupant.
- establishes methods and techniques to best carry out the compromise needed, and
- recognizes that codes and regulations establish only minimum levels of safety, and that others must accept a major responsibility for providing life safety

Once this philosophy is understood, details of design and planning will vary with construction type and location of the building.

The pattern suggested by the factors in life safety – the fire, the occupant, and time – suggests an important concept: there is a distinct philosophy of life safety for each occupancy type.

THE CHAIN: It will be shown that any philosophy of life safety must be built on the premise that life safety cannot depend on a single device or technique; it depends on an interlocked chain which has seven major links,

fire prevention
detection
alarm
escape or refuge
confinement
control
extinguishment

It is only with a full understanding of the function and implications of each of the individual links that a sound

THE OCCUPANT: Life safety is an INDIVIDUAL matter; it varies with the occupant and his limitations. This kind of thinking is particularly necessary, given the elderly occupant.

The code limitation of 100 feet to an exit, for example, is based on a 'normal' person's ability to run that far while holding his breath; a bed-ridden, or semi-ambulant, occupant cannot perform such a feat. A 21-year old can escape from a second-story window; a 78-year old cannot.

An understanding of the occupant, his physical and psychological limitations, and his behavior in time of fire is a prime essential in providing for his life safety.

THE REACTION TIME: The tension which ex tween the fire and the occupant can be best un in terms of time. First, the occupant takes react to fire and attempt to escape. During t the fire is building up to critical levels, beyo the occupant cannot possibly survive.

The race is for the highest stake. If the CR TIME for the fire to build to intolerable l shorter than the occupant's REACTION TIME, has won and the occupant has lost his life.

Every life safety decision can be evaluated b fect on time: What is its effect on CRITICAL What is its effect on REACTION TIME?

OVERVIEW / THE CONCERN

The two protagonists in the drama of life safety are the FIRE itself and the OCCUPANT of the building. There may be many supporting characters, but it is the tension between the lead players which must be thoroughly understood if life safety is to be provided.

THE FIRE: It is impossible to conceive of any aspect of life safety from fire which is not somehow related to the nature of fire.

While volumes have been devoted to fire and its products, all fires behave according to a few simple principles.

An understanding of these principles of ignition, burning and spread is basically more valuable than all the data and charts that have been assembled; if he understands the principles, the person responsible has a built-in reference for assessing all planning and design decisions.

INCOMPLETE RESPONSIBILITY: It is difficult to pinpoint responsibility for life loss from fire. And yet, unless clear responsibility for each element for life safety is assigned, effective implementation is not possible.

FRAGMENTATION OF EFFORT: The greatest problem in the study of fire is the diversity of interests on the parts of the people concerned with it. The fire problem is an animal of many heads, each with its own point of view. While most of the viewpoints are valid, each is usually subjective, limited in scope, and strongly related to a particular orientation.

PIECEMEAL ATTACKS: This fragmentation of effort results in piecemeal sorties rather than frontal attacks on the problem. Laws are made but not enforced; sophisticated alarms are installed, but no detection apparatus is used; great emphasis is devoted to drafting board details while basic planning is overlooked, and so on and on. Overall perspective is badly needed.

It is apparent that providing life safety today is regrettably more an ART than a SCIENCE. Although every fire is a potential laboratory for systematic exploration of life safety factors, this approach is rarely employed.

Based on the concepts presented in the remainder of the Overview, this report will attempt to:

- *provide an objective view of the problem,*
- *suggest a systematic approach to solving it,*
- *recount the best thinking on life safety approaches,*
- *point directions which may ultimately make life safety a quantitative science.*

INERTIA IN RECOGNIZING A NEW OCCUPANCY: A considerable effort will be needed to persuade everyone concerned with life safety that there are unique problems related to each occupancy. History has taught us that it may well take a series of disastrous fires before housing for the elderly is recognized as a distinct occupancy with distinct life safety problems.

Witness the nursing home: As this occupancy grew in importance from 1951 to 1966, it took no less than 48 multiple life loss fires (428 fatalities) in these 15 years to prompt virtually every state to take positive steps regulating life safety. While most of these simply enacted additional legislation in code form, many recognized the basic problem and undertook comprehensive solutions. Will it be necessary to learn the same lesson in housing for the elderly?

RELIANCE ON CODES AND REGULATIONS: Possibly the greatest misconception is that building codes and regulations provide for maximum life safety levels. For several reasons they cannot and do not:

- They are social instruments, designed to protect neighbor and community from fire spread and conflagration.
- They are structure-oriented, concentrating on saving the building by setting up fire-resistance ratings for structural elements. This concern is related to life safety, but can be misleading: it is like saying that a gasoline truck is safe because its contents are in a noncombustible container.
- They can require only minimum levels of safety.

The proliferation of codes, regulations and statutes on fire safety has discouraged the analysis of fire problems peculiar to any one occupancy or building type

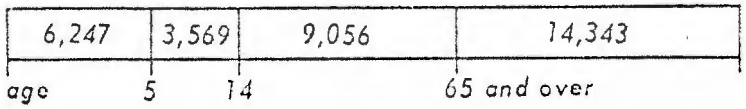
OVERVIEW / PROBLEM

Over the years, anyone concerned with life safety accumulates a collection of ideas, facts, concepts and approaches to the problem. Some of these notions are accurate, others are not; some are proven, others "just seem to work". Some are derived from systematic investigation, others are little more than old wives' tales. Some become formally embodied in codes, regulations, and planning manuals; others are much less formally applied throughout the planning, design, and operation of facilities.

The number of fire deaths, however, suggests that at least a few of these notions are less than adequate. Before reviewing the concepts around which this report is built, it might be wise to consider some of the more important "weak spots" in traditional approaches to to life safety.

A NEW OCCUPANCY TYPE: The emergence of housing for the elderly as a distinct facility type is a recent development. The usual reaction is to classify this new housing with nursing homes, conventional apartments, or other inappropriate occupancies. This thinking when applied to life safety from fire is potentially dangerous. It overlooks the fact that there are few or no attendants available; the occupant has not been considered as an individual with unique capabilities, reactions, and limitations.

Why this study? The simple diagrams shown are the justification for writing yet another book on fire.



- The bar chart shows that 14,340 of 33,220 (or 43 of every 100) persons who died in fire from 1955-1959 were 65 years of age and older, and,

- If children under 14 are included, it shows that age and judgment were factors in 73 of every 100 fire deaths.

These are compelling figures. They indicate that life safety efforts directed to "average" people of "average" age and judgment are not recognizing the essence of the fire problem.

What are the premises? In simple terms, this document is based on two premises:

- That, to a great extent, the expendability of these 14,340 elderly individuals was determined, and accepted, before the fact of the fire, and

- That many of these people could have been saved

To whom is it directed? A fundamental thesis of this document is that responsibility for life safety in fire is shared by many well-intentioned people who do not clearly understand their exact responsibilities. This vague, and often omissive approach, is too frequently the direct cause of life-loss. For this reason, this report is directed to several distinct decision makers and defines the specific responsibility of each. This audience includes city officials, fire prevention personnel, inspectors, owners, administrators, staff, architects, and the occupants themselves.

How should it be used? Not many readers will have the time or the interest to read the entire report. For them a perspective of the problem is presented in the Overview and chapters of particular interest are indicated in the Responsibility Chart in Chapter 5. It is to the "Decision Makers" on that chart that the entire report will be of value and interest.

What is the background for the report? This report is a result of a two-year research study conducted for the FHA by the Center for Architectural Research at Rensselaer Polytechnic Institute. During the study many experts were interviewed. literature was searched, and thousands of fires were screened to provide a data base of 1000 fires for detailed analysis. This is a distillation of all that experience, and more importantly, it is the summation of the ideas of many men who have spent much of their lives studying the problem of life-safety.

Troy, New York

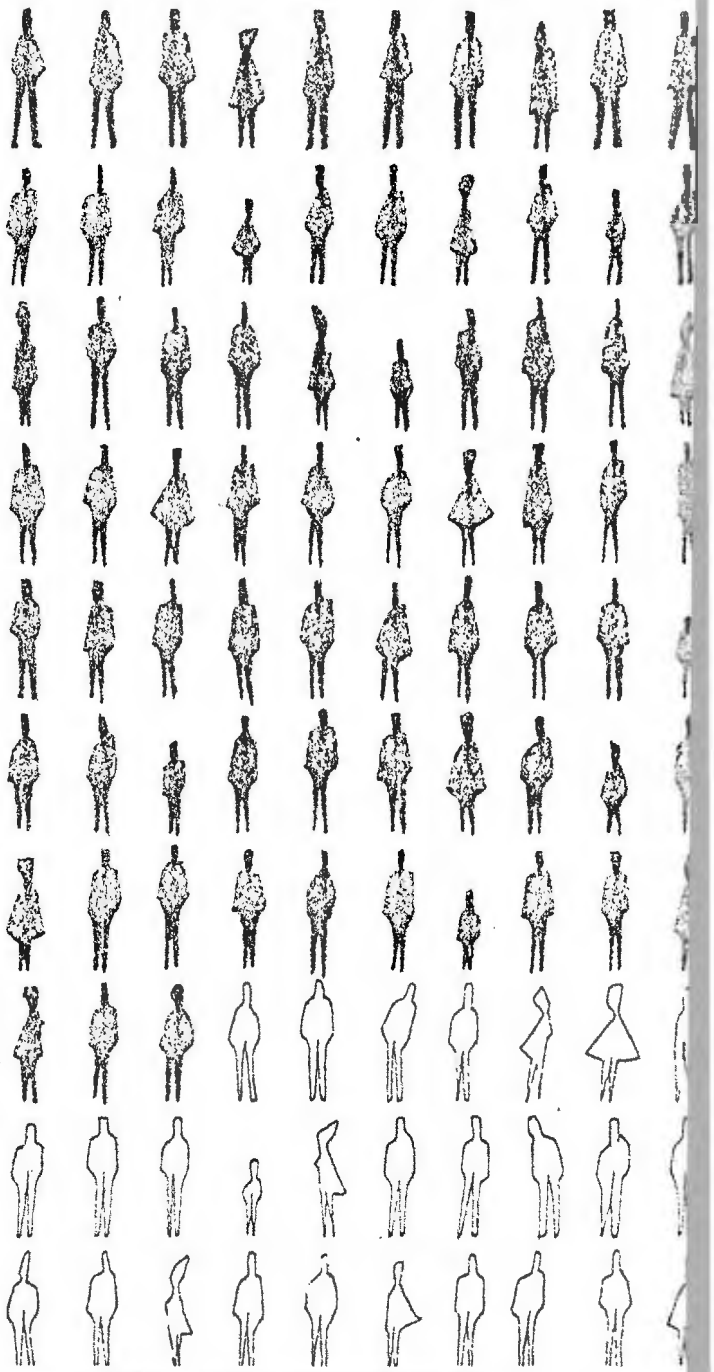
PREFACE

This Technical Study has been prepared for the Federal Housing Administration. It can also be used by architects, builders, and administrators of housing for the elderly projects as a source of information dealing with the problems of life safety and fire protection. It does not amend or supplant the FHA Minimum Property Standards.

As part of its continuing review and updating process, FHA regards this comprehensive collection of data to be a significant step in establishing scientific facts needed as a basis for strengthening life safety aspects of design of housing for the elderly. This study emphasizes human occupancy and personal safety rather than preservation of the structure. The results of investigative work include recommendations and procedures related to the protection and escape of the occupants through the use of early warning devices and/or special design and construction features based on the knowledge gathered from actual field experience and statistical data assembled for this specific purpose.

FOREWORD

The Department of Housing and Urban Development and the Federal Housing Administration are concerned with the livability of properties for which mortgage insurance is issued. Through the Technical Studies Program, FHA sponsors research to establish standards of acceptability and safety to improve this livability throughout a wide range of residential types of construction. This document is a collection of the most up-to-date ideas, facts, concepts, and approaches to dealing with the problem of fire protection and safeguarding the occupants in housing for the elderly.



From, N.F.P.A., Fire Protection Handbook.

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THE FUTURE

1

THE NATURE OF FIRE

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what is fire?

Fire has many faces. To the layman it is a fr
enemy. To the scientist it is a complex interre
ship of chemistry and physics. To all concerne
LIFE SAFETY, it is a deadly force to be reckone
an understanding of its nature is essential.

Fire often behaves in complex and unpredictable
Fires start at different temperatures, spread at
ent rates, in different manners, and produce di
amounts of by-products. Fundamentally, howev
fires are governed by three common principles:

- The first principle: A BURNABLE MATE
OXYGEN AND AN IGNITION SOURCE ARE
ESSARY TO PRODUCE FIRE.

- The second principle: THE MATERIAL MU
PREHEATED ENOUGH TO PRODUCE CO
TIBLE GASES BEFORE IT WILL BURN.

- The third principle: THE MATERIAL WILL
TINUE TO BURN UNTIL IT IS CONSUME
UNTIL THERE IS INSUFFICIENT OXYG
SUSTAIN BURNING, OR UNTIL THE MAT
IS COOLED BELOW THE TEMPERATU

fuel

The fuel for a fire consists of the materials of the building and its contents; if these are totally "fireproof", there can, of course, be no fire. The following fire characteristics of materials should be considered in their selection:

- COMBUSTIBILITY. This is the capability of undergoing combustion when exposed to an ignition source; the usual measure is the temperature at which a material becomes preheated enough to produce combustible gases which will burn if exposed to flame. There are dangers in accepting this measure wholly, however, since wood shavings will ignite more readily than a large block of wood, even though both have the same ignition temperature.

- While no material is "fireproof", some have such high ignition temperatures that they are virtually incombustible in time of fire.

- FLAME SPREAD. The tendency of flame under ordinary fire conditions to spread along the surface of a material without seriously consuming the material itself is a characteristic of many building materials. The "flame spread rating" given materials relates them on a scale from cement asbestos (index 0) to red oak (index 100) to some kinds of cotton fabrics (at index 2500). While these ratings are arrived at in laboratory simulation tests, they give a good relative indication of flame spread rates; this characteristic is particularly important in selecting finish materials in rooms, corridors, and exits.

ignition temperatures

material	*type of specimen*	*temperature °F*
douglas fir	*shavings*	*500*
white pine	*shavings*	*507*
newsprint paper	*cuts*	*446*
cotton, sheeting	*roll*	*464*
woolen blanket	*roll*	*401*
matches	*heads*	*325*

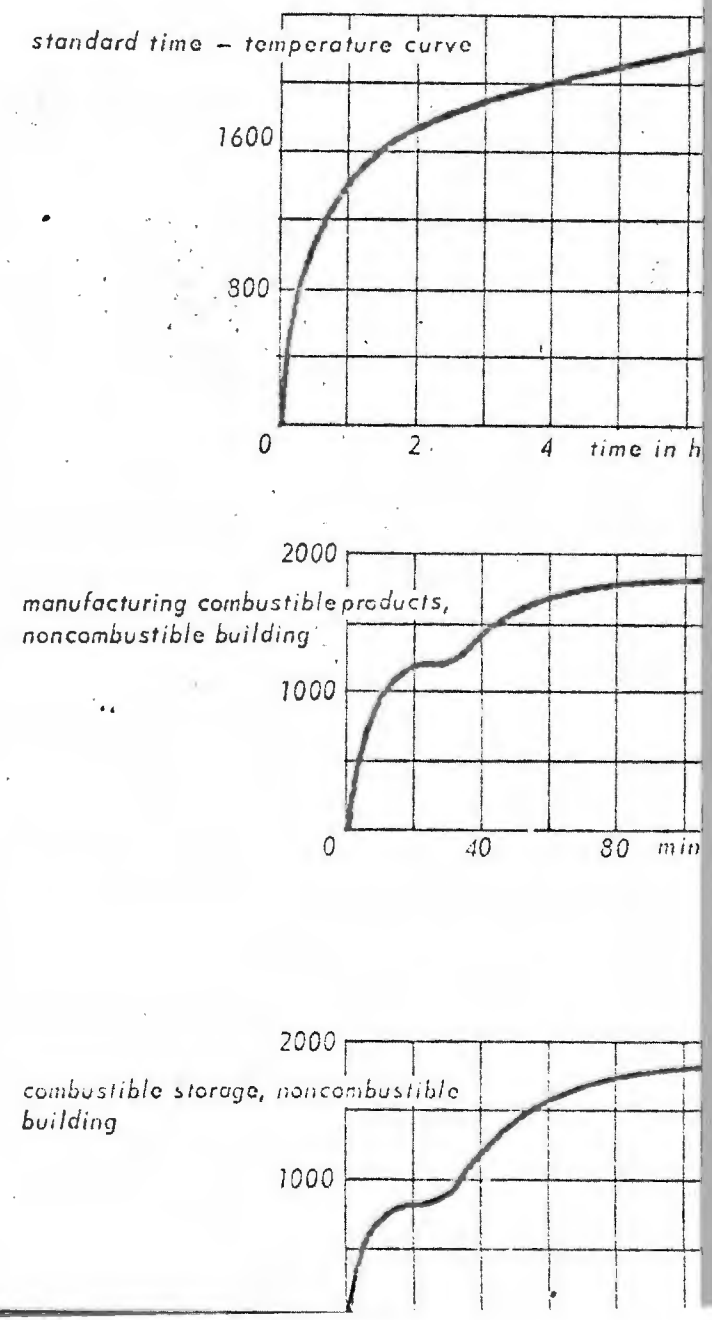
flame spread ratings

material	*flame spread*
cotton fabric in folds	*1600-2500*
lumber untreated	
birch	*105-110*
douglas fir	*115*
red oak	*100*
lumber, treated	
birch	*15-20*
douglas fir	*10-60*
red oak	*30-50*
gypsum wallboard	*10-15*
aluminum with baked enamel finish on one side	*5-10*
cement asbestos board	*0*

- FUEL CONTRIBUTED. Since new fuel must constantly be supplied and preheated to contribute to fire, the total amount of heat (and the rate of generating that heat) produced by already-burning material is a factor in fire spread. Tunnel and calorimeter tests to measure these quantities of fuel contributed provide an additional basis for the selection of materials.

- SMOKE AND GASES DEVELOPED. Since smoke and gases are the primary life safety hazards, a knowledge of the toxicity and quantities of gases likely to be produced from a material is fundamental to life safety. There is no direct relationship between the flame and smoke-producing characteristics of a material. So far, tunnel tests have been used to provide comparison with red oak (at index 100), but safety standards are not definite. The use of materials with the lowest possible smoke-producing ratings is the only available guideline.

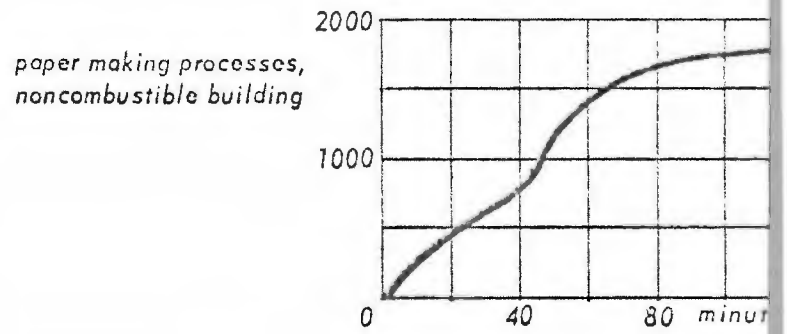
- FIRE RESISTANCE. While no material is fireproof, many can successfully withstand exposure to severe building fires. The quantitative measure of this capability is termed fire-resistance, and is measured by the so-called "hour ratings" given to materials and assemblies of materials.

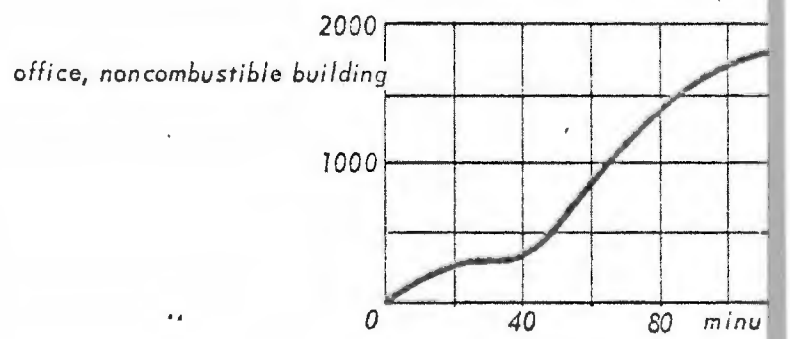


The standard fire test exposes the material or assembly being tested to the time-temperature conditions in the diagram; heat transfer, integrity under fire and subsequent hose stream are measured in terms of time and a fire-

In simple terms, any assembly given a "4-hour rating" can be expected to remain structurally sound, resist fire penetration, maintain a temperature of less than 250° above initial temperature on its cool side, and not fail if exposed to a hose stream for a total of 4 hours under the temperatures given.

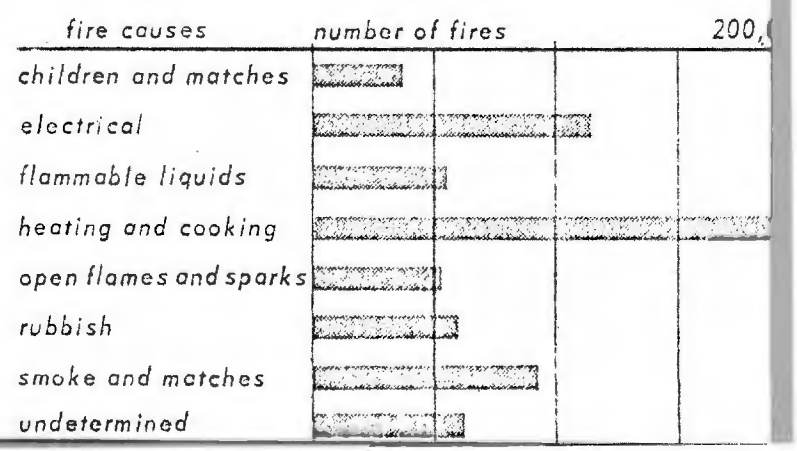
The determination of fire resistance ratings required for building elements is a function of the building code, and here occupancy type must be considered. As can be seen in the diagrams, different occupancies produce different fire loads, resulting in different degrees of fire severity and different time temperature curves. These curves influence the fire resistance ratings chosen for each occupancy.





ignition

In broad terms, any source of heat energy is a possible source of ignition; this includes all forms of mechanical, electrical, chemical and other energy sources. Even though other conditions must be met before a fire starts, it is common practice to attribute the cause of a fire to its ignition source, (that is, we say "matches" rather than "poor housekeeping").



spread

The margin of difference between most small fires and large fires is the fact of spread. While a quantitative measure for spread is not yet feasible, it is possible to anticipate the probable spread of any fire by understanding the basic principles of fire, the characteristics of its fuel, the quantity distribution of the fuel, and the principles of heat transfer. This kind of understanding cannot account for all the variables involved in spread, but it is the proper basis for designing for life safety.

Heat is transferred by three basic means . . .

CONVECTION, or transfer by air movement. This means that . . .

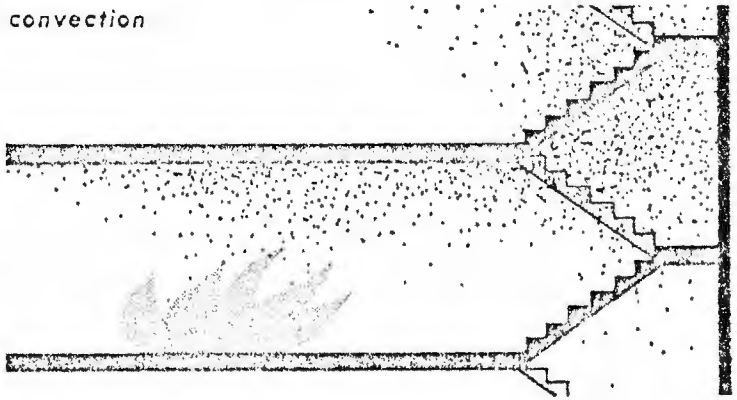
- Heat and gases will move rapidly to the ceiling and upper walls preheating new fuel sources.
- Heat and gases will readily move through vertical openings, chimneys, chutes, dumbwaiters, ducts, pipe openings, stairs, and shafts
- If confined vertically, fire will travel horizontally through plenums, ceiling spaces, ducts, and wall openings.
- Heated air will expand, exerting positive pressure against doors, dampers, or weak materials, penetrating any opening found or made.

CONDUCTION, or transfer through solids. In case of fire . . .

- Heat may be transferred through metal piping, conduits, ducts, or structural elements to all areas of the building.
- Heat may cause expansion and cracking, providing new paths for spread.

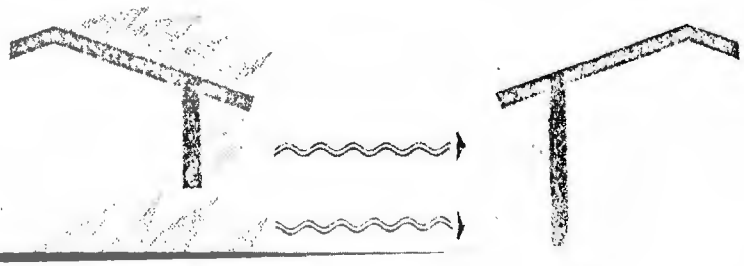
RADIATION, or transfer across space from a heated

convection



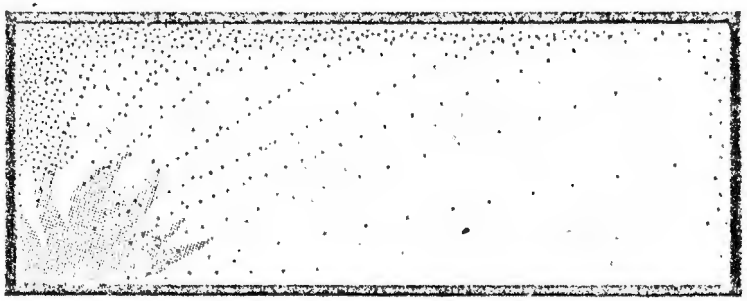
conduction

radiation



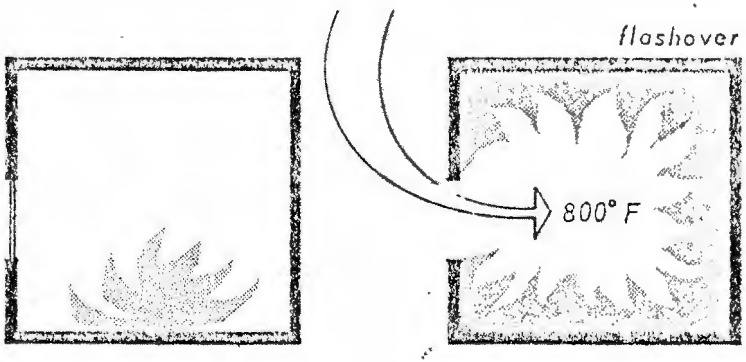
Certain patterns are always noticeable in the spread of fire:

- Since heated air rises, the ceiling and upper walls are preheated first, and most spreading occurs along these surfaces. Materials used in these areas must be carefully considered in terms of their flame spread ratings.



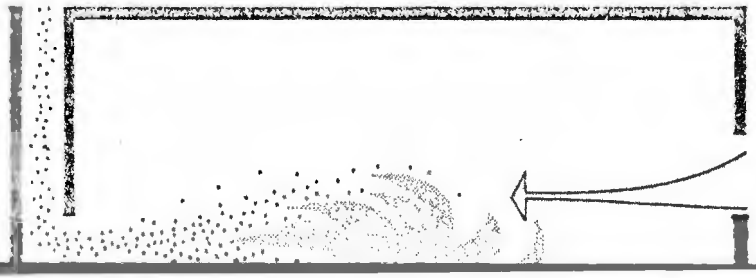
preheating

- Flashover, or the sudden and extremely rapid development of flame, is a common phenomenon in buildings with combustible surfaces and contents. When temperatures rise to about 800°, or oxygen-starved gases are suddenly oxygen-enriched, all the combustibles in an area ignite practically simultaneously, and the flames suddenly spread from local burning to total area involvement.



flashover

- Just as a fireplace chimney provides an escape route for heated gases, and creates a partial vacuum in the room (which attracts new supplies of oxygen for the fire), so do the vertical openings in a building provide an exhaust and a demand for additional fresh air. From a small vertical pipe opening to a large building inner court, the principle



partial vacuum

Control and extinguishment

The third principle of fire indicates that a material will burn until it is consumed, the oxygen is removed, or it is cooled below the point where combustible gases are produced. Every extinguishment technique is based on one or more of these approaches:

- Limit the combustibles
- Smother the fire
- Drown the fire

The techniques of control are less direct. The amount of fuel available must be controlled, and the fire and its by-products confined. In any case, a controlled or confined fire buys time until life safety can be achieved. This time is shortened as the area of containment increases from the room of origin, to the area of origin, to the floor of origin, and finally to the building of origin.

the by-products of fire

In addition to a basic understanding of fire itself, some knowledge of its by-products is necessary for those concerned with life safety. The by-products vary greatly from fire to fire, but the major ones are present to some degree in every building fire. They include flame, heat, smoke, toxic gases, and oxygen depletion

FLAME: This is the "light" of the fire and is the only life safety gift contributed by the fire:

- It is frequently the earliest warning that there is a fire.
- It is often closely associated with the source, and helps in finding the source.
- It assists in locating probable and improbable paths of escape

On the other side of the picture, however:

- It can inflict fatal burns.
- As a source of heat, it causes spread.
- Its first sighting may trigger panic.

HEAT: Heat is both a product of fire and a means for spreading it; by constantly preheating adjacent materials to their ignition temperatures, it provides new fuel. Temperatures rise quickly, and human tolerance levels are often as low as 110° or 115°; thus the control of heat is vitally important to life safety.

SMOKE: The result of incomplete burning, smoke is a prime hazard to life safety:

- It breaks down bodily processes, and is sometimes fatal.
- It attacks breathing and vision, lessening time for escape.
- It spreads with the expanding heated gases from the fire, permeating a building quickly and completely.
- It can block escape routes.

causes	fatalities	injuries
body burns from flames	27%	46%
suffocated or overcome by smoke or fire gases	64%	43%
other causes	9%	11%

From, An Investigation of The Hazards of Combustion Products in Building Fires, October 1963.

% oxygen in the air	normal reaction
21	normal respiration
15	muscular coordination reduced
10	faulty judgment and fatigue

On the positive side, however,

- It may serve as an early warning that there is a fire (although time from detection to intolerable levels tends to be short).
- It can be mechanically detected much faster than heat or light.

TOXIC GASES: The production of toxic gases during fire has made them the chief "killers" in an overwhelming number of multiple-casualty fires. These gases become progressively more toxic during the fire, thus decreasing the time available before intolerable conditions are reached. A sleeping person in the presence of a smouldering fire could die without ever waking, or, if awakened, could become so confused as to be incapable of logical response.

OXYGEN DEPLETION: Both the fire and the occupant compete for vital oxygen; it is possible that oxygen levels become critical for the occupant long before toxic levels are reached by the other gases. The chart shows the reaction of the average person to decreasing oxygen content in the air he breathes; with exertion, the symptoms will appear even more quickly than indicated.

2

THE OCCUPANT

introduction

As the human life span lengthens, and as an increasing proportion of our population moves into the upper age bracket, the task of providing shelter specifically for older people becomes one of real importance. For many decades there have been establishments dedicated to the aged sick and infirm, but the emergence of a building type for a group of healthy and reasonably active persons, whose only common characteristic is their age, is a relatively recent development.

Several factors have served to draw many of these older people into housing types specifically designed for them

- There is an increasing tendency for older people to live their own lives, independent of their families. People are retiring from active life earlier and are living longer after their children have left the household. Even though many older people do continue to live with their families, most American homes are not designed for this situation.

- A rising economic status and increasing mobility provided by retirement funds and social security reinforces this independence from family and allows more freedom in the choice of suitable housing.

- The need to remain active, and the desire for contemporary companionship tends to draw older people toward places where this activity exists and where they can be with persons of their own age.

- A concentration of older people gives rise to services and facilities directly related to their needs; this, in turn, attracts more people of the same age group.

where there are certain special services offered, or where medical care is readily available, there is an added attraction for becoming part of such an establishment.

- There is an increasing social concern for housing this age group, as evidenced by government programs, increased social security benefits, and aid to construction.

The result has been a proliferation of homes and building complexes designed specifically for the elderly. Some are privately owned and operated, others are operated by non-profit or public agencies. Developments are usually characterized as private housing (not institutions), and rentals may range from $50 to $900 a month per unit.

The social implications of separate housing for the elderly are often controversial and are not the subject of this report. They are of concern in life safety, however, since the degree to which a uniform population of older people can assist each other in case of fire is significantly reduced.

the elderly occupant: who is he?

A basic thesis here is the importance of the occupant; to a great extent, his characteristics, his habits and his limitations influence the course of action necessary to assure his life safety from fire.

Therefore, it is absolutely necessary to define which segments of the elderly population we are dealing with and then to determine their characteristics and limitations before life safety procedures can be established.

What is "housing for the elderly"? As defined by the Federal Housing Administration and others, the issue settles on three basic criteria: age, health, and degree of assistance needed.

AGE: The most obvious, but the most misleading, characteristic of housing for the elderly is the age of its occupants. It is hard to pinpoint any borderlines between the "aged" and the "middle-aged". Many are as young as 55, some are as old as 100 – a span of 45 years! Some persons in their 50's and 60's exhibit physical characteristics that one might expect of persons 30 years older, and vice versa. In spite of these variations, it is necessary to consider the average population of these establishments to be significantly older than residents of apartments or other dwellings; average life expectancy today is over 70 years, and the percentage of persons in the upper age bracket continues to climb.

The FHA considers a minimum age of 62 to distinguish residents of this building type; others have set limits as low as 52. The designer responsible for life safety should not be misled by this minimum however; the "average" resident is at least in his 70's, and, in many cases, older.

HEALTH STATUS: As a distinct building type, housing for the elderly tends to exclude those persons requiring constant medical attention. This housing type does not include nursing homes, convalescent units or hospital-associated care units.

There is, however, a trend toward designing complexes for the aged which include units for medical and nursing care. These buildings, or parts of the complex, are considered as nursing or hospital units with their own different life safety standards.

Even with the segment requiring continuing medical attention excluded, the health status of elderly people covers an extremely wide range. Other parts of this chapter are devoted to exploring and defining the range that might be expected; the designer must be careful to keep this range in mind when considering life safety.

NEED FOR ASSISTANCE: A critical distinction in defining housing for the elderly is the amount of organized assistance (nurses, attendants, orderlies) needed by and available to occupants. As outlined by the FHA, housing for the elderly does not presume or require such assistance; this absence of organized help in time of fire is an important life safety consideration.

In summary, the approach to life safety taken here will consider an occupant who is, on the average, older than 50 or 60, but may range to 90 or more. This occupant generally exhibits the general physical, physiological and psychological patterns associated with age and increasing deterioration; he is not, however, clinically infirm or regularly confined by sickness. Finally, he does not need continual assistance, and, in fact, any such assistance is assumed not to be available

physical factors

Based on the kind of elderly population described above, some general comments on the occupant's physical character and behavior can be made:

MOBILITY: While many elderly persons are bed-ridden, it can be assumed that the occupant of a housing for the elderly establishment is at least semi-ambulant: he can walk without constant assistance. He may, however, exhibit some marked limitations in getting around. Studies have suggested that perhaps as much as 35% of the ambulant population over 65 have trouble climbing stairs and performing other complex movements (such as climbing through windows).

There are other factors contributing to lack of mobility which should also be recognized. The elderly tend to lift their feet only half the distance of younger persons, dictating care in changes of level, thresholds, and so on. Decreased psycho-motor functions coupled with loss of strength diminishes sense of balance, making negotiation of stairs and the assumption of awkward positions difficult. Finally, the loss of strength often breeds a loss of confidence, causing fear of traffic and movement.

HEARING: A study of persons in Nursing Homes by the Public Health Service found that 10% of all persons in the 65-74 age bracket, and 26% of those over 85 suffer from serious impairments of hearing. Other studies estimate that by age 80, two-thirds of all persons have "significant" hearing problems. These impairments, which usually affect the higher frequencies first, are particularly important in time of fire; the person with poor hearing may not hear the alarm, shouted directions, or the fire itself.

VISION: With age also comes impairment of vision. Not only are significant portions of the elderly blind or near-blind (most of these people will be in facilities offering care), but a great portion suffer from loss of detail in dim light. In addition, when eye muscles begin to atrophy, the speed of accommodation to bright light begins to decrease, thus increasing the danger of "blinding" by fire and flame.

SENSE OF SMELL: As he ages, a person's sense of smell undergoes a general and progressive decline; at any time, his olfactory nerves may be suddenly obliterated, temporarily or permanently. This lessens his chances of detection of fire and its products – both when it breaks out and as the occupant tries to escape from it.

DISORIENTATION: The tendency to become confused and disoriented, caused by both physical and psychological factors, naturally tends to increase with age.

tolerance factors

Individual tolerance levels in terms of fire and its products vary. A limited amount of study has been undertaken in this area, and differences in ages, physical condition, degree of rest or exertion, and exposure time have made any uniform conclusions difficult. An "order of magnitude" is fairly well defined, however, and while this information has not been specifically compiled for the elderly, it is obvious that many of the tolerance levels given will decrease with age.

HEAT: The heat produced by fire can be dangerous in two ways:

- It can inflict burns. One authority reports second degree burns in 20 seconds at 130° F, and first degree burns at 160° F in 1 second.
- It can damage the respiratory tract through inhalation. Both time and the moistness of the air are factors; a range of 155-160°F exposure in a few minutes will probably do "irreversible damage", with the temperatures lowering as air becomes more moist. The range may drop to as low as 130° (or lower with increasing moisture) for the elderly.

SMOKE: Many studies have indicated that smoke makes conditions intolerable before excessive temperatures are reached. While inhalation of smoke is potentially dangerous, its effects on vision and visibility are probably more crippling as the occupant tries to escape. When visibility is cut to 4 feet or less, most escape routes become useless.

GASES: Along with smoke, gases are the "killers" among fire products. The kinds of gases, and the levels at which they become intolerable, are hard to predict since they will depend on the type of fire, the kinds of fuel available, and the reaction of the individual occupant. Slow-moving fires are particularly dangerous, since their gases reach high levels of toxicity before they ignite.

Gases, too, present a double danger to the occupant: in low concentrations they are irritating, causing gasping (and inhalation of more gases) and blinding, and in higher concentrations, they are fatal poisons.

Of primary concern in residential fires are carbon monoxide, carbon dioxide and the depletion of oxygen (or anoxia). The most common cause of death, carbon monoxide, has no odor or color and is the result of incomplete combustion of any carbonaceous fuel. Carbon dioxide is inherently less dangerous, but its presence in abnormal concentrations increases the rate of breathing, and hence the amounts of other gases inhaled. Oxygen depletion, as stated before, produces fatigue, faulty judgment, collapse, and death as less and less vital oxygen is made available to the occupant. The chart summarizes the critical levels for each of these gases.

gas produced		toxicity levels
(most common gases)		
CARBON MONOXIDE	results from incomplete combustion principle cause of fire death normal reaction passes from dizziness to nausea, sleepiness, unconsciousness and death no odor	1.28% concentration can cause death in three minutes
CARBON DIOXIDE	a heavy gas which tends to settle to the floor and block escape large amounts (3%) increases breathing rate (as much as 100%) increasing proportions of other gases taken in no odor	10% concentration can cause death in a few minutes
(other gases produced)		
HYDROGEN SULFIDE	the "rotten egg" gas	0.1% can be rapidly fatal
SULPHUR DIOXIDE	a respiratory irritant can cause paralysis of the lungs	0.5% to 1% will produce serious injury
AMMONID	an extreme irritant	one-half hour at 1% can be fatal

Other gases, such as hydrogen cyanide, nitrogen, nitro dioxide, acrolein and similar gases are normally associated with the burning of materials in commercial occupancies, are less likely to occur in housing for the elderly.

The likelihood of other, highly toxic gases is always present in a fire, especially where large concentrations of pyroxylins, wool, silk, rubber or chlorine are present. Most authorities, however, feel that the effects of these gases in residential occupancies are secondary to those of the three mentioned above.

SHOCK: Shock is an unpredictable and often inexplicable physiological reaction to disaster or emergency. It may be brought on by any of the products above, but may also be caused by the sight of, or the psychological reaction to, the presence of fire. It may be related to heart failure which, of course, is an ever-present spectre for many elderly persons.

psychological factors

While it is difficult to precisely assess the effect of psychological factors on the behavior of the elderly person in time of fire, most agree that there is a significant impact of some sort. The documentation is weak, but several reactions have been noted. Psychological reactions are particularly hard to accommodate in codes and regulations, and those involved in housing the elderly should pay particular attention to them.

BEFORE THE FACT OF FIRE: Psychological factors often characteristic of the elderly may significantly increase the possibility of fire outbreak:

- The collection, conscious and unconscious, of old objects, stuffed furniture, outdated appliances, and other assorted memorabilia is a characteristic of age. These not only provide additional ignition sources, but they also increase the problems of confinement and control when fire does break out.

- As a person loses friends, becomes depressed, or "doesn't care", it is an established fact that he is likely to have more accidents, also increasing the possibilities of fire outbreak.

WHEN FIRE BREAKS OUT: It is when fire occurs, and the elderly person first comes into contact with it, that the critical psychological factors become apparent. Again, there is a great need for further study in this area, but certain behavior patterns have been pointed out as "characteristic" of the aged:

- With persons of all ages, the instinct for self-perservation is fundamental. The thought of providing an alarm for other occupants is usually secondary, or completely overlooked, adding valuable minutes to the time that others may take to react to the fire.

- If the fire is small enough, there is an instinctive reaction to control the fire as best one can. This is particularly important to the elderly occupant since his self-sufficiency is often a point of personal pride; it is also particularly dangerous since his physical ability to cope with the emergency may have been greatly reduced through the years.

- Left with his apartment or room as his only significant material possession, the decision to leave it (particularly when the disaster cannot be immediately seen) may be an extremely reluctant one for the elderly occupant. Firemen have reported cases where the elderly have to be forcibly removed from the premises, even when faced with the fact of fire.

- The tendency toward confusion in the face of disaster is also important. Simple protective measures (such as closing transoms, using wet blankets, and pre-testing doors for heat) may be overlooked.

- The atavistic tendency to follow familiar routes in an emergency escape, is one which seems to be particularly characteristic of the aged; when the familiar route is blocked, the resulting confusion often leads to entrapment. This has important implications for training programs and the location of alternate escape routes.

- Finally there is the often false assumption that any alarm automatically summons professional assistance.

the occupant: in summary

Before proceeding with specific recommendations and suggestions for life safety measures for the elderly, it is important to reiterate their characteristics and limitations. Who is being designed for here?

- He is in his later years, older than 50 and more likely to be 70 or more.

- He is not clinically infirm, but may suffer significant impairments in mobility, vision, hearing, and smell.

- The whole realm of decisive movement may be physically and psychologically difficult for him.

- His physiological tolerances to fire products are lower than those of younger people.

- He may be less capable of clear and logical thinking in time of fire.

- The problems of security and attachment to premises and possessions may make abandonment a major problem in time of fire.

- No matter what his limitations are, design for life safety must be predicated on self help only; ready assistance by attendants is assumed to be unavailable.

regulations

This profile of the elderly occupant causes problems when contemporary life safety regulations are examined.

To a large extent, life safety from fire is reflected in applicable building codes, licensing, inspection and other regulations. These codes and regulations are set up and often administered by occupancy type, and, of course, the principles of life safety vary widely from one type of occupancy to another.

Because of its newness, housing for the elderly rarely rates consideration as a separate occupancy type in these codes and regulations. It is most often classed – formally, or, as a matter of practice, with NURSING HOMES or MULTI-FAMILY DWELLINGS.

Using the FHA guidelines and the description of housing for the elderly given in the preceding paragraphs, this occupancy is NOT the equivalent of nursing home, hospital intensive care unit, convalescent home, or even the generally accepted definition of a rest home. In each of these cases, some degree of responsibility and immediate assistance for the occupant is implied; such is not the case in housing for the elderly.

The majority of cities and states tend to class housing for the elderly with other apartments and multi-family dwellings. Only now are they beginning to realize the fundamental differences between a population of older people, with certain group limitations, and those who normally occupy these other multi-family dwellings.

Where code or regulation occupancy classifications have not been updated to include housing for the elderly, those responsible for life safety in this occupancy must be particularly aware of its essential differences and their implications for building design; such is the goal of this document.

3

TIME

a traditional measure

Through the years, time has become the accepted yard-stick for "measuring" fire and the effectiveness of techniques to prevent its ignition or spread. Intuitively this is logical, for common sense tells that the longer a fire is let run, the more dangerous it becomes.

The role that time plays in the various aspects of fire and safety is illustrated by these examples:

- Every fire house logs the time spent on every fire, including alarm time, departure, running, set-up, control and extinguishing times. Many innovations in practice – including the slide pole – result from this constant consciousness of time.

- Detectors, sprinklers, and other alarm or extinguishing devices are rated in terms of time. The fire resistance of building materials and assemblies are also rated in terms of time. Flame spread indices are comparative measures of time.

- Fire drills use constant training to reduce evacuation time. Distance, height and area limitations of buildings, too, are functions of evacuation needs and time.

- Fire walls, doors, and areas of refuge within the building buy additional time for survival during a fire.

relating time to life safety

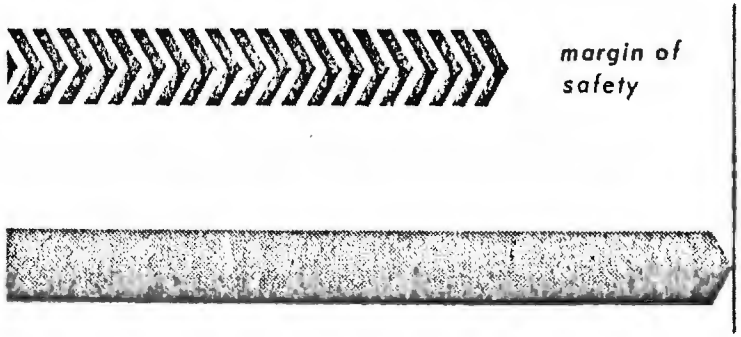
It is not hard to apply time as a "measure" of life safety; all one has to do is picture the attainment of life safety as a race against time. The two competitors in the race are CRITICAL and REACTION TIMES.

As a fire burns, its dangerous by-products build to higher and higher levels; at some point these levels become intolerable to the human occupant, and his life is lost. The elapsed time from the start of the fire to the attainment of these intolerable levels is called CRITICAL TIME.

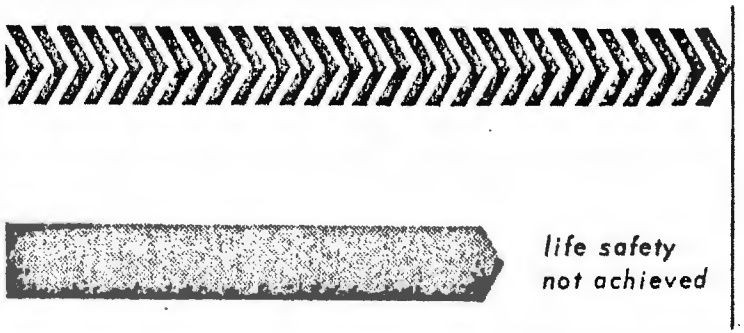
While these levels are building up, though, the occupant is hopefully reacting to the fact of fire and achieving life safety. The time it takes him to do this is called REACTION TIME.

Relating the two times, a pair of axioms results:

- If the occupant's REACTION TIME is less than the fire's CRITICAL TIME, he reaches life safety before intolerable conditions occur, and his life is saved.



- If the occupant's REACTION TIME exceeds the fire's CRITICAL TIME, intolerable conditions are reached before he can reach safety, and his life is lost.



looking at critical time

Critical time relates to a given occupant in a given space. It will normally be different for each occupant and each space. Whichever fire product reaches the intolerable level for the occupant first has determined his critical time:

- Time for temperature to reach a critical level.
- Time for smoke to reach a critical level.
- Time for gases to reach a critical level.

As indicated in Chapter 2, the tolerance level for each individual is different. It is also apparent that critical time will change as the occupant moves from space to space; hopefully always in the direction of increased time.

looking at reaction time

Reaction time is the time required for any occupant to reach life safety, and it can be said to be made up of three component parts.*

- Time from start of fire to detection
- Time from detection to alarm
- Time from alarm to reaching life safety

Some parts of reaction time may depend on mechanical devices or other people, but most often it is a function of the individual occupant himself; his ability to detect fire, to hear an alarm, and to escape or evacuate to a fire-safe area.

reaction time is an individual measure

child

young adult

elderly person

type of wall lining	*time to critical level*
non-combustible	*11.7 min.*
combustible	*5.6 min.*

From, N.F.P.A., Fire Protection Handbook.

Reaction time, then, varies from occupant to occupant. One person may achieve life safety instantaneously by simply stepping outside a smoke-filled room; another may have considerable difficulty in detecting the smoke, hearing the alarm, or moving to safety. For this reason, the essential characteristics and limitations of the occupant are extremely important in considering reaction time.

the goal of life safety

The broad goal of all life safety approaches and techniques is to do everything possible to insure that CRITICAL TIME EXCEEDS REACTION TIME, and that the "margin" between these two times is as great as it can be within the limits of economy. Accomplishing this objective is dependent on two factors.

- Keeping reaction time to a minimum. This is a real problem in housing for the elderly, since the physical and mental limitations of the occupants often increase their reaction time. Hearing may be poor, visibility below par, and mobility seriously restricted – all will significantly lengthen the reaction time and decrease the margin of safety. A simple rule to remember: THOSE RESPONSIBLE FOR LIFE SAFETY IN HOUSING FOR THE ELDERLY ARE DEALING WITH A LENGTHENED REACTION TIME AND, THEREFORE, A SHORTENED MARGIN OF SAFETY BECAUSE OF THE NATURE OF THE OCCUPANTS.
- Keeping critical time to a maximum. This time will, of course, vary from place to place in the building and with the fire products produced. The chart shows the effects of changing interior finish materials and time to reach intolerable conditions in one particular case.

The entire approach to life safety spelled out in the following pages of this document is based on these simple time relationships.

documenting reaction time

While some studies have been undertaken in both the areas of reaction time and critical time, no real integration of the two has yet been made. There is good information available on human tolerance levels as related to percentages and temperatures, but the time necessary to produce these conditions in a fire has not been thoroughly investigated. The entire area of reaction time remains largely unstudied, and only "order of magnitude" estimates are currently available as standards.

*The notion of reaction time, as presented here, is derived from a similar time measure developed by Rexford Wilson of the NFPA. This "reflex time" is defined as the time from ignition to "water on" for a fire, and was designed primarily to measure fire department effectiveness. Reaction time orients this approach more specifically to life safety.

4

PHILOSOPHY

a necessary compromise

It is simply not feasible to build, for every occupan in every housing for the elderly establishment . . .

. . . a fully fire-resistive compartment

. . . complete with alternate egress routes .

. . . which is sprinklered, flame-proofed, protectec by detectors and alarms, with . .

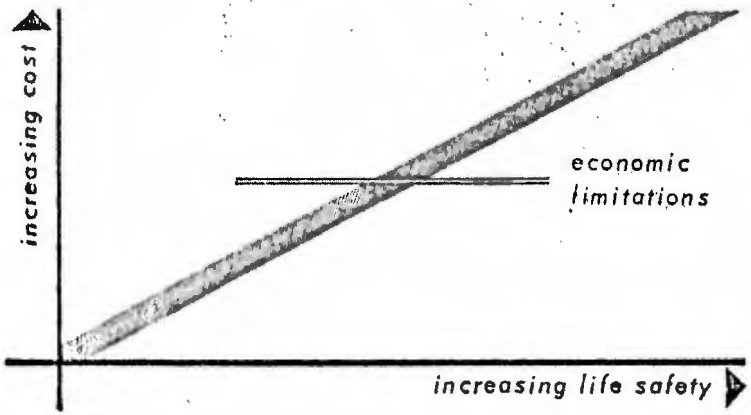
. . . a Class A fire department within one minute cal

Any compromise with these requirements accepts the fact that an occupant may lose his life in case of fire; yet for practical reasons, there usually must be a compromise.

The compromise is chiefly due to economic considerations. The conflict between the need for housing the elderly and the extremely high cost of "assuring" life safety creates a real dilemma: if the cost of housing is disproportionate, new facilities simply will not be built, and the elderly will be exposed to possibly greater fire hazards in existing buildings. The basic problem, and the basic compromise, has always been: how to achieve maximum life safety with reasonable economy.

To assure that the compromise is made as carefully as possible, it is necessary to approach the problem with a philosophy of life safety which,

- Assumes that some lives may be inevitably expendable



- Establishes priorities to keep this expendability to a minimum, and,
- Provides a framework for making decisions affecting life safety.

No philosophy can be applied with equal validity to all building types within an occupancy. The unique characteristics of the occupant and his situation must be considered in each case, and the philosophy derived accordingly.

the notion of expendability

A measure of validity for any philosophy – or for any decision dictated by that philosophy – is EXPENDABILITY. The application of the measure is often quite simple; one question is asked of every life safety decision: "How many lives may be expended as a result of this decision"?

For example, any philosophy which does not provide for the sleeping occupant in the room of origin of a slowly smouldering fire, inherently accepts his expendability. Likewise, any plan which does not recognize that entrapment is the greatest cause of multiple life loss has established a quota of expendable occupants at the outset.

Who establishes priorities, and where does responsibility for life loss lie? These questions will be discussed in the next chapter.

regulations . . . only a beginning

Many look to codes and regulations as complete statements of life safety philosophy, and as a result, the approach expressed in most buildings becomes that mandated by the regulations. It is only natural to feel that the primary function of regulations is maximum safety, and that the measures specified are sufficient; but this is only partly true.

It is important to realize that the basic intent of regulations is the protection of the greatest numbers: to protect the community from conflagration and mass spread of fire, to prevent the spread of fire to adjacent property, and to control the extent of fire within a building. The greater emphasis is not on the individual occupant and his limitations, but on the protection of the majority. By their nature, too, codes are structure-oriented, often concentrating on preventing property damage rather than on saving lives.

It has become apparent that life safety depends on a chain of elements, and that regulations are only one part of the chain. Many basic planning decisions, including site selected, numbers housed, maximum cost, and plan configuration are independent of mandated requirements and set life safety "limits" long before regulations are even consulted.

the components of a philosophy

It is a basic premise of this document that life safety can be provided by considering a chain of events, each link of which represents one aspect of life safety. The philosophy must consider each link, its importance, and its priorities in relation to the other links. The links include,

- PROTECTION and DETECTION, which are important in all occupancies.
- ALARM, which may be general, to only specific personnel, to central station, or fire departments (or any combination of these) depending on the capability of the occupant to respond and the degree of assistance available.
- ESCAPE, which is possibly only if the occupant is capable, responsible, and has been provided with the means.
- REFUGE in a specially-protected area, as an alternative to escape. This depends on the structure for CONFINEMENT of fire spread and CONTROL of fire development.
- EXTINGUISHMENT, which is important not only in saving property, but also in situations where occupants are "riding out" the fire in areas of refuge.

relating philosophy to occupancy

Fire philosophies have taken many orientations; they have been structure-oriented, egress-oriented, sprinkler-oriented, detection-oriented, and so on. These orientations normally reflect the viewpoints of their sponsors, whose interests are sincere, but whose viewpoints are often limited by their areas of concern.

In terms of life safety, the most logical philosophy is OCCUPANCY-ORIENTED. It should reflect the fact that each occupancy has a unique type of occupant with unique capabilities, reactions, and limitations. It recognizes that not all occupants are free to move as they please, and that the degree of assistance in case of fire varies widely from one occupancy to another. In short, it realizes that a school is not the same as a nursing home, and that nursing homes are not hospitals. To illustrate an occupancy-oriented philosophy and its effects on each of the links in the life safety chain, it can be seen that . . .

. . . in PUBLIC ASSEMBLY PLACES . . .

PROTECTION is mandatory,

DETECTION should be as rapid as possible,

ALARM should be general to all occupants,

ESCAPE of all occupants should be direct and unimpeded.

. . . in HOSPITALS, however . . .

PROTECTION and DETECTION remain critical,
ALARM may be controlled, alerting attendants but not occupants (or at least not all occupants),

REFUGE areas should be provided, to which patients may be removed, and,

EXTINGUISHMENT must be as rapid as possible.

. . . in NURSING HOMES . . .

the same general approach as for hospitals holds, except that there are likely to be fewer personnel per patient, thus reinforcing the concepts of refuge areas, confinement and "riding out" the fire with earliest extinguishment.

a philosophy for housing the elderly

Relating the unique requirements of the elderly to the links in the life safety chain yields a definite life safety philosophy for this occupancy. While its details will vary with location and type of construction, it must always recognize two critical issues:

- Reaction time, already lengthened by the slowed reactions of the occupant, must be shortened by rapid and automatic detection, followed by an alarm.
- Time for survival must, in most cases, be extended by evacuation, confinement, and extinguishment.

Briefly considering each of the links in the chain in terms of the elderly,

- PROTECTION: there is need for a program of legislation, enforcement, compliance and education, including recognition of housing for the elderly as a distinct occupancy.
- DETECTION: automatic detection, capable of detecting any of the products of fire, is essential to shorten reaction time.
- ALARM: there must be an immediate automatic alarm to all occupants, fire personnel (local brigade, central station, fire department), and an in-house warden responsible for making sure a follow-up alarm is sounded and assistance given where needed.
- ESCAPE: direct egress is important in single-story buildings, and acceptable alternate routes of escape must be provided in higher buildings.
- REFUGE: protected areas must be provided where direct egress or alternate routes are not available, or where occupants cannot react quickly enough to escape. Areas of refuge can be thought of as spaces for buying time for rescue or time until the fire is extinguished.
- CONFINEMENT: the building elements must be fire-resistive enough to contain the fire in selected areas and provide time for escape, evacuation, or extinguishment.
- CONTROL: techniques to control fire growth and the production of smoke and gases must be used to buy time for occupant survival.
- EXTINGUISHMENT: since the elderly cannot always be relied on for self-help, and hand extinguishers are of questionable value in this occupancy, standpipes should be included, but only for professional use. Automatic sprinklers are desirable if economically feasible, and an adequate fire department is needed to assure extinguishment, especially where evacuated occupants are "riding out" the fire.

Each of these links and their provision in housing for the elderly will be discussed in detail in the second part of this document.

5

RESPONSIBILITIES

PROPERTY OF NFPCA
NATIONAL ACADEMY FOR FIRE
PREVENTION & CONTROL
U.S. D[illegible] of Commerce
[illegible]. C. 20230

expendability and responsibility

As has been suggested, life safety decisions are not just "born," they are made. Each decision, as it compromises the ideal of 100% life safety, makes a clear statement about EXPENDABILITY.

Because planning and design decisions must be "made," and because specific people or agencies must make them, it follows that RESPONSIBILITY for life safety – and expendability – can be determined. Responsibilities can be pinpointed for such hazards as:

- the wedged fire door
- the accumulation of trash
- the single exit route
- the lack of detection
- the lack of sprinklers
- the combustible home for the elderly built twenty minutes from the nearest fire department.

Some day it will be possible to accurately predict critical and reaction times before the fact of the fire, thus predetermining the number of persons expendable in any building under any conditions.

Practically speaking, it will never be possible to legally fix the blame for every life lost in fire. A direct placement of responsibility on a specific decision-maker, however, can do a great deal to relieve the diffusion of responsibility that now exists. While this

approach is not yet totally feasible, there is much that can be done in the placing of responsibility.

legislated responsibility

Certain responsibilities for life safety can be legislated or delegated by law.

For many years, the only responsibility for even token life safety was shared by the building inspector (who administered the building code) and the fire department (who fought the resulting fires!). Several large life-loss fires in schools, hospitals, nursing homes, hotels, and night clubs, however, brought the lack of clear responsibility to the attention of the public – and their legislators.

Today, almost every state has assigned specific responsibility for fire safety in its institutions to a particular agency. Currently forty-nine states have regulations governing nursing homes, and in each case, responsibility for their enforcement is specified. While the extent of these regulations and the degree of enforcement varies widely, the best life safety records are invariably compiled by those states which have recognized the importance of the life safety chain and have clearly delegated the attendant responsibilities.

In terms of legislated responsibility, however, housing for the elderly is generally not considered as a separate type; usually it is grouped with other multi-family dwellings in codes and regulations. In order to avoid repeating the expensive lessons learned in other occupancies, it is urgent that the necessary special legislation designating it as a special type of occupancy be enacted as soon as possible.

non-legislated responsibility

Not all responsibility for life safety in any given occupancy can be assigned to fire prevention officials, however; many areas of life safety responsibility fall almost entirely to the architect, owner, occupant, or fire department. Lacking legal definition, these responsibilities are often hazy; and without some clear definition and understanding, the assurance of adequate life safety is not improved.

a summary chart

To aid in this definition, specific areas of responsibility are outlined as each link of the life safety chain is discussed in the following chapters. As in any subject involving personalities, ethics, and quasi-legal factors, this delegation is necessarily simplified, but it is hoped that it may serve as a take-off for the proper designation of these responsibilities.

These recommendations are summarized in the Responsibility Chart presented here, with a reminder to the reader that these responsibilities relate to a specific life safety philosophy pertaining to a particular occupancy type; any other occupancy type would, of necessity, produce a somewhat different chart.

FIRE PROTECTION	FIRE OFFICIALS AND ADMINISTRATORS ...	ARCHITECT . . .	OWNER	OCCUPANT . . .
legislation and codes affecting life safety	initiate studies request legislation provide enforcement	be aware of and understand legislation	knowledge of legislation	
education activities	conduct lectures, demonstrations, etc.	undergraduate study	invite fire officials to present demonstrations	
review with architect	review building plans before issuing permits	where official plan review does not exist, the architect performs the "critical" judgments		
evacuation plans and drills	prepare plans and conduct drills		co-operate with fire officials, accept responsibility	participate in drills
decisions affecting the basic planning of the building	initial review with architect	architect advises owner on decisions of size, location and building type in accordance with ultimate life safety consequences.		
maintenance of safe conditions	inspect premises and report violations promptly	encourage good housekeeping through design of proper facilities, etc; advise owner on reasons for safety devices (e.g., fire doors)	maintain good housekeeping; require that attendants and occupants do not violate rules	help owner in maintaining housekeeping.

DETECTION

decision about providing automatic detection	specify minimum requirements in codes	interpret codes, making decisions in accordance with life safety needs	co-operate with architect in authorizing proper devices	
specification, location of automatic detectors	specify minimum requirements in codes	select qualified consultants	co-operate with architect	
maintenance and testing of automatic detectors	provide minimum requirements in codes	advise owner on testing procedures	employ qualified testing organizations	
personal detection			provide watchmen, attendants, etc.	

Note: shaded area indicates principal responsibility

ALARM	ADMINISTRATORS . . .	ARCHITECTS . . .	OWNER . . .	OCCUPANT . . .
establishing guidelines for alarm selection	test, certify and publish guidelines.	gain familiarity with types and models		
alarm selection	specify minimum requirements in codes	selection in accordance with life safety philosophy	co-operate with architect by authorizing proper devices	
maintenance and testing	specify minimum requirements in codes	advise owner	perform testing or hire maintenance company	
operation of alarm in time of fire			automatic alarm needed to notify occupants; owner provide for call to fire department	occupant cannot be expected to sound alarm or notify fire department

ESCAPE AND REFUGE				
choice of escape or refuge	specify minimum requirements in codes	make selection based on building type and life safety philosophy		
means for escape and evacuation	provide minimum requirements in codes	complete responsibility for building features	insure building features by good housekeeping, not propping fire doors, etc.	protect building features by good housekeeping, not propping fire doors, etc.

CONFINEMENT AND CONTROL				
basic planning decisions about size, location, layout		advise owner and make decisions about occupant grouping, location of building, etc. in accordance with life safety consequences		
building features for confinement and control	provide minimum requirements in codes	undertake responsibility for building features	protect building features as above	protect building features as above
devices for confinement and control	provide minimum requirements in codes	select appropriate devices	co-operate with architect in authorizing devices	

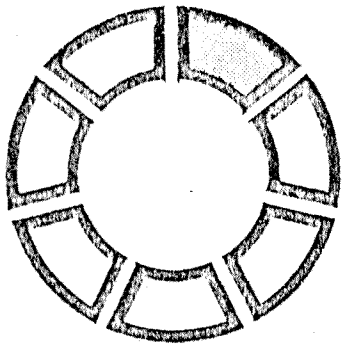
EXTINGUISHMENT				
personal extinguishment of fire	provide professional fire departments	provide access and devices	provide attendants to answer occupant's call for help.	only in some cases will the occupant be able to extinguish the fire
automatic devices for extinguishment	specify minimum requirements in codes	select in accordance with life safety philosophy	co-operate with architect in authorizing devices	

THE CHAIN OF LIFE SAFETY

The provision of life safety is not an unilateral act. Rather, it is like a chain, as strong as its weakest link. The architect, the owner, the fire protection official and even the occupant must consider these links if life safety is to be assured: PROTECTION, DETECTION, ALARM, ESCAPE OR REFUGE, CONFINEMENT, CONTROL, EXTINGUISHMENT. The remainder of this report explores each of these links in terms of housing the elderly.

6

FIRE PROTECTION



what is protection?

The first link in the life safety chain and the first component of any life safety philosophy is fire protection.

Protection, a broader concept than fire prevention, includes efforts to:

- Prevent fire outbreak.
- Prevent widespread damage when fire does break out.
- Prevent loss of life due to fire.

Protection encompasses the entire life cycle of a building and its occupants; its basic philosophy is one of minimizing fire hazards in every possible way. Protection includes:

- Initiation of legislation
- Enforcement of legislation
- Educational programs
- Basic planning decisions
- Evacuation plans and drills

initiation of legislation

Codes and regulations, including building codes, fire safety codes, and licensing regulations, are the foundation on which life safety programs have been traditionally built. Initiated in part by state and local fire officials, they provide the fundamental authority to develop and enforce fire safety measures. As has been

noted, however, codes and regulations can, in general, provide only minimum standards. Moreover, seldom do they recognize housing for the elderly as a distinct occupancy type.

Codes and regulations do make definite contributions to life safety by:

- Separating combustibles from ignition sources by fire separations, boiler room isolation, protection of appliances, etc.
- Limiting the amount of combustibles available and the amount of fuel contributed by controlling housekeeping practices and the choice of building elements. When available fuel is limited, critical time is extended.
- Requiring controls and maintenance checks on ignition sources such as boilers and electrical equipment.
- Setting up regulations for inspections, evacuation, and plan review.
- Establishing regulations covering the other links in the life safety chain.

enforcement of legislation

Enforcement of codes and regulations, both when the building is built and when it is operating, is a particularly important factor in life safety.

INITIAL ENFORCEMENT, including plan reviews, issuance of building permits, and certification of licensure, is designed to enforce the letter, and sometimes the intent, of the law in order to assure at least minimum life safety. The unfortunate result of this enforcement is that many architects depend on officials to detect all errors in design and planning. It is important to realize that plan reviews and allied techniques can do little more than establish a minimum standard of life safety. It is a basic tenet of fire protection that life safety begins on the drawing board; fire officials can enforce minimum standards, but they cannot be asked to make the architect's decisions for him.

CONTINUING ENFORCEMENT, in the form of periodic inspection, is designed to insure that the life safety standards established in the regulations are not compromised by haphazard operating practices. A strong correlation between life safety experience and the frequency of inspection has been found in many occupancies; some states require up to twenty-one inspections a year. Comprehensive check lists (from occupant count to housekeeping practices and checks of all possible fuel and ignition sources), unbiased reporting, immediate notification of violations, and close follow-ups are all essential to this aspect of life safety.

educational programs

Educational programs can serve to make personnel and occupants conscious of fire safety hazards on a day-to-day basis, and can decrease reaction time by instructions regarding procedures in time of fire. These programs include explanation of regulations, schooling in the nature of fire, evacuation plans, anticipation (if not drill) for a night fire, and information about other aspects of fire prevention and control.

basic planning decisions

Some decisions regarding the general nature of the project – made long before drawing board commitments – have a profound effect on life safety. In some cases they so constrict the designer that his efforts for a life-safe building are "band-aid" approaches, attempting to "patch up" the mistakes wrought by poorly-conceived basic planning decisions.

These decisions include,

- OCCUPANTS, including their numbers, types and densities.
- LOCATION, including distance from nearest fire department and availability of water.
- SITING, including access, manuevering room for apparatus, exposure to other buildings and possibilities of fire spread within the complex.
- BUDGET, available to do the job.

In many cases, these early decisions have pre-determined the approaches to life safety available to the designer. Certainly a suburban, low-budget, combustible housing project for 500 occupants (all over 70) in an area where the nearest fire department is ten minutes away, even when it meets all minimum code requirements, is a formidable life safety problem for any designer!

evacuation plans and drills

The evacuation PLAN shortens reaction time by providing a predetermined plan for evacuation or escape from fire. Prepared for a particular building in conjunction with the owner or administrator, it anticipates possible entrapment of each individual and provides alternate routes or extra protection where possible.

The evacuation DRILL is the extension of the evacuation plan down to the level of the individual occupant:

- It defines individual responsibility and procedures in time of fire.
- It reduces the probability of panic and confusion.
- It tends to produce a conditioned reflex in terms of individual detection, alarm, escape, or even extinguishment procedures.

Implementation of evacuation drills in housing for the elderly raises many practical problems, but their desirability is unquestionable. Three approaches are possible:

- They may be made mandatory by regulation.
- They may be voluntary on the part of the occupants.
- They may be accomplished on an individual basis, since life safety in this occupancy is ultimately oriented to the individual.

priorities and responsibilities

Because every philosophy and approach to life safety must include the activities in the "protection" link, the choice of considering them in any compromises that may be made for reasons of economy does not exist. Fire protection procedures and regulations are not "optional"; therefore these items do not figure in establishing priorities – THEY ALWAYS HAVE TOP PRIORITY.

In terms of responsibilities, the FIRE PROTECTION OFFICIALS should . . .

- Upgrade fire legislation and activities in all regions with poor life safety records.
- Acknowledge housing for the elderly as a distinct occupancy type, recognizing the unique requirements in codes and legislation.
- Recognize that enforcement requires personnel, and where economy is a factor, consider alternate methods of providing this personnel (use of firemen, police, health and welfare personnel, etc.).

The OWNER should,

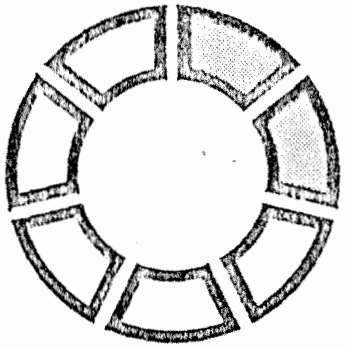
- Retain professional advice while making the basic planning decisions which have great effects on life safety.
- Insist on the designer's attention to the life safety problem.
- Cooperate with protection officials in devising evacuation plans, staging drills, and participating in educational programs.
- Insist on continuing adherence to rules and suggestions of protection officials in operating and maintaining the establishment.

The ARCHITECT should,

- Provide competent assistance to the owner in making the basic planning decisions; this requires a real awareness of the impact of these decisions on later life-safety design.
- Remember the "minimum standard" aspect of building codes, and that interpretation of the spirit of the code rests in his hands.
- Check applicable codes and regulations for their consideration of the elderly, using a clear understanding of a life safety philosophy for the elderly to augment and supplement code provisions where no specific mention of the elderly occupant is made.
- Refrain from relying on plan reviews to detect his neglect in design and planning for fire protection.

7

DETECTION



two means of detection

In any effort to increase the time available for life safety in case of fire, early detection is critical. If ignition and detection occur simultaneously, the maximum margin of safety is possible; every minute separating the two reduces this margin.

The two basic means of detection are,

- HUMAN DETECTION, by occupants, patients, attendants, visitors, police, outsiders, watchmen, etc.
- AUTOMATIC DETECTION, by mechanical or electrical devices.

detection by the occupant

The usual means of detection in most residential occupancies is the occupant himself; a recent study of apartment fires indicated that nearly 90% were detected by the residents themselves. This is significant in housing for the elderly since the occupant, with his decreased sensory capabilities, is less likely to act as the prime detection means. This places greater emhasis on the roles of administrative personnel (where they are available) and automatic detection (where assistance is not available).

automatic detectors . . . in general

The sequential development of fire runs from smouldering and the development of gases to the development of smoke, flame and finally, heat. Detectors are available which will respond to fire at any of these stages of development. The chart indicates that automatic detectors generally fall into four classes, depending on which product of fire they are designed to detect

The earlier the fire can be detected, the greater the life safety value of the detector used. As might be suspected, however, the earlier the detection, the greater the cost of the detection device.

The limited function of automatic detectors should be clearly understood: the detector is only a detector. While it can be connected to alarms, central station, fire department, fire doors, or even sprinkler systems, it does not, per se, provide an alarm or in any way attempt to control or extinguish the fire.

automatic detectors . . . heat-activated

Heat detectors are usually the simplest type, the most inexpensive, the slowest to react, and the least effective from the life safety standpoint, because the fire must be well developed to activate them. Two types are available:

- FIXED TEMPERATURE DETECTORS, which react at a predetermined temperature (in the 135° to 165° range). These include bimetallic strips, snap action discs, thermostatic cables, and fusible links.

- RATE-OF-RISE DETECTORS, which respond to abnormal heat rise (15° to 20° in a minute). These include pneumatic tubes, thermoelectric, and other rate-of-rise devices.

Unless the rate of temperature rise is very slow, the rate-of-rise detector is normally faster in detecting fire than the fixed-temperature device. Combination devices which combine the better features of both are also available.

activating product	*when produced*	*reaction time*	*relative cost*
heat	*fire's rapid development stage*	*longest*	*cheapest*
flame	*fire's rapid development stage*		
smoke	*smouldering stage before flame and heat are developed*		
gas	*incipient stage before smoke, flame, and heat are developed*	*shortest*	*most expensive*

automatic detectors . . . flame-activated

Flame-activated detectors sensitive to radiation and flicker caused by flame are also available. To be effective, they must be installed in places where they have unobstructed straight-line views of any possible fire; their use, therefore, is often limited to detecting ignition sources in hazardous areas.

automatic detectors . . . smoke-activated

Devices utilizing photoelectric cells to detect visible carbon particles in the air are designed to detect smoke. These detectors may be based on direct or reflected light, and utilized as spot, line or sampling detectors. In summary,

- They are extremely effective in detecting smoke, but not as fast as gas-activated types.
- They should not be used where smokeless fires are possible.
- Since they are based on optical principles, dust accumulating on the light source may cause false detection; for this reason, regular maintenance is necessary.

automatic detectors . . . gas activated

These devices use a steady flow of ions from a small radioactive source to make invisible combustion gases conductors, and, hence, electrically "visible" to the detector. While expensive, these devices are capable of protecting up to 3600 square feet of floor space and will usually detect a fire earlier than any of the other types. They can also be used as smoke detectors. Like smoke detectors, however, they may register false detection if not kept free of dirt particles.

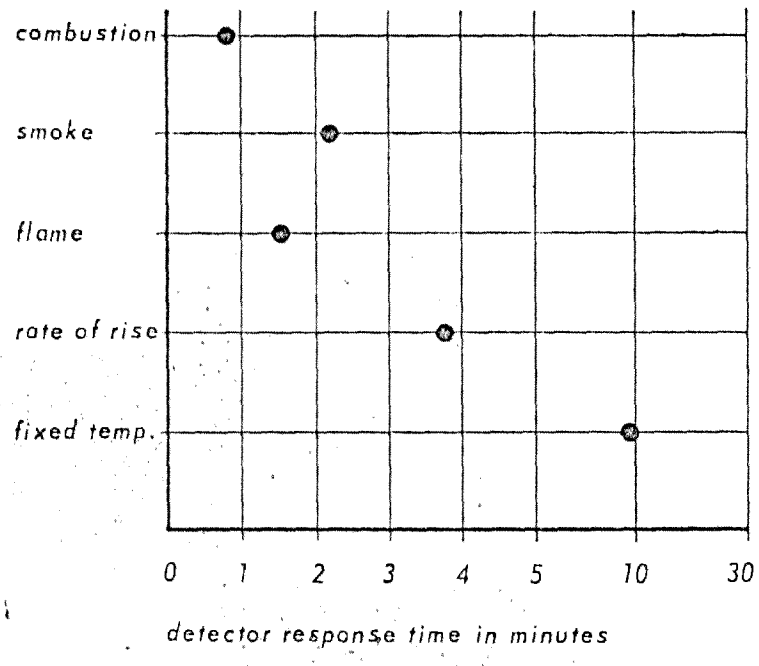
sensitivity and reliability

How sensitive should an automatic detector be? If it is not sensitive enough, the time margin available to the occupants will be reduced, if it is too sensitive, it may react to cigarette smoke or even reflected sunlight and cause false alarms. Sensitivity should be somewhere between these two extremes; it varies with tolerance levels permitted, the range of conditions normally expected, draft patterns, and location. Because of the occupant's sensory limitations, it is important that detectors with high sensitivity should be chosen in housing for the elderly.

The diagram indicates the sensitivity of various detectors in terms of response times based on an averaging of twelve test fires.

In terms of reliability, two important questions must be asked:

- CAN THE DETECTOR BE RELIED ON TO OPERATE AT THE SPECIFIED SENSITIVITY? Many detector tests have been conducted, but these are only approximations of what happens in time of fire. To the extent that test conditions parallel actual fire conditions, reliability information gained from these tests can be used in selection of detectors.
- CAN THE DETECTOR BE RELIED ON TO OPERATE SATISFACTORILY OVER THE LIFETIME OF THE BUILDING? The characteristics of many devices change with time, and the effective use of detectors requires regular maintenance and testing.



evaluation of detector performance

There are so many variables involved that it is impossible to categorically say that detectors will always save lives. Very little performance data has been collected on the effectiveness of detectors in providing life safety. It is obvious, however, that one must know that a fire exists before one can react.

In addition to sensitivity and reliability, detector "performance" in saving lives depends on:

- The "match" between the type of detector and the type of fire.
- The location of the detector.
- What is done after the detector detects the fire, the kind of alarm, and the condition of the person receiving the alarm are critical to life safety. A bell which rings in the night is of little value to a bedridden invalid.
- What provisions are made for escape or evacuation once the fire has been detected.
- What provisions are made for containing or controlling the fire once it is detected. The detector itself can serve the purpose only if it is connected to sprinklers, fire doors, dampers, etc.

specifying detector types

It is apparent that many considerations influence the proper specification of detectors: occupancy, construction type, related life safety measures, type of detector, location, installation, maintenance and testing all play roles in determining their life safety effectiveness.

Misuse based on misunderstanding can easily weaken this link in the life safety chain. For this reason, the selection, specification and location of detectors should be undertaken only by qualified people who are willing to accept the final responsibility for their decisions. THIS IS NOT A JOB FOR AMATEURS.

summary of responsibilities

FIRE PROTECTION OFFICIALS should,

- Encourage greater study of detection and early warn-systems and their effectiveness in time of fire. This ing systems and their effectiveness in time of fire. This implies the gathering, analysis and dissemination of data or detection performance, reliability and sensitivity.
- Recognize the contribution of detectors and early warning systems to shortening occupant reaction time. This is particularly critical in occupancies such as housing for the elderly where the occupant's limitations constantly serve to lengthen his reaction time.
- Set standards for maintenance and testing of automatic detectors.

The ARCHITECT should,

- Realize that in occupancies such as housing for the elderly, automatic detection is particularly important in compensating for the occupant's decreased sensory capabilities.
- Recognize that an automatic detection system can be justified only where escape or protection of the occupant is possible or assistance is assured. If this is not the case, the money may be better spent in techniques of confinement and control.
- See that automatic detection is included in all hazardous and unsupervised areas.
- Fully understand the differences among the generic detector types and their relative performances.
- Not confuse detectors with alarms or sprinklers . . . detectors may be connected to these devices, but they do not inherently raise an alarm or control the fire.
- Select qualified consultants who will specify detector types, make detailed location plans, and take responsibility for their work.
- Advise the owner on maintenance and testing procedures.
- Realize that codes and regulations set minimum standards and that their interpretation and application is in his hands.

The OWNER should,

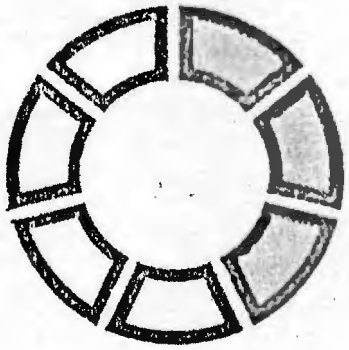
- Provide full co-operation to the architect by accepting his advice (and that of his consultants) and by providing the resources to do the job.
- Contract with reliable firms for the maintenance and testing of automatic detection systems.

- Recognize, too, that detectors are not inherently alarms or devices for extinguishing the fire; he should extend the recognition both to the staff and the occupants.

- Provide watchmen and other attendants whenever this is necessary and feasible.

8

ALARM



alarms: two objectives

Although there are many kinds of alarm devices, all exist for two fundamental reasons: NOTIFICATION TO ESCAPE OR TAKE REFUGE and CALL FOR ASSISTANCE. Some alarms accomplish both of these tasks at once; most, however, do not. The reader should keep these two tasks in mind, for too often it is simply assumed that EVERY alarm does BOTH – it is impossible to calculate just how many lives this false assumption has cost.

the internal alarm

The alarm which only notifies occupants and personnel within the building to escape or take refuge is called an INTERNAL ALARM. (Some internal alarms have outside bells hoping to alert passers-by and neighbors to call for assistance). This alarm, however, does not summon professional assistance unless it is connected to an external alarm as described below.

A specialized type of internal alarm, called a pre-alarm, is sometimes used to warn selected personnel or attendants before all occupants are notified. There is considerable debate about the effectiveness and appropriateness of the pre-alarm; in any case, it should be avoided in housing for the elderly – attendants are not assumed to be present, and the pre-alarm would add to the already lengthened reaction time of the elderly occupant.

The internal alarm can be activated in two ways:

- MANUALLY, by ringing a bell, pushing a button, pulling a handle, or smashing a pane of glass. Manual alarms should be located in all hazardous

areas and in "familiar" places throughout the building. All occupants should be familiar with their operation and should be trained to use the manual alarm as soon as the fire is detected.

- AUTOMATICALLY, by connection to detectors. An auxiliary power source should be available to allow activation even if the normal power supply fails.

the external alarm

The external alarm constitutes the call for professional assistance. While it may be accomplished in different ways, it must always be provided:

- INTERNAL ALARM CONNECTION: The internal alarm may be connected to the local fire department or privately-operated central station. This usually involves automatic detector-alarm connections and a private line since the amount of wiring needed and the limited number of circuits available usually mitigate against municipal alarm connections.

- SPECIAL TELEPHONE: Many institutions maintain a "red phone" connection to the fire department. This single-purpose connection is recommended for housing for elderly where an administrator is always in attendance.

- PULL-BOX ALARM: In urban areas, municipal alarms in the street can be used to summon assistance.

Even where the external alarm is "automatically" placed to fire department or central station, a telephone or pull-box BACK-UP ALARM should ALWAYS be placed in time of fire.

location of manual alarm devices

Location of alarm stations is one which must reflect a compromise between the ideal and the economically feasible. The ideal solution, of course, is an alarm station in every apartment unit. If this cannot be economically justified, there should be a station in familiar locations not more than a few dozen feet from the apartment door. Any code specifications on distance to alarms should be decreased (as much as 50%) because of the occupant's physical limitations.

In addition, manual alarm devices should be located in central locations (lobby, switchboard, owner's office) and hazardous areas.

signals

The general alarm signal should be clear and distinctive. Because the occupant may (in fact, probably will) possess a hearing handicap, the signal should be loud, and preferably of lower frequency since high frequency handicaps are more prevalent among the aged. Since the elderly are often confused easily, the signal should be unique, not similar to the signals of telephones, doorbells or chimes, Finally, the occupant should be thoroughly familiar with the signal and its meaning.

alarms and the elderly

As with the other links in the life safety chain, the specifics of alarm use must vary with occupancy type. For example . . .

- In SCHOOLS an evacuation alarm (with a back-up external alarm) is necessary since escape is fundamental.

- In HOTELS AND PRISONS a pre-alarm is generally given to selected personnel who notify the fire department and decide if evacuation is needed – if so, they direct it in an organized manner.

- In NURSING HOMES AND HOSPITALS elaborate alarm systems are usually established to permit orderly withdrawal to refuge areas when escape is not mandatory or feasible.

In Housing for the Elderly

- A pre-alarm should be avoided because attendants are not present and the occupant's reaction time is unduly lengthened.

- An internal alarm should be used to notify all occupants, personnel (and passers-by and neighbors where they may be of help).

- Where possible, the internal alarm should become a "combined" internal/external alarm by notifying professional assistance automatically. The faster professionals can arrive on the scene, the shorter the occupants' reaction time.

- If the internal alarm is not connected to fire department or central station, the external alarm should be manually raised as quickly as possible.

- Internal alarm signals should be loud, clear, distinctive and preferably not of high audio frequencies.

- A back-up notification of professional assistance is always necessary.

summary and responsibilities

FIRE PROTECTION OFFICIALS should,

- Continue and augment programs of alarm testing and certification.

- Assist owner and architect by publishing non-proprietary information on alarms and alarm systems.

- Continue to set minimum standards in codes and regulations.

The ARCHITECT should,

- Recognize that elaborate alarm systems are logical only if escape or evacuation of the occupants is feasible.

- Become thoroughly familiar with alarm types and operation.

- Carefully consider the location of manual alarms, placing them in familiar places and locations where fire is most likely to occur.

- Consider the possibilities of connecting alarms to fire department or central station.

- Consider alarm connections to detectors.

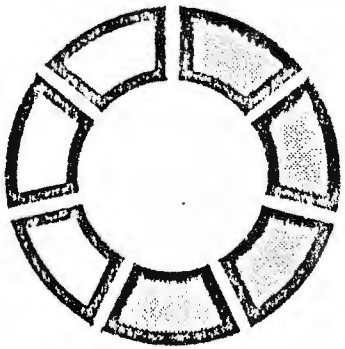
- Consider the possibility of an auxiliary power supply to operate the alarm system if normal power fails.

The OWNER should,

- Co-operate fully with the architect in authorizing proper devices.
- Know how the selected alarm system works and whether or not it automatically places a call for assistance to fire department or central station.
- Undertake responsibility for educating and drilling staff and occupants in the operation of the alarm system.
- Undertake responsibility for always providing the back-up alarm to fire department.
- Perform periodic alarm testing or hire a maintenance firm to do this.

9

ESCAPE AND REFUGE



escape or refuge: the distinction

The first three links in the life safety chain – protection, detection and alarm – are concerned with shortening the occupant's reaction time; they buy him time to escape from the fire. The problem of escaping or evacuating the fire area is the concern of the fourth link in the chain. Two definitions:

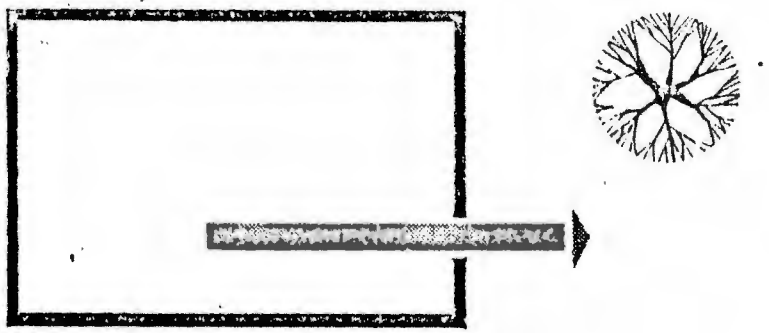
> *ESCAPE, as used in this document, is total separation of the occupant from a burning building.*

> *TAKING REFUGE does not imply total separation, but retreat to a fire-safe area somewhere in the building, to wait there for rescue, to "ride out" the fire, or to escape under controlled conditions. Taking refuge may, therefore, be an intermediate step before escape, or it may provide for the occupant's safety without his ever physically leaving the building.*

This distinction, as we shall see, is an important one. To the layman, life safety is usually synonomous with total escape, and certainly many of our code provisions are built around this notion. Unfortunately, escape is not always feasible in all occupancies and in all building types.

means of escape

If escape, or total separation from the burning building is feasible, it is, of course, ideal.



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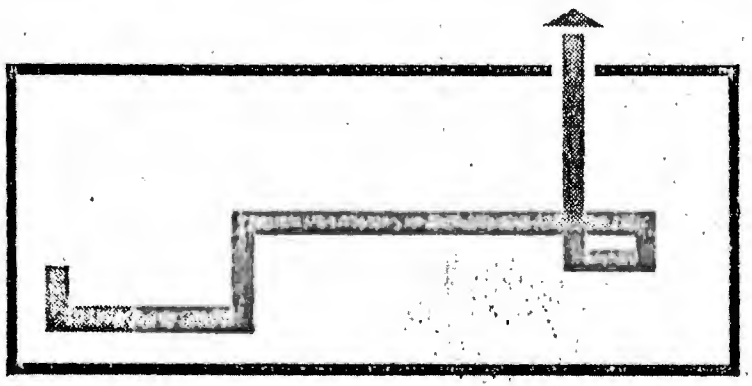

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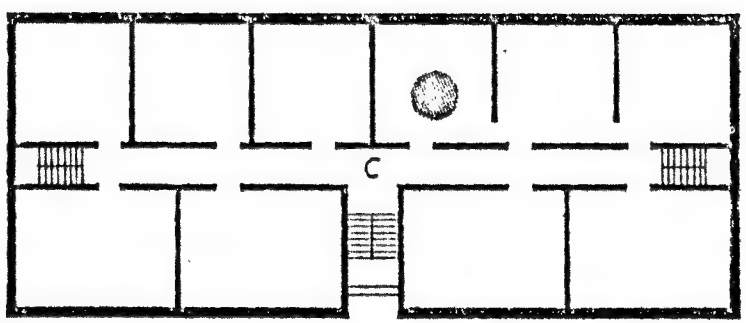


C

To escape from any fire area, some exit or means of egress is needed. This statement is disarming in its simplicity, however, one out of every four persons who dies in fire dies as a result of entrapment – the inability to reach an exit: for these people there are no exits.

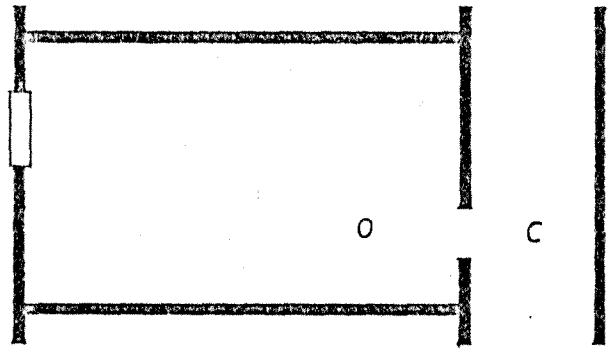
Exit requirements are dictated by the number of people, distance to an exit, and the possibility of alternate routes.

In simplest terms, exits may be doors opening directly at grade level . . . (A)

. . . or they may be torturous routes, involving several rooms of an apartment, a hundred feet of corridor, a smoke tower, and a dozen flights of stairs. (B)

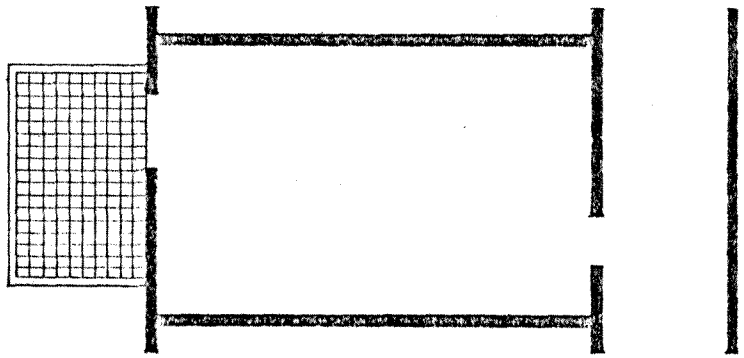
No matter how simple an exit route may be, however, the designer must face the fact that it may be blocked in time of fire. The tenant in plan (C) has three exits, all worthless, if corridor C is made untenable by fire or smoke.

Exit design, then, becomes much more important than an exercise in numbers. Each plan configuration must be evaluated in terms of potentially expendable occupants, using the general principle, IF UNTENABLE CONDITIONS CAN BE CREATED BETWEEN AN OCCUPANT AND AN EXIT, THAT EXIT DOES NOT EXIST FOR HIM. AN ALTERNATE ROUTE OF ESCAPE MUST BE AVAILABLE, OR THE DESIGN HAS CONSIDERED THAT OCCUPANT EXPENDABLE.

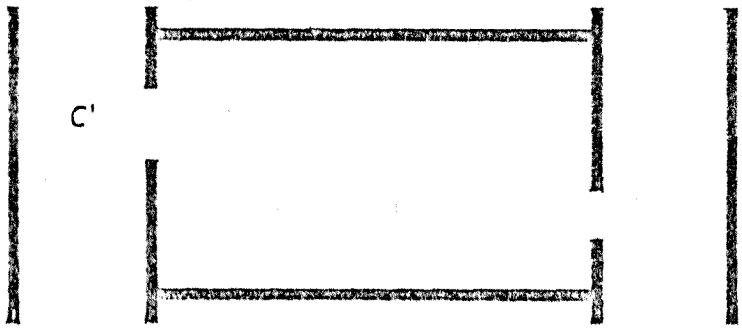


While escape becomes more complex as additional elements are introduced, the analysis of the escape sequence begins simply with the occupant in a given room . . .

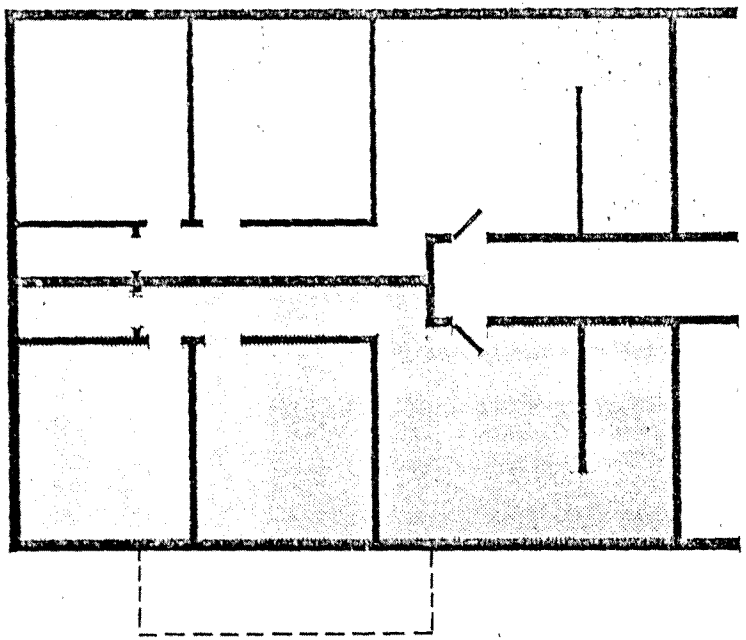
. . . the Occupant O in this room is considered expendable if critical levels occur in corridor C . . .



. . . while still considered expendable from the standpoint of entrapment, his chances of rescue and survival are improved by the addition of the balcony, as long as the balcony can be reached by rescue ladders . . .

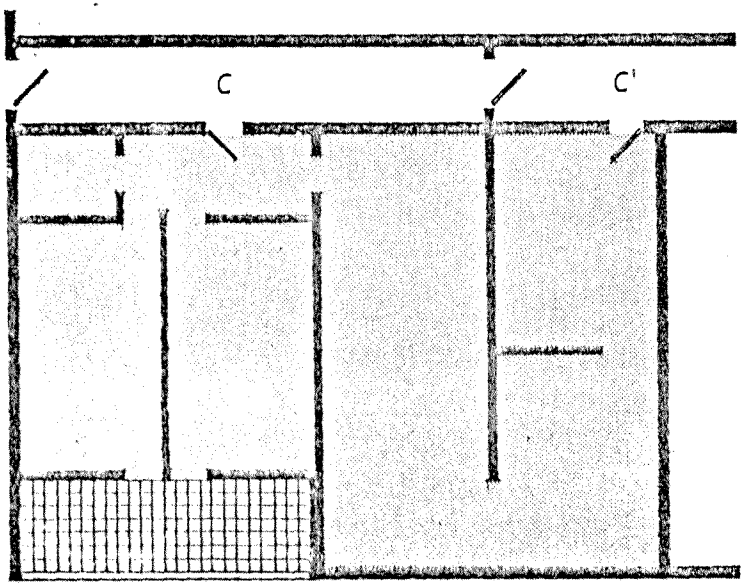


. . . with an alternate escape route, C', the occupant is no longer considered expendable.



As more and more units are added together to form an apartment . . .

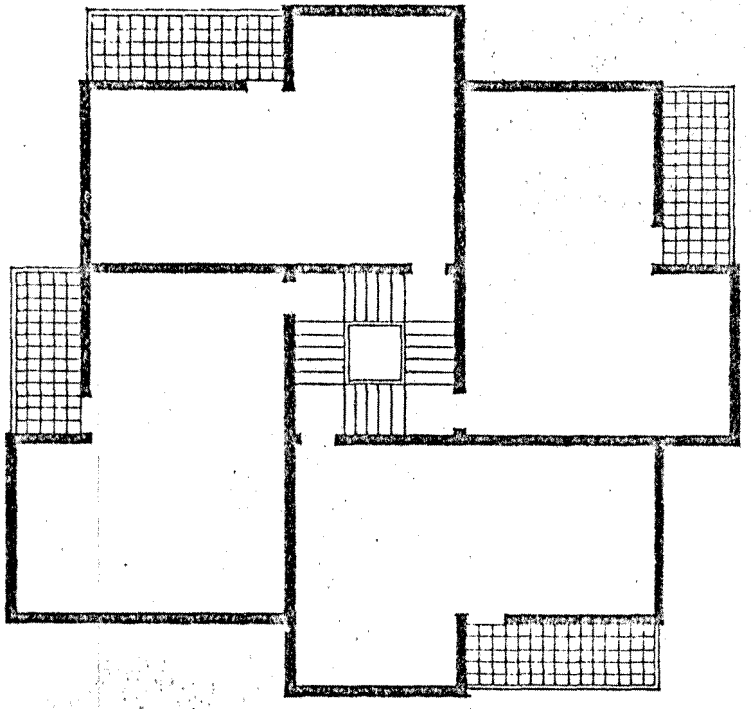
. . . If the corridor is untenable, or if critical levels occur in the living area of this apartment, the occupants have been considered expendable. (A balcony would improve the chances of survival).



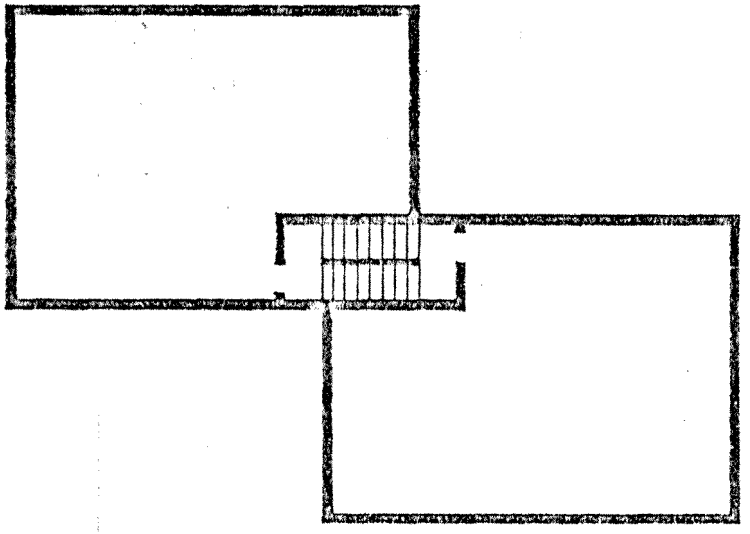
. . . with critical levels in either corridor C or C', or within any area of the apartment, the occupants have alternate routes of escape and are not considered expendable in this plan (as long as the balcony can be reached by rescue ladders).

If alternate escape routes are available from any point within the apartment, a good beginning has been made toward providing life safety. The apartment unit must now be related to the rest of the building.

The following plans represent generic multi-fam
schemes which are acceptable under certain conditic
in various building codes.

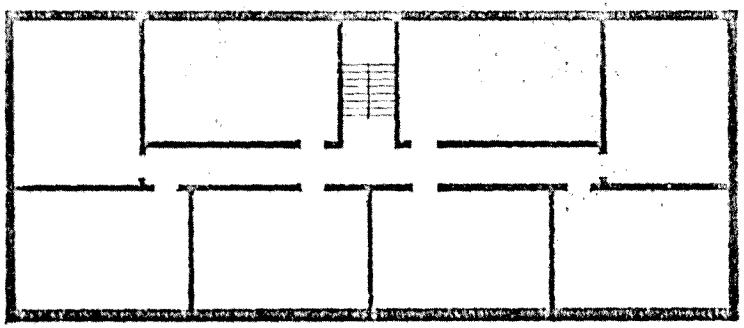


*. . . in CENTRAL CORE plans of this typ
an open door from a burning apartment c
quickly make the core untenable. Since
conventional wood panel door will act as
effective smoke barrier for only five minute
everyone above the ground floor is potentia
expendable unless they can be rescued from t
balconies . . .*



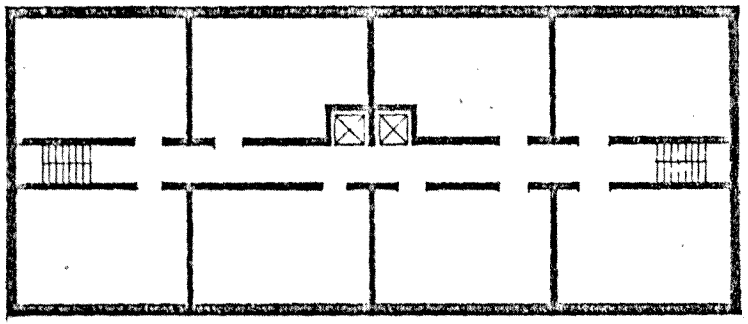
*. . . in SEPARATED CORE plans, an op
door from a burning apartment will only i
mediately affect the adjacent apartment
complete compartmentation has been achieve
Otherwise, all occupants in the core (abo
the first floor) are expendable . . .*

*. . . and even with good compartmentation,
there is but one stair (as in this plan), t
second core could become untenable in
matter of minutes.*

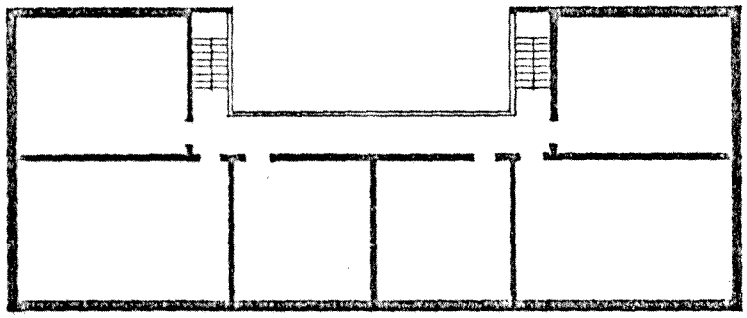


The linear corridor schemes are of three general types . . .

. . . the CENTRAL STAIR scheme, with its scissored double stairway and open corridor, assumes each story to be expendable . . .

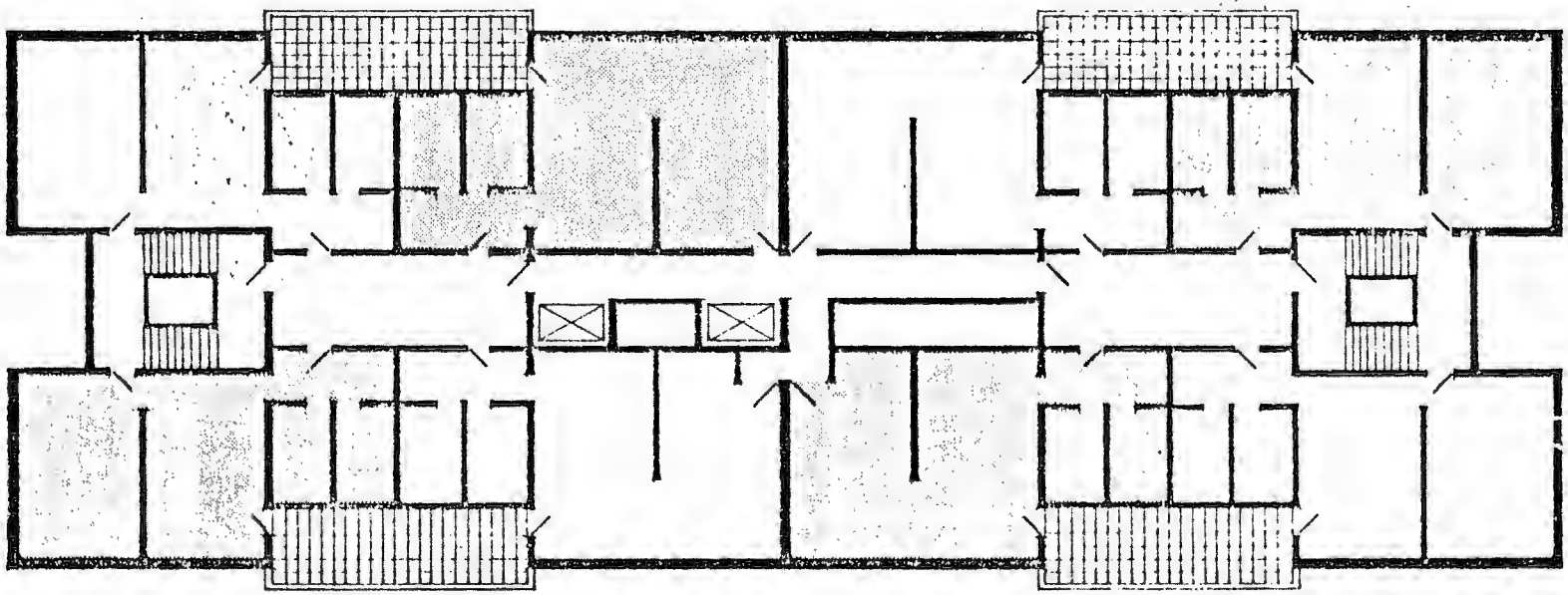


. . . the REMOTE STAIR plan presents only a slight life safety advantage over the central circulation scheme above . . .



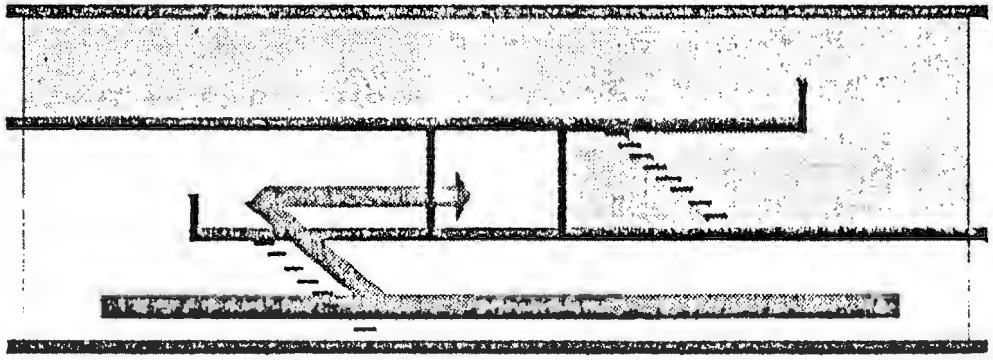
. . . the EXTERIOR STAIR scheme, used in the milder climates, is close to being an ideal escape plan, since only the occupant in the immediate apartment is potentially expendable. . .

One of the best linear corridor approaches for life safety is a modified version of the multiple-route plan shown on page 61. In the modification presented here, high levels of safety are provided, both in the apartments and in the corridors.

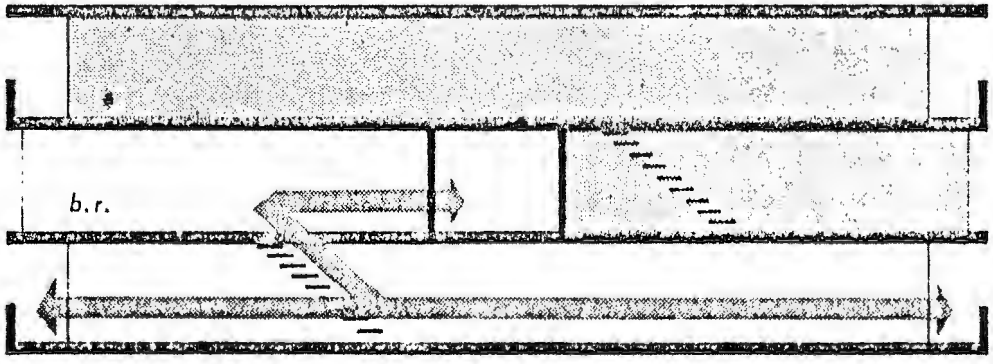


A wide range of safety is possible in DOUBLE STORY UNITS . . .

. . . this scheme provides only marginal life safety . . .

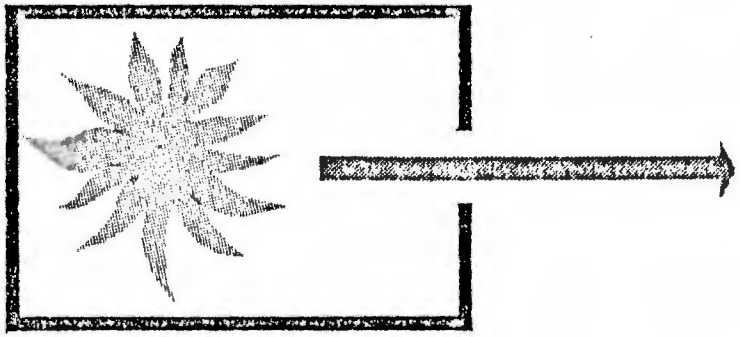


. . . while this approach provides a high degree of safety (except in the case of fire originating in the bedroom).



escape and the elderly

The ability to escape hinges on the TIME it takes a person to traverse through untenable conditions to an exit; this time, in turn, determines the maximum DISTANCE from the unit to the exit. The designer must remember the physical limitations of the elderly, and considerably SHORTEN the distances permitted in most building codes for normal multi-family occupancies.

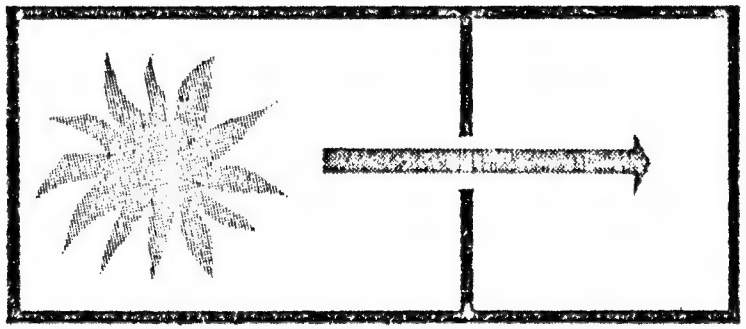


Shortening exit distance normally dictates more exits. Unless these additional exits can be provided economically, as in the case of the single-story scheme with continuous egress to the outdoors, it may become prohibitively expensive to consider escape as part of the life safety philosophy for the elderly.

Fire escapes, slides and chutes – while being acceptable in some remodelling – are of little value in housing for the elderly. Most states no longer permit their use in new construction.

refuge

Where it is not possible or feasible to provide total escape from the building, refuge can be provided to maintain this link in the life safety chain.



Evacuation techniques allow the occupant to leave the fire area and take refuge in another part of the building. Effective refuge areas, however, depend on satisfying a number of interrelated requirements.

- The building must be effectively compartmented so that fire can be confined to the area of origin while the occupants in that area evacuate to another compartment (or area of refuge).

- The area of refuge must be large enough to accommodate all evacuees.

- There must be some means of rescue or controlled escape from the area of refuge.

- The fire must be confined and rapidly extinguished, particularly if evacuees are to "ride out" the fire in an area of refuge.

In essence, refuge buys the time for survival until the occupant is rescued, until he escapes, or until the fire is extinguished. This approach is important in housing the elderly, for their slower reactions and limited physical capability often make total escape impossible and necessitates taking refuge.

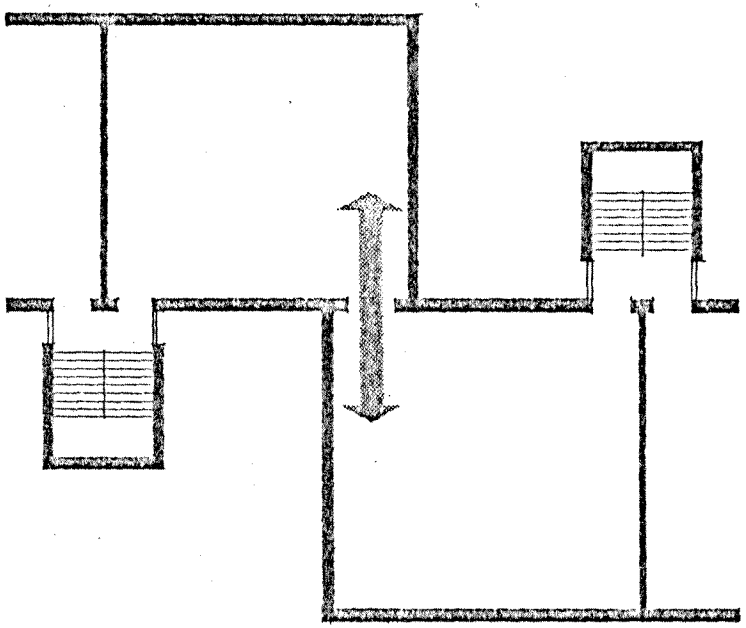
the area of refuge

An area of refuge is not a separate, special area to be occupied only in time of fire. It may be any area of a building appropriately fire-resistant on all sides, and accessible by horizontal or vertical access. Careful planning can make almost any part of the building an area of refuge.

Techniques and standards for planning and designing the compartment are presented in the next Chapter in the discussion of confinement of fire.

horizontal exits

The exit from the compartment is critical. An opening through a compartment wall is classified as a horizontal exit; most building codes stipulate that 50% of the exits from any fire area can be horizontal.



As was the case in designing escape routes, the number and location of horizontal exits determines the number of occupants considered expendable.

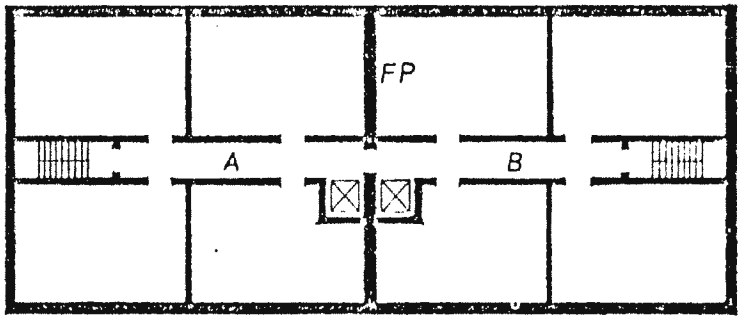
The basic concept of providing refuge in a fire-safe area is shown in this schematic plan...

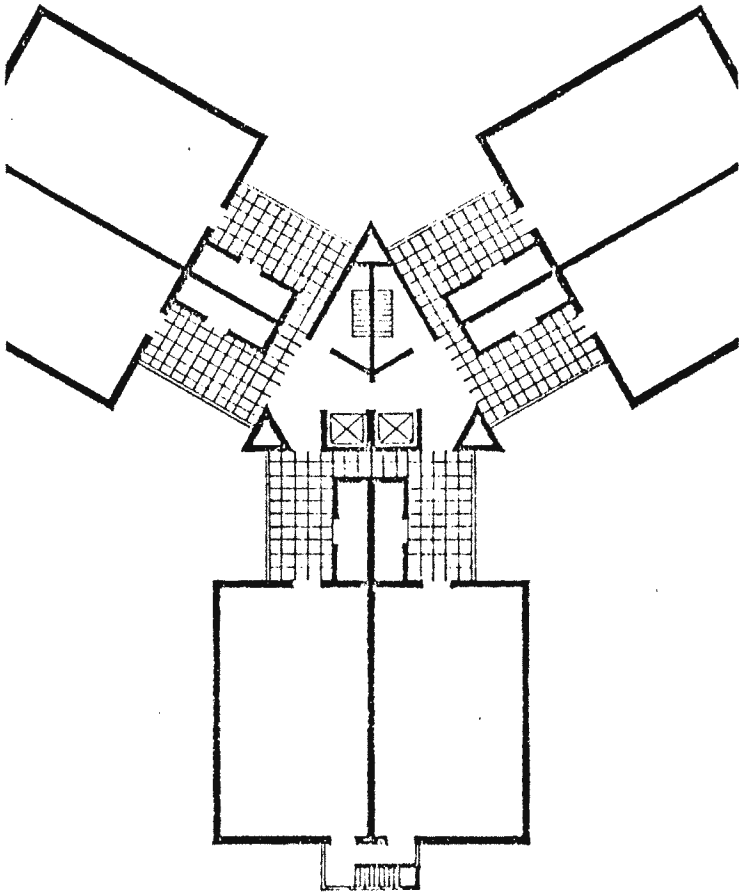
...the building is divided by a fire partition (FP) into two independent compartments, each containing an elevator and a stairwell...

...if a fire occurs in any apartment in fire area A, the occupants can move quickly to area B and ride out the fire or escape slowly using the elevator or stair...

...adding communicating doors between each apartment and through the fire partition will assure safe evacuation if the corridor becomes untenable.

The plan presented on page 64 represents a variation of this idea; a more elaborate approach to evacuation is demonstrated by this plan.





elevators as exit routes

With more and more high rise construction, elevators take on added importance as potential escape and evacuation routes. Elevators are not counted as exits, but they can be considered as supplementary escape routes when they are in distinct areas of refuge. This, of course, assumes that an emergency power supply keeps the elevators which are not in the fire area operating as usual.

Even if elevators cannot be depended on as supplementary exit routes, the designer should recognize that all people (and particularly the elderly) tend to follow their normal egress paths first. For this reason, secondary escape and evacuation routes should be related to elevator lobbies where feasible.

summary and responsibilities

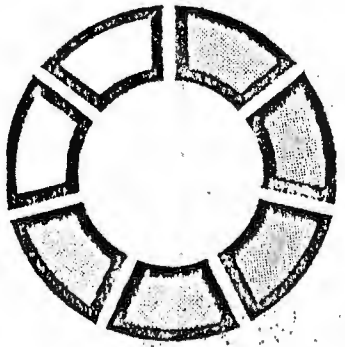
While the legal responsibility for the "choice" between escape and evacuation should be placed on the building codes and regulations, it is today the task of the architect to make this decision based on a full knowledge of the problem at hand, the advantages and disadvantages of each method, and the code requirements he must work within.

Once the "decision" has been made, the ARCHITECT should,

- Remember that entrapment figures in 1 of every 4 fire deaths.
- Recognize that the provision of exits is not a numbers game; each plan configuration must be evaluated in terms of expendable occupants.
- Remember the basic rule for exits: IF UNTENABLE CONDITIONS CAN BE CREATED BETWEEN AN OCCUPANT AND AN EXIT, THAT EXIT DOES NOT EXIST FOR HIM.
- Decrease distances to exits for the elderly if the code does not recognize this as a specific occupancy type.
- Carefully consider horizontal exits as potential evacuation routes.
- Remember that refuge areas are effective only if fire can be confined to its area of origin and occupants in that area can be accommodated in an area of refuge.
- Remember that early extinguishment becomes important if the occupants are to "ride out" the fire in an area of refuge.

10

CONFINEMENT



The confinement of fire to a small area in a building has always been considered important from the standpoint of property protection; it assumes greater importance, however, as a link in the life safety chain. This importance is easiest to see when confinement is related to the escape or refuge link.

- By confining fire and its products to the area of origin, the time before intolerable conditions are reached in other areas is extended. Since this critical time has been lengthened, the occupants in these areas have a greater margin of safety.

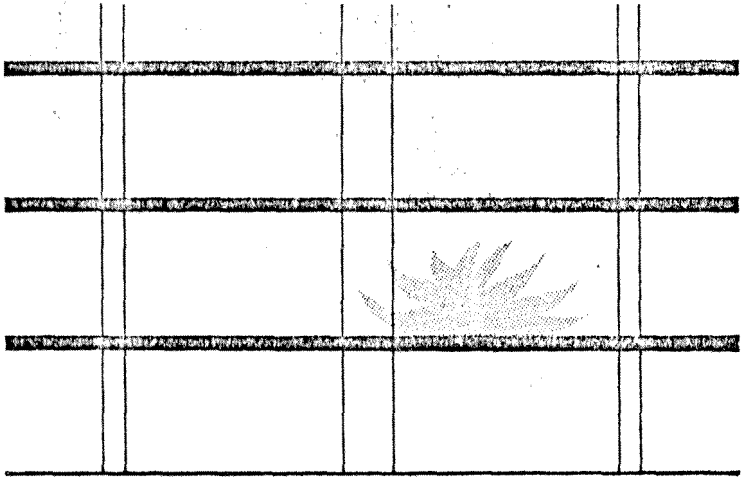
- This extra margin of safety is critical when the other areas contain evacuated occupants, waiting to escape, to be rescued, or who are "riding out" the fire

- Where confinement is successful, only the occupants in the area of origin are potentially expendable.

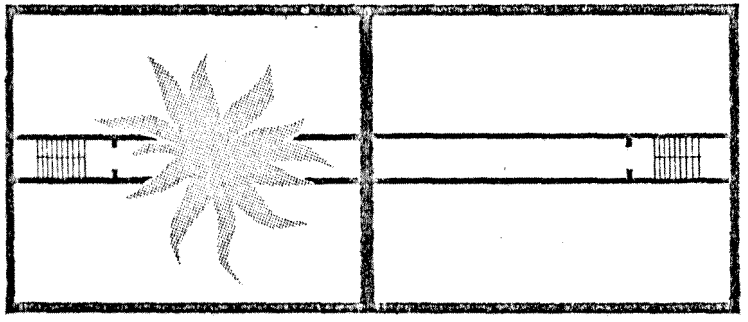
the compartment

The basic approach to confinement is the compartment, or the division within the building which is completely enclosed by "partitions" (including walls, floors, and ceilings), which will resist the spread of fire and gases from one part of the building to another.

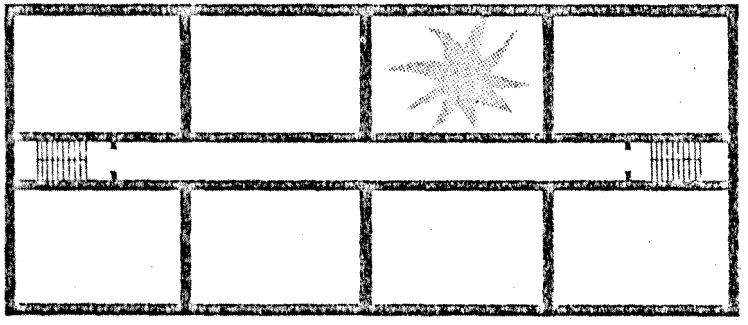
Compartmentation is important to life safety, not just as a method for containing fire, hoping that it will burn itself out, but also as a barrier to spread that will hold up at least long enough to protect occupants evacuated to an adjoining fire area. Compartmentation buys time for survival by extending the critical time in the adjoining areas of refuge.



It may be compartmented by floor. . .



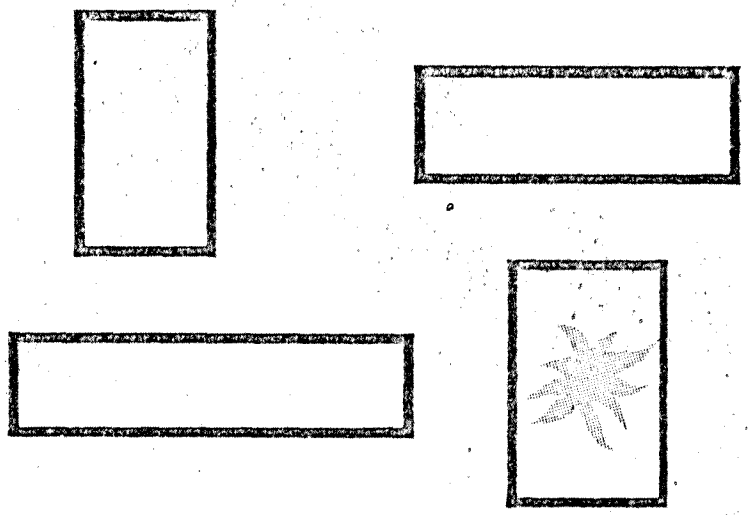
. . . By dividing floor areas into distinct areas of confinement. . .



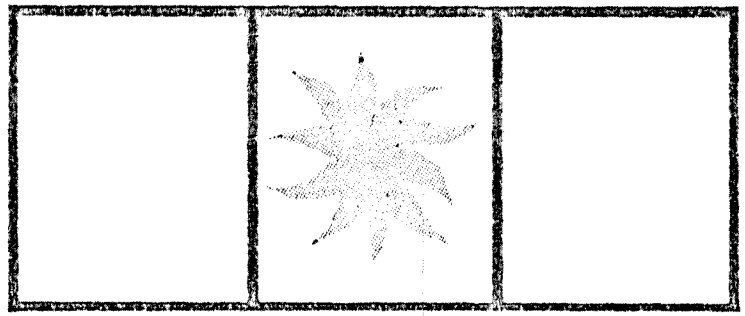
. . . Or each of the living quarters may become an area of confinement.

There are two general approaches that are frequently taken in defining building compartments...

Where site and climate permit, the compartmentation may be accomplished by physically separating the fire areas in a campus plan arrangement. This approach has the advantage of providing (in many cases) "instant" escape, and maneuvering room for fire-fighting apparatus. It is, however, more expensive and simply not feasible in many climates.



A more common approach is that of building fire-rated walls, ceilings and floors to separate adjacent fire areas.



compartment design

Compartmentation is accomplished by using appropriate fire-rated partitions (walls, floors and ceilings) on all sides of the compartmented area. From the life safety viewpoint, it is important to recognize that a compartment may be either an area of origin or an area of refuge. Because of this, the rating of its partitions (in hours) depends on,

- The amount of time it would take for all people in an area of refuge to evacuate, escape or be rescued, and,
- The amount of time it would take to extinguish the fire in the fire area if the people in the adjoining area of refuge could not escape.

The size of the compartment is also important to life safety. If compartments are small, and access between them easy, the chances for successful evacuation to areas of refuge are increased. The problem, of course, is one of economics: thorough compartmentation is expensive, and at some point the line must be drawn.

By relating fire loads and potential hazards for given occupancies, the building codes can provide the minimum hour-ratings of these partitions.

openings in the compartment

If each fire area could be a six-sided compartment with 4-hour walls, floor and ceiling, and no openings, confinement would be complete, and the life safety of the occupants in the remainder of the building reasonably assured. Unfortunately, this is rarely the case. In order for compartments to function, they must be punctured by doors, windows, ducts, pipes and other openings. Each of these openings introduces the possibility of fire spread.

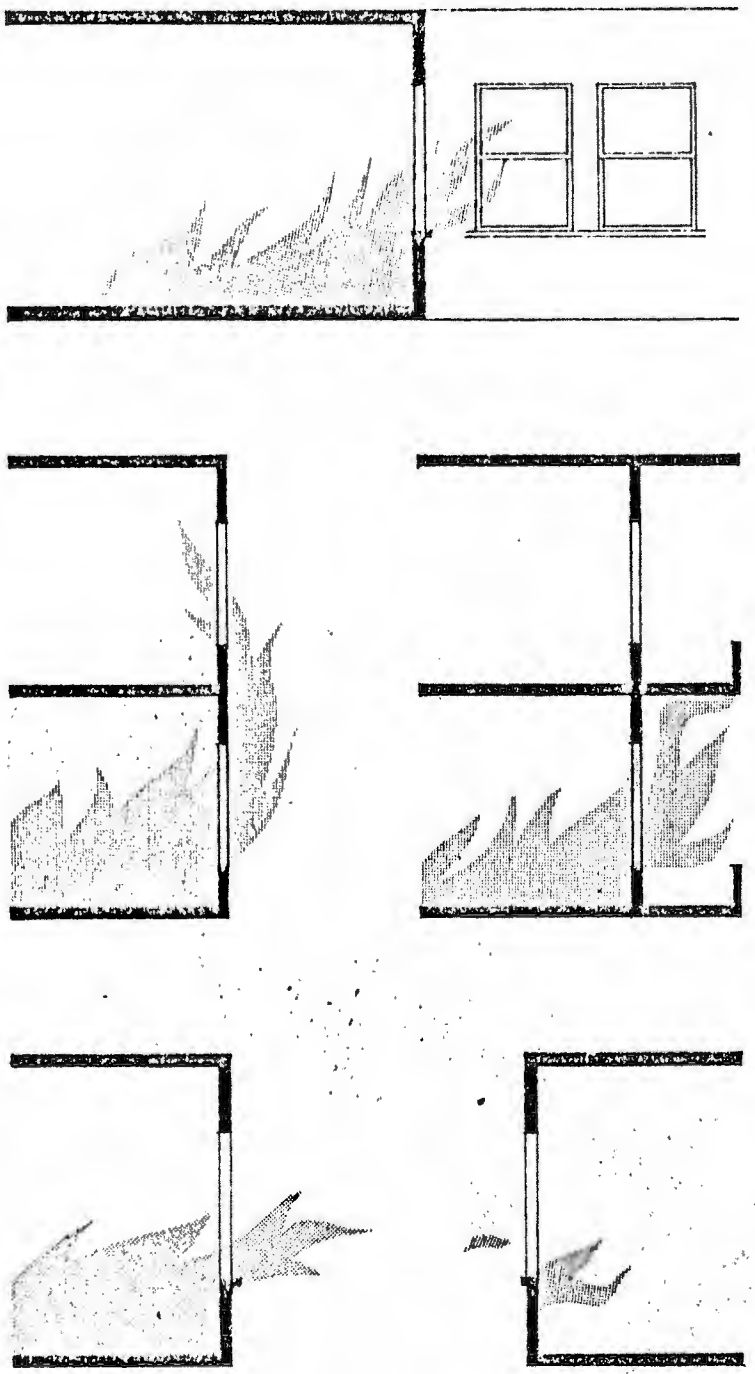
WINDOWS: Windows are particularly susceptible as paths for fire spread:

An operable window must be assumed to be an opening in a fire wall (there is no guarantee that it will be closed in case of fire!). Unless it contains wire or tempered glass, even a fixed window will act as a barrier to spread for only a few minutes in a severe fire

Windows stacked vertically lie directly in the path of rising flames. Three-foot spandrels, horizontal sun-shades, balconies and deep recesses are the only reasonable controls available to the designer.

PROPERTY OF NFPCA
NATIONAL ACADEMY FOR FIRE
PREVENTION & CONTROL
U.S. Department of Commerce
Washington, D.C. 20230

A window facing an adjacent fire area is exposed to intense radiation; fire has been known to "leap" across fifty-foot separations due to this radiation. "U"-shaped buildings and courts are particularly hazardous unless adequate spacing is maintained.



DOORS: Heated air expands and exerts positive pressure on doors. For this reason, louvers, transoms, unprotected glass and swinging doors are useless to confine fire. Where doors puncture fire partitions, positive-acting hardware must be employed to close the door and keep it shut.

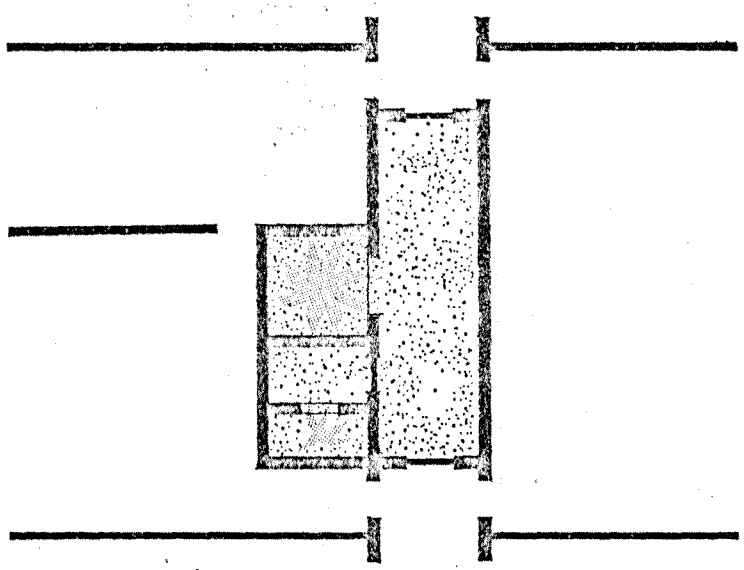
Fire doors are useless when wedged open. The designer must recognize that improper placing of these doors (such as in the path of everyday traffic) almost guarantees that someone will prop them open. Where such placement is necessary, automatic, self-closing hardware and strict enforcement (by the owner) are essential.

Finally, a fire door is rated only for flame and heat; unless it is adequately sealed, a one and one-half hour door may admit toxic gases or smoke in a matter of minutes. Even the best doors will restrain gases for less than twenty minutes.

PIPES AND DUCT OPENINGS: Since heated gases expand and provide positive pressure, openings for pipes and ducts become passages for fire and gas unless they are tightly sealed. Careful workmanship is necessary in providing these seals.

MECHANICAL DUCTS: Heating and air conditioning ducts penetrating fire partitions are natural passages for fire and smoke. Since they are fed from common plenums, this hazard is particularly difficult to control. The recirculated air they carry provides both oxygen to the fire and wide distribution of gas and smoke.

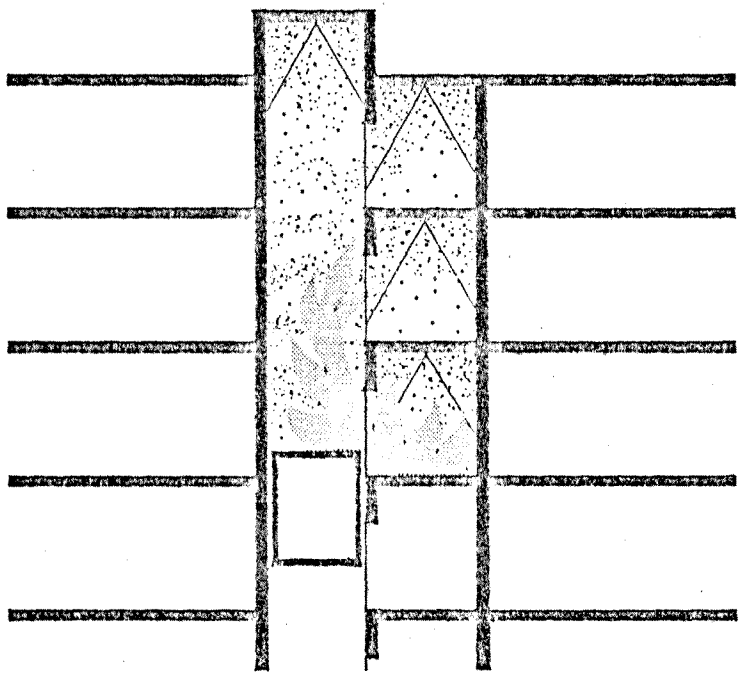
Detection devices capable of shutting down circulation and positive-acting dampers to seal off points of entry must be included in the system.



shafts and vertical openings

Continuous, vertical openings – elevators, shafts, chimneys, laundry chutes, chases, flues, incinerators, courts and light wells – are potential chimneys and must be carefully sealed off from adjacent areas.

Where access to these vertical openings is required, a "second line of defense" should be incarporated: for example, a fire door from a laundry chute should open into a fire-rated room or enclosure.



These vertical openings should be considered as hazardous areas and sprinklers provided for control. (These areas are also prime locations for detectors).

stairways

When a stairway is planned as part of an exit route, it becomes an area of refuge and should fulfill all the compartmentation requirements above.

Because stairways are designed to serve many, rather than few, occupants, special care should be exercised in compartmenting (highest fire ratings in the building) and selecting materials (lowest flame spreads and fuel contribution). Doors penetrating the stairway should be fire-rated and provided with automatic and positive closure against the pressure of gases and the neglect of occupants.

unobserved spaces

All unobserved spaces – including the boiler rooms, storage areas, crawl spaces, and even unrented spaces– should be treated as hazardous areas. Penetrations into these spaces should be avoided where unnecessary and should include a "second line of defense" such as sprinklers, detectors, double doors, or sealed passageways.

role of standards and criteria

It is in the areas of confinement and control that building codes should serve as a detailed technical reference. They should provide accurate standards for compartmenting without making buildings unduly expensive.

In general, codes provide extensive standards for compartmenting. If anything, the required fire-ratings are greater than required for life safety. Where most codes fail, however, is in not recognizing the lengthened reaction time for the elderly and not decreasing the sizes of compartments for their life safety.

summary and responsibilities

FIRE PROTECTION OFFICIALS should ,

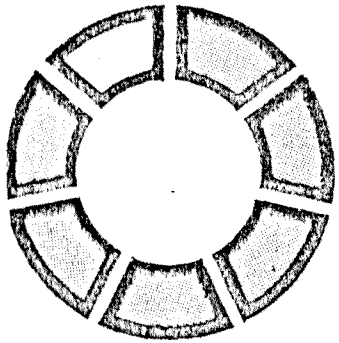
- Recognize housing for the elderly as a distinct occupancy type and establish appropriate compartment standards for this housing.

The ARCHITECT bears the prime responsibility for incorporating good confinement techniques. He should ,

- Realize that effective compartmentation is critical where temporary refuge is relied on to save lives.
- Remember that code limitations on the size of compartments may be somewhat liberal if they have not been established expressly for the elderly.
- Be careful to maintain the integrity of the compartment as he designs its openings. This requires that careful attention be given to windows, doors, pipe and duct openings.
- Protect vertical shafts within the building by providing "second lines of defense" where they open into other compartments.
- Recognize that stairwells are areas of refuge as well as escape routes.
- Consider unobserved spaces as hazardous areas, carefully protecting their openings into other compartments.

11

CONTROL



an intermediate step to extinguishment

Fire control and extinguishment techniques are closely-related. The purpose of these techniques is two-fold.

- to keep a small fire, once ignited, from becoming a large fire and producing excessive heat, flame, smoke and gas.
- to ultimately extinguish the fire.

At first glance, these techniques would seem synonymous, but there is an important distinction in terms of life safety: a fire may be controlled, but not extinguished, and still allow the occupant a chance to escape or take refuge and "ride out" the fire. Control can be looked at as an intermediate step to extinguishment – a step which "buys time" for life safety.

general approaches to control

Because control is an intermediate step to extinguishment, the general approaches for the two are similar:

- Limit the source of fuel, by selecting materials which will not contribute to the spread and growth of fire.
- Limit the source of oxygen, by blocking its flow into the fire area.
- Limit the intensity of heat by cooling or smothering the fire.

The more detailed approaches to be described will, in some way, reflect one or more of these control principles.

materials selection

Judicious selection of materials for structural elements, finishes, furnishings and contents is the first step toward effective control of fire. In all areas of the building, care should be taken to use materials which contribute as little fuel to the fire as possible and which have the lowest possible smoke-producing and flame spread ratings.

In HAZARDOUS AREAS . . .

- Non-combustible materials should be used wherever possible, particularly where natural ignition sources (such as heating and electrical equipment and appliances) are present.

- Non-combustible materials should be used for both structure and finishes where combustibles are concentrated (as in paint storage areas) and the radiation-spread possibility is high.

- Fire retardants which delay ignition of the materials they protect should be considered. An example is the family of intumescent paints which expand under heat and insulate the materials they cover. (These paints generate heavy smoke and may deteriorate in the presence of moisture, however).

In CIRCULATION and EXIT AREAS . . .

- Materials with the lowest available flame spread ratings should be used in these areas. Burning tests have proved that a completely healthy man often cannot outrun a fire spreading down a corridor's walls and ceiling.

- Materials with the lowest possible smoke producing ratings should be used.

For the CONTENTS of the building . . .

- Materials which have been flameproofed by immersion or spray should be used where economically possible. Flameproofing treatments, however, must be very thorough or they may wash away in the first cleaning; the owner should make sure before investing in them.

controlling the oxygen feed

To control fire, it is necessary to consider the oxygen that must be made available to it as it grows and produces its life-taking products. This is an obvious enough thought, but it is easy to underestimate the pulling power of a vacuum as the oxygen in the immediate vicinity of the fire is consumed; the openings around a door may serve as a path to keep the fire going for a long time.

Since the paths of oxygen feed may also be paths of fire spread, they were considered in more detail in the last chapter. The designer, however, should be particularly wary of:

- louvers, transoms, and excessive space around doors.

- operable windows and ventilation openings in the vertical planes of the building.

- service openings.

- the spaces around pipes and ducts.

- ducts which may serve as oxygen feeders.
- stairs and other vertical penetrations.
- the positive gas pressures exerted against doors, which can cause hardware to fail and provide wholesale supplies of oxygen.

equipment

Mechanical equipment and distribution systems are potential ignition sources and should be carefully protected.

HEATING EQUIPMENT has caused nearly 25% of all fire fatalities in resident occupancies; its isolation and insulation from combustible materials is fundamental to fire control. In addition, automatic controls capable of shutting down the heat sources at the first indication of malfunction are necessary.

ELECTRICAL EQUIPMENT caused an additional 6% of fire fatalities in resident occupancies and is also fundamental to effective control.

- aging effects on electrical insulation should be recognized by using non-combustible materials near all wiring, junction boxes and outlets.
- automatic shutdown from overloading should be included in all equipment.
- sufficient outlets should be provided to avoid overloading, multiple plugs, and extension cords.
- appliances should be periodically inspected as a fire prevention measure.

devices for control

SPRINKLERS: In addition to extinguishing the fire, sprinklers are excellent control devices; in fact there is no record of multiple life-loss (outside the area of origin) in which sprinklers performed. Codes recognize this fact by making greater area and height allowances for sprinklered buildings, and insurance companies provide lower rates in structures where sprinklers are used.

Where initial cost considerations rule out the comprehensive use of sprinklers, a priority schedule can be established:

1. HAZARDOUS AREAS, as boiler rooms, laundry rooms, and repair shops.
2. UNOBSERVED SPACES, as attics, crawl spaces, plenums, vertical shafts, and suspended ceilings.
3. EQUIPMENT ROOMS
4. KITCHENS
5. EGRESS ROUTES
6. PUBLIC SPACES
7. PRIVATE UNITS

EXPLOSION VENTING: In any area where explosive gases or materials are likely to accumulate, provision must be made for explosion venting. This is a specialized condition not usually found in homes for the elderly. If there are possibilities of explosion, the reader is referred to NFPA Fire Protection Handbook for more details.

role of standards and criteria

As has been previously suggested, it is in the areas of confinement and control that the building code should serve its most important function. It should be the detailed technical reference for control techniques by,

- Requiring the use of materials of proper ratings, flame spreads, fuel contribution, smoke and gas production levels.
- Specifying proven hazardous areas and their minimum acceptable protection.
- Requiring safety devices and safeguards.
- Specifying controls for mechanical and electrical equipment.

Unfortunately codes and standards do not always provide this "detailed technical reference"; and by being specification-oriented (rather than performance-oriented) many codes simply reflect the current state-of-the-art rather than allowing innovation and new approaches.

summary and responsibilities

FIRE PROTECTION OFFICIALS should,

- Consider the building code as a detailed technical reference for fire control. If this cannot be accomplished in the code per se, technical manuals should be prepared.
- Upgrade attempts at continuing enforcement by thorough inspection, recommendation, and follow-up procedures.

As in confinement, the ARCHITECT bears a great responsibility for effective control. He should,

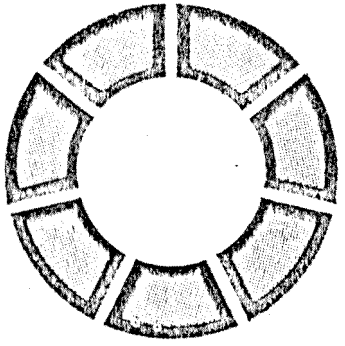
- Recognize that fire can be controlled without necessarily extinguishing it.
- Exercise great care in selecting materials which contribute little fuel and produce little smoke for building elements.
- Exercise great care in selecting materials which produce little smoke and have low flame-spread ratings for use in circulation and exit areas.
- Exercise great care in selecting materials of low fuel contribution near and adjacent to ignition sources.
- Advise the owner to use care in selecting and flame-proofing furnishings.
- Consider critically any source which may serve to continuously feed oxygen to a fire.
- Undertake judicious selection, isolation and installation of mechanical and electrical ignition sources. Automatic shut-down controls, activated in time of fire, should be included when feasible.
- Consider the use of sprinklers as control mechanisms, particularly in hazardous areas.

The OWNER should,

- Cooperate fully with the architect in authorizing proper control devices and building features.

12

EXTINGUISHMENT



introduction

Extinguishment is obviously the final and best answer to the life safety problem: put out the fire and it can do no more damage.

But extinguishment cannot be considered as an isolated link in the life safety chain.

Who attempts to extinguish a fire,

How one attempts to extinguish it,

When it is extinguished, and even

If it can be extinguished,

all depend on other links in the chain.

The seeming simplicity and finality of extinguishment is misleading in terms of life safety – for many small fires have become large, multiple-death fires because of the delay caused by hopeless attempts to extinguish it by misguided people.

In housing the elderly, since taking refuge rather than escape will frequently constitute the basis for design, there will be occupants "riding-out" the fire in the building. For these people there must be assured ex-extinguishment, or escape again becomes necessary.

strategies for extinguishment

Unless the fire burns itself out, fire is extinguished by the combination of two forces: an AGENT and some sort of DEVICE utilized by the agent.

The AGENTS include,

- The OCCUPANT, or someone in the building,
- The BUILDING itself, through design or inclusion of automatic devices, and
- The PROFESSIONAL, such as a fire department.

Devices used by these agents operate on one or more principles, all strongly relating to the nature of fire. Fire may be extinguished by,

- COOLING, as with water,
- REMOVING OXYGEN, as in smothering,
- REMOVING FUEL, as in removing combustibles and, by
- INTERRUPTING THE PRODUCTION OF COMBUSTIBLE GASES, as with chemical extinguishment.

Approaches to extinguishment can be determined only in the light of which AGENTS are available in any situation, and what DEVICES they have at their disposal. This will be clarified in the following paragraphs.

the agents

THE OCCUPANT: All occupants have limitations in extinguishing fire; indeed, the belief that the single occupant can easily put out the small fire has led to some of the major fires in our time. The elderly operate under even more stringent limitations; an elderly woman cannot remove a smouldering divan from a tenth-floor apartment, and it is doubtful that she could handle a 40-pound portable extinguisher, or even control a kitchen grease fire.

This thinking rules out dependence on the elderly occupant as a prime agent for extinguishment.

THE BUILDING: The role of successful compartmentation in confining and controlling fire has been discussed previously. Other building features and devices, such as standpipes and automatic sprinklers, will be discussed in detail as extinguishment devices.

THE PROFESSIONAL: A fully-equipped and properly trained fire-fighting unit provides the most positive assurance of extinguishment if it can effectively perform before critical levels are reached in occupied areas of the building.

It is unrealistic to take the assistance of the professional fire-fighter for granted:

- First, there must be assurance that professional help can arrive quickly and in sufficient number. It has been suggested that – before design and safety decisions are made – the people responsible for a housing for the elderly project should wait on the proposed site, stop watch in hand, and sound a fire alarm. The quantity, quality, and the reaction time of the response will begin to establish the parameters that determine the design.
- Even if the response is good, there are other factors which control the performance of the professional fire fighter. These include water supply, site and building access, maneuvering area for equipment, possibility of temporarily impassable routes, and so on.

Where codes and regulations cannot cope with these issues (some are minimally reflected in fire zones, heights and separations, etc.), it becomes the task of the designer to determine which elements of the life safety chain must be strengthened to compensate for inadequate water supplies, poorly equipped fire departments, poor site conditions, and other limitations.

the devices

THE OCCUPANT HIMSELF: The first extinguishing device is the occupant, his hands, his feet, his ability to throw water on the fire or beat it out with a blanket. As indicated above, this device for extinguishing fire cannot be depended on in housing for the elderly.

PORTABLE EXTINGUISHERS: Cumbersome portable equipment is less effective in housing for the elderly (because it often depends on the occupant, with his limitations, to operate); it should, however, be available in hazardous, public, and other supervised areas.

The danger of portable extinguishers lies in the implication that the occupant is expected to fight the fire. The basic rule is that if any other individual is conceivably endangered: first sound an alarm.

Fire extinguishers come in many types and are designed to put out different kinds of fires; an improper extinguisher is not only useless but is often dangerous. Fire extinguishers are classified by the type of fuel involved and the technique used:

class	fuel	technique
CLASS A	paper, wood, cloth	cooling
CLASS B	gasoline, oil, grease	smothering
CLASS C	electrical	non-conducting agents

Certain all purpose extinguishers are beginning to become available

STANDPIPE AND HOSE: A standpipe and hose system can be likened to an internal fire hydrant with the hose already connected. While it is primarily designed for professional fire-fighters, it can be used by personnel and attendants (not the elderly occupant) if the standpipe is of the "wet" variety.

The distinction between the two types of standpipe systems is important:

- The DRY STANDPIPE is not attached to a permanent water supply. It must be fed by fire fighters from outside the building and is, therefore, limited to their use.
- The WET STANDPIPE is connected to an assured water supply and will pour water on the fire as soon as it is activated. When the system is designed for use by personnel or attendants, a wet standpipe is necessary. This is particularly important in rural settings where professional assistance may be more than minutes away.

AUTOMATIC SPRINKLERS: An automatic sprinkler is a network of pipes and distributing heads designed to distribute water in sufficient quantity to extinguish or confine the fire; its mechanics are simple to understand:

- the piping system operates from a large main water supply.

- the system may be "wet" (water in the piping), or "dry" (if there is danger of freezing).

- the distribution heads are usually activated by fusible links which melt at a predetermined temperature, but they may be activated by detectors of any type.

- the distribution heads, usually discharging at 15 psi, form patterns 16 feet in diameter, 4 feet below the sprinklers. Heads are spaced with an overlapping pattern so that only about 100 square feet is covered by a single sprinkler.

- a system for controlling water flow is used as an alarm or early warning system which is activated whenever water flows through the system.

The advantages and disadvantages of sprinkler systems are critical to life safety and are summarized on the chart.

extinguishment and the elderly

One of the potential agents for extinguishment – the OCCUPANT – cannot be depended upon. This implies that other agents – the BUILDING and the PROFESSIONAL take on added significance. For this reason, DEVICES which depend on the occupant for use – such as portable extinguishing equipment – become less important. Conversely automatic extinguishment takes on added importance.

the advantages of automatic sprinkler systems include:

- *The life safety record of sprinklers is statistically impressive. There is no record of multiple life loss in fully sprinklered buildings.*

- *In the large majority of fires only one or two heads are activated, holding water damage to a minimum.*

- *The system can successfully monitor and extinguish or control fire in unobserved or hazardous areas.*

- *Its relatively high initial cost can usually be amortized in insurance savings in from four to a dozen years.*

the disadvantages of automatic sprinkler systems include:

- *Unless specially activated by detectors the normal relatively high fixed temperature heads are not activated by slow or smouldering gaseous fires.*

- *Under normal operating conditions Critical Levels are frequently reached before the head is activated.*

- *A sprinkler system requires a positive and relatively large reservoir of water which is becoming increasingly difficult to obtain in rural areas.*

- *Sprinkler systems are expensive to install.*

In relating extinguishment to other links in the life safety chain in this occupancy type, it is suggested that,

- Detection, alarm, escape (or taking refuge), confinement and control all take precedence over professional extinguishment. Professional extinguishment is necessary particularly from the property viewpoint, but alone it cannot be depended on to save lives, unless almost instantaneous and comprehensive reponse can be guaranteed!

- The record on automatic extinguishment is good, especially in terms of multiple life loss, but initial cost will probably remain a determining factor in its use.

- The alarm should be sounded first, unless the fire is so small that it can be extinguished surely and easily, and without risk.

- Where refuge is involved (as opposed to escape) and where occupants may be "riding out" the fire, assured extinguishment is of particular importance.

THE FUTURE

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the future

It is apparent from what has been said in the body of this document that life safety from fire is today, more an ART than a SCIENCE. Until this situation is changed, subjective rather than objective life safety must be the rule rather than the exception.

What would characterize a SCIENCE of life safety? The answer lies in the ability to predict quantitatively two conditions directly related to a specific fire:

1. When the fire protection engineer can predict, in the planning stages, the time it will take to reach intolerable levels in any space in any building. (CRITICAL TIME).

2. When the architect-psychologist can predict the time it will take any occupant located anywhere in the building to achieve life safety. (REACTION TIME).

Raising the state-of-the-art to the point where it is possible to quantitatively define and evaluate means for achieving life safety will not be an easy task, but it is not an impossible one. In broad terms, what is needed includes:

1. A systematic attack on the entire problem of life safety from fire. Some method must be established to coordinate the current fragmented efforts in the field of fire safety by employing the scientific methods found so effective elsewhere.

2. The employment of new tools and techniques, such as computer simulation of fire behavior, to accurately predict the probable results of a fire before the fact of a fire.

This requires that the attack be pressed on a variety of fronts:

THE NATURE OF FIRE . . .

. . . an increased understanding of the physics and chemistry of fire is necessary to predict its behavior and its spread under varying conditions.

. . . each fire is a potential laboratory involving size, shape, materials, climate, layout and many other factors related to the behavior of fire. Some method must be developed to relate simulation to actual fire conditions.

THE OCCUPANT . . .

. . . greater emphasis must be placed on understanding the individual occupant, his characteristics, and limitations in all endeavors relating to life safety.

. . . more must be known about the occupant, his characteristics, and how he behaves in time of fire. Questions such as these must be answered . . .

- what temperature range is critical for an elderly occupant?
- what are his toxic gas tolerances?
- what auditory and visual responses are normal?
- what is the psychological reaction to fire?
- how quickly will he normally react to an alarm?
- how far and how fast can he move when awakened?
- etc.

FIRE PROTECTION . . .

. . . the importance of prevention activities cannot be overstated; too often the potential of prevention is nullified by inadequate staff and lack of enforcement authority.

. . . the potential of every fire as a laboratory should not be overlooked. More data or specific fire experience is critical to a scientific approach to life safety.

DETECTION . . .

. . . the potential of automatic detection must be objectively investigated; there exists little evidence relating to its function, sensitivity, performance, reliability and limitations. Field results on all types are unavailable, and performance has been clouded by exaggeration, misuse and misunderstanding. Meaningful, objective, standard tests and evaluation are badly needed.

ALARM . . .

. . . in many occupancies, such as in housing for the elderly, the reliance on the individual occupant to transmit the call for outside assistance creates an additional hazard to occupants. Some inexpensive, automatic, fail-safe device is needed as a primary, or back-up, system in calling for outside help after a fire has been detected.

ESCAPE OR REFUGE . . .

. . . greater emphasis on the potential importance of taking refuge (rather than escaping) as a life safety measure is warranted in many occupancies.

. . . concepts with the definiteness of "expendability" must be developed and used to evaluate escape and evacuation routes.

. . . further work and research in the field of area and height limitations, egress and exit requirements are necessary.

CONFINEMENT AND CONTROL . . .

. . . the physics and chemistry of fire are generally understood, but the mechanics of fire spread needs a great deal of attention.

. . . the developments of positive flame-proof and fire-proofing methods for surfaces and furnishings are a distinct need.

. . . better standards for both heating and electrical appliances and equipment are needed.

EXTINGUISHMENT . . .

. . . the development of self-contained, automatic extinguishing equipment would be of great value to persons such as elderly occupants in hazardous household areas.

PHILOSOPHY AND RESPONSIBILITY . . .

. . . a clear-cut philosophy of life safety must be established for each occupancy type.

. . . a clear assignment of responsibility for each life-safety decision must be made; this involves a re-orientation from the minimum standards necessarily set by codes and regulations to the appropriate decisions arrived at within the framework of an overall life safety philosophy for each occupancy.

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In summary, a technology which is capable of measuring the temperature and gaseous composition of the surface of Venus should have little trouble in predicting the temperatures and gaseous composition of the apartment next door in the event of fire.

Nor should it be difficult in an age of computers to record and profit from the lessons taught by almost one million building fires per year.