Fire Detection & Suppression for Buildings in Historic Districts

Contents

By Nick Artim and Jack Watts in cooperation with the Bellefonte Preservation and Fire Prevention Task Force

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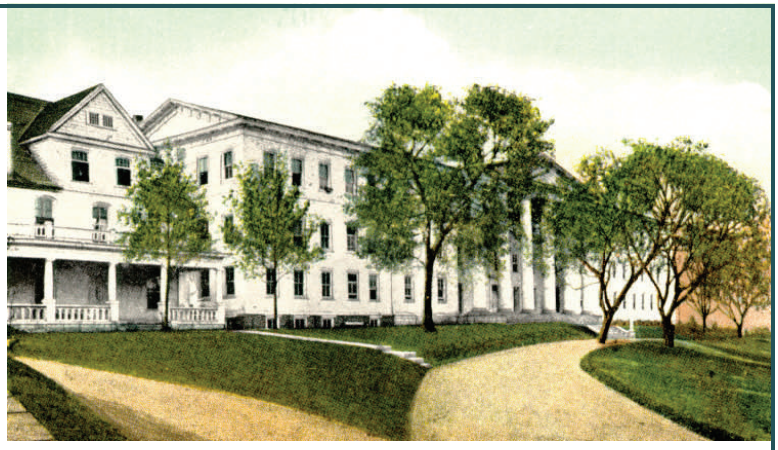
Introduction

Bush House hotel, Bellefonte, Pennsylvania. Destroyed by fire February 8, 2006.



Bellefonte Academy, Bellefonte, Pennsylvania. Destroyed by fire July, 2004.

In 2004 and 2006, the small town of Bellefonte in Centre County, Pennsylvania lost two very significant historic buildings to fire: The Bellefonte Academy, a private secondary school that in 1909 had "educated more governors, more senators more judges and more public men than any other school in Pennsylvania," was destroyed by fire in July of 2004; and the Bush House, a grand hotel built along Spring Creek in 1868, burned to the ground in February of 2006. The sites of both of these large, freestanding buildings are still vacant today, taking a severe toll on the local economy. While these fires were devastating, even greater fear lays in the possibility of conflagration in the dense commercial core of the town, which could lead to the loss of more than one building or – worse yet – loss of life in addition to loss of property.

The losses resulting from the large fires mentioned above prompted Bellefonte to establish a task force to review the current fire problem in the historic district and propose an initiative to reduce the risk of future large loss fires. The goal of the Bellefonte Fire Department Preservation and Fire Prevention Task Force is to prevent destructive fires in historic Bellefonte and provide the highest degree of life safety possible, while still preserving the town's historic character and retaining the architectural integrity of the individual buildings.

Like many other communities, Bellefonte contains a historic district that is listed in the National Register of Historic Places, as well as a locally designated historic district. In historic districts, it is important to consider not only individual historic buildings, but the district as a whole, as well. National Register eligibility helps to protect properties from impacts resulting from federally funded or licensed projects. And in order to ensure the preservation of the individual buildings as well as the historic character of the community, Bellefonte adopted an ordinance in 1970 that would require the review of all changes to the exterior of buildings in the local historic district. Bellefonte uses the most commonly used standards for evaluating impacts on historic buildings, the *United States Secretary of the Interior's Standards and Guidelines for Rehabilitation.* The primary intent of these *Standards* is to ensure the protection of the qualities and characteristics of a historic property (individual or district) that make it significant. Unfortunately, nothing is in place to protect the historic community from the impacts of fire.

In an effort to inform the local community and others that may be facing similar issues, Bellefonte is working with experts Nick Artim of the Heritage Protection Group and Jack Watts of the Fire Safety Institute to identify appropriate systems and techniques for installing modern fire and safety equipment in historic buildings while maintaining their architectural integrity. The primary purpose of this guide is to help property owners: 1) determine if a fire suppression system is appropriate for their historic building; 2) determine what type of system would be best; and 3) identify factors to be considered when having a system designed and installed. This bulletin has been organized into sections discussing basic concepts in fire safety, providing information about options for fire detection and alarm systems, discussing available types of fire suppression systems, and providing additional detail on system and component options and costs for fire sprinklers, the most common type of fire suppression system. Additional issues and concepts are highlighted throughout the text, and a frequently asked questions and a reference section are provided at the end.

The goal of Bellefonte's Preservation and Fire Prevention Task Force is to help prevent destructive fires in historic Bellefonte and provide the highest degree of life safety possible, while still preserving the town's historic character and retaining the architectural integrity of the individual buildings. This discussion of alternatives for the installation of fire suppression systems is one step in implementing that goal.

Fire Safety Basics

Fire protection for historic buildings is necessary for safety of occupants, security of property value, and income for building owners. However, it may also be critical to preservation of the cultural heritage of the local community and thereby future economic survival.

Fire safety can be achieved by minimizing the likelihood a fire will occur (fire prevention) and by limiting the damage from a fire that does occur (loss control). Fire prevention is the best line of defense as it can avoid even small fires.

Ignition can occur when something hot comes in contact with something that burns, typically, paper, wood, or plastic. The most likely heat sources are smoking, heating, electrical wiring and appliances, and cooking. With care and attention, these can be eliminated or controlled. For example, maintaining a clear space around furnaces or other heat producing devices, avoiding use of extension cords, installing AFCIs (see box below for more information), and awareness of the combustibility of both ordinary materials and flammable liquids.

While these are the prevalent situations, it is important to understand that anything that produces heat can be a source of fire ignition. And, anything that burns can be set afire by an ignition source. Additional information on these and other aspects of fire safety can be found in the resources listed at the end of this bulletin.

Fire control involves keeping the fire small if it does start, both by structural confinement and fire suppression. Fires look for ways to spread from one part of a building to another. Sometimes this can be inside walls where void spaces act as chimneys to allow fire spread from lower to upper floors of a building. Keeping doors closed will help control the spread of fire from one room to another. In addition to such measures, automatic fire detection notifies occupants to call the fire department and automatic fire suppression puts water on the fire soon after it starts.

Building and fire codes dictate a minimum level of fire safety for the public welfare. Insurance requirements and a building owner's vested interest in protecting assets may lead to additional fire safety measures. Preserving a building for its cultural heritage may involve alternative approaches to fire safety and sensitive installation of fire protection systems.

The primary causes of fires in historic buildings and the types of things that are commonly ignited are shown below.

TYPICAL IGNITION SOURCES IN HISTORIC BUILDINGS

- Arson
- Electric wiring
- Heating equipment
- Fire in adjacent building
- Smoking
- Appliances
- Candles

MATERIALS COMMONLY IGNITED IN BUILDING FIRES

- Combustible waste
- Combustible storage
- Furniture & curtains
- Wood construction
- Flammable liquids
- Holiday decorations
- Clothing

Highly combustible materials stored in the basement of a historic house.

AFCIs

An AFCI (Arc Fault Circuit Interrupter) breaker can prevent a fire by shutting off an electrical circuit in a fraction of a second if undesired arcing occurs. Regular circuit breakers respond to an overload that causes heat to build up and the breaker to trip. Arcing, although usually visible, does not always have a high enough current to trip a regular breaker. AFCIs are designed to tell the difference between a working arc in say a light switch or household appliance, and an unwanted arc that may arise from a lamp cord with a broken conductor, for example. Such arcing is a major cause of electrical fires, especially in historic buildings. The older the wiring, the more likely unwanted arcing may occur. Refitting branch circuits with AFCIs can reduce the chance of fires from such conditions. Electrical circuits that employ fuses should be upgraded to a code-compliant breaker panel. (Note that AFCIs are not the same as GFCIs. Ground Fault Circuit Breakers, protect against electrical shock hazard, while AFCIs protect against electrical arcs.)

Fire Detection and Alarm

When a fire starts, the threat to a building and its occupants increases rapidly as the time from ignition advances. However, if the fire can be detected early, there is an opportunity to safely evacuate, summon the fire department and reduce the amount of damage. In general, people can be excellent fire detectors with their ability to recognize heat, flames, and smoke, and sound an alarm. But they may not be present when the fire starts, or they may not be in perfect health to detect the fire, and/or may be physically unable to activate the alarm. To compensate for these situations, automatic fire detection and alarm systems are available.

Common initiating device or manual pull.

Automatic door closers help reduce the spread of fire through a building and maintain a safe exit route for its occupants. Fire doors are held open by electromagnetic devices that will release and close the doors when the fire alarm activates.

Fire alarm systems consist of several main components including control panels, initiating devices such as manual fire alarm pull stations and automatic smoke and/or fire detectors, alarm notification devices, and in some instances additional features such as door closers and damper controls.

Control Panels

The control panel is the "brain" of the fire alarm system and is responsible for continuous monitoring of the automatic and manual detectors and raising the alarm when a fire condition is detected. Fire alarm control panels may range from relatively simple units with simple input and output circuits to advanced microprocessor-based addressable systems that can provide detailed information regarding the type and location of device that has detected a fire. A fire alarm control panel may cover a single building or group of buildings. Fire alarm panels also monitor the operating condition of the system to insure system integrity and operational reliability. Consultation with a fire alarm manufacturer's representative or fire protection specialist can help to insure that the proper system type is selected for a specific property.

Initiating Devices

Initiating devices are the components that detect a fire and provide information to the control panel to start the alarm function. Initiating devices include manual fire alarm pull stations (shown above), automatic fire and smoke detectors, and switches that activate when a fire sprinkler operates. Additional information about common types of automatic smoke and fire detectors is provided on the next page.

Notification Devices

Notification devices sound the alarm when a fire has been detected. These consist of bells, horns, chimes, visual warning lights and voice notification speakers. Fire alarm communication is the component of a fire alarm system notification that summons the fire department. In many cases, fire alarm communications are done manually, with a person detecting the fire or being notified by an alarm, and calling the fire department. In automatic systems, the alarm system will communicate immediately and directly with a fire alarm monitoring company who will in turn alert the fire department. Monitoring companies will also contact service technicians if the fire alarm system malfunctions.

Additional Features

Additional features that help reduce the spread of fire in a building and improve the safety of its occupants may be added to the fire alarm system. For example, automatic fire door closers can help contain fire and smoke to limited areas of a building, slowing fire spread and enhancing exit ways for occupants. Air handling systems can be automatically shut down to restrict the migration of smoke and flames within the building. And alarm systems can send elevator cars to a designated floor where it will be "parked" to prevent its use by occupants during the fire.

Common Detector Types

For most buildings, automatic detectors sense either smoke or heat and initiate the alarm system. Although a wide variety of technologies are available, some of the more common applications are described briefly below.

Smoke detectors replicate the human senses of sight and smell and are used to identify the "incipient" or smoldering fire before it becomes advanced.

Spot Detectors. The most common smoke detector is the spot detector, which is placed along ceilings or walls at nominal 30 foot spacing (top right). They are available in fast responding ionization and photoelectric models and very fast but more costly laser-based models.

Another type of smoke detector samples the room's air through a network of tubes. It can recognize extremely minute quantities of smoke and often activate the alarm before the smoke becomes visible. They are the most expensive detectors but are beneficial where valuable contents such as fine artifacts are found, or with ornate spaces since the tubing and smoke sampling points can be placed to minimize aesthetic impact.

Projected Beam Detectors. Another type of smoke detector, commonly used for large open spaces such as churches, uses a projected beam of light to detect smoke. This type of detector consists of two components, one wall mounted device that transmits light, and another that receives it. When the amount of light is diminished, the alarm is activated. These projected beam detectors are usually more expensive than spot detectors, but can eliminate the need to place detectors on ornate ceilings (bottom right).

Heat detectors are the oldest type of automatic device and are designed to trigger an alarm when the room's temperature reaches a set temperature (usually 135º-165ºF), or if there is an abnormally fast change to the room's temperature. Heat detectors can be either "spot" devices that are located at nominal 30-50 feet spacing, or as heat sensing cables routed throughout the protected space, called "line" devices.

Heat detectors are highly reliable with good resistance to false alarms, and a generally low cost to install and maintain. However they will not operate until the fire has reached flaming combustion, which is the point at which there may be high danger to occupants and immediate damage to the building is underway. *Heat detectors should never be used for life safety including bedrooms and escape corridors.* Heat detectors are best used where the space is subject to sub-freezing temperatures and smoke detectors may not be effective.

This style of smoke detector is perhaps the most common initiating device in buildings without elaborate fire detection and alarm systems. In many municipalities, an interconnected system of smoke alarms that are all hard wired to the building's electrical system are required. In other locations, only one smoke alarm is required to be hard wired, and the remaining units can be battery operated and connected to the system wirelessly.

The smoke detector to the right is connected to the home's electrical system, and all other smoke detectors connect to it wirelessly. This is the most cost effective means of achieving a reasonable level of fire detection and alarm, and has a minimal and reversible impact on a building's historic fabric.

Automatic smoke detectors effectively identify fires and initiate alarm systems to notify building occupants of the danger. Some systems also notify and summons the fire department.

A projected beam smoke detector has been placed to transmit a detection beam across the ornate ceiling of this church. A corresponding receiver is located approximately 100 feet away on the opposite wall.

Fire Suppression

When a fire occurs it must be extinguished as soon as possible to prevent a major loss of property and/or life. If detection occurs early, then a portable fire extinguisher may be very effective. However, a flaming fire can rapidly exceed an extinguisher's capabilities. When this happens the fire department must apply large volumes of water to prevent complete loss. An alternative is to provide an automatic fire suppression system that can detect the fire and start to control or even extinguish it before the fire department arrives. This will reduce the amount of damage and recovery effort needed to place the building back into use.

BENEFITS OF AUTOMATIC FIRE SUPPRESSION

FAST RESPONSE TO THE FIRE

When a fire is detected, suppression starts immediately, allowing building occupants an opportunity to exit the building, and controlling the fire while the fire department responds.

REDUCED DAMAGE

Since the fire is suppressed at an early point in its development, the damage caused by flames and heat will generally be less. The fire will also require less water for extinguishment, resulting in less water damage, as well.

ENHANCED LIFE SAFETY

The safety of the building's occupants and responding firefighters will usually be increased.

FLEXIBILITY

Building codes frequently permit the use of less restrictive fire resistance and egress requirements when the building is protected by automatic fire suppression. In historic buildings, fire suppression systems may eliminate the need to modify historic features and character defining aesthetic details to meet contemporary codes.

REDUCED INSURANCE COSTS

Buildings protected by automatic fire suppression systems will often see reductions in their insurance rates.

Conventional Suppression Systems - Fire Sprinklers

For most fire situations, water is the ideal and most widely used extinguishing agent. It is an extremely efficient coolant that is environmentally safe, relatively inexpensive, and easily stored and transported. Conventional fire sprinkler systems consist of the water supply, a network of pipes to transport water throughout the building, and series of spray valves or sprinkler heads. System operation occurs when elevated heat levels from the fire (typically in excess of 165º F) cause the sprinkler's thermal sensing element to break and open the waterway, permitting water to flow onto the fire. Fire control is accomplished by the water absorbing heat from the flames and wetting adjacent combustibles to prevent fire spread. This wetting action is commonly referred to as "water damage" - but wetting surrounding objects is actually necessary to limit the fire size and reduce burn damage, and hopefully eliminate the need for large quantities of water to extinguish the burning materials.

It is important to realize that water flow from a sprinkler is initiated by its individual thermal element. Contrary to popular misconception the *only sprinklers that will operate are those in the immediate vicinity of the fire.* Statistically, more than 82% of all fires are controlled by four or fewer simultaneously operating sprinkler heads. What's more, smoke does NOT initiate sprinklers, so burning dinner will not activate the system.

Water damage from sprinklers is another common concern. However, each sprinkler head distributes an average of 15 to 20 gallons per minute of flow, significantly less water than is introduced to the building by fire hoses, which dispense 100 - 250 gallons per minute.

A conventional sprinkler spray discharging approximately 15 gallons per minute. Because only those heads in the immediate vicinity of the fire go off, and even ten heads produce far less water than a single fire hose, water damage is greatly reduced when sprinkler systems are used.

Fire sprinklers cannot shut themselves off. Therefore, to reduce water damage, the building owner should provide the fire department with the location of the shut-off valves when a sprinkler system is installed so that they can readily go to the valve location if the owner is not present when a fire occurs.

Fire Suppression

Alternative Suppression Systems

For most fire situations, water is the ideal and most widely used extinguishing agent. However, alternatives are available and may be appropriate for installation in some historic buildings.

Gas Suppression Systems

These specialized fire extinguishing systems utilize inert or chemical gases rather than water to control fires by a combination of physical and chemical mechanisms that diminish oxygen or interrupt the combustion process. Gas systems consist of stored gas cylinders, a network of pipes to transport the gas to the protected space, open nozzles to distribute the gas into the space, and a fire detection and alarm component.

Fire control occurs when the detection system identifies the fire and opens valves to release the gas, which then flows to the protected room through the piping and nozzles. To be effective, the gas must remain within the room where the fire is occurring. Since an air-tight enclosure is rarely possible in most buildings, gas systems are only recommended for unique situations that can be tightly sealed such as rare document vaults, art galleries and communications switch gear enclosures. They are generally not recommended for an entire building. When considering a gas system, consultation with the system manufacturer's technical representative is important to make sure that the system is appropriate and feasible.

Deluge Suppression Systems

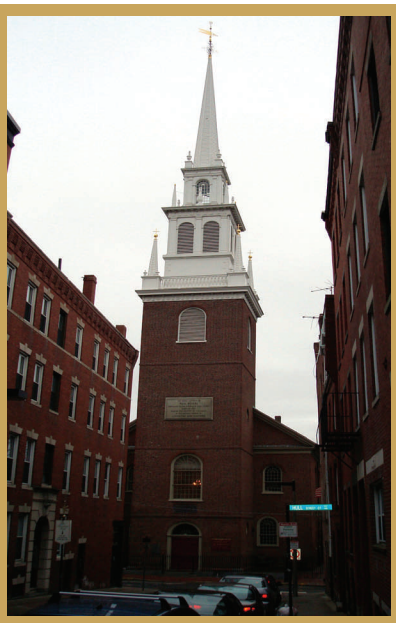
A type of sprinkler system that is unusual but may be found where buildings are closely spaced is the deluge system. This is the exception to the earlier statement that only those sprinklers that are heated by the fire, and not all, sprinklers will operate. A deluge system has an array of pipes and open sprinkler heads along the outside of the building and a heat detection system. When a fire occurs in a neighboring property the system will operate and wet walls to prevent fire spread.

Water Mist Suppression Systems

Water mist systems are the newest generation of sprinklers and are used where excessive water damage must be avoided, where water supplies are limited or restricted (i.e. rural properties), or where a building's construction makes use of conventional pipe sizes problematic.

The basic water mist system is similar to a conventional sprinkler system, consisting of a water supply, piping network, and series of individual sprinkler heads. The main difference, however, is that water mist systems operate at higher pressures to force water through very small sprinkler orifices, producing a cloud of mist rather than large droplets of water.

Water is transported through specialized tubing that - due to the lower water usage rates - will be smaller than conventional systems. This smaller pipe size can reduce the cutting and aesthetic impact in historic and architecturally sensitive buildings. The disadvantage of a mist system is its cost, which may be twice that of a conventional sprinkler system.



A deluge sprinkler system has been installed on the outside of the historic Old North Church in Boston to prevent a fire that occurs in the adjacent building from extending into the church.

Water Mist

A water mist sprinkler spraying approximately 2 gallons per minute. Conventional fire sprinklers spray approximately 15 gallons per minute, and fire hoses distribute at least 100 gallons per minute. Thus, it is clear that the amount of potential water damage from water mist systems is far less than that of other systems.

A series of 12 mm (0.5 inch) water mist supply tubes in a historic wall under reconstruction. The tubes are less than one half the size of conventional sprinkler pipes, and therefore have less physical & visual impact on the historic structure.

Sprinkler System Design & Installation

Design Team

The design of a fire protection system for an existing building can be complex and may require innovative approaches that accomplish protection and preservation goals simultaneously. Several individuals may need to be involved to ensure that full compliance is achieved. These persons can include:

- ***Building Owner or Manager*** to define important building features and aesthetic details and identify specific occupancies and functions of the building. This person should provide information regarding any expected alterations or changes in use so that future modifications to these systems can be minimized.
- ***System Designer*** to produce the design and installation details and identify technical solutions that comply with code requirements for the existing or intended use while preserving the building's significant features. In some instances, a fire protection engineer with experience in historic buildings may be necessary or appropriate.
- ***Code Official*** who is responsible for code and standard requirements and will approve the design including non-standard solutions to unique aspects of the project.
- ***Fire Official*** to provide information on the fire department's emergency capabilities and offer guidance to the design team to insure that the fire protection systems are compatible with the emergency response procedures and abilities. In some instances, the code official and fire official will be the same person.
- ***Insurance Representative*** to identify potential insurance savings with the additional fire protection. If the location does not have a code or fire official the insurer may fulfill that role.
- ***Historic Preservationist*** who can help ensure that the design is compliant with historic preservation standards. In communities such as Bellefonte where exterior changes to buildings located in a regulated historic district require review, the preservationist can help guide the design through any necessary review processes. This person may also be able to help the owner identify preservation grants and tax credits that reduce the financial outlay. They may be affiliated with a preservation architect, an architectural historian, or the state historic preservation office.
- ***Others:*** In addition to the individuals listed above, the fire suppression design team may also include assistance from the local administrator (mayor, borough manager), public works director, and chamber of commerce to ease the construction effort or help to promote a fire safe facility.

Installation Approaches

Conventional fire sprinkler systems include pipes to transport water throughout the building and sprinkler heads that disperse the water in the event of a fire. When designing a sprinkler system, decisions about the type of pipe and sprinkler heads will have to be made. These options are discussed and illustrated in the following pages. But perhaps the most important factor to consider when designing an automatic fire sprinkler system is how the system will be installed. With respect to the actual placement of sprinkler components, there are three general approaches; exposed, camouflaged, and concealed.

- ***Exposed.*** This type of sprinkler system is designed and installed in existing buildings with sprinkler pipes and heads exposed. No attempt is made to hide or camouflage them. Because the labor required to cut, patch, and refinish existing walls and ceilings is a large part of the expense of installing a sprinkler system in an existing building, this will be the least expensive option in most cases. Because of the cost savings, this approach is commonly used in basements, attics, and secondary spaces where appearance concerns are minimal. It is rarely recommended for the most aesthetically sensitive spaces. However, in some instances it may be used when the physical harm of cutting and channeling a building's historic surfaces outweighs the visual impact.
- ***Camouflaged.*** The second design approach also leaves sprinkler piping exposed to avoid cutting and patching of historic materials, but places sprinklers and other fire system components in the least visible portion of a room. The pipe can also be painted to match the background colors of the wall or ceiling.
- ***Concealed.*** The third approach is to conceal the sprinkler components as much as possible. This minimizes the sprinkler system's visual impact in the space, and is preferred where aesthetics are a concern. It is however the most expensive approach since it requires the largest amount of cutting and repair of historic surfaces, and may require additional sprinklers to provide proper coverage since the sprinklers cannot always be placed where they are the most effective. Use of this approach is often limited by budgetary constraints and therefore is often only applicable for the most sensitive spaces.

It is always advisable to consult a historic preservation expert during the design process for assistance in identifying the character defining features of each building and space, so that appropriate installation approaches can be used. The goal of any system design is to find a suitable balance, cutting historic fabric only where it can be appropriately repaired, yet limiting the visual impact of the system on key spaces.

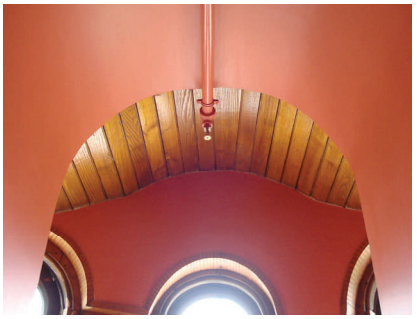
Installation Approaches Illustrated

Example: Centre County Courthouse Annex, Bellefonte, Pennsylvania

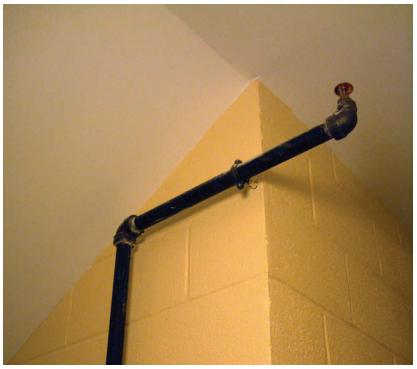
Located on "the Diamond" adjacent to the Centre County Courthouse in the heart of Bellefonte, this historic building (right) that formerly housed a bank was recently rehabilitated by the Centre County Commissioners for use as an additional courtroom, judges chambers, and a public meeting room. As part of the extensive rehabilitation, a fire sprinkler system was installed throughout the building in 2005. The photographs below illustrate the well-designed system, which utilized a combination of concealed, camouflaged and exposed sprinkler pipes to protect the building's important architectural features and maintain the aesthetics of primary spaces to the highest degree possible while still satisfying building code requirements and considering budgetary constraints.

In the primary spaces of the Courthouse Annex such as the public meeting room (top), the courtroom (bottom left), and the elevator lobby (bottom right) where aesthetics are a primary concern, the fire sprinkler system was concealed to minimize its visual impact. Only the small pendant sprinkler heads are visible where they penetrate the ceiling.

This decorative corner feature (interior: right exterior: top right) is a character defining feature of the building. The space required a sprinkler, but cutting the historic fabric to conceal it would be harmful and therefore inappropriate. Therefore, an exposed pipe was installed as inconspicuously as possible and painted to camouflage it.



In parts of the building, including the basement, this service stairway (right) and other secondary locations in the building where aesthetics were not a concern, less expensive exposed pipe components of the fire sprinkler system were installed.



System Component Options—Pipe

There are several piping options for sprinkler systems in historic buildings including copper, steel (galvanized or non-galvanized), and plastic. For many years steel was the most common sprinkler pipe material. However, because of the bulk of steel pipe and its fittings, and its tendency to corrode over time, other options are also common. Copper is more expensive than steel, but because of its relatively small diameter and more delicate fittings, it is often an appropriate choice for installation in historic buildings. When it comes to plastic sprinkler piping, both rigid Chlorinated Poly Vinyl Chloride (CPVC) and flexible cross linked polyethylene pipe, such as PEX, should be considered.

CPVC is a thermoplastic pipe and fitting material commonly used for potable water distribution and fire suppression systems. CPVC piping is resistant to corrosion, and therefore provides a long service life. It is less expensive than copper and steel. CPVC pipe is also easier to install in existing and historic buildings because the plastic pipes can easily be cut to size on site and fitted into awkward spaces, and they are installed with solvent-welded joints, which eliminate problems of using large tools that generate large quantities of heat in confined spaces. CPVC materials do not support combustion and cannot burn without an external fuel source, making them an appropriate alternative to steel and copper pipe for fire sprinkler applications in many cases.

Another type of plastic piping that has distinct advantages for use in fire sprinkler systems in historic buildings is Cross-linked Polyethylene (PEX). The most important advantage to PEX is that it is flexible tubing with a small diameter, which can be "pulled" through the walls and ceilings of historic buildings much like electric wiring. Installation of PEX does require limited cutting and patching – but much less than other types of installation. Cuts are only necessary as required to pull the tubing, and at joints. However, because the tubing is flexible, far fewer joints are necessary. PEX comes in coils, much like wiring, so long runs without joints are possible. Because of its small diameter, many system designers feed water to sprinkler heads from two directions rather than one to ensure sufficient flow to the head. PEX is very inexpensive compared to other types of pipe, so even with the additional material used for dual feeds, the cost of installing PEX systems is comparable to other system types. PEX is not appropriate for exposed installation since it is flexible.

Wet vs. Dry Sprinkler Systems

All water sprinkler systems, whether conventional or mist, are available in wet-pipe and dry-pipe configurations.

Wet Pipe Sprinkler Systems are the most common type and are used where temperatures will remain above freezing. As the name implies, the system's piping is constantly filled with water that is discharged onto flames when the sprinkler head's linkage breaks.

Wet pipe sprinklers are:

- highly reliable with few components that can malfunction;
- fast responding with immediate water discharge onto the fire;
- relatively easy to install and operate;
- typically the lowest cost system to install and maintain;
- offering the largest amount of component offerings;
- flexible and well suited for historic structures with limited cutting and patching.

The main disadvantage of a wet pipe system is that they cannot be used for spaces that are subject to sub-freezing temperatures.

Dry Pipe Sprinkler Systems use compressed air or nitrogen to fill pipes rather than water. This air prevents water from entering the pipes. When the sprinkler operates, the compressed air is released, allowing water flow to the sprinkler.

The disadvantages of a dry system are:

- increased design and installation requirements to ensure proper drainage;
- longer response time than comparable wet systems;
- increased pipe corrosion potential, if they are not properly drained.

Dry-pipe sprinkler systems are only recommended in buildings or portions thereof where freezing can occur.

Often in buildings that are protected by wet-pipe sprinklers, a dry-pipe sprinkler sub-zone can be installed or specially manufactured "dry-sprinkler" heads can be provided for those spaces where freezing can occur, such as exterior porches.

Example of a dry sprinkler sub-zone on the front porch of a historic building in Bellefonte, Pennsylvania. The part of the system that is outside contains compressed air—not water—in the pipes. When these sprinkler heads are activated, the air will escape out of the system, allowing water to flow. The portions of the system that are inside the building where temperatures are above freezing use "wet" pipes.

System Component Options

Pipe

Above: Pendant sprinkler head being fed from both sides by flexible PEX tubing. Below: CPVC

This black iron pipe feeds the dry system shown on the previous page. Although it stands out now because it has not been painted, notice its location behind the door adjacent to existing radiator pipes in the entry hall of this apartment building. In many cases, exposed fire sprinkler systems can be installed very cost effectively in similar locations to the heating system, and simply camouflaged to match the surroundings.

Sprinkler Heads

Sprinklers come in an array of styles depending on the type of hazard that they are protecting, ambient room temperatures, and aesthetic details. For aesthetic compatibility they are produced in several standard finishes including chrome, bright and dull brass, white and off-white, and black. In special cases they may even be custom color painted by the manufacturer to match an existing wall or ceiling finish.

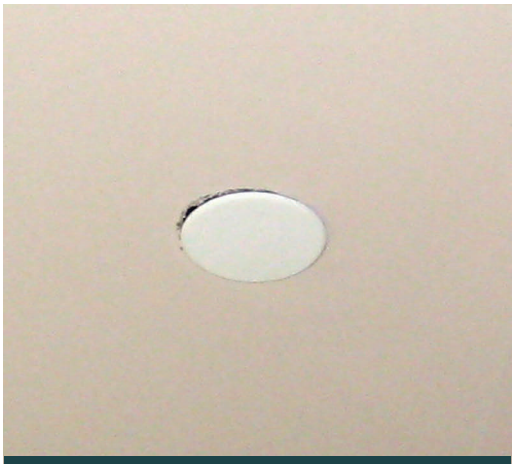
Pendent. These sprinklers are mounted below pipes and are usually located along ceilings where pipe is placed above the ceiling. These are the most common sprinkler styles where finished ceilings are used.

Concealed Pendent. Sprinklers that are mounted below the pipes but the majority of the sprinkler head is located in an enclosure that is mounted immediately above the ceiling plane. A protective flat cover is placed over the sprinkler that reduces aesthetic impact.

Sidewall. A sidewall sprinkler is mounted along the upper plane of a wall and is designed to project the water spray outward from the wall surface. These are frequently used where ornate ceilings are found or to avoid cutting into ceiling materials.

Upright. An upright sprinkler is mounted above the pipe and is usually installed in unfinished spaces such as basements and garages.

Pendent Sprinkler Head



Concealed Pendent Sprinkler Head

Sidewall Sprinkler Head

Upright Sprinkler Head

Design Considerations

In an existing building, the selection of piping material is exceptionally important, since the ability to install the system with the least amount of cutting and patching is desirable. The following factors should be considered when deciding whether or not to install a fire suppression system, which type of system to install, and what installation method and components should be used:

Visual Impact. Each piping material will have different visual aspects. When concealed behind walls and ceilings, this may not be important; but where the pipe must be exposed, the aesthetic impact may need to be minimized with less obvious pipe and fitting choices. For example, copper tube and its trim fittings may be preferred over steel pipe in an architecturally sensitive area because the steel pipe and fittings are bulkier, and will have a greater visual impact in that space.

Physical Impact to Historic Fabric. When retrofit work is undertaken, the building will be altered as holes are drilled, walls and ceilings are channeled, and anchors are fastened. System components should be installed in a reversible manner so that the system can be removed in the future without compromising the integrity of the historic building. Therefore, cutting work must be done to materials that are easily repaired rather than those that cannot be fixed. For example, a hole that is drilled in plaster can often be repaired with minimal effort so that it has the original appearance. On the other hand if a hole is drilled in unpainted wood or stone, it can never be fully repaired.

Installation Factors. Each sprinkler pipe material has unique installation requirements, with some materials taking longer to install than others. For buildings that are out of service during renovation, this may not be important; but when the building is in use during installation, then the ease of installation can be important to minimize disruption to operations. The amount of disruption will depend on the ease with which a component can be installed and the amount of cutting and patching that is required. Whenever possible, the more disruptive work should be done in secondary use areas. In historic buildings where cutting and patching is expensive and can damage historic materials, the use of some pipe materials can result in an easier and less harmful project. Plastics tend to be the easiest to install.

Cleanliness. Some materials - such as carbon steel - can experience the buildup of minerals and other deposits in the water. When the sprinkler operates, these deposits will discharge and can stain artifacts and historic fabric. Other materials such as copper, stainless steel and plastic are less prone to this condition and result in clean water discharge.

Durability. All of the approved sprinkler pipe materials can be durable; however, there may be environmental or placement factors that can have an effect on the physical impact or corrosion of the material. Copper can have a low visual impact when exposed—but it tends to suffer more damage if it receives physical impact than steel pipes do. An analysis of where a pipe will be placed and the condition of water supply should be undertaken during the selection process.

Life Expectancy. Certain pipe materials have an inherently longer life expectancy than others - but this can come at an added cost. If a portion of the building is readily accessible and does not require a high amount of cutting and patch work, then a lower cost material may be appropriate since it can be easily replaced when it wears out. Where an installation requires extensive wood and plaster work, which will add to the system cost, then a pipe material with a longer life expectancy, such as copper, stainless steel or plastic may be preferable.

Cost. Different system types and their components will have varying costs, which must be weighed against the potential benefits.

The ornately finished room shown above provides an opportunity to think through the available design considerations. The property owner would have to decide whether cutting and patching the walls would have enough of an impact that it would be worth exposing and camouflaging the sprinkler pipes. If the pipes were exposed, copper would likely be chosen for this room because of its minimal size, its ability to be painted, and the cleanliness of the water that will be discharged in case of fire. If the pipes are concealed, PEX would likely be the preferred material since it could be pulled through the walls with minimal cutting and patching. Regardless of the type of system, sprinkler heads could be selected and placed to minimize their visual impact.

Water Supply

Most sprinkler systems are supplied by the municipal water authority, which is usually the most reliable and least expensive source. Pressures available in most municipal water systems are adequate for buildings that are less than five stories in height. However, for some taller or exceptionally large buildings, a supplemental fire pump may be needed to boost the sprinkler system pressure. The local water authority can be a useful resource to help determine if enough flow and pressure is available for a sprinkler system.

In rural areas not served by a public water agency, water for a sprinkler system can be supplied by gravity tanks, tanks with a pump, or a pressurized tank. Rarely will a rural well system be able to meet the flow demands of a sprinkler system, even a light demand residential sprinkler, and therefore a separate pump that is designed for fire sprinkler service may be needed.

System Costs

Cost is an important issue when a deciding to install a fire sprinkler system. Fire sprinklers are specialty systems with several factors that can impact the overall cost including the location distance from qualified sprinkler contractors, the system's size, the availability of water, the type of materials used, and the amount of building fabric cutting and patching that will be needed. It is always advisable to contact a local sprinkler contractor to obtain a more accurate estimate for your locality.

As a starting point, an average cost of $2-3 per square foot of floor area may be used for a wet pipe sprinkler system with steel piping exposed and where a public water supply is available.

Metal prices are often subject to price fluctuations; however; for estimating purposes, using copper instead of steel will typically add 10%-15% to the system cost. Conversely, systems with CPVC or PEX plastic piping may cost as little as $1.20 to $2.00 per square foot. For a dry-pipe system, an average cost of $3-5/ per square foot may be used. System prices will often be higher for rural structures that lack a public water supply.

If the historic building requires an aesthetically sensitive installation, this cost can increase to approximately $10-$12 per square foot, as walls, ceilings and various architectural details are removed to install piping and then reconstructed. For these situations a restoration carpenter should be consulted to determine the associated costs for this work.

The corridor illustrated above is an extremely visually important space. Therefore, sprinklers were placed so that all piping is routed behind the walls in a secondary utility space. The white sidewall sprinkler is placed further than normal from the ceiling and its satisfactory performance verified by the manufacturer.

The photograph below shows the pipe located in a the utility closet that supplies the sprinkler head shown in the photograph above.

IMPACT OF AUTOMATIC SPRINKLERS ON SAFETY CODE REQUIREMENTS

Because of the effectiveness of automatic sprinklers in controlling fires, building and fire codes relax certain requirements in a fully sprinkled building.

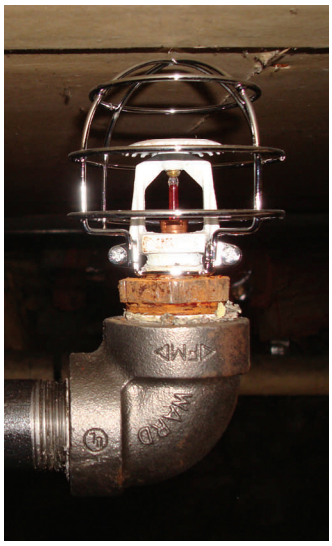
- Reduced structural fire resistance requirements
- Greater height and area allowances
- Increased allowable egress travel distances
- More latitude for flame-spread rating of interior finishes
- Acceptable floor opening configurations

Although fire sprinkler systems can be expensive, they often have very positive off-setting benefits.

In many communities, installing fire sprinkler systems is an allowable alternative to installing additional means of egress. In historic districts, where the character and integrity of the district as a whole is important as well as that of the individual building, sprinklers provide a good alternative. Unlike the fire escape shown above, they have little or no visual impact on the historic district—and may help to save a building from destruction in addition to providing for the safety of the occupants.

Left: The fire sprinkler system in this room in a historic building was left exposed to avoid cutting of the historic surfaces and to save on installation costs. Copper pipe was selected since the fittings have a slim profile and it can be easily painted to camouflage with the surrounding wall colors. The pipes were also located so that they were out of the "photographic" angle, so that they are not visible when entering the room. Sidewall sprinkler heads were used in this room.

Right: White upright sprinkler on exposed black iron pipe, with protection cage in the basement of a historic apartment building.



Frequently Asked Questions

This bulletin covers a lot of information. Every historic building is unique in its use and features so there is no one recipe that will work for everybody. Here are some typical questions that you may have on how to use the bulletin for your specific building:

Q: How do I take all of this and make it happen for me?

A: Develop a plan. Assess your fire safety situation and then list what could be done to improve it. Consider the basic items of fire hazards, construction features, how fire can spread, and what will control it. This will vary by the type of building you have and the priorities you establish.

Q: What are my first steps?

A: Do a walk through survey of your building looking at things that might allow a fire to start or spread. You may want to get local input to help identify these issues in your building. Talk with your local preservation board or planning commission, your fire department, your insurance agent, and your contractors or service people. Show them this bulletin and ask them to help assess what is needed. The information you have read should help you ask the right questions and understand the answers.

Q: How do I determine priority for a phased project since my budget is limited?

A: The priorities are: 1) prevent fires from starting and spreading; 2) alert occupants and authorities if a fire starts; and 3) control spread of the fire to minimize damage. Use the information you have collected and make a list of items to be accomplished and the parts of each item that can be dealt with individually. Timing is important. If you are planning construction or refurbishing projects, then improved fire protection can be included at lower cost. Each building will vary by the nature of the activity and your specific fire safety objectives.

Q: If I can do only one thing, what would it be?

A: A lot of fire safety is awareness and common sense. Look at your plan try to assess what would make the greatest impact on fire safety for your building. Decide what your fire safety objectives are and investigate how they can be achieved. In most cases, life safety will be most important. Figure out which occupants are at greatest risk and how they can be better protected. Smoke detectors are essential for occupant safety and alerting the fire department. A fire escape may be very important for the safety of occupants. Sprinklers will protect both the people and the building.

Q: Which rooms typically contribute to the start or spread of fire?

A: Every building is used differently. Fires start where there is something hot and something that will burn. In residential occupancies this can be the kitchen, which by its function has heat producing appliances. Staff areas in commercial occupancies are comparable. Smoking is a leading cause of fires, making smoke-free environments serendipitously more fire safe. Upholstered furniture is easy to ignite and space heaters are notorious sources of ignition. Basements are a threat because they often contain central heating units and are used for storage of combustible materials.

Q: What about partial sprinkler systems?

A: Most authorities, including insurance companies, look for "full coverage" sprinkler systems that protect all or most areas of a building. A partial system is one that is installed only in one part of a building. The limitation is that if a fire starts in the unsprinklered portion of the building it may overpower a partial system. Partial sprinkler systems in basement areas can be cost-effective to install when the ceiling is open and accessible.

Fire sprinkler systems are designed and installed in accordance with standards established by the National Fire Protection Association, specifically:

NFPA 13: Standard for the Installation of Fire Sprinkler Systems.

The standards are different depending on the type and use of a particular building, so consult with a fire protection engineer or your local building official to determine what type of system is right for your building.

These are the common variations in sprinkler systems:

- 13 standard used for most commercial buildings
- 13R standard used for multiple unit dwellings
- 13D standard used for one and two family residences

Fire sprinkler systems are becoming increasingly common, and will in fact be required in all new connected dwellings built after January 1, 2010, and in all new single family residences built after January 1, 2011 throughout Pennsylvania. This will likely be a benefit to historic buildings, as technologies will continue to improve, making materials easier to install with minimal impacts, and more cost effective as the demand on contractors increases.

Above: Concealed sprinkler pipe with white sidewall heads have a minimal visual impact on this important historic interior. **Below:** Exposed sprinkler system in a building where concealing the components would harm the building's historic fabric and thus not be appropriate.

Resources

The following is a partial list of qualified organizations and manufacturers where additional information and assistance can be obtained:

Historic Building Fire Safety

- *NFPA 914, Code for Fire Protection of Historic Buildings*, National Fire Protection Association, Quincy, MA, 2005. www.NFPA.org
- *Fire Safety in Historic Buildings*, Jack Watts, National Trust for Historic Preservation, Washington, DC, 2007 www.PreservationNation.org
- *Fire Safe Building Rehabilitation*, John M. Watts, Jr., and Marilyn E. Kaplan, Fire Safety Institute, Middlebury, VT, 2003. www.FireSafetyInstitute.org

Fire Protection Consulting Engineers

- Fire Safety Institute • 802-462-2263 • www.firesafetyinstitute.org
- Heritage Protection Group • 802-388-1064 • fire-safe@gmavt.net

Fire Detection and Alarm Systems

- Airsense Technology • 877-641-2453 • www.airsense.us/
- Edwards Systems Technology • www.gesecurity.com • 888-437-3287
- Fire Control Instruments • 203-484-7161 • www.gamewell-fci.com
- Notifier • 800-289-3473 • www.notifier.com
- Tyco Fire and Building Products • 800-746-7539 • www.tycofireandsecurity.com
- Xtralis • 800-229-4434 • www.xtralis.com

Fire Protection Standards

- National Fire Protection Association (NFPA) • 800-344-3555 • www.nfpa.org
- International Code Council (ICC) www.iccsafe.org

Fire Sprinkler Systems

- Marioff Hi Fog • 410-354-9020 • www.marioff.com
- Reliable Automatic Sprinkler Company • 864-843-5227 • www.reliablesprinkler.com
- Viking Corporation • 877-384-5464 • www.vikingcorp.com
- Tyco Fire and Building Products • 800-746-7539 • www.tycofireandsecurity.com

Extinguishing Gases

- E I DuPont de Nemours and Company • www2.dupont.com/FE/en_US/products/index.html
- Tyco Fire and Building Products • 800-746-7539 • www.tycofireandsecurity.com

Summary

This Bulletin does not include everything you need to know about fire detection and suppression, but it does introduce some of the resources and options available to help you protect your historic property from fire. You can start here and determine who you need to talk to and what else you need to read. There is no way to guarantee that your building will not experience a serious fire, but there is a lot that you can do to make a fire event less likely and less severe if it does occur.

Fire is one of the most serious threats to a building, with consequences that can include harm to occupants and firefighters, damage to the structure and its contents, loss of building use, visual harm to the streetscape, and impact on the tax base. A comprehensive fire safety program that includes fire prevention and fire resistance features is needed to reduce the ignition and fire spread potential. Fire detection and alarm and automatic fire suppression systems can further reduce a fire's impact by identifying a fire while it is small, alerting the building's occupants, and initiating fire control before the fire department can respond.

There are many types of detection devices ranging from heat detectors that confirm the existence of visible flames to highly sensitive air aspirating smoke sensors that identify the invisible particles of an incipient smoke condition. There are several kinds of automatic suppression systems including conventional sprinklers, water mist sprinklers, deluge sprinklers, and extinguishing gases. The selection of a particular system or group of systems is dependent upon a variety of factors including the life safety, building significance, content value, aesthetics, historic features, and cost.

The Brockerhoff House, a former hotel that has been rehabilitated for mixed commercial use on the first floor and senior housing on the upper levels, had a fire sprinkler system installed many years ago. The system of concealed pipes and sidewall and pendant sprinkler heads helps to illustrate that technologies are always improving. The components are being refined so that they can be installed with less and reduced in size and visual impact.

Above: The Brockerhoff House—the first building in Bellefonte to have a complete fire sprinkler system. Above right: Large sidewall sprinkler head located in the stair hall. Right: Historic stairway in the lobby, with sprinkler head and fire emergency light.

Front Cover Photo: The sprinkler pipe could not be channeled through the wall details without causing permanent harm to the building surfaces. Therefore, exposed copper pipe was selected and placed so that the room's architectural features reduced the visual impact.

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