FIRE SAFETY IN HISTORIC BUILDINGS

By Jack Watts

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Cover—In May 2007 a fire destroyed almost 75 percent of Washington, DC's historic Eastern Market. Unfortunately fires—either accidental or set intentionally—destroy many historic landmarks each year.

Photo by Lori Feinman.

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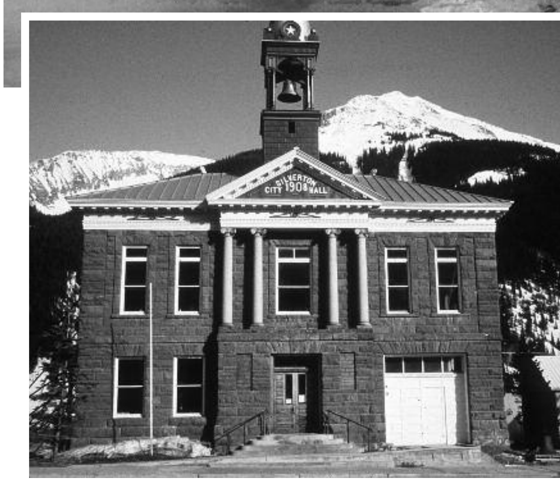
To own or to live or work in a historic building engenders a sense of pride as well as responsibility as a custodian of our cultural heritage. Damage by fire can be one of the speediest and most ruthless threats to this heritage. In many cases, when historic buildings were first occupied, the users were more familiar with the risks of fire; their methods of cooking, heating, and lighting, which all involved the use of open flame, were a constant visual and tactile reminder. With today's standards of comfort and convenience we expect far more of our buildings, and our needs are so conveniently supplied with concealed mechanical and electrical services that we are left virtually unaware of their fire potential.

There are no statistical records kept on the number of historic buildings that are damaged or destroyed by fire each year. Many cities have lost landmarks as the result of accidental or, all too often, intentionally set fires. Repair or restoration of older buildings often increases the risk of fire, by exposing their combustible spaces during the process and generating flammable debris. It may also involve heat-producing operations that can create sparks or flames.

We make valiant efforts to protect our historic buildings from the ravages of time and neglect, and we try to protect them from unwarranted demolition. But equal attention should be paid to the potential loss from fire. Preservationists should not simply view fire safety requirements as mandated intrusions on authenticity. Instead they should view satisfying them as an integral part of their stewardship responsibilities.

Fire is sometimes looked upon as an act of God, something that is unavoidable. But there is a maxim among fire professionals that the three most common causes of fire are men, women, and children. Fire occurs because of a failure to prevent it. Fire destroys because of a failure to control it.



In November 1992, Silverton Colorado's 1908 Town Hall caught fire in sub-zero temperatures. The fire was believed to have been caused by an electric ice melt system, installed as a preservation measure to mitigate water infiltration. Today the Town Hall has been meticulously restored.

Photos courtesy of the San Juan County Historical Society. Top photo by Zeke Zanoni.

Every historic building deserves to be protected from fire. At the same time, that protection must be designed so that it does not, in and of itself, damage or unnecessarily intrude on the historic significance of the building. There needs to be a balance of protection and authenticity.

This booklet is intended as the first step in helping property owners protect older and historic buildings. Not every building owner can be an expert in fire safety. However by gaining an understanding of some of the basic considerations in fire safety, building owners and managers can work more effectively with restoration contractors, construction workers, building inspectors, architects, engineers, and code officials to protect a historic site from the devastating effects of a fire.

WHAT IS A FIRE PROTECTION ENGINEER?

Fire protection engineers use science and technology to protect people, property, and businesses from destructive fires. They analyze how buildings are used, how fires start, how fires grow, and how fire and smoke affects people, buildings, and property. Fire protection engineers use the latest technologies to:

- Design systems that control fires, alert people to danger, and provide means for escape;
- Evaluate buildings to pinpoint the risks of fires and the means to prevent them;
- Conduct fire safety research on consumer products and construction materials;
- Investigate fires to discover how they spread, why protective measures failed, and how those measures could have been designed more effectively.

Fire engineers work with architects and other engineers, state and local building officials, and local fire departments to build and maintain fire safe communities. They make recommendations for cost-effective fire protection solutions to ensure that the structure, and the property and occupants contained within, are adequately protected. For more information go to the Society of Fire Protection Engineers website at www.sfpe.org.

HISTORIC BUILDINGS AND FIRE SAFETY

All too often, older buildings are unfairly dismissed as being "firetraps" and unsafe for occupancy. Many existing buildings are considered vestiges of earlier times and targeted for replacement as funds became available. Until recently existing structures were often not addressed by the codes and standards that provided minimum building standards for new construction. As building codes evolved and became more sophisticated, it became more of a challenge for historic buildings to meet modern fire safety standards. In some cases, aspects of a building that make it historically significant have been destroyed in order to meet strict compliance with safety requirements. In other cases, historic buildings have been demolished because the cost of meeting fire safety regulations was too high.

The most commonly used standards for evaluating alterations and additions to historic buildings are the Secretary of the Interior's Standards and Guidelines for Rehabilitation. Written in a language of broad philosophical statements, the standards are used by federal and state agencies and many historic districts and planning commissions as the criteria against which preservation proposals are evaluated for their appropriateness. These standards are a useful tool to help fire officials understand the objectives of historic preservation which may come into conflict with the objectives of life safety from fire. The following six standards (out of ten) are those that typically have the greatest conflict with building codes:

- A property shall be used for its historic purpose or be placed in a new use that requires minimal change to the defining characteristics of the building and its site and environment.
- The historic character of a property shall be retained and preserved. The removal of historic materials or alteration of features and spaces that characterize a property shall be avoided.
- Each property shall be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or architectural elements from other buildings, shall not be undertaken.
- Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.
- Distinctive features, finishes, and construction techniques or examples of craftsmanship that characterize a property shall be preserved.
- Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.

A critical concept is that both historic preservation and fire safety have a common goal of protecting the building. A structure that is fire safe for its occupants will also be much less likely to be destroyed by fire.

FIRE SAFETY

What is fire? We all have a general concept of fire in the form of a burning match, a candle flame, or a welcoming blaze in a fireplace. Those who have experienced an uncontrolled structural fire have a greater appreciation for its potential effect.

Fire is both a chemical and physical phenomenon. Chemically, it is an oxidation process that changes common materials into other substances such as char, smoke, and toxic gases. Physically, this is an exothermic (heat releasing) process that produces such large amounts of heat that it becomes self-propagating. The important concept is that there are many known scientific aspects of fire that can be used to avoid and control it.

Fire safety involves the application of known principles to protect people, property, environment, and cultural heritage from fire. Professionally, this is the realm of the fire protection engineer. Whether or not the fire safety measures to be used call for engineering expertise, it is important for owners of historic buildings and historic site administrators to understand some basic concepts.

A fire safety assessment of a historic or older building will focus to a large extent on life safety as prescribed by local building codes. However, fire safety objectives also include protecting the historic structure from fire, which may go well beyond the minimum prescriptive requirements for life safety.

This booklet will consider the following fire safety topics:

- Fire prevention
- Basic code provisions
- Means of egress
- Fire barriers
- Fire detection and alarm
- Fire suppression
- Smoke control
- Operational considerations

FIRE PREVENTION

If ignition can be prevented, there will be no fire. This then is the first line of defense against fire in historic buildings. The basic concept of fire prevention is to avoid something very hot from coming in contact with something that burns. This can be accomplished in any of three ways: controlling heat producing situations, limiting the combustibility of materials, or making sure the two don't meet. Let's look in greater detail at these three key steps in fire prevention.

Sources of Ignition

Heat is energy that can exist in several physical forms. Technically, these forms include electrical, chemical, mechanical, and solar.

Electrical ignitions are typically produced from overloaded or defective wiring that can produce dangerous arcing conditions. All electrical systems should comply with the National Electrical Code to help prevent current overloads. To be safe, the use of extension cords should be avoided. If they must be used in temporary situations, they should have a large capacity; avoid the use of thin extension cords, especially of more than six

U.S. NATIONAL PARK SERVICE FIRE SAFETY CODE REQUIREMENTS

Federal agencies that are charged with maintaining historic buildings, such as the National Park Service (NPS) and the General Services Administration (GSA), have developed general approaches to historic preservation and fire safety. The guidelines below are adapted from the U.S. General Services Administration, Historic Preservation Technical Procedures, 01091-17, "Guidelines for Rehabilitating Historic Buildings: Health and Safety Code Requirements." For the complete guidelines go to http://w3.gsa.gov/web/p/hptp.nsf.

It is often necessary to make modifications to a historic building so that it can comply with current health, safety, and code requirements. Such work needs to be carefully planned and undertaken so that it does not result in a loss of character-defining spaces, features, and finishes.

1. **Assessing Historic Features**
   Recommended: Identifying the historic buildings' character-defining spaces, features, and finishes so that code-required work will not result in their damage or loss.

   Not Recommended: Undertaking code-required alterations to a building or site before identifying those spaces, features, or finishes which are character-defining and must therefore be preserved.

2. **Preserving Historic Features**
   Recommended: Complying with fire safety codes in such a manner that character-defining spaces, features, and finishes are preserved.

   Not Recommended: Altering, damaging, or destroying character-defining spaces, features, and finishes while making modifications to a building or site to comply with safety codes.

3. **Seeking Alternatives**
   Recommended: Working with local code officials to investigate alternative life safety measures or variances available under some codes so that alterations and additions to historic buildings can be avoided.

   Not Recommended: Making changes to historic buildings without first seeking alternatives to code requirements.

4. **Stairways**
   Recommended: Upgrading historic stairways and elevators to meet health and safety codes in a manner that assures their preservation, i.e., so that they are not damaged or obscured.

   Not Recommended: Damaging or obscuring historic stairways and elevators or altering adjacent spaces in the process of doing work to meet code requirements.

5. **Fire Protection Equipment**
   Recommended: Installing sensitively designed fire suppression systems, such as a sprinkler system for wood frame mill buildings, instead of applying fire-resistant sheathing to character-defining features.

   Not Recommended: Covering character-defining wood features with fire-resistant sheathing which results in altering their visual appearance.

6. **Fire Resistance**
   Recommended: Applying fire-retardant coatings, such as intumescent paints, which expand during fire to add thermal protection to steel.

   Not Recommended: Using fire-retardant coatings if they damage or obscure character-defining features.

[A]ny form of energy is a potential ignition source. The most common sources are open flames or electrical wiring and appliances. Smoking, candles, solid fuel heating, and similar combustion processes may also cause ignition.

feet in length. Modern "power strips" provide greater electrical capacity and overload protection. A new device, called an Arc Fault Circuit Interrupter (AFCI), is not yet required by codes in all situations, however, to be safe, every historic building should be retrofitted with AFCIs.

Open flames and lighted smoking materials are forms of chemical heat energy. In historic buildings, fireplaces and chimneys were once the most common ignition source. While this hazard remains, smoking is now the most common fire cause. Enforcing a no-smoking policy is not only fire-safe but also produces a healthier environment. Candles also pose a significant danger, and their increased popularity may soon put them at the top of the list of ignition sources.

Sometimes the use of electrical and chemical energy to produce heat is intentional. Heat-producing appliances for warmth and cooking are a necessary part of our lives, yet they present potential fire hazards. Proper operation and maintenance are critical. If you operate a historic house museum or if your organization has its offices in a historic building, avoid the use of space heaters. If food preparation is required for special events, avoid hot plates; rely on regularly inspected central kitchen facilities instead of dispersed food preparation. Kitchen appliances such as toasters, coffeemakers, and toaster ovens should be installed correctly and monitored for defective operation. Staff rooms are a likely place for a fire to start because of unattended appliances.

In some cases heat producing appliances are needed for the rehabilitation process. This is a worst case scenario because the building is also most vulnerable then. Fire safety during construction activities is addressed in detail later in this booklet.

Mechanical heat energy is not a common source of fire ignition but it can result from excessive friction. While our early ancestors relied on rubbing two sticks together to produce fire, now unintentional excessive friction can lead to unwanted fire. Malfunctioning drive belts on laundry appliances, for example, are possible sources of frictional heat.

Solar energy can start a fire when concentrated through a magnifying glass. There is a documented case of reproduction "bull's-eye" glass in a restored building causing a fire. Today's production process yielded a more perfect magnification.

Paying careful attention to potential ignition sources is the most effective way to avoid unwanted fire. Some other common ignition sources, however, are harder to predict and manage such as arson, fire spread from other structures, and natural events. Arson is an increasing threat that is difficult to control. Good building security can not only prevent theft but also deter malicious arson. In congested areas there is the danger of fire spreading from another nearby building, while in open areas lightning is a potential ignition hazard. In many areas of the country, especially in the West, wildfires can endanger structures in their path. If you live in areas that are prone to wildfires, contact your local fire officials to find out what they recommend.

In short, any form of energy is a potential ignition source. The most common sources are open flames or electrical wiring and appliances. Smoking, candles, solid fuel heating, and similar combustion processes may also cause 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.

A good approach to fire prevention is to use a checklist to help identify potential ignition sources. In the following chart, the "Installation OK?" column has a No in several locations to indicate that those items should never or rarely be used. (For the special conditions that occur during rehabilitation, another checklist is included later in this booklet.)

ARC FAULT CIRCUIT INTERRUPTERS

An Arc Fault Circuit Interrupter (AFCI) breaker will shut off an electrical circuit in a fraction of a second if arcing develops. The current inside of an arc is not always high enough to trip a regular breaker. A cut or worn piece of a cord or a loose connection in a junction box or receptacle can arc and burn without tripping the regular breaker. This is a major cause of fires, especially in older buildings.

There is a difference between AFCIs and GFCIs (Ground Fault Circuit Interrupters). AFCIs are intended to reduce the likelihood of fire caused by electrical arcing faults; whereas, GFCIs are personnel protection intended to reduce the likelihood of electric shock hazard. Don't misunderstand, GFCIs are still needed and save a lot of lives.

Combination devices that include both AFCI and GFCI protection in one unit are also available. AFCIs can be installed in any 15 or 20 ampere branch circuit in buildings today and are currently available as circuit breakers with built-in AFCI features. In the near future, other types of devices with AFCI protection will be available.

Limiting Combustibility

The second key step in preventing fires is to limit the combustibility of materials. It is often difficult to assess the combustibility of materials outside of the laboratory or testing facility. In general inorganic materials are the least combustible. Metal, marble, and ceramics are about as safe as you can get. Wood burns but not as fast or as hot as modern plastic materials. Untreated low-density materials such as foamed plastic should be avoided.

Furnishing Materials

Typically the first item ignited in an unwanted fire is an item of furnishing. Other typical items in a living or working space would be a computer or the contents of wastebasket. Noncombustible materials should be used as much as possible for furnishings and other contents in the building. When combustible materials must be used—historic fabrics or interior woodwork, for example—the resultant amount of potential fuel must be considered when fire suppression systems and evacuation systems are designed. The State of California has the most rigid requirements for fire safe furnishings.

Interior Finish Materials

Interior finishes should be chosen carefully. For example, if highly combustible wood veneer paneling must be replaced, it may be appropriate to substitute a fire resistant product. If appropriate, fire resistant carpeting and draperies of glass fiber or other fire resistant materials should also be considered.

Coatings and treatments are available that will effectively reduce the surface flame spread rating of many combustible materials. Although they may 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. But avoid using any coatings that contain a chemical or other product that will damage any historic material.

Construction Materials

Careful consideration should be given to using fire resistant construction materials and methods whenever these materials and methods will not damage the structure's historic character. For example, they may be the best choice for concealed or unexposed areas such as attics and crawl spaces.

Inert or fire resistant materials should also be considered when the structure is to be substantially rebuilt or when items used in original construction are no longer available. There are a number of fire safe products that simulate wood roofing and other building components. 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 that 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 investigated.

After taking steps to control heat producing situations and limit the combustibility of materials, the other key step is to keep ignition sources away from combustible materials. When the two come in contact, human error is traditionally to blame. Fire safety education and staff training is the best way to prevent situations where ignition sources come in contact with combustible materials.

CHECKLIST TO IDENTIFY POSSIBLE IGNITION SOURCES

Ignition source	Present?	Installation OK?	Inspected?
Electrical Energy			
Wiring		(AFCIs ?)	
Extension cords		No	
Chemical Energy			
Smoking		No	
Candles			
Chimneys			
Heating Equipment			
Central Heating			
Space Heating		No	
Kitchen Equipment			
Stoves			
Countertop Appliances			
Other			

FIRE AND FLAME RETARDANTS

Fire/Flame Retardant—Chemical added to a combustible material to delay ignition and combustion of the resulting material when exposed to fire.

Fire/Flame Retardant Coating—Paint or varnish applied to a combustible surface to reduce the likelihood of ignition and flame spread of the surface material. Such coatings can be clear or colored and are usually applied over wood surfaces.

Intumescent Coating—An intumescent coating is a substance that swells as a result of heat exposure, thus increasing in volume, and decreasing in density. When exposed to a fire, the coating bubbles and foams and then hardens into a charred surface. Such coatings can be colored or clear. They are sometimes used to improve the fire resistance of wood doors.

BUILDING CODES

Building codes regulate the construction of new buildings and the rehabilitation of existing ones. Most fire-related code requirements are based on principles for new construction and are often assumed to be applicable to existing buildings. However, the problems associated with using new construction standards for existing buildings can be a major deterrent to the preservation and reuse of existing buildings.

The assumption that modern code requirements prescribe a safer building than earlier requirements may be true when considering the overall level of safety of an entire building, but has less merit when single building components are considered. Some modern materials are inferior to their historic counterparts with respect to inherent fire safety. For example, smaller dimensioned, lighter weight, less fire resistant structural materials and assemblies such as web trusses reflect a contemporary reliance on fire suppression systems rather than solely on the integrity of building construction. Similarly, increasing applications of plastics introduces new hazards where none previously existed.

Existing buildings must meet updated building code requirements when a substantial change is made. But for many projects it is tricky to determine what are minor repairs not requiring a permit or adherence to a revised building code and substantial projects where, in the eyes of the code enforcer, both are required. Most difficult for enforcement personnel are situations in which the code insufficiently addresses an issue and relies instead on individual interpretations. Establishing a rational approach to determining when the revised building code should be applied based on the type or quantity of proposed repair, is one of the key items addressed in the most recent rehabilitation codes. Confusion and overlap often exist in jurisdictions where building and fire code enforcement are separated.

Public officials, national organizations, and private corporations now recognize that it is shortsighted to ignore our existing buildings and infrastructure. Since the 1970s numerous attempts have been made to develop special rehabilitation codes for them. These codes, developed at municipal, state, and national levels, incorporate a range of approaches that have produced varied degrees of success.

Common model U.S. codes include:

- NFPA 101—National Fire Protection Association Life Safety Code
- NFPA 1—National Fire Protection Association Fire Prevention Code
- NFPA 5000—National Fire Protection Association Building Construction and Safety Code
- NFPA 914—National Fire Protection Association Code for Fire Protection of Historic Structures
- IBC—International Building Code
- IEBC—International Existing Building Code
- IFC—International Fire Code

Copies of the building code should be available at the city clerk's office and public library. Copies are also available for purchase through code groups and bookstores.

Basic Code Criteria

Building and fire codes use certain criteria to determine which specific requirements are applicable to which buildings and what basic structural forms are acceptable. The three fundamental criteria are occupancy, construction, and size.

Occupancy Classification

A fundamental concept of fire safety is the classification of buildings according to their occupancy or use. Building occupancy is classified according to the number and capabilities of the people that are expected to occupy the building and according to the combustibility of the contents expected to be in the building.

Public officials, national organizations, and private corporations now recognize that it is shortsighted to ignore our existing buildings and infrastructure.

The intent of building occupancy classifications in building codes is to simplify the application of regulations governing construction, fire protection, and other life safety requirements. Occupancy class, once determined, becomes the basis for most code requirements. The categories of building use recognized by the NFPA Life Safety Code are listed in the chart on the opposite page.

The limited number of categories can sometimes lead to problems. For example, if the intended operation is a historic house museum, the building could be classified as an Assembly, i.e., "An Occupancy used for a gathering of 50 or more persons." If the number of occupants is less than 50, the same building would be classified as a Business. While the actual occupancy load may be close to 50, it should be recognized that this is an arbitrary designation. Building code requirements for an assembly use are significant while requirements for business use are minimal.

Construction Class

In early codes only two classes of construction were used: fireproof and nonfireproof. The term fireproof was replaced by the term fire-resistive in recognition of the fact that no material or building is totally fireproof. Modern building codes classify construction according to the materials used for the structural elements and the degree of fire resistance afforded. Classification depends on the combustibility of materials used and the type and size of framing members. Both combustible and noncombustible elements can be part of a structural or barrier assembly that can achieve a fire-resistive rating.

Code classes of construction are derived from five fundamental types: fire-resistive, noncombustible, ordinary, heavy timber, and wood frame. These names do not have technical precision and are not used in current building codes because today's design and construction methods no longer follow the concepts in vogue when the names were developed. The descriptive names have been relabeled with the corresponding designations Type I, Type II, Type III, Type IV, Type V.

Building Height and Area Limitations

Limiting the size of buildings has long been acknowledged as a means to control the magnitude of fires. Legally imposed or voluntary limits on building size serve two important functions: controlling the size of a single fire incident and controlling the number of persons at risk in any single fire incident. Although the need to limit building size is widely recognized, there is no universal agreement on the limitations themselves or a method that will achieve a balance of the various risks.

Although an important concern in code compliance, allowable building heights and areas should be considered a guide and not regarded as absolute. The values identified define only subjective limits of size, and exclude many other factors that contribute to a building's fire safety. Codes implicitly recognize this by permitting larger buildings when good fire department access and automatic suppression systems are provided. It is assumed that fire service operations can be more effective when more of a building's perimeter directly faces streets or similar open and accessible spaces, so the codes grant an increase in building area for such structures. In addition, codes permit an increase in the maximum allowable area and building height when fire suppression equipment is installed throughout the building.

OCCUPANCY CLASSIFICATIONS IN THE NFPA LIFE SAFETY CODE

Assembly	Detention & Correctional	Mercantile
Educational	Residential	Business
Day Care	Residential Board & Care	Industrial
Health Care		Storage
Ambulatory Health Care		

MEANS OF EGRESS

Evacuation of occupants in a fire is the primary approach to life safety. Evacuation features specified by codes include the number of exits, exit capacities, arrangement of exits, construction details of exit components, and the marking and illumination of exits.

In historic buildings the most common concerns are whether or not existing doors and stairs are an acceptable means of egress and whether the marking and illumination of exits is adequate.

Exit doors must swing in the direction of evacuation travel and must be easy to operate. According to NFPA 101, Life Safety Code: "Locks, if provided shall not require the use of a key, a tool, or special knowledge or effort for operation from the egress side."

Stair requirements in codes are even more numerous and detailed than those for doors. These requirements specify protection from fire in other spaces, allowable materials, handrails, tread and riser dimensions, landings, platforms, and guards. Although codes make many allowances in these details for existing buildings, often stairs in historic buildings do not comply.

Codes specify that exits be as remote from each other as practical, and be arranged to allow direct access in separate directions. While the term "remote" is subjective and frequently a matter of interpretation, the intent of providing exits in different locations is to minimize the probability that a single fire will block access to all exits. It is also important to prevent smoke from a fire on a lower floor from reaching all stairwells, blocking all interior means of egress from higher floors.

One approach to improving the means of egress is to compartmentalize the building into separate vertical fire zones so that a fire on one side of the building will not spread to the other side. Then the non-fire side of the building will provide a protected means of egress for evacuation. Existing walls can sometimes act as fire barriers if the openings in the walls can be closed with doors, opened only to allow passage for persons that need to move to the other side for safe evacuation.

A fire in August 2004 damaged most of a 200-year-old mansion in Vacherie, La., outside New Orleans. Sparked by a faulty electrical outlet, the blaze left only the facade, walls, and floor of the house that is the center of Laura Plantation, a former sugar plantation. As part of the restoration, two additional fire hydrants, which tied into the new water pipeline that was dug for sprinkler system installed in the main house, were installed on plantation grounds. The above photo shows the house with scaffolding and a tarp a month after the fire, and the photo below shows the restored plantation in 2006.

Photos by Joseph Dunn and Linden Waguespack, courtesy of Laura Plantation.

FIRE BARRIERS

The term fire barrier refers to the wall or floor that will block the spread of fire from one room to another and from one story to another. Both vertical and horizontal openings act as means of spreading fire between floors or within a floor of a building.

In most historic buildings, fire is likely to spread vertically by means of unenclosed stairs. Another possibility in very old buildings with no subflooring is that cracks between floorboards will allow fire and smoke to quickly spread to the upper floors.

In some older buildings there are inherently fire resistant walls and doors that perform as horizontal fire or smoke barriers to subdivide floor areas. Evaluation of fire resistant compartment barriers can be made using the US Department of Housing and Urban Development "Guideline on Fire Ratings of Archaic Materials and Assemblies" which is available online at www.huduser.org/publications/destech/fire.html.

FIRE DETECTION AND ALARM SYSTEMS

Fire detection and alarm systems are increasingly becoming required in all buildings, old and new. Smoke and thermal sensors are typically placed throughout the building in compliance with national fire alarm standards. Smoke detectors are located in heated portions of the building, while thermal sensors are found in the unheated areas such as attics and rear entrance porches. This is a common practice since smoke detectors are subject to failure at temperatures below freezing. However the downside of this arrangement is that thermal sensors are inherently slower in responding to a developing fire, activating only after flames appear rather than during the smoldering period that would cause activation of smoke detectors. By the time a thermal sensor activates, the building is in great danger and resultant fire loss can be substantial.

Alarm bells or similar warning devices are generally located at a central point on each floor level to notify occupants. Strobes or other visual devices can be installed to alert hearing impaired occupants; however, their effectiveness has not been scientifically established.

Fire detection and alarm systems are among the most cost-effective fire technologies. Technical advances have dramatically improved detector sensitivity, allowing earlier recognition of a smoldering fire, while also increasing overall fire detection reliability. Other improvements include features that can reduce the systems' maintenance costs.

In assessing fire detection and alarm options for historic buildings it is necessary to consider the aesthetic impact on the building along with cost and reliability. Installation of detection systems may necessitate some cutting and patching of interior surfaces. Most smoke sensors are placed in the center of each room's ceiling where they are most visible. There is some flexibility with new sensors to allow placement in less obtrusive locations.

AIR SAMPLING FIRE DETECTION

An air sampling or aspiration detection system is nominally 50 to 100 times faster responding to early smoke conditions when compared to common smoke detectors. Subsequently there is a greater chance to detect a fire while it is smoldering, which increases the opportunity for occupants and the fire department to respond before flames start and heat damage occurs.

Small tubes continuously draw samples of the air in a room and send it to a very sensitive smoke detector located elsewhere in the building. Detection sampling points are substantially smaller than regular smoke sensors so the aesthetic impact can be considerably less. Aspiration detection can be used to provide smoke warnings in unheated spaces, which allows a faster detection capability for those rooms and areas that are presently fitted with slow responding thermal detectors.

On the down side, aspiration systems are expensive to install and may require cutting and patching to insert the tube network. And such systems do not identify the specific location where fire has been detected.

FIRE SUPPRESSION

If a fire starts it must be controlled and extinguished. If it is discovered while it is relatively small—waist high, for example—it can often be suppressed by a trained person using a fire extinguisher. However larger fires generally require fire fighting professionals or automatic extinguishing systems. The nearest fire station may be many minutes away, assuming that firefighters are available and not handling another emergency elsewhere. In that a case a more distant fire station would have to respond. Automatic suppression systems can significantly help prevent loss of a historic building to fire—and can also save lives.

Several types of water and non-water fire suppression systems are available. These include systems that use various extinguishing agents such as chemical blend gases and inert gases. The main advantage of gases over other agents is that they cause less residual damage to building contents. But to be effective they must be confined to the space where the fire occurs for an extended duration (typically greater than 10 to 15 minutes). Otherwise they will leak to the outside atmosphere without controlling the fire. In most historic buildings, that confinement cannot be guaranteed so the likelihood of successful fire control by a gas is very low.

Water is the most widely used and effective extinguishing agent for common fire situations, and it is especially efficient at suppressing fires in materials such as wood, paper, and most plastics. Residual damage can occur, primarily by saturation, but generally this is easier to recover from than fire damage.

There are two basic options for most historic buildings. The first uses conventional sprinkler technology while the other uses high-pressure sprays or mists. Each works on the same basic principal—water is transported to the fire area via a piping network and is then sprayed through an open nozzle directly on the fire.

Sprinklers

With an automatic sprinkler system, water discharge occurs only when a specific nozzle's thermal sensing element is activated by the fire's heat. Subsequently only those sprinklers in close proximity to the fire will actually function, with most fires controlled by two to four operating sprinklers. Water for the sprinkler system is usually supplied by an upgraded service from the public water supply.

During restoration, a portable fire extinguisher should be located in each room along with an emergency exit sign. Fire extinguishers should be checked on a regular basis to make sure they are in working order.

Photo by John Jeanes, courtesy of Montpelier.

In many areas of the country, especially the West, wildfires pose a threat to historic buildings. In October 2007 fires destroyed more than 20 major historic buildings and severely damaged many more undocumented buildings and archeological sites in San Diego County including the county's only remaining one-room school, the Adobe Schoolhouse, constructed in 1882.

Photos courtesy of Save Our Heritage Organisation.

"Wet-pipe" sprinklers have their piping distribution system filled with water at all times. Some limited area "dry-pipe" zones are often needed for attics and other areas that may be subject to freezing. Here, the piping system is filled with air until a sprinkler opens from the heat of a fire.

Advances in technology include new, low-profile, quick response sprinklers. Piping may be steel, copper, or plastic with the diameter typically determined by with hydraulic calculations to ensure proper fire suppression rates. Plastic piping can be a good choice for concealed wet-pipe areas (i.e. within floor/ceiling assemblies) due to the ease of installation and resistance to corrosion. Steel will generally be preferred for those areas where piping is exposed. Galvanized piping is often used for dry-pipe sprinkler zones because of its corrosion resistance.

Wet-pipe sprinkler systems are among the most reliable, inexpensive, and simplest systems to install and maintain. These systems offer significant design flexibility that can be used to minimize aesthetic impact. Modifications to the system can be made relatively easily. This would, for example, allow a building owner to install a partial system in the highest risk areas of the building, and then expand it to other areas as funds permit and/or restoration work occurs.

However, there are some disadvantages. A sizable amount of site trenching, with associated costs, may be needed to run a new water service into each building. The public water supply will need to be evaluated to determine if adequate pressure exists without installing a fire pump on the property to boost the pressure. If a fire pump is required, the cost per building will go up substantially. Because pipe diameters can be relatively large, significant cutting and patching of interior fabric may be required. It may take careful design to minimize aesthetic impact from components.

Water Mist

A water mist system consists of thermally activated (similar to sprinklers) nozzles with water supplied through high-pressure stainless-steel tubing. Nozzles can be spaced farther apart than sprinklers. They are typically located on the ceiling since options for placing them on sidewalls are limited. Special pumps are needed to achieve the required high operating pressure. A mist system can use either the existing water service or new dedicated storage tanks.

High-pressure mist systems are highly effective with very low water use. Subsequently, post-fire water damage is considerably lower than it would be with a comparable sprinkler system, which means lower recovery cost. Tubing sizes are considerably smaller than sprinkler piping, which makes tubes easier to conceal and less intrusive on historic fabric. Overall water demand for these systems is considerably less than conventional sprinklers. Pump reliability is very good since the system operates on compressed nitrogen and does not rely on utility electric service.

There are presently few manufacturers and installers of water mist systems, and the equipment is more expensive than typical sprinklers and more expensive to maintain. Some of these costs may be offset by the need for less cutting and patching of historic fabric because the supply piping networks are smaller in diameter.

SMOKE CONTROL

In a fire that produces both intense heat and copious amounts of toxic and corrosive smoke, it is most often smoke that presents the greater hazard to both life and property. Differences in air pressure within a building can draw smoke far beyond the site of the fire. Even in buildings with sprinkler systems where fire temperatures are controlled, uncontrolled smoke eventually will contaminate exit stairways. Smoke will also spread through mechanical shafts, openings for pipes and conduits, and doorways.

Smoke-proof barriers can impede the flow of smoke away from the fire areas. Smoke can also be removed from a building in a controlled manner by means of the air supply and exhaust systems. Smoke control will aid the fire department in locating and fighting a fire resulting in reduced hazardous exposure of occupants, fire fighters, and property. Smoke control can also be part of the compartmentalization approach described earlier as a key way to protect life and property. Smoke control systems can be incorporated into new HVAC mechanical equipment or designed as separate systems.

Design criteria are described in *ANSI/NFPA 92A, Recommended Practice for Smoke-Control Systems*. This document addresses smoke control utilizing barriers, air flows, and pressure differentials to confine the smoke from a fire to the zone of origin, thereby maintaining a protected environment in the other zones. It also provides guidelines on control system supervision and instrumentation, and on testing for leakage of smoke control enclosures.

BUILDING OPERATIONS

Building operations include staff training and supervision and emergency procedures. Although not included in the legal requirements for buildings, operational factors are among the most important aspects of fire safety because human behavior before and during a fire is the major determinant of fire risk. However, except for special hazards, code provisions that direct the day-to-day building operations are not often enforced by jurisdictional authorities. Yet every authority recognizes the importance of safe operations: Code officials' intuitive assessments of the quality of

IMPLEMENTING FIRE SAFETY

There are three approaches to identify options for correcting fire safety deficiencies: using alternatives, equivalency, or modifications of the regulations to comply with the prescriptive provisions of the local codes; using risk indexing to establish compliance with a comparable level of life safety; and, using a performance evaluation to verify that fire safety and preservation objectives are met.

Prescriptive Compliance

There are many documented approaches to dealing with deficiencies in the fire safety requirements of prescriptive codes. The concept of equivalency is often used to address specific components; for example, a small stairway used only by a few people might be considered equivalent to a code-compliant stair used by the expected occupancy load.

An alternative to component equivalency is systemic equivalency. In systemic equivalency, the combination of all relevant components is examined; thus certain compensatory fire safety features may reduce the impact of non-compliant components. While some code officials may have the knowledge and experience to make professional judgments about systemic equivalency, most often it requires a structured decision approach such as risk indexing or performance evaluation.

Fire Risk Indexing

Fire risk indexing systems—also referred to as risk ranking, rating schedules, point schemes, and numerical grading—are simplified models of fire safety. They involve analyzing and scoring hazard and safety parameters to produce a rapid and simple estimate of relative fire risk. Such quantitative approaches to fire risk assessment have been used by the insurance industry for over a century.

A fire risk index is a single numerical value used in fire-safety decision-making. A value is assigned to selected variables representing both positive and negative fire safety features. The selected variables and assigned values are then operated on by some combination of arithmetic functions to arrive at a single value that is then compared with other similar assessments or to a standard.

Several risk-indexing systems are widely used for historic buildings. The Fire Safety Evaluation System (FSES) is an indexing approach to determining equivalencies to the NFPA Life Safety Code. It is occupancy based and does not include assembly uses. The Historic Fire Risk Index (HFRI) is a more rational and more transparent method than risk indexing systems currently published in model codes and standards. The HFRI is unique in its focus on historic house museums and its inclusion of attributes for fire prevention, building significance, fire growth rate, and emergency response.

Performance Evaluation

A performance-based option for evaluating fire safety in historic buildings is presented in Chapter 6 of NFPA 914. In the performance option, goals and objectives are translated into performance criteria. Fire models and other calculation methods are then used in combination with the building design specifications, potential fire scenarios, and explicit assumptions to calculate whether the performance criteria are met. If the criteria are met, then compliance with objectives under the performance-based design option has been achieved

The detailed data requirements for the modeling aspects of a performance evaluation are extensive. The appropriate input of this data into a computer model is a time-consuming professional activity. Interpretation of the model output requires in-depth understanding of the underlying processes of fire dynamics and human behavior in fire that are being modeled. For these reasons, performance evaluation can be a slow and costly approach.

NFPA 914—CODE FOR FIRE PROTECTION OF HISTORIC BUILDINGS

This code is unique in that it emphasizes historic preservation in the application of principles of fire protection. It specifies a team approach to fire safety and delineates means of accomplishing both fire safety and preservation objectives including options for providing equivalent levels of protection, fire risk indexing, and performance-based fire safety evaluation. The annexes provide a wealth of information that can be incorporated into protecting and preserving a historic building. Copies of the code can be found in public libraries or can be purchased from the National Fire Protection Association (www.nfpa.org).

Contents	Annexes
1. Administration	A. Explanatory Material
2. Referenced Publications	B. Planning and Design Approval
3. Definitions	C. Survey Criteria for an Historic Structure
4. Goals and Objectives	D. Basics of Fire and Fire Protection Systems
5. Reserved	E. Resources for Protection of Cultural Resource Property Projects
6. Security	F. Examples of Compliance Alternatives
7. Process	G. Performance-Based Fire Safety Code Compliance
8. Prescriptive-Based Option	H. Methods to Determine Untenable Conditions
9. Performance-Based Option	I. Assessment Methods
10. Management Operational Systems	J. Fire Safety Inspection Forms
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13. Fire Precautions During Construction, Repair, and Alterations	M. Sample Ordinance Adopting NFPA 914
14. Inspection, Testing, and Maintenance	N. Secretary of the Interior's Standards
15. Special Events	O. Guideline on Fire Ratings of Archaic Materials and Assemblies
Index	P. BSI Timber Panel Door Standard
	Q. Informational References

building operations establish a subjective basis that informs specific code discussions. For example, a code official is more likely to allow minor exceptions for a well-kept building in which experience suggests a fire is less likely to occur than in a poorly maintained building where a fire is more likely.

Unlike other codes, NFPA 914 explicitly addresses operations in Chapter 10, "Management Operational Systems." Operational considerations begin with management and include staff training, fire prevention, and liaison with the local fire department. Evaluation is based on the written procedures describing these activities and interviews with management and staff.

FIRE SAFETY DURING CONSTRUCTION ACTIVITIES

A disproportionately large number of destructive fires in historic buildings occur during renovations. All too often, fires are started by use of torches or heat guns to remove old paint. The potential for fire during a building rehabilitation is greater than during normal use and occupancy. Fire protection upgrades are not yet completed, for example, and walls and floors are opened up which creates paths for fire spread. Highly combustible materials—demolition debris, crates and boxes, and so on—are left lying around. Welding and cutting operations, plumbing torches, tar kettles, temporary heating equipment, and wiring may serve as ignition sources and create a rapidly developing fire. Building owners and historic site administrators need to pay extra careful attention to fire safety during restoration so that the greatest threat to the building is not the restoration itself.

Planning for the construction phase should include discussions with the owner of the building, architect, contractor(s), and project manager about fire safety. Owners should designate a person to represent their interests in making sure that fire safety 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 fire safe manner. The municipal fire department and other fire protection authorities should also be consulted.

Fire safety was a main focus of the extensive restoration of Montpelier, a National Trust Historic Site in Montpelier, Va., which took place over a four-year period starting in 2004. The restoration team kept the local fire department informed of the work being undertaken and the conditions of the project throughout each phase. During the deconstruction phase of the project, Montpelier contracted with off-duty fire fighters to monitor the site at the end of the work day—a statistically high risk time for fires.

A high pressure mist system has been installed in the mansion. This system uses much less water than a traditional sprinkler system, resulting in less water damage if it ever has to be used. Having a smaller amount of water means that the pipes can be smaller which cuts down on damage to the building during installation.

Photo 3: A gas-powered pump is used to pressurize the mist sprinkler system. The pump is powered by compressed air which eliminates the need for electrical power—if the site loses power, the pump will still function. Four, plastic water-storage tanks will provide a minimum of 30 minutes of water for the system. The total tank capacity is approximately 900 gallons which is considerably less than the approximate 15,000 gallons needed for a conventional sprinkler system.

Photo 1: The mist supply tube and a pendent sprinkler in the basement are visible between the exposed ceiling joists. The tube is 0.5 inches high pressure stainless steel. In the background along the wall is a typical 1-inch main tube.

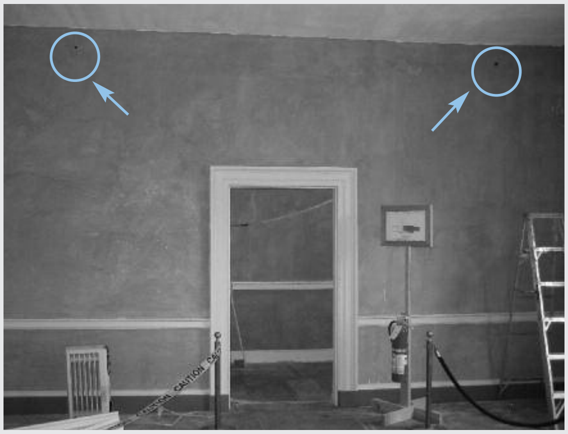


Photo 4: The locations for the sidewall sprinklers on the first floor were selected in consultation with the architect and curator so that they would not be initially visible when visitors enter the room. These temporary sprinkler heads will be replaced with brass finished sprinkler heads when the plaster work is completed.

Photo 2: A pendent sprinkler was used in the basement south kitchen which has a plaster ceiling. Only the white finished sprinkler head is exposed.

Photo 5: A vertical mist tube serves the first floor entry and drawing room. The 0.75 inch tubing—pictured here during the restoration—was channeled into the brickwork and then covered over with plaster. The fittings are extremely durable, high pressure compression couplings that are similar to those used in aircraft hydraulic and industrial applications.

As a safety measure, only florescent lighting was used during the restoration of the Montpelier Mansion (above). A special detection system (below) monitored the air in each space for emissions from a high heat or fire situation. Plastic tubing would draw air samples back to the main air sampling unit which was located in the basement. In the event of smoke or fire, the system would automatically alert the fire department and activate the building's fire alarm.

Photos by John Jeanes, courtesy of Montpelier.

Keeping public facilities safe during construction poses additional challenges. If the facility can be closed to the public during the rehabilitation work, then fire safety efforts can simply concentrate on the construction process. However, if a historic site or office space has to remain open to visitors and users during the rehabilitation process, exceptional fire safety and life safety hazards may be created. Extra effort must be made to ensure that any construction process does not compromise necessary life safety features. To reduce the level of hazard to occupants and the building, construction areas should be separated from public use areas by noncombustible partitions as much as possible. Required exits should be maintained or supplementary routes provided. Security personnel may need to be employed to help keep visitors out of construction areas and to assist them in exiting when alternate exit routes are required.

During rehabilitation building owners and site managers should focus on the following concerns:

- construction facilities and materials,
- construction processes,
- construction site conditions,
- fire protection,
- fire fighting, and
- site management.

Construction Facilities and Materials

Temporary construction offices, trailers, sheds, and other storage facilities, when located within the building or nearby, should be of noncombustible construction. Only safely installed, approved heating devices should be used in construction offices and sheds. Provide ample clearance around stoves and heaters and all chimneys and vent connectors to prevent ignition of adjacent combustible materials.

Internal combustion engines powered by air compressors, and hoists, derricks, and pumps 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 inches (152 mm) should be maintained between such piping and combustible materials. Service areas or fuel for construction equipment should not be located within buildings.

Keep construction materials to a minimum within the structure, and store materials not immediately required safely away from the structure. Choose a storage place that will not impede egress from buildings or access of fire apparatus to hydrants.

Carefully control and monitor storage and use of flammable liquids during rehabilitation operations. Potential sources of ignition should be identified and safeguarded whenever operations involving flammable liquids take place. Provide ventilation for operations involving the use or application of materials containing flammable liquids. Requirements for storing flammable liquids are specified in fire prevention codes.

Construction Processes

Cutting and welding operations on the job site require a permit from the appropriate authority, usually the fire department. Any such operations should be carried out under the supervision of the person in charge of fire protection and in accordance with the requirements of local fire prevention codes.

Permission 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 at least 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 supervisor should inspect the work 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. Take adequate precautions so that wetting down will not introduce a personnel safety hazard (such as slippery floors) or cause damage to historic building materials or finishes.

Locate asphalt and tar kettles, when used in roofing or other operations, in a safe place outside of the building or on a noncombustible roof at a point where there is no risk of igniting combustible material below. Do not store used roofing mops 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. Provide suitable fire extinguishers in the vicinity of such operations.

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 work can be safely conducted at the desired location, that combustibles have been moved away or safely covered, and that the worker has a charged fire extinguisher close by. At the close of the workday the supervisor must inspect the work so that any smoldering may be detected.

Install electrical wiring and equipment for light, heat, or power in compliance with the requirements of the National Electrical Code. Make sure that temporary lighting, bulbs, and fixtures do not come in contact with combustible materials. Circuits not in use should be shut off at the breaker switch.

Paint stripping operations involving open flames should not be permitted. At the end of the day, make sure to empty dust accumulation bags from floor sanders. Dispose of dust in closed metal containers outside of the building. Other operations should be similarly controlled to reduce the possibility of fire ignition. Review operations that introduce fire hazards to determine if other, safer methods could be used.

Construction Site Conditions

Construction sites are prone to vandalism and malicious mischief—including arson. Appropriate security on the premises will help reduce the incidence of intentional fires as well as protect the facility from other destructive acts.

As much as possible, keep the permanent heating equipment in service to provide heat for the workers and to prevent water pipes from freezing. Situate heating devices so they are not likely to overturn and install them according to the manufacturer's directions, including providing ample clearance away from combustible material, equipment, or construction. Move oil burning and liquefied petroleum gas burning heaters to a safe location and wait for them to cool before refueling.

Temporary heating equipment, when used, should be attended and maintained by competent personnel. 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. Make sure the design and installation of these heaters complies with appropriate standards. Chimney or vent connectors, where required from direct-fired heaters, must be at least 18 inches (457 mm) from combustibles.

Prohibit smoking entirely or restrict it to designated areas. Select smoking areas based on 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. Provide receptacles for spent smoking materials in the smoking area and empty them on a regular basis. Stringent restrictions on smoking also serve to promote general consciousness of the need for fire safety. Surreptitious smoking should be dealt with severely.

Take extreme care to prevent even small accumulations of debris or rubbish inside construction areas or close to an exterior fire hazard. Remove debris and rubbish from the site daily. Require contractors to provide ample receptacles for rubbish and papers. Chutes installed for the removal of debris should be erected on the outside of the building.

Good 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.

During construction all flammable liquids should be stored in a fire safe storage cabinet (above). Dispose of solvent rags in containers designed specifically to store spontaneous combustion items (below).

Photos by John Jeanes, courtesy of Montpelier.

Unfortunately many historic buildings are lost to fires started by arsonists. The 1868 Grange in Ferrisburgh, Vt., was destroyed in a 2005 fire. Using salvaged materials from the burned structure and architectural plans prepared for a planned pre-fire rehabilitation of the building, the town reconstructed a new Grange hall that will house town offices and community space.

Photo courtesy Preservation Trust of Vermont.

Fire Protection

If new firewalls and exit stairways will be required for the completed building, they should be given priority in the construction schedule. Install fire doors with approved closing devices and hardware as soon as practical and before combustible materials are introduced. After installation, do not allow construction equipment or materials to prevent doors from closing.

Maintain existing fire detection and alarm systems in operating order wherever possible. If smoke detectors are located in the construction area, they must be protected from dust, dirt, and extreme temperatures during construction. When construction work has finished for the day, a security guard or other authorized person should be instructed to remove any temporary protective covering from smoke detectors to avoid delayed alarms during nonworking hours. Care should be taken to avoid accidentally disabling the fire alarm system or causing false alarms during the rehabilitation work.

If automatic sprinkler protection is to be installed in the building, it should be put 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.

Fire Fighting

Planning for fire fighting during construction begins with designating a suitable location at the site as a command post and providing it with plans, emergency information, keys, and communications equipment, as needed. The person in charge of fire protection should go to the location immediately if a fire occurs.

It should be possible for heavy fire fighting equipment to enter the job site at the start of construction and this access should be maintained until all construction is completed. Maintain unobstructed access from the street to fire hydrants and to outside connections for standpipes, sprinklers, or other fire extinguishing equipment, whether permanent or temporary, at all times. Make sure protective pedestrian walkways do not block access to hydrants, hose connections, or fire extinguishing equipment.

During construction operations, maintain easy access to permanent, temporary, or portable first aid fire equipment. In all buildings over one story high, at least one stairway should be accessible at all times.

Make sure that the water supply for either temporary or permanent fire protection is available as soon as construction begins and combustible material accumulates. Contact the local fire authority to confirm that the water supply is adequate for hose lines. Where underground water mains are to be provided as part of the construction project, they should be installed, completed, and in service with hydrants or standpipes located as directed by the local fire authority before construction begins.

Provide on-site hoses and nozzles as soon as either the temporary or permanent water supply is available. For every building operation—including those occurring in a tool house, storeroom, or other structure located in or adjacent to the building under rehabilitation, or within a room or space used for storage, workshops, or employees changing clothes—portable fire extinguishers should be provided and maintained in an accessible location. Provide at least one approved fire extinguisher in plain sight on each floor at each useable stairway.

Site Management

Assign a capable and qualified person having the necessary authority to be in charge of fire protection. Responsibilities should include maintaining and locating fire protection equipment, supervising safeguards and location of portable heating equipment, and establishing and maintaining safe cutting and welding operations. Where an alarm monitoring service is provided, make sure monitor personnel are acquainted with developments during the day and be sure to pass along any special instructions on the status of fire protection equipment and emergency procedures.

Have a public fire alarm box near the premises, telephone service to the fire department, or equivalent communications readily available. Instruct employees to notify the fire department immediately in case of fire. Post the local fire department number conspicuously near each telephone.

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

Pay attention to possible fire exposure hazards created by the weather and environmental conditions. A fire at an adjacent property can spread. If the fire threat to adjoining or nearby buildings is severe, consider additional precautions such as the use of fire doors, temporary barriers, or sprinkler water curtains.

Windstorm damage may in fact contribute directly to an increase in the fire hazard. Buildings damaged by high winds—especially those open to the elements during rehabilitation—are even more susceptible to the threat of fire. Water supplies may freeze in cold weather if temporary doors or window closures are blown away. Roof construction may also be damaged to the extent that equipment may freeze. 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.

Checklist and Overview

A convenient way to plan and monitor fire safety at a renovation site is to use a checklist. The left-hand column of the checklist lists the

CHECKLIST FOR FIRE SAFETY DURING CONSTRUCTION

Item	N/A	Safe	Unsafe
Construction Facilities and Materials			
Temporary Offices and Sheds			
Construction Equipment			
Combustible Materials			
Flammable Liquids			
Construction Processes			
Cutting and Welding			
Roofing			
Plumbing			
Electrical			
Paint Removal			
Other			
Construction Site Conditions			
Security			
Temporary Heating Equipment			
Smoking			
Housekeeping			
Fire Protection			
Fire Barriers			
Fire Detection			
Automatic Sprinklers			
Fire Fighting			
Access			
Water Supply			
Standpipes			
Fire Extinguishers			
Site Management			
Supervision and Monitoring			
Environmental Conditions			

INSURING YOUR HISTORIC PROPERTY

What makes our historic buildings unique can also make them more vulnerable in a fire. When creating a plan for fire prevention and suppression, take the time to review insurance policies with your agent and determine if your coverage will provide the protections that your historic building needs after a fire occurs.

When historic buildings are underinsured, the consequences can be tremendous. One of the most important aspects of insuring a historic structure is determining the right insurance value. Many historic building owners and homeowners do not have the correct coverage limit for their property. Often these buildings are insured for the market value, mortgage value, or the purchase price. While market values and real estate appraisals work for the sale and transfer of real property, they don't speak to the costs of building, rebuilding, or restoring the structure. Insuring structure for what you can buy or sell it is never a smart idea, and will greatly reduce your ability to recover in the event of an underinsured loss. New construction cost estimates are also not appropriate in determining the replacement cost of a historic building, as they do not take into consideration the restoration or replication of damaged historic attributes, such as intricate carved wood moldings, panels, murals, etc.

The best way to determine the historic building's replacement cost is by seeking a Replacement Cost Insurance Appraisal for Historic Buildings. These specialty appraisals are performed by professionals who are experienced with the cost of renovation, repair, and restoration of historic structures. The appraiser will visit your property, do a walkthrough of all areas, and gather information about the building and its history including photo documentation. After completing the appraisal, the appraiser submits a very detailed report that outlines the age, history, architectural style, dimensions, specific historic attributes of your building (such as murals, gold leafing, etc.), as well as the estimated cost of historic replacement after a loss.

While proper insurance values are important, equally so is the type of coverage an insurance policy will actually provide after a loss and the claims philosophy of the insurance company. Is the insurance company going to replace the property with "like and kind quality?" If so, how is it defining "like and kind quality?" Will there be a deduction for depreciation? Will the company pay to restore the building? Will it guarantee replacement and restoration, regardless of cost?

Some of the many valuation options available in today's insurance market include:

Replacement Cost Valuation (RCV). This option pays the actual cost to replace/rebuild the property of the same quality and construction, without a deduction for depreciation. An RCV does not necessarily guarantee restoration to historic requirements, particularly if materials are difficult to replace or replicate.

Actual Cash Value (ACV). "Actual Cash Value" is the replacement cost of property damaged or destroyed at the time of loss, with deduction for depreciation. Actual cash value cannot exceed the applicable limit of liability shown in the declarations of the policy, and it can't exceed the amount it would cost to repair or replace such property with material of like kind and quality within a reasonable amount of time after a loss. It is an agreed value of present worth.

Functional Replacement Cost: This insurance option is the minimum cost to repair or replace the damaged property using materials and workmanship that performs the same functions as the original, though it may be less expensive and lesser quality than the original.

Guaranteed Replacement Cost: This option ensures your property will be replaced even if the cost exceeds the limit on the policy (for many companies, how much the cost may exceed your policy level is limited). Virtually all companies require that you be insured to 100 percent of replacement cost in order to obtain guaranteed replacement cost coverage. Although this is the most preferred coverage valuation, this option is not available in all areas and often not available at all for historic properties.

Historic Replacement Cost: This insurance option pays the actual cost to replace or rebuild the property to its original condition prior to the loss, including historic restoration and acquisition of the historic materials (when available) needed to replace damaged materials, without a deduction for depreciation.

Make sure to choose a policy that will pay to replace damaged historic property, or pay to replicate it when replacement is not an option. Ask your insurance company if your policy will pay for, and if the company has the resources to hire, a historic restoration consultant or qualifying contractor to assist after a loss. If not, then the insurance company may not be the right insurer for your historic property.

construction site hazards and safety features discussed in the paragraphs above. The second column indicates if the item is applicable to the particular project (checking N/A indicates the item is not applicable). The rightmost columns identify the conditions of the items as either safe or unsafe. If an applicable item is designated unsafe, corrective action is necessary. Depending on the nature of the project, a checklist such as this could be implemented as often as two or even three times a day to ensure continued fire safe practices on the site.

Historic building restoration projects are especially vulnerable to fire given the presence of combustible construction systems and materials and the often limited areas available for separating combustible and flammable stored materials from other areas. Most fires during construction can be avoided by hiring trained construction personnel, selecting non-hazardous construction materials and processes, maintaining full control over the site and personnel, and ensuring that fire protection features and systems are in place and operational.

FIRE RISK MANAGEMENT

Fire risk management involves developing strategies for reducing the likelihood of fires and the consequences should they occur. It can run the full gamut of actions from preventing fires, to reducing damage in the event of a fire, to providing emergency response, to handling damage, and having insurance to compensate for financial loss. Risk management usually involves some investment, and the allocation of limited financial and human resources should be guided by the assessments of fire risks and what we know of how people and organizations perceive and react to them.

Fire risk management involves primarily those activities performed to prevent fire and, secondarily, creating ways to meet fire losses that are not preventable or that occur despite preventive measures. In general the four approaches to fire risk management are:

- Risk Avoidance—eliminating fire hazards
- Risk Optimization—reducing risk by minimizing adverse effects of fire
- Risk Transfer—economically shifting fire risk to other parties
- Risk Retention—determining the portion of the fire risk that is acceptable.

Risk Avoidance. It is not possible to avoid all fire risks, but it is the most certain way of preventing any chance of loss. It is always possible to eliminate some fire hazards through design and fire prevention activities and to thereby avoid their associated risk.

Risk Optimization. Reducing risk can be accomplished with fire control strategies and before-loss planning. Fire loss can be minimized by enacting appropriate fire protection measures and maintaining disaster preparedness plans.

Risk Transfer. Transferring risk to an insurance company is an expensive, but often necessary risk management approach. Large deductibles can greatly reduce costs while helping to cope with a catastrophic loss. The financial options of risk transfer are myriad and require careful analysis.

Risk Retention. Acceptable risk is a tricky approach that requires some hard decision making. The important thing about accepted or retained risk is that it be identified as such. Accepting risk is very different form ignoring risk, either intentionally or through ignorance. Ignoring risk is managerially unacceptable.

Of these, risk transfer, or insurance, is the most common approach to managing fire risk. However it should be recognized that one cannot insure against loss that does not have identifiable monetary value, such as life, authenticity, heritage, symbolism, and so on. The destruction by fire of the 600-year-old Sungnye Gate in Seoul Korea in February 2008 was much a much greater loss to the people than the $20 million estimated cost to create a replica.

SUMMARY

There are three basic concepts of fire safety in historic buildings: fire prevention (avoiding ignition), passive fire protection (building construction), and active fire protection (detection and suppression). There are no statistics that can verify the major importance of fire prevention, but every knowledgeable person will tell you prevention is more significant than any other activity. As most preservationists are well aware, fires that occur during a restoration or renovation are a major factor in the loss of historic structures, and good preventive measures are key to avoiding the loss of another irreplaceable historic building.

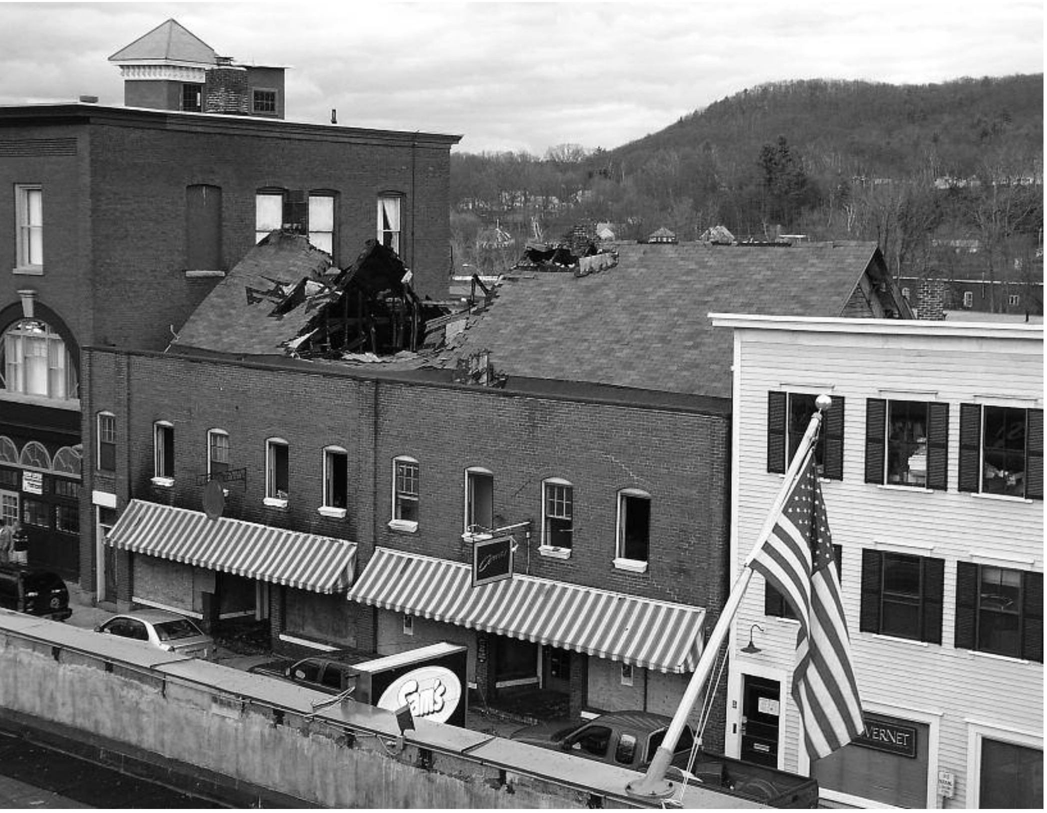
Many people overlook the value of the inherent construction of historic buildings. Luckily today there are means to improve the fire resistance of archaic construction assemblies with minimum intrusion on authenticity, including intumescent coatings and fire-retardant treatments. Modern fire control systems, including fire detection and alarm systems, automatic sprinklers, water mist, and smoke controls can help ensure that older and historic buildings remain safe for visitors and occupants alike.

ABOUT THE AUTHOR

Jack Watts is the director of the Fire Safety Institute in Middlebury, Vt. Brian Phoebus from the National Trust Insurance Services, LLC in Baltimore, Md., contributed to the section on insurance for historic properties.

RESOURCES

National Fire Protection Association (NFPA) is a nonprofit, membership organization that promulgates consensus fire safety codes and standards and conducts related activities. The association offers educational seminars, research studies, and literature searches for a fee. It also maintains a list of fire protection consultants and responds to telephone and e-mail queries from members and users of its products. Much of NFPA's technological proficiency is derived from more than 200 committees made up of volunteer experts. Members of the NFPA Technical Committee on Cultural Resources have a wide range of experience and knowledge in fire safety applications for heritage properties. This committee is responsible for producing the content of *NFPA 914, Code for Fire Protection of Historic Structures* (latest edition: 2007). For more information go to www.nfpa.org.



When a fire occurs in a historic commercial building, residents not only have to cope with the loss of a community landmark, but also with the effect a vacant burned-out building may have on the downtown economy. In 2006 this popular gathering place and restaurant in Bellows Falls, Vt., suffered major damage from an early morning fire. Today the building has been stabilized but remains vacant and leaves a gap in the fabric and vitality of the streetscape.

Photo by Rebecca Williams.

State and Local Fire Officials

Many states and local jurisdictions have resources to help building owners with fire safety issues. Some of these are knowledgeable in dealing with historic structures. For example, the State of Vermont has a specific webpage answering questions about how its regulations address historic buildings www.dps.state.vt.us/fire/Historic.htm.

A list of state fire marshals websites is maintained by the National Association of State Fire Marshals and can be found at www.firemarshals.org/links/state-fire-marshals-websites/. Keep in mind that not all fire officials are well-versed in dealing with historic buildings as they often focus on new construction.

Fire Safety Consultants

A fire safety consultant can be a valuable resource when dealing with technical issues, such as codes, emergency egress, detection and suppression systems, etc., as long as his or her credentials and background are appropriate. A reliable consultant typically needs to have more education than just employment in fire service or code enforcement. The most important qualification is experience with historic buildings, which, in many cases, is not the person's original background or major area of expertise. Check with references to determine how the consultant has performed on similar projects.

Fire safety engineers work with architects and other engineers, state and local building officials, and local fire departments to build and maintain fire safe buildings. For major projects it may be appropriate to enlist such services early in the design. The Society of Fire Protection Engineers (www.sfpe.org) can be contacted for names of members of local chapters. Like others, their principal area of expertise may not include historic buildings.

Additional Reading

Watts, John M. Jr. and Marilyn E. Kaplan. *Fire Safe Building Rehabilitation*. Quincy, Mass.: NFPA, 2003. Although out of print, this book may be available in many libraries.

Fire Prevention & Building Code Compliance for Historic Buildings: A Field Guide. Burlington, Vt.: University of Vermont, 1997. www.dps.state.vt.us/fire/HistoricPreservationGuideIntro1.pdf

Guidelines on Fire Ratings of Archaic Materials and Assemblies. Washington, D.C.: Department of Housing and Urban Development, February 2000. www.huduser.org/publications/destech/fire.html

Green, Melvin, and Anne Watson. *Building Codes and Historic Buildings*. Washington, D.C.: National Trust for Historic Preservation, 2005.

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