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NFPA 914 Rehabilitation and Adaptive Reuse of Historic Structures 1989 Edition

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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All questions or other communications relating to this document should be sent only to NFPA Headquarters, addressed to the attention of the Committee responsible for the document.

For information on the procedures for requesting Technical Committees to issue Formal Interpretations, proposing Tentative Interim Amendments, proposing amendments for Committee consideration, and appeals on matters relating to the content of the document, write to the Secretary, Standards Council, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Licensing Provision

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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MGR AM-89

NFPA 1914

Testing Fire Department Aerial Devices

1991 Edition

Reference: 1-4.3*, A-1-4.3, 2-1, 2-5.5, 2-7.2, 3-1, 3-11.5, 4-1
TIA 91-1

Pursuant to Section 15 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 1914, *Standard for Testing Fire Department Aerial Devices*, 1991 edition. The TIA was processed by the Fire Department Apparatus Committee and was issued by the Standards Council on April 14, 1993.

A Tentative Interim Amendment is tentative because it has not been processed through the entire standards-making procedures. It is interim because it is effective only between editions of the standard. A TIA automatically becomes a Proposal of the proponent for the next edition of the standard; as such, it then is subject to all of the procedures of the standards-making process.

1. Revise 1-4.3 to read as follows:

1-4.3* If the aerial device is involved in a situation that produces any structural damage, or if the inspections and tests required in this standard reveal any problems that affect the structural integrity of the aerial device, the aerial device shall be placed out of service. The aerial device shall be repaired to an acceptance level in accordance with the manufacturer's standard. If the manufacturer is no longer in business and therefore cannot be consulted with regard to repair of the aerial device, the repairs shall be performed by a repair facility acceptable to the authority having jurisdiction. The aerial device shall be tested to the full operational load and NDT of this standard before it is placed back in service.

2. Add an Appendix item to 1-4.3 to read as follows:

A-1-4.3 If possible, the manufacturer of the aerial device should be consulted when structural defects are revealed by the service test in this standard. The recommendations for repair made by the manufacturer should be strictly adhered to. However, situations can arise in which the manufacturer cannot be consulted because the company is no longer in business. In these cases, the authority having jurisdiction must choose a repair facility to conduct the repair work. Choosing a repair facility to perform structural repair on an aerial apparatus is a process that requires a great deal of research and careful thought. Some of the items that should be considered are:

(a) Does the facility have past experience with the same structural repair as your aerial device needs and will the facility provide a reference list?

(Continued)

(b) Does the facility have the original design, construction, and operation specifications for the make and model of your aerial device?

(c) Does the facility have in its possession written procedures for structural repair that were previously developed by the manufacturer of your aerial device?

(d) Does the facility employ an engineering staff to analyze structures and recommend structural repair methods?

(e) Will the facility provide you with the engineering analysis used to substantiate the structural repair method recommended?

(f) Will the facility provide an independent certification by a professional engineer of the analysis used to substantiate the recommended structural repair method?

(g) Will the facility warrant the work performed?

3. Delete the first sentence of the second paragraph of Section 2-1.

4. Delete 2-5.5 and renumber 2-5.6 through 2-5.28 as 2-5.5 through 2-5.27.

5. Revise 2-7.2 by deleting the wording starting with "and the condition shall be reported ..." *through the remainder of the paragraph.*

6. Delete the second paragraph of Section 3-1.

7. In 3-11.5 delete the words "or the manufacturer notified."

8. Delete the second paragraph of Section 4-1.

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NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 914

Recommended Practice for Fire Protection in

Rehabilitation and Adaptive Reuse of Historic Structures

1989 Edition

This edition of NFPA 914, *Recommended Practice for Fire Protection in Rehabilitation and Adaptive Reuse of Historic Structures*, was prepared by the Technical Committee on Cultural Resources and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 15-18, 1989 in Washington, DC. It was issued by the Standards Council on July 14, 1989, with an effective date of August 7, 1989.

The 1989 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 914

The Committee on Protection of Cultural Resources: Libraries, Museums, Places of Worship, and Historic Structures was first organized as the Committee on Libraries, Museums and Historic Buildings in 1940. The first Committee document, published in 1948, was a manual, *Protecting Our Heritage: Historic Buildings, Museums and Libraries*. A second edition of the booklet was published in 1970.

The Committee has revised and updated this material as a Recommended Practice to incorporate changes in the state of the art, to make the document more useable, and to reflect new technology of both fire detection and fire extinguishing systems. The Recommended Practice, NFPA 913, was adopted at the 1987 Annual Meeting in Cincinnati.

The Committee approved a request in November, 1984 to develop a publication similar to NFPA 913 for buildings rehabilitated for new uses. A Recommended Practice was prepared in draft form for the 1988 Annual Meeting, but was not considered by the Committee to be ready for publication. The document was slipped to the 1988 Fall Meeting as the Committee continued to revise and organize the material, and again to the 1989 Annual Meeting. The first edition of NFPA 914 was adopted at the 1989 Annual Meeting in Washington, DC.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Contents

NFPA 914

Recommended Practice for Fire Protection in Rehabilitation and Adaptive Reuse of Historic Structures

1989 Edition

NOTICE: Information on referenced publications can be found in Chapter 5 and Appendix D.

Chapter 1 Introduction

1-1 Scope. This recommended practice addresses fire protection and prevention as it relates to all aspects of historic preservation. It is intended for application to a wide range of historic building types undergoing any level of rehabilitation or restoration.

The document provides background material on the historic preservation field and its requirements, information regarding the identification of fire hazards, and recommendations for planning and design approaches and solutions appropriate for the historic building. The document assumes that its reader has a basic understanding of building technology and construction concepts, and refers to other NFPA documents and resource materials for more in-depth discussion of the issues.

1-2 Purpose. The purpose of this recommended practice is to provide guidance relative to the fire prevention and protection of historic buildings — irreplaceable artifacts of history and culture.

Protection of these buildings, their contents, and occupants from fire and other hazards presents unique problems not addressed by codes and requirements intended for modern construction. This document provides strategies and solutions for these problems and is intended for use by building and fire officials, architects and engineers, fire protection specialists, contractors, and other design and preservation professionals involved with the protection of historic buildings.

1-3 Background.

1-3.1 Historic Preservation. In the last 20 years, the recognition of historic buildings has increased nationwide. Although structures such as house museums or monumental public structures have long been identified as having historical and cultural significance, the type and quantity of built resources determined to be worthy of protection has expanded greatly and now includes a wide variety of building types.

Current estimates are that more than 500,000 properties are included in the *National Register of Historic Places* as either individual listings or as components of historic districts. In addition to the federal government, local cities and states can also designate structures historic. Designation is intended to protect the architectural character and integrity of a structure, including all original and significant exterior and interior spaces and features.

Review of proposed rehabilitation or maintenance work may be required by a local, state, or federal authority for a variety of regulatory requirements or incentive programs. These reviews are separate from those conducted for building code and fire protection purposes.

Where local design review commissions have authority, approval is typically necessary for exterior work only. State or federal authorities are usually involved when state or federal funds or tax incentives are to be used; the scope of these reviews is likely to include all exterior and interior work. Although local review commissions may adopt their own guidelines for treatment of historic buildings, the Secretary of the Interior's *Standard for Rehabilitation and Guidelines for Rehabilitating Historic Buildings* (*see 3-1.1.1*) are used for all federally funded or assisted projects, and in many cases projects receiving state funding, permits, etc.

As early as possible, the authorities having jurisdiction for review should be consulted. Local historic preservation organizations and State Historic Preservation Offices can be of assistance in identifying these authorities and consultants and architects who specialize in historic preservation. (*See Appendix B.*)

1-3.2 Building Codes and Firesafety. Building and fire codes are documents written primarily for new construction and adopted by a legal authority for the primary purpose of providing life and property safety. Although it is but one issue the codes address, fire protection concerns dominate most codes. Associated review processes often require separate reviews by the building code official and fire marshal.

Codes establish a minimum standard for building construction through the use of prescriptive standards that specify allowable materials or techniques, or performance standards that specify the level of performance any proposed material or assembly must meet. Most codes determine allowable construction techniques or materials by weighing the degree of safety provided by the building (its construction classification) against the degree of hazard presented by the user (occupancy classification) and by taking into account factors such as installed fire detection and suppression systems.

Each state or authority may write its own code or, either partially or in entirety, adopt one of the model codes prepared by private organizations whose primary purpose is to prepare codes for the protection of life and property. At present three model building codes are commonly used in the US: the *BOCA National Building Code* published by the Building Officials and Code Administrators International, Inc. of Country Club Hills, Illinois, used primarily in the midwestern and northeastern states; the *Uniform Building Code*, published by the International Conference of Building Officials of Whittier, California, in the western states; and the *Standard Building Code*, published by the Southern Building Code Congress International of Birmingham, Alabama, in the southeastern states. In addition, most codes include appendices that reference industry standards prepared by manufacturers or research associations. These standards are typically narrowly focused and provide more detailed information than do the building

codes. Examples are the standards of the National Fire Protection Association and ASTM (formerly American Society for Testing and Materials).

Most code documents are modified at regular intervals to respond to increasing safety standards and technological advances. Each modification has the potential to exacerbate inherent conflicts that exist between the code and the historic or existing building constructed prior to the adoption of that code. The conflicts may be resolved by the local building official who has the authority to approve noncomplying alternatives in special instances, or through variance hearings usually conducted at a higher level of government.

1-4 Definitions.

Adaptive Use. A use for a building other than that for which the structure was originally designed or intended.

Addition. An extension or increase in floor area or height of a building or structure.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Atrium. A floor opening or series of floor openings connecting two or more stories that is covered at the top of the series of openings and is used for purposes other than an enclosed stairway, elevator hoistway, escalator opening, or utility shaft used for plumbing, electrical, air conditioning, or communication facilities.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

Early Warning. A signal provided by a fast response detection system, such as one using smoke or flame detectors, that detects fire in its earliest stages of development so as to enhance the opportunity of building occupants for escape and commencing manual suppression of the fire prior to arrival of fire service units.

Exit. That portion of a means of egress that is separated from all other spaces of the building or structure by construction or equipment to provide a protected way of travel to the exit discharge.

Exit Access. That portion of a means of egress that leads to an entrance to an exit.

Exit Discharge. That portion of a means of egress between the termination of an exit and a public way.

Fire Barrier. A continuous membrane, either vertical or horizontal, such as a wall or floor assembly, that is designed and constructed with a specified fire resistance rating to limit the spread of fire, and that will also restrict the movement of smoke. Such barriers may have protected openings.

Fire Compartment. A space within a building that is enclosed by fire barriers on all sides, including the top and bottom.

Fire Resistance Rating. The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*.

Hazardous Areas. Areas of structures, buildings, or parts thereof having a degree of hazard greater than that normal to the general occupancy of the building or structure, such as storage or use of combustibles or flammables, toxic, noxious, or corrosive materials, or use of heat-producing appliances.

Historic Building. A structure and its associated additions and site deemed to have historical, architectural, or cultural significance by a local, state, or federal jurisdiction. Designation may be in an official existing or future national, state, or local historic register or inventory, such as the national or state *Register of Historic Places*.

Historic Character. The essential quality of a historic building or space that provides its significance. The character may be determined by the historic background including association with a significant event or person, the architecture or design, or the contents or elements and finishes of the building or space.

Historic Fabric. Original or added building/construction materials, features, and finishes that existed during the period deemed to be most architecturally and/or historically significant.

Historic Preservation. A generic term that encompasses all aspects of the professional and public concern related to the maintenance of an historic structure, site, or element in its present condition, as originally constructed, or with the additions and alterations determined to have acquired significance over time.

Means of Escape. A way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out.

National Register of Historic Places. The federal listing of all historic structures, districts, and sites considered to possess architectural, historic, or cultural significance and worthy of protection.

Occupancy. The purpose for which a building or portion thereof is used or intended to be used.

Occupant Load. The total number of persons that may occupy a building or portion thereof at any one time.

Rehabilitation. The process of returning a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving significant portions and features of the property.

Restoration. The process of accurately recovering the form and details of a structure and its setting by the removal of later work and the accurate replacement of missing earlier elements.

Secretary of the Interior's Standards. Document prepared by the National Park Service, Department of the Interior, to direct appropriate work undertaken on historic buildings. Used by federal agencies and adopted by state and local preservation officials and historic district and planning commissions.

Self-closing. Equipped with an approved device that will ensure closing after having been opened.

Smoke Barrier. A continuous membrane, either vertical or horizontal, such as a wall, floor, or ceiling assembly, that is designed and constructed to restrict the movement of smoke. A smoke barrier may or may not have a fire resistance rating. Such barriers may have protected openings.

State Historic Preservation Office. The state agency or office responsible for coordinating all federal and state preservation activities including compliance review, *National Register* designations, and grant and tax incentive programs.

Vertical Opening. An opening through a floor or roof.

Chapter 2 Identification and Evaluation of Existing Conditions

2-1 Historic Spaces and Features. Providing adequate fire protection to the historic building while protecting the historic character can be a difficult task. It can occur only after the building has been thoroughly surveyed to identify fire hazards and code deficiencies and those surviving historic elements and spaces worthy of retention. This survey will be the basis of all planning and design decisions, and is essential for rehabilitation projects of all types, including those that continue original or existing uses and those that involve new uses.

2-1.1 Historic Documentation. This information may exist in the files of a local historic organization, or at the State Historic Preservation Office (SHPO) (*see Appendix B*). If the historic resource is listed in the *National Register of Historic Places*, a careful review of the official *National Register* nomination (on file at the SHPO) should be the first step in this assessment. An understanding of why and when the individual building or historic district achieved significance will help to evaluate those spaces and features that are significant for their association with specific events or persons, architectural importance, or information potential.

In some cases, older *National Register* nominations may neglect to describe all architectural spaces and features of the building's exterior and interior. This should not be construed to mean that the building possesses no character-defining elements. In such cases, professional preservation judgment can be of great assistance.

2-1.2 Identification of Historic Elements.

2-1.2.1 Exterior. Exterior historic elements may include the sheathing or facade material, roofs, chimneys, skylights, cornices, window and door lintels or sills, windows, doors, stoops, or railings and fencing. Major and minor facades should be studied such that if exterior modifications or additions are necessary, they can be located on the least visible and significant elevation to have minimal impact.

2-1.2.2 Interior. Character-defining aspects of the interior may consist of spaces that are important in and of themselves, or they may consist of architectural features and their finishes or both. Historic fabric and spaces will include those original to the building and those later changes that have acquired significance in their own right.

(a) *Plan.* The floor plan may be an important characteristic of the building type, style, period of construction, or historic function. Even if the plan has been altered over time, it may have historic significance: alterations that have been additive (large rooms divided into smaller ones) versus subtractive (where walls have been taken out) may be easily corrected to restore the building's integrity.

(b) *Spaces.* Significant rooms or spaces may be those that are typical of the building type or style, or are associated with specific persons or events.

The sequence of consciously designed spaces may be important to the understanding and appreciation of the building or architect. Examples are a foyer opening into a large hall; front and rear parlors connected by pocket doors; an office lobby opening into an elevator hall; a hallway leading to a stairwell, etc.

Spaces may have distinctive proportions such as ceiling height to room size, or significant or unusual room shapes or volumes such as rooms with curved walls, rooms with six or eight walls, rooms with vaulted ceilings, etc.

(c) *Features.* Distinctive architectural details of significance, construction, or historic function that are characteristic of the period might include wainscoting, parquet flooring, picture molding, mantels, ceiling medallions, built-in bookshelves and cabinets, crown molding, arches, as well as simpler, more utilitarian features such as plain windows and doors and associated trim. The significance of some architectural features may be that they are worked by hand, exhibit fine craftsmanship, or are particularly characteristic of the building style.

Some features may indicate later changes and alterations that have gained significance over time, such as lobby alterations, changes to wall and floor finishes, and later millwork.

2-2 Code Deficiencies. The evaluation of existing conditions should include a review of all safety related requirements to determine if and where the historic building is deficient with respect to applicable codes.

In some instances, this code review can be used to determine the use of a building that will cause the least damage to historic character. In others, this review will illustrate those areas of the building where code requirements are most stringent and conflicts between code requirements and historic preservation concerns are most likely to occur.

Common code or safety deficiencies of the historic building are listed below. Although some can be readily addressed without damage to the historic character of the building, others require innovative solutions not in strict compliance with the codes or standards for new construction.

Inadequately sized mechanical and electrical systems.
Nonoperative or insufficient sprinkler protection.
No standpipe system.
Inadequate water supply for fire protection use.
Inadequate number of smoke detectors and alarms.
Smoke detectors not centrally monitored.
Exterior walls inadequately fire rated.
Chimneys of inadequate design, height, or lining.
Inadequate distance between buildings.
Attic inadequately compartmented.
Fire stopping inadequate.
Fire separation between tenancies inadequate.
Wood frame construction inadequately protected.
Building height and fire area not within limitations.
Use or occupancy not allowed in construction type.
Enclosures for mechanical/electrical rooms inadequate.
Lightning protection nonexistent or inadequate.
Number of exits inadequate.
Width of exits inadequate.
Exit corridors or stairways inadequately fire rated.
Exit corridors do not lead directly to exterior.
Exit corridors or stairways contain combustible materials or flammable finishes.
Dead-end corridors.
Excessive exit travel distance.
Corridor doors inadequately rated.
Exit stairways of inadequate width.
Configuration of exit stairway inadequate.
Unenclosed, open monumental stairs.
Inadequate ceiling heights.
Corridor transoms.

2-3 Fire Hazards. A fire hazard is a condition that may contribute to the start or spread of a fire, or to the endangerment of people or property by fire. General categories of fire hazards are: ignition sources, combustibility of materials, and structural fire hazards.

2-3.1 Ignition Sources. Ignition is the initiation of combustion. It originates with the heating of a fuel by a heat source, a process controlled by thermodynamic properties of materials and the environment. When the temperature of the material is raised sufficiently, it begins to pyrolyze or decompose from the heat into simpler substances, primarily combustible gases and vapors. Different substances are produced at varying rates and temperature regimes. When an adequate mass of combustible gases and vapors is mixed with oxygen or air and exposed to an energy source of sufficient intensity, ignition will take place.

Any form of energy is a potential ignition source. Most often this is open flames or electrical wiring and appliances. Smoking, candles, solid fuel heating, and similar combustion processes represent likely sources of ignition. In older structures, chimneys are particularly dangerous if not properly lined and pointed. Inadequate electrical service and misuse of appliances are also common hazards. Certain occupancies such as restaurants and repair facilities significantly increase the number and variety of heat sources. An example of a more unusual ignition source associated with historic buildings is the capacity of a "bull's eye" glass to focus rays of the sun (Goldstone, 1982).

In congested areas there is the danger of fire spreading from another nearby building, while in open areas lightning is a potential ignition hazard. Arson is a major threat to firesafety and should always be considered.

2-3.2 Combustibility of Materials.

2-3.2.1 Material Properties. The tendency of a material to ignite is a function of its chemistry, physical state, surface texture, and moisture content. Different chemical compositions have different minimum temperatures at which they will ignite. Ignition is a function of time as well as temperature. A potential fuel subjected to a relatively high temperature for a short period of time may not ignite, while the same fuel can undergo ignition when exposed for a longer duration to a lower temperature. For example, wood products have a normal ignition temperature of 400-500 °F (204-260 °C), but they have been found to ignite when subjected to a much lower heat source of 228 °F (109 °C) for four days. (*See NFPA Fire Protection Handbook, 16th Edition, p. 5-14.*)

Contents of most buildings consist of combustible materials. Accumulations of readily ignitible items constitute a fire hazard. Construction materials such as siding and roofing can increase the possibility of fire spread from other buildings. This is especially true of wood shingles that are not fire retardant treated.

2-3.2.2 Flame Spread. Combustibility is the principal factor contributing to the spread of flame across surfaces. Once ignition takes place the flame heats surrounding material, causing it to ignite and thereby spread across the surface. The rate at which flame spread occurs is measured by test. (*See NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.*) Most model building codes and NFPA *101®, Life Safety Code®*, place restrictions on the use of materials with high flame spread rates.

A single layer of paint and most wall coverings add little fuel to a fire. Even if it burns completely, only a small amount of heat is liberated and little damage results. On the other hand, the substrate on which the paint or paper is applied can have a great influence on flame spread. Paint on a metal ceiling may not ignite at all under fire exposure because the heat is dissipated in the metal.

Walls in older buildings may have been repeatedly painted or papered. When five or more layers of paint and paper are present, flame spread may be significantly increased.

The existence of interior wood paneling as found in many historic structures adds to the fuel and thereby increases flame spread. Combustible composition ceiling and wall materials and plastics, both in the form of high density solids and expanded foam products, may also contribute to flame spread. Flame spread in low density cellulosic materials used extensively in some older buildings for ceiling tile and wall panels may be faster than most people can run.

2-3.2.3 Environmental Factors. Sustained burning of the fuel material depends on its combustibility and additional factors such as interaction of surfaces, fluid flows, and thermal absorptions. These are neither well defined nor predictable outside of the laboratory. Observed conditions that produce these effects include arrangement of combustibles, wall materials, and room dimensions.

Furnishings and other combustibles that are close together will cause fire to spread easily from one item to another. A fire starting in a corner will grow in size about four times faster than one in the middle of a room. Flame spread is much faster on vertical surfaces than on horizontal ones.

In general, fire develops more slowly in larger spaces. This is particularly true with respect to the height of the ceiling. A high Victorian ceiling is inherently more firesafe than a low colonial ceiling. Fires that can vent themselves to the outside through windows or other means are less likely to spread to other parts of the building.

2-3.3 Structural Fire Hazards. Structural features of buildings that constitute fire hazards are of two types. There are structural conditions that promote the spread of fire and conditions that may lead to structural failure in a fire.

2-3.3.1 Fire Spread. Most buildings take the form of a connected series of compartments. As such they are inherently firesafe if a fire can be contained to the compartment of origin. Unfortunately, design, construction, and use practices create many avenues for fire spread. For example, balloon frame construction creates virtual chimneys in the stud channels, allowing fire to spread the full height of the building. Paths of fire spread may be either horizontal or vertical.

2-3.3.1.1 Means of Horizontal Fire Spread.

Doorways.

Ceiling voids over walls.

Floor cavities under walls.

Utility and service chase through walls.

Void in projecting eave or cornice.

Breaching of wall by fire.

Opening produced by distortion or failure of structural members in a fire.

Open attic space.

2-3.3.1.2 Means of Vertical Fire Spread.

Stairways.

Conduction of heat through hearth slab to supporting timbers below.

Wall cavities penetrating floor.

Utility and service chase penetrating floor.

Shafts for elevator, dumbwaiter, laundry, trash, etc.

Breaching of floor or ceiling by fire.

Atriums.

Exterior openings.

2-3.3.2 Structural Integrity. The ability of structural framing to resist the effects of a severe fire is dependent on the framing material and its dimensions. Wood members, while combustible, may have limited fire resistance according to their size, since fire resistance is a function of the surface-to-mass ratio of the member. Large dimensioned lumber such as that used in heavy timber construction provides significant endurance from the effects of fire. Studs and joists have little fire resistance although older, fully dimensioned members are significantly better than modern thin-webbed, strap-hung construction.

Steel, although noncombustible, is subject to decreased structural capacity at relatively low fire temperature. Steel members can be protected to improve their resistance to fire.

2-4 Means of Egress. Evacuation of occupants is the primary approach to life safety from fire. NFPA *101, Life Safety Code*, and model building codes detail specific requirements for assuring adequate means of egress. The Life Safety Code defines an exit as separated from other spaces of the building to provide a protected way of travel to a safe area. Egress problems in existing buildings generally arise with respect to number of exits, exit capacities, arrangement of exits, or construction details.

2-4.1 Number of Exits. Codes specify the number of exits that must be provided for each floor as well as for the entire building. Requirements for a minimum number of exits are established to increase the reliability of the egress system. The intent is that for any single fire situation that prohibits travel to one exit, there will be an alternative exit available. A minimum of two means of egress is a fundamental life safety principle and codes allow very few exceptions to this rule. Additional exits may be required under consideration of arrangement or capacity of exits.

2-4.2 Exit Capacities. Codes regulate the capacity of exits by relating the required width of various exit elements to the number of occupants they serve and by establishing minimum widths for each of the exit elements. It is the intent of the codes to provide an exit capacity large enough to move the total expected number of occupants into the

safety of the exits before access to the exits becomes difficult.

2-4.3 Arrangement of Exits. In addition to their number and capacity, codes generally require that exits be located to facilitate their use in a fire emergency. Requirements address remoteness, maximum travel distance, direct exit to the exterior, and minimum dead ends.

2-4.3.1 Remoteness. Codes generally require that exits be as remote from each other as practical, and be arranged to allow direct access in separate directions. The intent of providing exit remoteness is to minimize the probability that access to all exits will be blocked by a single fire. The term "remote" is subjective and frequently a matter of interpretation.

2-4.3.2 Travel Distance. Requirements governing travel distance to an exit are intended to establish a maximum interval of time for an occupant to reach an exit. Travel distances are measured by mapping the path of travel to an exit. When combined with requirements for minimum number of exits and exit remoteness, the limitations on travel distance assure that even if one exit is blocked by a fire, an occupant should still be able to reach another exit or a location of refuge before the fire has spread in a manner that would prevent escape. The actual time for escape implied by maximum travel distance limitations is not explicitly stated in the codes.

2-4.3.3 Dead-End Travel. Dead-end corridors of any length are undesirable features in buildings for two reasons. People who use a dead-end corridor to get to an exit could be trapped by fire or smoke between them and the exit. Secondly, it is possible to mistakenly enter the dead-end corridor rather than the exit and under smoky or low light conditions become trapped or confused.

2-4.4 Construction Details. Codes set out many requirements for the details of various exit components that make up a building's egress system. Typical areas include: means of separation from other spaces, allowable materials, handrails, tread and riser design, landings, platforms, guards, door hardware, signs, lighting, alarms, and emergency lighting. The intent of these provisions is to assure a quality design that will promote safe and easy passage. Individual code requirements tend to be numerous and highly specific.

Chapter 3 Planning and Design

3-1 Objectives in Rehabilitation Planning. The primary fire protection objective in rehabilitation planning is to achieve the best protection program for the historic building while maintaining its historic integrity and character. Because of the unique character of each historic structure, achieving this objective requires an understanding of historic preservation and fire protection concepts.

3-1.1 Historic Preservation. Historic buildings should be treated with sensitivity, as described in the Secretary of the Interior's *Standards for Rehabilitation*, published by the US Department of the Interior, National Park Service.

3-1.1.1 Secretary of the Interior's Standards.

1. "Every reasonable effort shall be made to provide a compatible use for a property which requires minimal alteration of the building, structure, or site and its environment, or to use a property for its originally intended purpose."

2. "The distinguishing original qualities or character of a building, structure, or site and its environment shall not be destroyed. The removal or alteration of any historic material or distinctive architectural feature should be avoided when possible."

3. "All buildings, structures, and sites shall be recognized as products of their own time. Alterations that have no historical basis and which seek to create an earlier appearance shall be discouraged."

4. "Changes which may have taken place in the course of time are evidence of the history and development of a building, structure, or site and its environment. These changes may have acquired significance in their own right, and this significance shall be recognized and respected."

5. "Distinctive stylistic features or examples of skilled craftmanship which characterize a building, structure, or site shall be treated with sensitivity."

6. "Deteriorated architectural features shall be repaired rather than replaced wherever possible. In the event replacement is necessary, the new material should match the material being replaced in composition, design, color, texture, and other visual qualities. Repair or replacement of missing architectural features should be based on accurate duplications of features, substantiated by historic, physical, or pictorial evidence rather than on conjectural designs or the availability of different architectural elements from other buildings or structures."

7. "The surface cleaning of structures shall be undertaken with the gentlest means possible. Sandblasting and other cleaning methods that will damage the historic building materials shall not be undertaken."

8. "Every reasonable effort shall be made to protect and preserve archaeological resources affected by, or adjacent to any project."

9. "Contemporary design for alterations and additions to existing properties shall not be discouraged when such alterations and additions do not destroy significant historical, architectural or cultural material, and such design is compatible with the size, scale, color, material, and character of the property, neighborhood or environment."

10. "Wherever possible, new additions or alterations to structures shall be done in such a manner that if such additions or alterations were to be removed in the future, the essential form and integrity of the structure would be unimpaired."

3-1.2 Administrative and Review Requirements.

3-1.2.1 Historic Preservation. Depending on funding sources and federal, state, or local legislation, review by state or federal preservation offices or local historic review commissions may be required to ensure that the historic

building is treated with sensitivity. Projects should be discussed with the appropriate preservation authorities as early as possible in the planning stages.

3-1.2.2 Code Enforcement. Proposed rehabilitation projects should be discussed with the appropriate building and fire code officials as early as possible in the planning stages to determine if code or safety conflicts exist. Many codes have special provisions for historic buildings (*see Appendix B*) and for the consideration of alternative methods or systems that will provide equivalent levels of safety as those required for new construction. (*See NFPA 101, Section 1-5, "Equivalency Concepts."*) In some cases, special appeal or variance boards exist and should be requested to address those situations where firesafety and protection concerns and historic preservation goals cannot acceptably be resolved by the standard review process. Most building code officials are willing to work with owners, architects, and engineers and will consider alternative construction methods provided that a reasonable or equivalent level of life and property protection be proposed.

3-2 Concepts of Firesafety Planning.

3-2.1 Management Responsibility. The key to any successful fire protection program lies in the effort extended by the management. Without the active participation and direction of high level management the effectiveness of the fire protection effort will be seriously hindered. This is true in an operational facility as well as in one undergoing rehabilitation.

Firesafety is an essential and permanent part of historic structure operations and must be a key consideration when that structure is scheduled for rehabilitation. Owners and others entrusted with the management or operation of buildings having historic significance have prime responsibility in assuring that the historic structure is protected against the disastrous effects of fire.

Using advice from qualified firesafety professionals (*see Appendix B*), the management team should develop firesafety objectives and a firesafety plan for the complete facility. As part of this plan, the management must decide how the building, its contents, and the occupants are to be protected during the rehabilitation process as well as when completed.

Regardless of the complexity or size of the project, management should collaborate with preservation architects, structural engineers, fire protection engineers, fire service representatives, and others with experience and expertise in the design of fire protection systems.

3-2.2 Elimination or Control of Firesafety and Life Safety Hazards. The planning process for the rehabilitation of a historic structure should include provisions to control hazards that are not an inherent part of the historic fabric of the structure or its operation. Firesafety problems identified in the evaluation of existing conditions (*see Chapter 2*) should be ranked by priority to help identify the most undesirable conditions. These hazards may include life safety issues such as exit facilities as well as fire ignition and material combustibility considerations. Every effort should be made to eliminate as many of the identified hazards as possible.

Where a specific hazard is an essential part of the historic fabric of the building, the threat to the building and contents should be controlled by providing special protection for the hazard. The approach taken can use any or a combination of the elements discussed in Section 3-3.

As part of the elimination and control of fire hazards, the planned rehabilitation should build upon the building's inherent firesafety features and not introduce new fire hazards. Alterations may change the conditions that have kept the building firesafe.

3-3 Elements of a Firesafety Plan.

3-3.1 Management Involvement.

3-3.1.1 Management should consider the following four steps to ensure the firesafety of the historic property both during and after the rehabilitation process:

(a) Fully evaluate the existing conditions of the building.

(b) Educate and train appropriate personnel as to the importance and implementation of a sound fire prevention program. Provide or have available a trained, properly equipped fire fighting and salvage organization.

(c) Institute management and operation practices that eliminate the cause of fire both during and after the planned rehabilitation. Construction contracts should specify methods of control of combustibles and hazards, including measures such as those indicated in NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations.*

(d) Incorporate appropriate fire protection measures in the rehabilitation effort to limit any damage should a fire occur, including structural compartmentation, automatic detection and alarm, and fixed extinguishing systems.

3-3.2 Prevention.

3-3.2.1 General. When planning for the rehabilitation of a historic building, great care must be exercised to provide for the abatement of fire hazards throughout the construction period and following rehabilitation.

3-3.2.2 Design. To reduce the possibility of fire, existing firesafety standards such as NFPA 70, *National Electrical Code®*, and other NFPA standards and industry standards should be consulted during the design stage of electrical, mechanical, and similar systems.

3-3.2.3 Education and Training. For buildings that will be occupied during the rehabilitation process, staff members should be instructed to identify obvious fire hazards and report them to a designated individual. Staff members should also receive hands-on training in the use of the fire suppression equipment provided. They should be instructed to report a fire and evacuate the area before attempting to extinguish the fire. If not practical for the entire staff, then specific staff members should be designated for such training.

A fire brigade or floor marshal plan can help organize specific staff members to react quickly to any fire emergency. Members of the brigade should be kept apprised of the rehabilitation work in progress and the possible hazards that will be introduced during construction.

3-3.2.4 Operation and Maintenance. Special precautions should be taken during the demolition and construction processes necessary to complete the rehabilitation proj-

ect. See Chapter 4 for a discussion of specific hazards and processes.

3-3.2.5 Enforcement. The responsibility for enforcement of fire prevention measures should be definitely assigned, including enforcement of the construction contract requirements relating to fire perils. Authority should be given to stop work pending correction of flagrant abuses. The responsible local authorities such as fire and building departments should be consulted.

3-3.3 Limiting Combustibility.

3-3.3.1 Construction Materials. Careful consideration should be given to the use of fire resistive materials and methods whenever these materials and methods will not damage the structure's historic character. This is especially true in concealed areas and other areas not exposed to the public.

Inert or fire resistive materials should be used where appropriate including some cases where the structure is to be substantially rebuilt or when items used in original construction are unavailable. Ingenuity can produce firesafe components that simulate wood roofing and numerous other products. In some instances the use of substitute materials for original wood may be appropriate: rough sawn wood can be duplicated in appearance by casting concrete in a mold or form which bears the marks that are desirable on the surface of the finished product, or wood shingles can be easily simulated with fire resistant materials. Wood shingles and shakes that have been given a fire-retardant treatment are commercially available. Even if community fire regulations and codes do not require the use of such materials, they should be considered.

Mechanical systems should be designed to minimize the use of combustible materials or lubricants. Noncombustible insulation materials should be used where such materials are to be installed.

Scaffolding and forms should be required to be of noncombustible materials. When noncombustible materials cannot be substituted, scaffolding and form lumber should be fire-retardant treated. Tarpaulins, if used, should be fire-retardant treated.

3-3.3.2 Interior Finish Materials. Choice of furnishings and interior finishes should be given careful consideration. For example, where highly combustible wood veneer paneling must be replaced, it may be appropriate to substitute a fire resistive product. Fire resistant carpeting is available, and draperies of glass fiber or other fire resistive materials should be considered.

Coatings are available that will effectively reduce the surface flame spread rating of many combustible materials. Although they do not render a material noncombustible, they significantly reduce the ease with which a material will ignite. Such applications should be considered whenever a noncombustible substitute is either not available or not suited to a particular application. Caution is necessary to avoid a coating that contains a chemical or other product that will damage any historic material on which it will be applied.

3-3.3.3 Furnishings and Contents. Noncombustible materials should be used as much as possible for furnishings and other contents of the building. Where the intended occupancy of the building introduces combustible contents that cannot be substituted, the fire loading must be considered when fire suppression systems are designed.

3-3.4 Compartmentation.

3-3.4.1 Horizontal Fire and Smoke Barriers. The planning for the rehabilitation of a historic structure should consider the use of fire rated walls and doors to subdivide building areas into separate fire areas and to segregate specific hazards, such as furnaces, boilers, or storage areas, from the remainder of the building. These fire rated barriers should be designed to resist the passage of smoke. Other walls should also be designed to resist smoke passage and to confine the effects of a fire where possible. Such designs can often be incorporated while maintaining the historic fabric and character of the structure.

3-3.4.2 Vertical Enclosures. Provisions should be made to enclose stairways, ventilation shafts, and other vertical openings with fire rated construction to prevent the vertical spread of fire and smoke. Where the historic fabric of the building prevents such enclosures, alternative protection should be provided.

3-3.4.3 Fire Stops. Fire stops should be provided in concealed spaces to prevent the spread of fire within walls and between rafters and floor joists. Filling concealed spaces with inert material, such as mineral wool insulation or other similar fire resistive materials, can further retard the spread of fire. However, it is necessary to guard against the effect of condensation within the insulation in exterior wood frame or furred masonry walls by using an appropriate vapor barrier.

3-3.5 Structural Protection. The existing structural fire resistance should be determined whenever possible. For older structures, the US Department of Housing and Urban Development has developed the "Guideline on Fire Ratings of Archaic Materials and Assemblies," Number 8 in their series of *Rehabilitation Guidelines*, to assist in identifying approximate fire resistance qualities of older construction methods and materials.

Wherever possible, new materials to be installed should be selected based on their ability to enhance the fire resistance of the basic structure. Gypsum wallboard, plaster, and other finish materials can improve the fire resistance rating of structural members if applied correctly.

3-3.6 Detection and Alarm. Significant improvement in protection from fire can be achieved by installation of a detection and alarm system connected to a central station or fire department. Fire has much less chance of doing great damage if it is detected and contained at an early stage. Furthermore, structures can be evacuated more quickly if prompt warning of a fire is given.

Various types of fire detection and signal systems are described in Appendix A.

3-3.6.1 Fire Detection Systems.

3-3.6.1.1 Various automatic fire detectors can detect a fire condition from smoke, a critical temperature or rate of temperature rise, or infrared or ultraviolet radiation from the fire. These detectors can provide the early warning

needed to get people safely out of the structure, notify the fire department, and start fire extinguishing action promptly. In buildings with automatic sprinkler systems the early warning detection system provides a window of time for manual suppression by building occupants before detection and suppression by the automatic sprinkler head(s) directly above the fire. Fire protection specialists should be consulted to determine what kinds of detectors best fit the conditions in different parts of the structure (*see Appendix B*).

3-3.6.1.2 Installed detection and alarm systems should not only sound an alarm within the structure but should also transmit a signal to a central station or to a local fire department. Subsequent to an alarm, the fire department should be contacted immediately to verify that the alarm was received.

3-3.6.2 Fire Detectors. Fires produce heat, smoke, flame, and other signatures that detection systems recognize and to which they respond. Fire detectors are most typically designed to detect fire at a specific point in space (spot detectors), requiring a number of properly located units to cover a large area. There are also linear or line type detectors (wires, pneumatic tubes, and photoelectric beams) which can be arranged to provide automatic detection less obtrusively and in unusual configurations. Sampling type detectors use a pipe or tubing system to draw air samples from the protected space to the detector where the air is analyzed for fire products.

3-3.6.2.1 Heat Detectors. Heat detectors are designed to respond when the operating element reaches a predetermined temperature (fixed temperature detector), when the temperature rises at a rate exceeding a predetermined amount (rate-of-rise detector), or when the temperature of the air surrounding the device reaches a predetermined level, regardless of the rate of temperature rise (rate compensation detector). Heat detectors respond best to relatively large, high heat producing fires.

3-3.6.2.2 Smoke Detectors. In almost every structural fire, measurable amounts of smoke are produced prior to measurable amounts of heat. Thus, smoke detectors are preferred for earlier warning of fire. Smoke detectors respond to the visible or invisible particulate matter produced in fires. Three principles of operation are available for smoke detection: ionization, photoelectric, and cloud chamber. (*See Appendix A.*)

3-3.6.3 Applications.

3-3.6.3.1 The primary function of an automatic detection system is to alert the occupants of a building to the presence of a fire. This may be especially important under the following conditions:

(a) In large buildings where persons in one part of the building may not be aware of a fire in another part.

(b) In buildings where a fire may start in an unoccupied area.

(c) In occupancies where there is a large number of people, requiring a significant time to evacuate.

(d) In situations where there are relatively long travel distances to exits.

(e) In buildings where the nature and arrangement of fuel makes a fast-growing fire possible.

(f) In buildings that do not have sufficient barriers to limit the spread of fire and smoke.

(g) In residential occupancies.

3-3.6.3.2 Automatic fire detection also performs the function of initiating the process of fire suppression by trained occupants or the municipal fire service. Before any suppression can begin, a fire must be detected and the suppression activated. This can be accomplished on-site by individuals trained in the use of fire extinguishers, or by a properly equipped and staffed fire department. Fire size at detection will impact the ability of manual suppression to control the fire.

3-3.6.4 Design Considerations. Expected fire size should be considered when designing a fire detection system (*see Appendix C of NFPA 72E, Standard on Automatic Fire Detectors*).

Where ceilings are 20 ft (6.1 m) or greater in height, it is imperative that engineering assistance be obtained (*see Appendix B*).

The design of fire detection systems should also consider normal combustion processes in the occupancy so as to minimize false alarms. Attention should be given to activities that normally produce products of combustion (i.e., food preparation, automobile parking, smoking, etc.)

System design should include detectors throughout the entire building. Partial protection may result in a delayed response to a fire causing larger losses.

3-3.7 Fire Extinguishment.

3-3.7.1 General. An essential element in any firesafety plan is the consideration of the means to suppress a fire once it has begun. Management must make critical decisions as to the type of fire suppression capability that will be provided in the building. An immediate response by trained building personnel with appropriate extinguishing equipment or the operation of an automatic extinguishing system can be crucial in minimizing the damage to historic structures and their contents. Operation of any of these systems should cause activation of an alarm at a constantly attended location, or activation of the building alarm system as described in NFPA 101, *Life Safety Code*. The provision of these systems is equally important during the rehabilitation process and afterward.

3-3.7.2 Automatic Fire Extinguishing Systems.

3-3.7.2.1 General. Automatic fixed extinguishing systems are the most effective means of controlling fires in buildings. Their use in historic buildings is recommended. They should be installed carefully to avoid damage to architectural and historic features and spaces.

Without some type of automatic extinguishing system, a fire will increase in intensity until the fire department arrives. At this time, the fire department would be extinguishing a much larger fire than would exist if an automatic extinguishing system had activated, and the damage due to extinguishing the fire in this manner would be sufficiently greater.

Example: Fire department using one or more hose lines inside the building delivering water at a rate of 250 gpm (946 L/min) per hose line.

vs.

Automatic sprinkler system that discharges water at 15 to 25 gpm (57 to 95 L/min) per head that is opened by the fire.

or

An automatic extinguishing system that discharges a gaseous agent.

In general, it is considered good engineering practice to utilize total flooding gaseous systems in combination with automatic sprinkler systems, rather than as an alternative. (*See the NFPA Fire Protection Handbook, 16th Edition, pp. 11-78 and 11-83. Also see comparative design attributes listed in Appendix A.*) The combination of a total flooding gaseous system with an automatic sprinkler system provides a higher probability of confining fire growth to an area less than that typically covered by one sprinkler head [100 sq ft (9.3 m^2)]. The total flooding gaseous system becomes a reliable substitute for manual suppression in the window of time between early warning detection and sprinkler operation. Human response (i.e., occupant manual extinguishing action) is the least reliable means of fire suppression especially considering periods when the building is not occupied and most vulnerable.

The various types of automatic extinguishing systems are described in Appendix A.

3-3.7.2.2 Automatic Sprinkler Systems. An automatic sprinkler system consists of a network of piping with sprinkler heads uniformly spaced along the piping to provide protection to a specified area or building. Water is supplied to the piping from a supply system such as a municipal or private water distribution system. Proper operation is dependent upon an adequate and dependable water supply.

Different types of sprinkler systems can be designed for specific areas. These include wet-pipe systems, dry-pipe systems, and preaction systems; all are discussed in Appendix A. Systems vary in method of operation and whether or not water is normally in the piping system. In most systems only those heads that are heated to the predetermined temperature will operate; heads in other areas will remain closed. Typically, most fires are controlled by fewer than five sprinkler heads operating.

Where it is determined that it is desirable to provide an opportunity for building occupants to employ manual fire suppression before the sprinkler head(s) over the fire opens, a separate early warning fire detection system should be considered that utilizes the detection device providing the fastest response with respect to the type of fire expected from combustibles in the occupancy.

The potential for water damage from automatic sprinklers is often misunderstood. Some water damage will occur when sprinklers operate to control a fire. However, this damage is usually small when compared to the amount of damage the fire would have caused if the sprinkler system had not controlled or extinguished it. Reports of water damage in sprinklered buildings are often exaggerated in comparison to the small amount of fire damage resulting from successful fire control by the sprinklers.

3-3.7.2.3 Halon 1301 Total Flooding Systems. Halon 1301 is a colorless, odorless, electrically nonconductive gaseous agent that leaves no residue and requires no agent cleanup after discharge.

Halon 1301 extinguishing systems can be designed to protect rooms or enclosures of large or small size, or even entire buildings in some special applications. They are often used to protect hazards with high-value contents particularly susceptible to water damage.

Halon 1301 works by interfering with the combustion process, not by diluting or displacing oxygen. Consequently, the usual 5 to 7 percent concentration of Halon 1301 will extinguish most fires. Although Halon 1301 vapor has a low toxicity, its decomposition products, during a fire, can be hazardous. Therefore, the fire area should be promptly evacuated. The safety precautions described in NFPA 12A, *Halon 1301 Fire Extinguishing Systems*, should be followed.

A Halon 1301 system consists of a supply of the extinguishant in one or more containers and nozzle(s) strategically spaced throughout the protected enclosure. The containers may be centrally located and connected to the nozzles by a piping network or placed at various locations in or near the hazard with each container connnected directly to its nozzle or piped to one or more nozzles. The type of nozzles selected, and their number and placement, should be such that their force of discharge will not adversely affect the building or room contents.

The Halon discharge is usually released automatically by a fire detection system within the protected hazard which includes a means for manual release.

3-3.7.2.4 Carbon Dioxide Systems. Carbon dioxide extinguishes a fire by lowering the oxygen level below the 15 percent required for flame production. Personnel must be evacuated before agent discharge to avoid suffocation and reduced visibility during and after the discharge period. These systems should not be used in occupied areas.

3.3.7.2.5 Other types of systems are discussed in Appendix A. These other systems are not recommended for complete area or building protection. They are used primarily for protection of specific hazards such as cooking equipment.

3-3.7.3 Manual Fire Fighting Capability.

3-3.7.3.1 Portable Fire Extinguishers. Portable fire extinguishers are important items of fire protection equipment and should be installed in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. These extinguishers permit the use of a limited quantity of extinguishing agent on a small fire at the moment the fire is discovered and therefore should be present in adequate numbers.

The extinguishers should be the type intended for the class of fire anticipated. Multi-class portable extinguishers are available which remove any doubt whether the correct extinguisher is being used. Extinguishers should be prop-

erly located and inspected regularly so they will be in working order when needed. Personnel should know their locations and be instructed in their use. It must be emphasized that the use of fire extinguishers should not delay the transmission of alarms to the fire department.

3-3.7.3.2 Standpipe and Hose. Where standpipes and hose lines are required or installed to provide reliable and effective fire streams in the shortest possible time they should be installed in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*. Training and skill in the use of hose streams are essential to avoid injury and unnecessary property damage. It must be emphasized that the use of standpipe hose lines, as with the use of fire extinguishers, should not delay the transmission of alarms to the fire department. A water flow alarm should be provided on a wet standpipe system.

3-3.7.3.3 Hydrants and Outside Protection. Where a municipal water system or a private water system with sufficient capacity and pressure is available, fire hydrants should be provided to enable the fire department to quickly connect their pumpers and lay hose lines to the building. Where possible, hydrants should be provided on all sides of the building. Care should be taken to avoid placing hydrants too close to the building so that the fire department will not be prevented from using the hydrant due to fire exposure from the building.

3-4 Developing the Firesafety Plan.

3-4.1 Selecting Firesafety Plan Elements.

3-4.1.1 Elements of a firesafety plan should be selected to control or mitigate identified fire hazards as appropriate to the objectives of historic preservation and firesafety. The best protection will be afforded by a combination of strategies, designed to address specific firesafety problems. In addition, reliability can be greatly improved by the use of redundant or overlapping strategies.

A realistic firesafety objective for the firesafety plan is to provide a high probability of confining fire to the room in which it originates.

Table 3-4.1.2
Categories of Fire Hazards in Historic Buildings

Ignition Sources
- Arson
- Lightning
- Chimneys
- Exposures
- Heating, mechanical, electrical systems
- Smoking (management)
- Special hazards (i.e., restaurants, laboratories, etc.)

Combustibles
- Roofing materials
- Siding
- Construction materials
- Interior finish
- Contents
- Trash (management)

Structural Features
- Superstructures
- Concealed spaces
- Horizontal openings (large fire areas)
- Vertical openings
- Structural assemblies

Means of Egress
- Number of exits
- Capacity of exits
- Location of exits
- Travel distances
- Protection of means of egress

3-4.1.2 Fire Hazards. Table 3-4.1.2 shows categories and examples of fire hazards discussed in Section 2-3. Firesafety plan elements should address the specific hazards of each building.

3-4.1.3 Firesafety Plan Elements. Possible elements of a firesafety plan discussed in Section 3-3 are summarized in Table 3-4.1.3. These are the alternative strategies for dealing with the identified fire hazards.

Table 3-4.1.3
Elements of a Firesafety Plan

Prevention
- Operation and maintenance
- Education and training
- Enforcement

Limiting Combustibility
- Material substitution
- Protection with overlayer
- Coating
- Fire retardant treatment

Compartmentation
- Enclosure
- Subdivision
- Barriers, doors, dampers

Structural Protection
- Fire resistance

Detection and Alarm
- Facilitating egress
- Facilitating suppression

Suppression Systems
- Manual
- Sprinklers
- Special hazard systems

3-4.1.4 Table 3-4.1.4 shows the categories of fire hazards and categories of firesafety plan elements most likely to be effective at elimination or control of various problem situations. The table emphasizes two points:

(a) There is typically more than one way to deal with a particular fire hazard, and

(b) The same firesafety plan element may be effective at controlling or mitigating more than one fire hazard.

In general, the choice of firesafety plan elements can be based on evaluation of costs and benefits of each alternative. However, removing or changing an essential historic feature represents a cost or loss of value that cannot

Table 3-4.1.4

FIRE HAZARDS \ FIRESAFETY PLAN ELEMENTS	PREVENTION	LIMITING COMBUSTIBILITY	COMPARTMENTATION	STRUCTURAL PROTECTION	DETECTION AND ALARM	SUPPRESSION SYSTEMS
IGNITION SOURCES	✔	✔				
COMBUSTIBLES	✔	✔	✔		✔	✔
STRUCTURAL FEATURES			✔	✔		✔
MEANS OF EGRESS			✔		✔	✔

be readily quantified. The concern for authenticity may be so strong that the feature must be preserved, thus limiting the choice of design alternatives.

3-4.2 Sources of Information. To successfully develop a firesafety plan, knowledge of the subject and a constructive attitude are necessary. The requisite knowledge is available from a number of sources described below. More specific identification of resources may be found in the appendices to this document.

3-4.2.1 Human Resources. Every building is unique, and no two firesafety problems exist under the same set of conditions. However, experience allows the grouping of certain similar sets of conditions and solutions. This expertise is most often found in the organizations and consultants which focus on firesafety. Appendix B identifies some of the resources that may be appropriate for a particular situation.

3-4.2.2 Codes and Standards.

3-4.2.2.1 Model Codes. Almost every jurisdiction has applicable codes and standards for firesafety. However, not all building codes are the same. For example, NFPA *101, Life Safety Code*, is the only such code that provides specific chapters for both new and existing buildings. There may be situations where the approach to firesafety of one code is more fitting to particular circumstances than another code. Appendix B lists the most common model building codes and their specific approach to historic buildings.

3-4.2.2.2 Special Legislation. Many states have adopted special legislation to deal with the particular problems of firesafety in historic structures. These ordinances should be consulted to determine alternative approaches to identified firesafety issues.

3-4.2.3 Special Publications. In 1980 a series of *Rehabilitation Guidelines* was prepared by the National Institute of Building Sciences for the Department of Housing and Urban Development. They were designed for voluntary adoption and use by states and communities as a means to upgrade and preserve the nation's building stock, while maintaining reasonable standards for health and safety. Two of these guidelines which are particularly applicable to firesafety are the "Egress Guidelines for Residential Rehabilitation" and the "Guideline on Fire Ratings of Archaic Materials and Assemblies."

3-4.2.3.1 Egress Guidelines for Residential Rehabilitation. This document lists design alternatives for the components of egress that are regulated by current codes, such as number and arrangement of exits, corridors, stairs, travel distance, dead-end travel, and exit capacity and width. Although written primarily for residential occupancies, it has a much broader application.

3-4.2.3.2 Guideline on Fire Ratings of Archaic Materials and Assemblies. This document contains fire ratings of building materials and assemblies that are no longer listed in current building codes and related reference standards. Introductory material discusses flame spread, the effects of penetrations, and methods for determining ratings of assemblies not listed in the guideline.

3-4.2.4 Firesafety Concepts Tree. One approach used to qualitatively evaluate alternative arrangements for equivalent safety from fire is the NFPA Firesafety Concepts Tree. This tool is documented in NFPA 550, *Guide to the Firesafety Concepts Tree*. The tree represents all possible means of meeting firesafety objectives. By increasing firesafety measures on one branch of the tree, one can theoretically offset a lack of required measures on another branch, thus establishing an arrangement of equivalent fire protection.

Chapter 4 Firesafety in the Construction Phase

4-1 Introduction. The potential for fire during the rehabilitation of a building is usually greater than during normal use and occupancy. During this period, fire protection facilities generally have not been completed and unprotected steel or wood structure may be exposed throughout the building; the products of demolition and crating, boxes, cartons, etc., are highly combustible, and welding and cutting operations, plumbing torches, tar kettles, temporary heating equipment, and wiring may serve as ignition sources and create a rapidly developing fire situation. Frequently, automatic sprinkler protection, yard hydrant systems, and standpipe and hose facilities have not yet been finished, thereby severely hampering fire fighters. Proper steps to safeguard these conditions must be taken to reduce the loss potential in structures undergoing rehabilitation and restoration.

Preplanning of the construction phase should include discussions with the owner of the building, the architect, the contractor(s), and project manager about firesafety. Owners should have a designated person that will represent their interests in making sure that firesafety precautions are practiced on the job site. The general contractor should designate a person who will ensure that the job site is maintained in a firesafe manner. The public fire department and other fire protection authorities should be consulted for their guidance. If a facility can be closed to the public during the rehabilitation work, firesafety efforts can concentrate on the construction processes and the hazards introduced to the facility.

When the facility will remain open to the public during the rehabilitation process, extreme firesafety and life safety hazards can be created. Extra effort must be made to assure that necessary life safety features are not compromised by any construction process. To reduce the level of hazard to occupants and the structure, construction areas should be separated from public use areas as much as possible, including the use of noncombustible partitions. Required exits should be maintained or supplementary routes provided. Guards may need to be employed to help keep the public out of construction areas and to assist the public in exiting when alternate exit routes are required.

4-2 Temporary Construction and Equipment.

4-2.1 Construction Offices and Sheds. Construction offices, trailers, sheds, and other facilities for the storage of tools and materials, when located within the building, on the sidewalk bridging, or within 30 ft (9.2 m) of the

building should be of noncombustible construction. Only safely installed, approved heating devices should be used in construction offices and sheds. Ample clearance should be provided around stoves and heaters and all chimney and vent connectors to prevent ignition of adjacent combustible materials.

4-2.2 Construction Equipment and Materials. Internal combustion engine-powered air compressors, hoists, derricks, pumps, etc., should be located such that the exhausts discharge away from combustible materials. When the exhausts are piped outside the building under construction, a clearance of a least 6 in. (152 mm) should be maintained between such piping and combustible materials. Service areas or fuel for construction equipment should not be located within buildings.

Construction materials should be kept to a minimum within the structure. Materials not immediately required should be safely stored away from the structure. Storage of construction materials should not impede egress from buildings or access of fire apparatus to hydrants.

4-3 Construction Processes and Hazards.

4-3.1 Cutting and Welding Operations. Cutting and welding operations on the job site should require a permit that is under the supervision of the designated person in charge of fire protection. Any such operations should be carried out in accordance with the requirements of NFPA 51B, *Standard for Fire Prevention in Use of Welding and Cutting Processes*.

A permit should not be issued until it has been determined that cutting and welding can be safely conducted at the desired location and combustibles have been moved away or safely covered. The permit should require that a person trained in the use of fire extinguishers be stationed in the vicinity of the cutting or welding operation for the duration of the work and for 30 minutes thereafter to assure that sparks or drops of hot metal from the work do not start a fire. At the close of the workday the work should be inspected by the supervisor so that any smoldering may be detected.

If the structure has a wooden floor, the floor should be wetted down before and after welding or cutting operations are conducted. Adequate precautions should be taken so that wetting down will not introduce a personnel safety hazard or cause damage to historic building materials or finishes.

4-3.2 Temporary Heating Equipment. As much as possible, the permanent building heating equipment should be maintained in service to provide heat for the workers and to prevent freezing of water pipes.

Heating devices should be situated so they are not likely to overturn and should otherwise be installed in accordance with their listing, including clearance to combustible material, equipment, or construction. Refueling operations for oil burning equipment and liquefied petroleum gas burning equipment should be safely conducted by removing the heater to a safe location and waiting for it to cool prior to refueling. Temporary heating equipment, when utilized, should be attended and maintained by competent personnel.

Where temporary heating equipment must be used, only steam heaters, approved electric heaters, approved gas and oil fired space heaters or indirect-fired gasoline heaters located outside the building should be permitted. The design and installation of these heaters should comply with appropriate standards such as NFPA 31, *Standard for the Installation of Oil Burning Equipment*, NFPA 54, *National Fuel Gas Code*, and NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

Chimney or vent connectors, where required from direct-fired heaters, shall be maintained at least 18 in. (457 mm) from combustibles.

4-3.3 Flammable Liquids. The use and storage of flammable liquids during rehabilitation operations should be carefully controlled and monitored. Potential sources of ignitions should be identified and safeguarded whenever operations involving flammable liquids are to be conducted. Ventilation should be provided for operations involving the use or application of materials containing flammable liquids. Flammable liquids should be stored in accordance with the provisions of NFPA 30, *Flammable and Combustible Liquids Code*.

4-3.4 Roofing. Asphalt and tar kettles, when used in roofing or other operations, should be located in a safe place outside of the building or on a noncombustible roof at a point where they avoid the danger of igniting combustible material below. Used roofing mops should not be stored within the building. Continuous supervision should be required while kettles are in operation, and metal covers should be provided for all kettles to smother flames in case of fire. Suitable fire extinguishers should be provided in the vicinity of such operations.

4-3.5 Plumbing. Plumbing operations involving open flame should be conducted only under the supervision of the person in charge of fire protection. Such work should occur only after it has been determined that the plumbing can be safely conducted at the desired location, that combustibles have been moved away or safely covered, and that the workman has a charged fire extinguisher with him. At the close of the workday the work must be inspected by the supervisor so that any smoldering may be detected.

4-3.6 Other Hazardous Operations. Operations that introduce fire hazards should be reviewed to determine if other, safer methods can be utilized. Paint stripping operations involving open flame should not be permitted. Floor sanders should have their dust accumulation bags emptied before the close of the day. Dust should be disposed of in closed metal containers outside of the building. Other operations should be similarly controlled to reduce the possibility of fire ignition.

4-3.7 Smoking. Smoking should be prohibited or restricted to designated areas. Smoking areas should be selected on the basis of their remoteness from exposed combustible materials, the low degree of danger that an incipient fire could spread rapidly, and the availability of fire protection equipment and personnel. Receptacles for spent smoking materials should be provided in the smoking area, and housekeeping should be exemplary. Stringent restrictions on smoking also serve to promote general consciousness of the need for firesafety. Surreptitious smoking should be dealt with severely.

4-3.8 Housekeeping. Extreme care should be taken to prevent even small accumulations of debris or rubbish inside construction areas or close to an exterior fire hazard. Debris and rubbish should be removed from the site daily, and not burned in the vicinity. Contractors should be required to provide ample receptacles for rubbish, papers, etc. If a chute is employed for removal of debris, it should be erected on the outside of the building. Burning of waste materials on the premises should not be permitted.

Housekeeping is always an essential consideration in any fire protection plan. During periods of construction it takes on added importance since the construction process introduces many transient hazards.

4-3.9 Electrical. Electrical wiring and equipment for light, heat, or power shall be installed in compliance with the requirements of NFPA 70, *National Electrical Code*. Attention should be given to assure that temporary lighting, bulbs, and fixtures do not come in contact with combustible materials. Circuit breakers should be shut off on circuits not being utilized.

4-3.10 Environmental Conditions. Attention should be focused on possible fire exposure hazards created by the weather and environmental conditions. Fire damage may not be confined to the building of origin and could spread to adjacent property. If the fire threat to adjoining or nearby buildings is severe, the provision of fire doors, temporary barriers, or sprinkler water curtains should be evaluated.

Windstorm damage, while not necessarily related directly to loss by fire, may in fact contribute directly to an increase in the fire hazard. Open structures are particularly susceptible to damage from high winds that may cause skewing and misalignment of the structure and disrupt existing water supplies for fire protection. Water supplies may be affected, and may freeze in cold weather if temporary doors or window closures are blown away. Roof construction may also be damaged to the extent that freezing of equipment may occur. Entry of wind into a building may also blow debris, lumber scraps, or tarpaulins against heating devices, thereby causing ignition of these materials. Consequently, proper care should be given to eliminating both direct loss from wind and the attendant possibility of resultant fire damage.

4-4 Fire Protection.

4-4.1 Fire Cutoffs. Fire walls and exit stairways, if required for the completed building, should be given construction priority. Fire doors with approved closing devices and hardware should be installed as soon as practical and before combustible materials are introduced. After installation, fire doors should not be obstructed from closing.

4-4.2 Existing Fire Detection Systems. Existing fire detection and alarm systems should be maintained in operating order wherever possible. Should a temporary fire detection system with some form of connection to the fire department be installed, this system should only include heat detectors and manual fire alarm boxes with smoke detectors installed in areas that are not affected by the construction. The smoke detectors that are deemed necessary to be used within the construction area must be protected from dust, dirt, and extreme temperatures during construction. When construction has finished for the day, a security guard or other authorized person should be instructed to remove the covering from any of the smoke detectors in the construction area to avoid delayed alarms during nonworking hours. Care should be taken to avoid disabling the fire alarm system or causing false alarms during the rehabilitation work.

4-4.3 Fire Fighting.

4-4.3.1 Access. A suitable location at the site should be designated as a command post and provided with plans, emergency information, keys, communications, and equipment, as needed. The person in charge of fire protection shall return to the location immediately if a fire occurs.

Access for use of heavy fire fighting equipment should be provided to the immediate job site at the start of construction and maintained until all construction is completed.

Free access from the street to fire hydrants and to outside connections for standpipes, sprinklers, or other fire extinguishing equipment, whether permanent or temporary, should be provided and maintained at all times. Protective pedestrian walkways should not be constructed so as to impede access to hydrants, siamese connections, or fire extinguishing equipment.

During construction operations, free access to permanent, temporary, or portable first aid fire equipment should be maintained. In all buildings over one story in height, at least one stairway should be provided in usable condition at all times.

4-4.3.2 Water Supply. Water supply for either temporary or permanent fire protection, should be made available as soon as construction begins and combustible material accumulates.

The local fire authority should be contacted regarding adequacy of water supply for hose lines.

Where underground water mains are to be provided, they should be installed, completed, and in service with hydrants or standpipes located as directed by the local fire authority prior to construction work.

4-4.3.3 Standpipes. In all buildings in which new standpipes are required or where they exist in buildings being altered, they should be maintained in accordance with the progress of building activity such that they are always ready for fire department use.

4-4.3.4 Sprinkler Protection. If automatic sprinkler protection is to be provided, the installation should be placed in service as soon as possible. In buildings where sprinkler protection existed prior to the rehabilitation project, the system should be kept in service as long as possible during the rehabilitation work to provide continuous protection to the building.

4-4.3.5 First-Aid Fire Equipment.

4-4.3.5.1 Hose and nozzles should be provided and made ready for use as soon as either the temporary or permanent water supply is available.

4-4.3.5.2 For every building operation, including those occurring in a toolhouse, storeroom, or other structure

located in or adjacent to the building under rehabilitation, or within a room or space used for storage, workshop, or employee changing, fire extinguishers should be provided and maintained in an accessible location.

At least one approved fire extinguisher should also be provided in plain sight on each floor at each useable stairway.

4-5 Supervision and Watch Service.

4-5.1 A capable and qualified person having the necessary authority should be placed in charge of fire protection. Responsibilities should include maintenance and location of fire protection equipment, general supervision of safeguards and location of salamanders or portable heating equipment, and the establishment and maintenance of safe cutting and welding operations. Where watch service is provided, he or she should be acquainted with developments during the day and pass along any special instructions on the status of fire protection equipment and emergency procedures.

4-5.2 A public fire alarm box near the premises, telephone service to the fire department, or equivalent facilities should be readily available. Instructions should be issued to notify the fire department immediately in case of fire. When telephone service is employed, the local fire department number should be conspicuously posted near each telephone.

4-5.3 If welding operations have been conducted during the previous working period, the incoming watchman should be alerted to check the location where welding was done as a part of the regular rounds. Where watch service is not provided, use of gas-operated welding or cutting equipment should be discontinued a minimum of three hours before the end of the workday.

Chapter 5 Referenced Publications

5-1 The following documents or portions thereof are referenced within this recommended practice and should be considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

5-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1988, *Standard for Portable Fire Extinguishers*

NFPA 12A-1989, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 13-1989, *Standard for the Installation of Sprinkler Systems*

NFPA 14-1986, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 30-1987, *Flammable and Combustible Liquids Code*

NFPA 31-1987, *Standard for the Installation of Oil Burning Equipment*

NFPA 51B-1989, *Standard for Fire Prevention in Use of Cutting and Welding Processes*

NFPA 54-1988, *National Fuel Gas Code*

NFPA 58-1989, *Standard for the Storage and Handling of Liquefied Petroleum Gases*

NFPA 70-1990, *National Electrical Code*

NFPA 72A-1987, *Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm, and Supervisory Service*

NFPA 72B-1986, *Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1986, *Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems*

NFPA 72D-1986, *Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems*

NFPA 72E-1987, *Standard on Automatic Fire Detectors*

NFPA *101*-1988, *Life Safety Code*

NFPA 241-1989, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*

NFPA 251-1985, *Standard Methods of Fire Tests of Building Construction and Materials*

NFPA 255-1984, *Standard Method of Test of Surface Burning Characteristics of Building Materials*

NFPA 550-1986, *Guide to the Firesafety Concepts Tree*

Fire Protection Handbook, 16th Edition, 1986.

5-1.2 Other Publications.

5-1.2.1 BOCA Publication. Building Officials and Code Administrators International, 4051 West Flossmoor Road, Country Club Hills, IL 60477.

BOCA National Building Code, 1987.

5-1.2.2 ICBO Publication. International Conference of Building Officials, 5360 South Workman Mill Rd., Whittier, CA 90601.

Uniform Building Code, 1988.

5-1.2.3 SBCCI Publication. Southern Building Code Congress International, 116 Brown Marx Building, Birmingham, AL 35213.

Standard Building Code, 1988.

5-1.2.4 Goldstone, Barbara M., "Hazards from the Concentration of Solar Radiation by Textured Window Glass," *Building Research Establishment Report*, Department of the Environment, UK, 1982.

5-1.2.5 US Government Publications. Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

"Egress Guideline for Residential Rehabilitation," *Rehabilitation Guideline #5*, US Department of Housing and Urban Development, 1980

"Guideline on Fire Ratings of Archaic Materials and Assemblies," *Rehabilitation Guideline #8*, US Department of Housing and Urban Development, 1980

The Secretary of the Interior's *Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings*, National Park Service, US Department of the Interior, 1983.

National Register of Historic Places.

Appendix A

This Appendix is not a part of the recommendations of this NFPA document, but is included for information purposes only.

A-1 Most fires that occur in historic structures and landmarks can be expected to fall into one or more of the following categories:

Class A. Fires involving ordinary combustible materials, such as paper, wood, textile fibers, etc., where a cooling, blanketing, or wetting extinguishing agent is required.

Class B. Fires involving oils, greases, paints, and flammable liquids, where a smothering or blanketing action is required for extinguishment.

Class C. Fires involving live electrical equipment where a nonconducting extinguishing agent with a smothering action is required.

A-2 Glossary of Fire Protection Systems.

The following information has been prepared to assist in the description and evaluation of the principal kinds of detection systems, signaling systems, and extinguishing systems that are appropriate for use in historic structures. Terminology, insofar as is possible, has been limited to nontechnical language in order to be readily understandable to those personnel who have been delegated firesafety responsibility.

FIRE DETECTION SYSTEMS

Type	Description	Comments
1. Smoke detection systems.	These smoke detectors operate on the ionization, photoelectric, or cloud chamber principle. Spot-type smoke detectors use either the ionization principle of operation or the photoelectric principle. Line-type smoke detectors use the photoelectric principle. Air sampling-type smoke detectors use either the ionization, photoelectric, or cloud chamber principle. Properly installed, smoke detectors can detect smoke particles in very early stages of fire in the areas where they are located.	Intended for early warning. Some are designed for installation in ventilation ducts. See NFPA 72E, *Standard on Automatic Fire Detectors.*
2. Heat detection systems.	These systems use heat-responsive devices either of the spot- or line-type mounted on exposed ceiling surfaces. Operate either at fixed temperatures or on a sudden temperature increase, called the rate-of-rise principle. Some devices incorporate both fixed temperature and rate-of-rise actuation. Spot detectors are usually small electrical devices, a few inches in diameter, and interconnected with wire. Line detectors are usually lengths of heat-sensitive wire or small-bore metal tubing.	Relatively low cost. Cannot detect small, smoldering fires. Line-type detectors can be installed in a relatively inconspicuous manner by taking advantage of ceiling designs and patterns. See NFPA 72E, *Standard on Automatic Fire Detectors.*
3. Flame detection systems.	These systems are infrared, ultraviolet, or photoelectric flame detectors.	Intended for early warning; may be useful in high ceiling spaces. See NFPA 72E, *Standard on Automatic Fire Detectors.*

FIRE SIGNALING SYSTEMS

Type	Description	Comments
1. Local protective signaling system.	An alarm system operating in the protected premises, responsible to the operation of a manual fire alarm box, waterflow in a sprinkler system, or detection of a fire by a smoke or heat detecting system.	The main purpose of this system is to provide an evacuation alarm for the occupants of the building. Someone must always be present to transmit the alarm to fire authorities. See NFPA 72A, *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service.*
2. Auxiliary protective signaling system.	An alarm system utilizing a standard municipal fire alarm box to transmit a fire alarm from a protected property to municipal fire headquarters. These alarms are received on the same municipal equipment and are carried over the same transmission lines as are used to connect fire alarm boxes located on streets. Operation is initiated by the local fire detection and alarm system installed at the protected property.	Reliable, fast means of summoning help from municipal fire department. Some communities will accept this type of system and others will not. See NFPA 72B, *Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems.*

FIRE SIGNALING SYSTEMS — cont.

Type	Description	Comments
3. Central station signaling system.	An alarm system connecting protected premises to a privately owned central station whose function is to monitor the connecting lines constantly and record any indication of fire, supervisory or other trouble signals from the protected premises. When a signal is received, the central station will take such action as is required, such as informing the municipal fire department of a fire or notifying the police department of intrusion.	Flexible system. Can handle many types of alarms, including trouble within system at protected premises. See NFPA 71, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service.*
4. Remote station protective signaling system.	An alarm system connecting protected premises over leased telephone lines to a remote station such as a fire station or a police station. Includes separate receiver for individual functions being monitored, such as fire alarm signal, or sprinkler waterflow alarm.	Requires leased lines into each premises. See NFPA 72C, *Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems.*
4. Remote station protective signaling system.	An alarm system connecting protected premises over leased telephone lines to a remote station such as a fire station or a police station. Includes separate receiver for individual functions being monitored, such as fire alarm signal, or sprinkler waterflow alarm.	Requires leased lines into each premises. See NFPA 72C, *Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems.*
5. Proprietary protective signaling system.	An alarm system which serves contiguous or noncontiguous properties under one ownership from a central supervising station at the protected property. Similar to a central station system but owned by the protected property.	Requires 24-hour manning of central supervising station on the premises. See NFPA 72D, *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems.*
6. Emergency voice/ alarm communication system.	This system is used to supplement one of the systems listed above by providing voice communication within the building for use during a fire emergency either with prerecorded messages or for use by the fire department, or both.	See NFPA 72F, *Standard for the Installation, Maintenance and Use of Emergency Voice/Alarm Communication Systems,* and NFPA 72G, *Guide for the Installation, Maintenance and Use of Notification Appliances for Protective Signaling Systems.*

FIRE EXTINGUISHING SYSTEMS

Type	Description	Comments
1. Wet-pipe automatic sprinkler system.	A permanently piped water system under pressure, using heat-actuated sprinklers. When a fire occurs, the sprinklers exposed to the high heat open and discharge water individually to control or extinguish the fire.	Automatically detects and controls fire. Protects structure and contents. May cause water damage to protected books, manuscripts, records, paintings. Not to be used in spaces subject to freezing. See NFPA 13, *Standard for the Installation of Sprinkler Systems,* and NFPA 22, *Standard for Water Tanks for Private Fire Protection.*
2. Preaction automatic sprinkler system	A system employing automatic sprinklers attached to a piping system containing air that may or may not be under pressure, with a supplemental fire detection system installed in the same area as the sprinklers. Actuation of the fire detection system by a fire opens a valve which permits water to flow into the sprinkler system piping and to be discharged from any sprinklers that are opened by the heat from the fire.	Automatically detects and controls fire. May be installed in areas subject to freezing. Minimizes the accidental discharge of water due to mechanical damage to sprinkler heads or piping, and thus is useful for the protection of paintings, drawings, fabrics, manuscripts, specimens, and other valuable or irreplaceable articles that are susceptible to damage or destruction by water. See NFPA 13, *Standard for the Installation of Sprinkler Systems,* and NFPA 22, *Standard for Water Tanks and Private Fire Protection.*

FIRE EXTINGUISHING SYSTEMS — cont.

Type	Description	Comments
3. On-off automatic sprinkler system.	A system similar to the preaction system, except that the fire detector operation acts as an electrical interlock, causing the control valve to open at a predetermined temperature and close when normal temperature is restored. Should the fire rekindle after its initial control, the valve will reopen and water will again flow from the opened heads. The valve will continue to open and close in accordance with the temperature sensed by the fire detectors. Another type of on-off system is a standard wet-pipe system with on-off sprinkler heads. Here each individual head has incorporated in it a temperature-sensitive device which causes the head to open at a predetermined temperature and close automatically when the temperature at the head is restored to normal.	In addition to the favorable feature of the automatic wet-pipe system, these systems have the ability to automatically stop the flow of water when no longer needed, thus eliminating unnecessary water damage. See NFPA 13, *Standard for the Installation of Sprinkler Systems,* and NFPA 22, *Standard for Water Tanks for Private Fire Protection.*
4. Dry-pipe automatic sprinkler system.	Has heat-operated sprinklers attached to a piping system containing air under pressure. When a sprinkler operates, the air pressure is reduced, a "dry-pipe" valve is opened by water pressure, and water flows to any opened sprinklers.	See No. 1. Can protect areas subject to freezing. Water supply must be in a heated area. See NFPA 13, *Standard for the Installation of Sprinkler Systems,* and NFPA 22, *Standard for Water Tanks for Private Fire Protection.*
5. Standpipe and hose system.	A piping system in a building to which hoses are connected for emergency use by building occupants or by the fire department.	A desirable complement to an automatic sprinkler system. Staff requires training to use hoses effectively. See NFPA 14, *Standard for the Installation of Standpipe and Hose Systems.*
6. Halon automatic system.	A permanently piped system using a limited stored supply of a halon gas under pressure, and discharge nozzles to totally flood an enclosed area. Released automatically, by a suitable detection system. Extinguishes fires by inhibiting the chemical reaction of fuel and oxygen.	No agent damage to protected books, manuscripts, records, paintings or other irreplaceable valuable objects. No agent residue. Halon 1301 can be used with safeguards in occupied areas. Halon 1211 total flooding systems are prohibited in normally occupied areas. Halons may not extinguish deep-seated fires in ordinary solid combustibles such as paper, fabrics, etc.; but are effective on surface fires in these materials. These systems require special precautions to avoid damage effects caused by their extremely rapid release. The high velocity discharge from nozzles may be sufficient to dislodge substantial objects directly in the path. See NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* and NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems.*
7. Carbon dioxide automatic system.	Same as No. 6, except uses carbon dioxide gas. Extinguishes fires by reducing oxygen content of air below combustion support point.	Same as No. 6. Appropriate for service and utility areas. Personnel must evacuate before agent discharge to avoid suffocation. May not extinguish deep-seated fires in ordinary solid combustibles such as paper, fabrics, etc.; but effective on surface fires in these materials. See NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems.*
8. Dry chemical automatic system.	Same as No. 6, except uses a dry chemical powder. Usually released by mechanical thermal linkage. Effective for surface protection.	Should not be used in personnel-occupied areas. Leaves powdery deposit on all exposed surfaces. Requires clean-up. Excellent for service facilities having kitchen range hoods and ducts. May not extinguish deep-seated fires in ordinary solid combustibles such as paper, fabrics, etc.; but effective on surface fires in these materials. See NFPA 17, *Standard for Dry Chemical Extinguishing Systems.*

FIRE EXTINGUISHING SYSTEMS — cont.

Type	Description	Comments
9. High expansion foam system.	A fixed extinguishing system which generates a foam agent for total flooding of confined spaces, and for volumetric displacement of vapor, heat, and smoke. Acts on the fire by: a. Preventing free movement of air b. Reducing the oxygen concentration at the fire c. Cooling.	Should not be used in occupied areas. The discharge of large amounts of high expansion foam may inundate personnel, blocking vision, making hearing difficult, and creating some discomfort in breathing. Leaves residue and requires clean up. High expansion foam, when used in conjunction with water sprinklers, will provide more positive control and extinguishment than either extinguishment system used independently, when properly designed. See NFPA 11A, *Standard for Medium and High Expansion Foam Systems.*
10. Wet chemical extinguishing system.	Same as No. 6, except uses liquid agent usually released by automatic mechanical thermal linkage. Effective for restaurant, commercial, and institutional hoods; plenums; ducts; and associated cooking appliances.	Leaves agent residue that is confined to the protection area(s). Requires clean-up. Excellent for service facilities having range hoods and ducts. See NFPA 17A, *Standard for Wet Chemical Extinguishing Systems.*

Appendix B Resources

This Appendix is not a part of the recommendations of this NFPA document, but is included for information purposes only.

B-1 NFPA. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA publishes this and related documents on fire protection and they will answer inquiries on these documents. They also conduct educational seminars, studies, and literature searches for a fee. NFPA maintains a list of fire protection consultants.

B-2 SFPE. Society of Fire Protection Engineers, 60 Batterymarch Street, Boston, MA 02116.

SFPE is a professional society of fire protection engineers. They meet annually, publish technical information, conduct technical seminars, and support local chapters. Members are located in all parts of the world. Names and addresses of members in a particular geographic area may be obtained from Society headquarters.

B-3 NICET. National Institute for Certification in Engineering Technologies, 1420 King Street, Alexandria, VA 22314.

NICET certifies technicians in the following areas of fire protection: (a) automatic sprinkler system layout, (b) special hazards systems layout (automatic and manual foam water, halon, carbon dioxide, and dry chemical systems), and (c) fire alarm systems. People with a NICET certification can also assist in the selection and use of fire protection systems.

B-4 UL. Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062.

UL has a certification service through which alarm companies may be qualified to issue certificates that installed fire warning systems comply with NFPA standards and are properly tested and maintained. A list of alarm service companies authorized to issue UL certificates is available. UL also publishes safety standards and annual directories of labeled and listed products and fire resistant assemblies.

B-5 APT. Association for Preservation Technology, Box 2487, Station D, Ottawa, Ontario K1P 5W6.

APT is organized for the preservation of historic resources, rehabilitation and reuse of historic structures, and history of building technology. They will respond to inquiries and provide consulting references. They distribute publications and offer training courses in various aspects of the preservation/rehabilitation field.

B-6 NPS. National Park Service, National Register of Historic Places Branch, Interagency Resources Division, Department of the Interior, 1100 L Street NW, Room 640, Washington, DC 20004.

NPS publishes the Secretary of the Interior's *Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings*. They answer inquiries, provide reference services, conduct seminars, and make referrals.

B-7 NTHP. National Trust for Historic Preservation, 1785 Massachusetts Avenue NW, Washington, DC 20036.

NTHP promotes preservation of sites, buildings, and objects. They publish magazines and books on historic preservation and offer advisory services, conferences, and workshops.

Appendix C Bibliography

This Appendix lists publications that are not referenced but which may provide additional helpful information. It is not considered to be a part of the recommendations of this NFPA document.

C-1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

"Protecting Our Heritage," 2nd Ed., 1970.

NFPA 910-1985, *Recommended Practice for the Protection of Libraries and Library Collections*

NFPA 911-1985, *Recommended Practice for the Protection of Museums and Museum Collections*

NFPA 912-1987, *Recommended Practice for Fire Protection in Places of Worship*

NFPA 913-1987, *Recommended Practice for the Protection of Historic Structures and Sites.*

C-2 Other Publications.

Association of Preservation Technology, *Bulletin*, Vol. 13, No. 2, 1981.

"Building Codes and Historic Preservation," *Preservation Forum*, Vol. 2, No. 1, Spring 1988, pp. 11-17.

Fisher, Thomas, "Fire Breaks: Fire Safety in Historic Buildings," *Progressive Architecture*, Vol. 67, No. 11, 116-121, November 1986.

Parnell, Alan, and David H. Ashford, "Fire Safety in Historic Buildings," Technical Pamphlet 6, Society for the Protection of Ancient Buildings and the Fire Protection Association, London, 1978.

Pielert, James H., "Removing Regulatory Restraints to Building Rehabilitation: The Massachusetts Experience," Center for Building Technology, National Bureau of Standards, Washington, DC, October 1981.

Sussman, Gail, "Fire Prevention in Heritage Buildings," British Columbia Heritage Trust, 1983.

Uniform Code for Building Conservation, International Conference of Building Officials, Whittier, CA, 1987.

Appendix D Referenced Publications

D-1 The following documents or portions thereof are referenced within this recommended practice for informational purposes only and thus are not considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

NFPA 11A-1988, *Standard for Medium and High Expansion Foam Systems*

NFPA 12-1989, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 12A-1989, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 12B-1985, *Standard on Halon 1211 Fire Extinguishing Systems*

NFPA 13-1989, *Standard for the Installation of Sprinkler Systems*

NFPA 14-1986, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 17-1985, *Standard for Dry Chemical Extinguishing Systems*

NFPA 17A-1986, *Standard for Wet Chemical Extinguishing Systems*

NFPA 22-1987, *Standard for Water Tanks for Private Fire Protection*

NFPA 71-1989, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*

NFPA 72A-1987, *Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm, and Supervisory Service*

NFPA 72B-1986, *Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1986, *Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems*

NFPA 72D-1986, *Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems*

NFPA 72E-1987, *Standard on Automatic Fire Detectors*

NFPA 72F-1985, *Standard for the Installation, Maintenance, and Use of Emergency Voice/Alarm Communication Systems*

NFPA 72G-1989, *Guide for the Installation, Maintenance, and Use of Notification Appliances for Protective Signaling Systems.*

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