FIRE SPRINKLER RETROFIT IN HISTORIC STRUCTURES

HISTORIC PRESERVATION

Protecting places that matter to each of us...
the stories of our communities and lives

APRIL 2019

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

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ACKNOWLEDGEMENTS

On the 15th of April 2019, a devastating fire severely damaged the Cathedral Notre Dame de Paris. At the time, the NFSA was working on a Retrofit Guide for existing buildings. One of the subjects in that guide was a section on historical structures. That section of the guide will remain but, as a result of the Paris fire, President Shane Ray tasked me to prepare a stand-alone document for historical retrofits. To that end, several people were of enormous help in preparing this report:

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FORWARD

It is unfortunate, but true; we are exceedingly reactive to fire safety in the United States and, for that matter, the world. We change our regulations only when shocked into doing so; we always seem to ask, "How could this have happened" after major fires. It has been observed that "...fires involving major loss of life have resulted in important changes in building and fire codes and in standard protection and prevention practices."[1] But, if we learn our lessons by studying the past; can we not be proactive in order to assure that history does not repeat itself? The fact of the matter remains "Automatic fire sprinkler use has the ability to solve much of America's fire problem in every class of occupancy."[2]

Can we not assure that future generations will not be denied the awe of our history because that history was destroyed by fire? Can we not take steps now to assure that historical structures, and their invaluable contents, are provided the protection needed to secure their continued existence for generations to come? Do we not owe this to our descendants so they will not have to ask, "How could this have happened?"

John R. Waters, EFO, MA, MS
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April 2019

[1] Hall, J. & Cote, A. (1997). *Fire protection handbook.* Quincy, MA: National Fire Protection Association.

[2] The Johnson Foundation (2016). *Wingspread VI – statements of national significance to the United States Fire and Emergency Services.* Racine, WI: Author

Historic Preservation

PREFACE

"At its most basic, preservation is about protecting places that matter to each of us. We want our children to know these places. We want them to stand as beacons for us and for those who come after us... to tell our stories, and the stories of our communities and our lives."

– Stephanie K. Meeks
President and CEO
National Trust for Historic Preservation

NATIONAL PARK SERVICE RECOMMENDATIONS

One cannot "unburn" a historical structure; it's gone forever, as is its story. That which might replace it can be, at best, a replica. Historic preservation is a challenge, a balancing act; how does one preserve the historic character of the building, and its contents, while assuring that it will stand for generations by protecting itself from the ravages of fire? Jack Watts, author of *Fire Safety in Historical Buildings* seems to have answered that question. In writing his guideline for the National Trust for Historical Preservation, he states:

- 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.[1]
- "Automatic suppression systems can significantly help prevent loss of a historical building to fire – and can also save lives."[2]

Unfortunately, historically significant buildings are not immune to fire and the loss of these buildings can have far-reaching effects beyond those that an insurance claim may cover.

- **July 2004**, in the Borough of Bellefonte, PA, Bellefonte Academy, a historical private school which educated "more governors, senators and judges than any other school in Pennsylvania" was destroyed by fire.[3] In February of 2006, two years later in the same town of Bellefonte, the historic Bush House Hotel build in 1868, was also destroyed by fire. The small town suggests that the fires and loss of two significant historical properties put a considerable dent in the local economy.[4]
- **Christmas Day 2009**, in the town of Longford, Longford County Ireland, St. Mel's Cathedral was lost to fire, leaving just the shell of the building standing. The fire appears to have begun in the chimney, spreading into the area of the altar and, ultimately, burning the church "from end to end."[5]

St. Mel's Cathedral (Longford County, Ireland)

St. Mel's Cathedral (Longford County, Ireland)

One of the artifacts lost to the fire, was St. Mel's Crosier, a staff carried by a bishop as a symbol of his pastoral office; it was over 1,000 years old, obviously irreplaceable. It took 5 years to rebuild.

- **September 25, 2013**, the City of Georgetown, South Carolina suffered a fire "that leveled the center of the town's historic waterfront district... one century-old building after another was consumed until an entire city block, mainstay businesses, restaurants and apartments lay in ruin.[6]

Waterfront District (Georgetown, South Carolina)

[1] Watts, J. (2008). *Fire safety in historic buildings*. Retrieved from https://forum.savingplaces.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=aaa38a6e-c709-6a92-4a90-24a444c1c4fc&forceDialog=0

[2] Ibid.

[3] http://www.collegian.psu.edu/archives/article_8271497f-f7ce-5751-a995-7cd634a54717.html

[4] http://www.firehouse.com/photostory/10549771/historic-building-destroyed-in-bellefonte-pennsylvania

[5] Retrieved from https://en.wikipedia.org/wiki/St_Mel%27s_cathedral,_Longford

[6] Retrieved from http://www.wmbfnews.com/story/26629195/wmbf-investigates-the-front-street-standoff/

NATIONAL PARK SERVICE RECOMMENDATIONS *(continued)*

Waterfront District (Georgetown, South Carolina)

Four years later, there was still a gaping hole in the middle of Georgetown's historic district.

Seven buildings and over 130 jobs were lost, and the cause is officially listed as "undetermined."

- **July 30, 2017**, in Wagoner, OK a massive fire burned down several historic buildings in the downtown area that were built in the 1800's. This fire prompted the Mayor of Wagoner to encourage residents to "limit water usage" because of the amount of water utilized to contain the fire.[7]
- **August 2017**, compare the Notre Dame fire to a fire event that was experienced at the Smithsonian Institution Building, also known as "The Castle," in Washington, DC.

The Castle (Washington, DC)

Completed in 1855, it was retrofitted with sprinklers to protect the building, those who work and visit there and, of course, any and all historical artifacts stored there. The fire occurred on the 3rd floor, in a staff area, was electrical in nature and, according to Smithsonian Spokesperson Linda St. Thomas, "…the sprinkler put it out." The building was re-opened the following day. The unsprinklered Notre Dame restoration will take years and millions of dollars. The sprinklered Smithsonian Castle was closed for less than 24 hours and damage was minimal. A perfect comparison and a compelling example of the difference sprinklers make.

- **October 9, 2017** in Spring Valley MN, a fire engulfed a historic building and residents from neighboring apartment buildings were evacuated. This building was dated back to 1870 and listed in the National Register of Historic Places database, however the after the fire the building was considered a "total loss."[8]
- **January 13, 2018** in Stratford, Connecticut, the Shakespeare Theater was a total loss. The Theater, which hosted such greats as Fred Gwynne, James Earl Jones, Kim Hunter, Hal Holbrooke and Ed Asner, burned to the ground after the fire department was called to the building at about 1:00 am. According to Fox 61 News, the structure was still burning at 6:00 am and had suffered at least a partial collapse.[9]

Shakespeare Theater (Stratford, CT)

[7] http://kfor.com/2017/07/31/several-historic-buildings-destroyed-in-wagoner-fire/

[8] http://www.hometown-pages.com/Content/Default/Breaking-News/Article/Fire-levels-downtown-Spring-Valley-historic-building/-3/549/69616

[9] https://fox61.com/2019/01/13/historic-shakespeare-festival-theater-burns-to-the-ground-in-stratford/

NATIONAL PARK SERVICE RECOMMENDATIONS *(continued)*

Construction started in the year 1163 and completed in 1345; the Cathedral Notre-Dame de Paris is an iconic structure known throughout the world. The laying of the corner stone was completed in 1163 and was witnessed by King Louis VII and Pope Alexander III.[10] The Cathedral Notre-Dame de Paris has witnessed history as few other structures have, through revolutions and wars; and yet it stood, until...

Cathedral Notre-Dame de Paris (Paris, France)

On April 15th, 2019, it suffered a devasting fire, which, according to Frederic Letoffe, the head of several companies that restore historic monuments, feels that full restoration of the Cathedral could take up to 15 year. It is reported that the Cathedral, as a tourist site, is visited by up to 12 million people per year. Fire spares nothing; only through the efforts of the Brigade des sepeurs-pompiers de Paris, France's army-based fire department, were many of the historical and religious artifacts saved.

Fire cares nothing about the "historical fabric" of the building or its contents; there must be found some happy medium to assure that such cultural icons are not lost forever; our children deserve no less.

PROTECTING HISTORIC STRUCTURES FROM FIRE

These are a few recent examples of historical building fires that changed the lives, character and history of many communities.

The Brockerhoff Hotel is a historical building in Bellefonte PA. Later named the Brockerhoff House, this building was rehabilitated and retrofitted with a fire sprinkler system. Subsequently, the building was utilized as a multi-use facility, housing residential individuals. Furthermore, the Brockerhoff House was added to the *National Register of Historic Places* on April 11, 1977 and is quaintly located in the Bellefonte historical district.

Brockerhoff House (Bellefonte, PA)

Many communities with historical buildings utilize those buildings to enhance their economy. For example, the City of Annapolis, MD is a National Historic Landmark District (NHLD), which means it is officially recognized as by the United States government for its outstanding degree of historical significance. National Historic Landmarks such as the Maryland State House, St. Anne's Church, and William Paca House are a part of the historic district.[11]

As a result, many tourists visit Annapolis to view the historic structures and learn about their rich history.

On December 12, 2015 a fire occurred at the Historic Annapolis Yacht Club that caused $9,000,000 worth of damage. In addition to the loss of the building itself, numerous artifacts that were displayed in yacht club were lost.

The Yacht Club fire prompted the city to consider adopting a retrofit ordinance for their historic district to ensure that the city would not experience a similar catastrophic loss. To facilitate the process a taskforce was put together consisting of various community stakeholders consisting of alderman,

10 Retrieved from https://en.wikipedia.org/wiki/Notre-Dame_de_Paris

11 Historic Annapolis accessed May 2, 2018. http://www.annapolis.org/historic/historic-district

PROTECTING HISTORIC STRUCTURES FROM FIRE *(continued)*

Historic Annapolis Yacht Club (Annapolis, MD)

business owners, emergency management, fire department, and the Bureau of Inspections and Permits, to name a few.

In 2002, a devasting fire in Petaluma, CA severely damaged five businesses in their downtown/historic district. Realizing the risk fire posed to this historical area, City Council passed a "Fire Sprinkler Retrofit Ordinance for Existing Buildings in the Historic Downtown Business District."[10] In its executive summary, the justification for the ordinance states:

The architecture and building configurations contribute to the charm and ambience of the downtown area. Since 1960, the Historic Downtown has suffered 16 fires... The potential exists to a have a fire that destroys several of our vintage buildings and forever changes the face of the downtown area. The installation of fire sprinklers in these buildings would significantly reduce the risk of fire and preserve the City's structural heritage for years to come. To that end, the City:

- Physically identified the historic district boundaries
- Required the retrofit of sprinklers:
  - At any change of use
  - When the building or occupancy is increased by 25%
  - In below-grade areas by December 31, 2014
  - Throughout the entire building by December 31, 2024

Certain sections of the Historic District did not have the infrastructure to support fire sprinklers. Working with the Fire Department, their Water Department planned to replace the water mains in this area and install connections for sprinklers as part of that project. It should be noted that in the sections that did have the supporting infrastructure, the Water Department installed these connections as part of the upgrade. In the sections that needed the upgrade the requirement for final installation of sprinklers became effective:

- 10 years after the upgrade for below-grade areas
- 20 years after the upgrade for the entire building

Christ Church in Philadelphia's Old City section took heed of the words of a former member, Benjamin Franklin, who stated "A penny of prevention is worth a pound of cure."

Christ Church (Philadelphia, PA)

They retrofitted not only the interior of the church but installed a deluge system to protect the steeple.

When built in 1754, the steeple was the tallest structure in the city. The system was tested recently to demonstrate the commitment the congregation has in protecting this iconic symbol in the place where the United States was born. The building houses historic artifacts going back to 1695. The Church hosted members of the Continental Congress during the American Revolution and such notables as George Washington and John Adams attended services there. Its loss would be devastating to the City of Philadelphia, thus the investment in the retrofit of fire sprinklers.

[10] City of Petaluma, CA. (2004). *Fire sprinkler retrofit ordinance for existing buildings in the historic downtown business district.* Petaluma, CA: author

[11] National Fire Protection Association. (2018). NFPA 14 – Code for the protection of historic structures. Quincy, MA: author

[12] Ibid.

NFPA 914 – CODE FOR THE PROTECTION OF HISTORIC STRUCTURES

This code introduces the concept of goals and risk tolerance. It states, "Goals and objectives shall be adopted that reflect the tolerance for risk that is acceptable to those responsible for the historic structure and historic district."[14]

Essentially, it asks "those responsible" to consider the possible fire scenarios that could occur within the structure or district and to determine the possible consequences of such fires, including: "the development of fire, the spread of combustion products throughout the building or portion of the building, the reactions of people to fire, the impact of a fire on the historic significance, and the effects of combustion."[15]

"Those responsible," then, would determine what degree of loss is tolerable and how to mitigate those effects that are intolerable.

Apparently fire sprinklers were considered for the Cathedral Notre Dame de Paris; in an article in the New York Times, it was reported that there was a "conservative approach" to preserving the historic wooden structure in its "unadulterated form."[16] From a risk assessment/management approach, "those responsible" for the Cathedral decided to forego modern fire protection features, banked on fire prevention and detection; obviously that did not work as expected.[17]

THE DECISION-MAKING PROCESS

Once the decision has been made to retrofit a historic building steps should be taken to increase the probability of success. A guide titled *Fire Safety Retrofitting in Historic Buildings* which was jointly issued by the Advisory Council on Historic Preservation and the General Services Administration provides steps that could be taken to assess how a historic building currently performs in the event of a fire, define what deficiencies need to be corrected to ensure building and content preservation, and to determine how best to correct these deficiencies in a manner that both ensures fire safety and preservation of historical features.

Project Team Organizational Chart for Fire Safety Retrofitting[13]

[13] https://www.gsa.gov/cdnstatic/Fire_Safety_Retrofitting_in_Historic_Buildings.pdf

[14] National Fire Protection Association. (2018). *NFPA 14 – Code for the protection of historic structures.* Quincy, MA: author

[15] Ibid.

[16] Bennhold, K. & Glanz, J. (2019, April 19). Notre Dame's safety planners underestimated the risk, with devastating results. *The New York Times.*

SPRINKLER SYSTEM DESIGN AND INSTALLATION

Designing a fire protection system for a historical building can be complex and often require innovative approaches that protect and preserve the building simultaneously. Multiple stakeholders should be involved to ensure that protection and preservation goals are accomplished. Listed below are a few of the stakeholders that you may want to consider:

- 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 nonstandard 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 ensure 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 protection design team may also include assistance from the local administrator (mayor, city manager), public works director, and chamber of commerce to ease the construction effort or help to promote a fire safe facility.[14]

Conventional fire sprinkler systems include pipes which transport water throughout the building and sprinkler heads that disperse the water in the event of a fire. When designing a sprinkler system, decisions must be made concerning the type of pipe and sprinkler heads that will be used. However, 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 a historical 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 camouflaged 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. Pipes 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

[14] Artim, N. and Watts, J. (2009). *Fire Detection & Suppression for Buildings in Historic Districts.* Bellefonte, PA: available at https://bellefonte.net/wp-content/uploads/2009/05/Fire-Grant.pdf

[15] Ibid.

[16] Ibid.

SPRINKLER SYSTEM DESIGN AND INSTALLATION *(continued)*

minimizes the sprinkler system's visual impact in the space and is favored where aesthetics is 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. Utilizing the concealed approach is frequently limited by budgetary constraints and therefore is often only applicable for the most sensitive spaces.[15]

INVESTING IN FIXED FIRE PROTECTION

Identification of cost for retrofitting historical or heritage buildings will be of wide variance. These variances will be based upon the aesthetic sensitivity of the building and architectural design of the building, as well as the use of a restoration carpenter to facilitate the artistic blueprint of the building.[16]

In summary, fire is one of the most serious threats to a historical building, with consequences that can include harm to occupants and firefighters, damage to the structure and its contents, loss of building use, and impact on the tax base. Automatic fire sprinkler systems can further reduce a fire's impact by identifying a fire while it is small and initiating fire control before the fire department can respond. Selecting a fire protection system is dependent upon a variety of factors including the life safety, building significance, content value, aesthetics, historic features, and cost. As mentioned above, there is an inherent responsibility to ensure that historic structures are maintained and protected so that they can be seen and appreciated for many generations.

WHAT IS RETROFIT?

The Merriam Webster Collegiate Dictionary defines "retrofit" as "to install (new or modified parts or equipment) in something previously manufactured or constructed."[17] As you will see as you go through this guide, fires have changed and changes in the building code result from experience... i.e., a tragic fire occurs and then the building code is modified to prevent a reoccurrence of the circumstances that contributed to the tragedy.

Unfortunately, building codes are only applicable for new construction, yet there are thousands of buildings out there, that, if newly built, would require fire sprinklers, but, since they already existed when the changes in the building code were adopted, they remain without sprinklers.

As we study these tragic fires: how the fire started, how it grew, that which fire department found when they arrived, and how to prevent them in the future; we find that, perhaps in certain instances, we need to pass laws that would require the retroactive requirement for sprinklers regardless of when the building was built. That is what "retrofit" is all about; identifying high risk occupancies and buildings that were built before sprinklers were required and passing legislation to require that sprinklers be installed within some reasonable timeframe, either through adoption of model codes that require retrofit or adopting stand-alone ordinances for the requirements.

[14] Artim, N. and Watts, J. (2009). *Fire Detection & Suppression for Buildings in Historic Districts.* Bellefonte, PA: available at https://bellefonte.net/wp-content/uploads/2009/05/Fire-Grant.pdf

[15] Ibid.

[16] Ibid.

[17] Retrieved from https://www.merriam-webster.com/dictionary/retrofit

[18] National Fire Protection Association. (2019). *NFPA 13 – Standard for the installation of sprinkler systems.* Quincy, MA; author

[19] National Fire Protection Association. (2019). *NFPA 13D – Standard for the installation of sprinkler systems in one- and two-family dwellings and manufactured homes.* Quincy, MA: author

PROPERTY PROTECTION VERSUS LIFE SAFETY PROTECTION

Typically, when discussing fire sprinkler protection, the issue is raised as to whether a fire sprinkler system is a property protection or life safety system. The purpose of NFPA 13 "...shall be to provide a reasonable degree of protection for life and property from fire through standardization of design, installation, and testing requirements for sprinkler systems, including private fire service mains, based on sound engineering principles, test data, and field experience."[18]

NFPA 13R and 13D's purpose is a little different; it is "…to prevent flashover (total involvement) in the room of fire origin, where sprinklered, and to improve the chance for occupants to escape or be evacuated."[19] As such, NFPA 13R and NFPA 13D must be considered a life safety system. A benefit of the system is that its designed "to prevent flashover (total involvement) in the room of fire origin," however, the system will also reduce the property damage resulting from a fire.

As organized as a fire department may be in responding to a fire emergency, or any emergency for that matter, it must be said that they can only respond to the alarm once it has been called in and subsequently dispatched. Until arrival at the scene of an emergency, there is little that can be accomplished to control and extinguish a fire. Both the firefighter and the automatic fire sprinkler work a schedule that is 24-hours, 7-days a week, 365-days a year. The difference is that a fire sprinkler is located directly over the area of fire origin and can operate as soon as the temperature in that area reaches the activation temperature, which in the case of a residential fire sprinkler is 135°-170° F.

Similarly, an automatic fire alarm system works the same schedule but can only detect and alert the fire department or occupants in the event of a fire. While the need for detection and notification is essential, through the use and installation of smoke alarms, for a balanced fire protection design, it must also be recognized that fire detection does not proactively control the growth of a fire.

WHY ARE RETROFIT PROGRAMS NEEDED?

Fires have changed; it's a simple as that. The key to saving lives and reducing property damage, once the fire has started, is the prevention of a phenomena called "flashover." According to Dr. James Milke, Department Chair of Fire Protection Engineering at the University of Maryland, "flashover is considered the point of transition from a 'small fire,' involving a small number of objects in the room, to a 'large fire,' involving all objects in the room."[20] NFPA 921 defines flashover as "A transitional phase in the development of a compartment fire in which surfaces exposed to thermal radiation reach its ignition temperature more less simultaneously and fire spreads rapidly throughout the space resulting in full room involvement or total involvement of the compartment or enclosed area."[21]

Most are aware that people who succumb to fire are felled by "smoke inhalation." The primary constituent of smoke is carbon monoxide and Gordon Hartzell observed "…a rapid increase in carbon monoxide yield occurs almost simultaneously with flashover."[22] If we can prevent flashover, we can save lives. The key is time ... we need to get water on the fire before flashover. Fire sprinklers buy time – time buys life.

So, what of the time to flashover? As mentioned, fires have changed and the time to the achievement of flashover in a compartment fire has changed drastically. Prior to the requirement for sprinklers in many of our buildings and occupancies, the fire

[20] Milke, J. (1984). *Fire dynamics.* Lexington, MA: Ginn Custom Publishing.

[21] National Fire Protection Association. (2017). *Guide for fire and explosion investigations.* Quincy, MA: author.

[22] Hartzell, G. (1997). Combustion products and their effect on life safety. In A. Cote (Ed.) *Fire protection handbook.* Quincy, MA; NFPA

[23] National Fire Protection Association. (2019). *NFPA 1221 Standard for the installation, maintenance and use of emergency services communications systems.* Quincy, MA: author

[24] Ibid

[25] National Fire Protection Association. (2016). *NFPA 1710 Standard for the organization and deployment of fire suppression operations, emergency medical operations and special operations to the public by career fire departments.* Quincy, MA: author

[26] National Fire Protection Association. (2014). *NFPA 1720 Standard for the organization and deployment of fire suppression operations, emergency medical operations and special operations to the public by volunteer fire departments.* Quincy, MA: author

WHY ARE RETROFIT PROGRAMS NEEDED? *(continued)*

department had time to receive the information, be dispatched and arrive in a timely manner to interdict in the march towards flashover. Unfortunately, this is no longer true. If a picture is worth a thousand words, a video must be worth millions. The following video succinctly depicts the difference in fire growth between then and now...

https://www.youtube.com/watch?v=aDNPhq5ggoE

As you can see, flashover in a typical living room is occurring in under 4 minutes. As for the office environment, the National Institute of Science and Technology (NIST) conducted tests of a fire in single work station...

https://www.youtube.com/watch?v=VUXdRcEO1DY

In a video in which we urge caution in watching, that of The Station nightclub fire, first indications of ignition occur at the 0:18 mark in the video; flashover appears to occur by the 1:38 mark. One hundred people died in this fire...

Again, caution is urged due to depictions and language in this video.

https://www.youtube.com/watch?v=9e_19dUezCQ

FIRE DEPARTMENT RESPONSE TO FIRES

And what of fire department response times? Large metropolitan fire departments have the best of modern firefighting equipment, they are exceedingly well trained and, since their stations are staffed 24/7/365, have lower response times. Suburban or rural area fire departments are also exceedingly well trained but can have longer response times.

The National Fire Protection Association publishes numerous standards, but for the purpose of this guide, we will look at those standards that pertain to modern fire department response.

When a call is placed to "911," it is expected that call will be answered within 15 seconds, 90% of the time (7.4.1). Further, dispatch of the fire department is expected within 60 seconds of the telecommunicator answering "911, what's your emergency?" again 90% of the time. (7.4.3)[24]

Once the fire department is dispatched, the crew has 80 seconds to hit the street (4.1.2.1 (2)) and the first arriving engine is expected to be "on-scene" within 4 minutes of leaving the station (4.1.2.1(3)).[25]

FIRE DEPARTMENT RESPONSE TO FIRES *(continued)*

Suburban and rural area departments have a slightly different response standard, depending on the density (number of people per mile2) of the area served. In addition to the best practices regarding the answering of the "911" call and dispatching the fire department, are as follows:[26]

Table 4.3.2 Staffing and Response Time

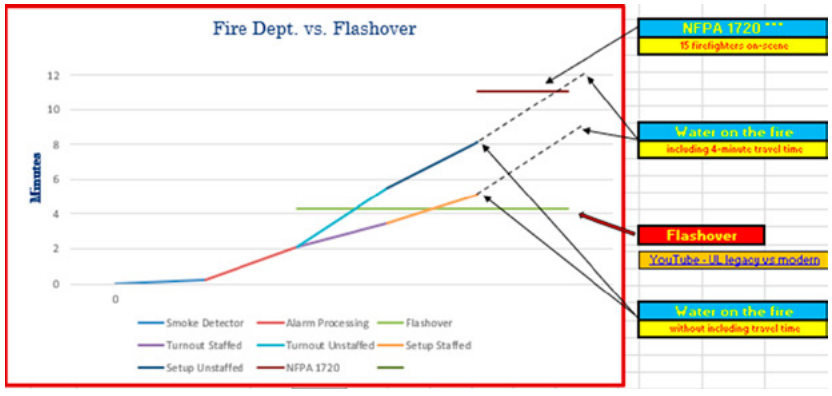
Demand Zone[a]	Demographics	Minimum Staff to Respond[b]	Response Time (minutes)[c]	Meets Objective (%)
Urban area	>1000 people/mi²	15	9	90
Suburban area	500–1000 people/mi²	10	10	80
Rural area	<500 people/mi²	6	14	80
Remote area	Travel distance ≥ 8 mi	4	Directly dependent on travel distance	90
Special risks	Determined by AHJ	Determined by AHJ based on risk	Determined by AHJ	90

[a]A jurisdiction can have more than one demand zone.
[b]Minimum staffing includes members responding from the AHJs department and automatic aid
[c]Response time begins upon completion of the dispatch notification and ends at the time interval shown in the table.

To recap, you can expect the first engine to arrive, in a career department, in about 6.5 minutes after the caller dials "911." In a volunteer department, with the most stringent recommendation, you're looking at a little under 9.5 minutes.

The chart below, in addition to showing the various NFPA standards' benchmarks, includes preburn time (the time between ignition and the time the "911" center is notified), set-up time (the time between the arrival of the fire apparatus and water hits the fire).

With flashover occurring in in 3 to 5 minutes from ignition, depending on the fire department to prevent flashover in today's environment is simply unrealistic.



TENABILITY

It's not just time to flashover that is of concern; it is well known that smoke is the killer, specifically, its constituents. In January of 2010, the fire research division of the National Institute of Standards and Technology (NIST) conducted experiments regarding room tenability and the impact of the presence of sprinklers.[27] Human untenability criteria was listed as:

- **Temperature >120° C**
- **O^2 levels <13%**
- **CO^2 levels >8%**
- **CO levels >1%**

With flashover occurring in in 3 to 5 minutes from ignition, depending on the fire department to prevent flashover in today's environment is simply unrealistic.

The tests were conducted by NIST, in cooperation with the University of Arkansas and the Fayetteville, Arkansas Fire Department, in a 4-story building of fire resistive construction built in the 1950's.

Photograph of the outside of the northwest wing of the dormitory building, looking southwest (University of Arkansas, Fayetteville, AR)

[27] Madrzykowski, D. and Walton, W. (2010). *Impact of sprinklers on the fire hazard in dormitories: sleeping room fire experiments.* Retrieved from https://ws680.nist.gov/publication/get_pdf.cfm?pub_id=904640

TENABILITY *(continued)*

The tables below show the results; in all experiments with sprinklers, tenability criteria were maintained.

Table 4.4-1. Sprinkler and Smoke Alarm Activation Times and Temperatures at Those Devices at the Time of Activation

Experiment	Door Position	Active Sprinkler System	Room Smoke Alarm Activation Time/Temp	West Corridor Smoke Alarm Activation Time/Temp	Center Corridor Smoke Alarm Activation Time/Temp	East Corridor Smoke Alarm Activation Time/Temp	Room Sprinkler Activation Time/Temp	Corridor Sprinkler Activation Time/Temp
			(s) / (° C)	(s) / (° C)	(s) / (° C)	(s) / (° C)	(s) / (° C)	(s) / (° C)
1	Closed	No	24 / 52	160 / 27	216 / 27	316 / 27	120 / 118	NA
2	Closed	Yes	12 / 32	NA	NA	NA	105 / 119	NA
3	Open	Yes	22 / 46	68 / 27	36 / 28	62 / 29	112 / 112	NA
4	Open	No	14 / 45	60 / 31	32 / 29	62 / 32	76 / 136	128 / 99
5	Open	No	26 / 31	62 / 30	80 / 31	98 / 31	110 / 82	224 / 125

Table 4.4-2. Time to Reach Given Untenability Criteria (Red) or Most Significant Tenability Risk Encountered (Blue) for the Dorm Room and Corridor

Experiment	Door Position	Active Sprinkler System	Dorm Room				Corridor			
			Temp.	O_2	CO_2	CO	Temp.	O_2	CO_2	CO
			> 120 ° C	< 10 %	> 8 %	> 1 %	> 120 ° C	< 10 %	> 8 %	> 1 %
1	Closed	No	156 s	14 %	6 %	0 %	26 °C	21 %	0 %	0 %
2	Closed	Yes	84 °C	20 %	1 %	0 %	27 °C	21 %	0 %	0 %
3	Open	Yes	68 °C	20 %	1 %	0 %	27 °C	21 %	0 %	0 %
4	Open	No	128 s	310 s	318 s	340 s	110 °C	426 s	398 s	410 s
5	Open	No	182 s	328 s	292 s	346 s	101 °C	454 s	426 s	444 s

The results were unequivocal, only with sprinklers were all tenability criteria kept within the parameters of human survivability, both within the room of origin and its adjoining corridor.

The fastest times in reaching untenability was (both with the corridor door in the open position):

- In the room of origin: 128 seconds 2.1 minutes
- In the corridor: 398 seconds 6.6 minutes

THE BLACK SWAN EVENT

A "black swan" event is one that is a surprise to everyone; has large-scale consequences and is often followed by the comment "I could have told you that was going to happen." From a risk management standpoint, such events are termed "low probability – high consequence" incidents. The chances of them happening are small, but the outcome, in terms of life loss and property damage, can be catastrophic. It's a gamble, you're betting the fire won't happen, but if it does, you lose, and you lose big.

Certainly, the fire at the Cathedral Notre-Dame de Paris was such an event. The building stood for over 7 centuries, yet its loss is incalculable; but this fire does not stand alone. In September of 2018, the National Museum of Brazil suffered a fire during which 92.5% of its archive of 20 million items were lost.[28]

National Museum of Brazil (Rio de Janeiro, Brazil)

The President of Brazil is quoted as stating: "Two hundred years of work, research and knowledge were lost."[29]

THE ECONOMICS

Fire sprinklers cost money; there is no denying that fact. In addition, the retrofit of sprinklers is not cheap. But that is only if one considers the installation of fire sprinklers an outright cost, as opposed to an investment.

GENERAL COST ESTIMATES

So, how does one calculate costs for a low-probability, high-consequence fire in a building and compare it with the investment of installing sprinklers in existing buildings? Certainly, years after a fire event, when all the bills to repair or replace are paid and all the lawsuits are settled, the cost of a given fire can be determined with some degree of accuracy; such numbers can be staggering.

Attempting to provide a cost estimate for retrofitting sprinklers is a challenging chore, but it can be said with certainty, that it is but a small fraction of the cost of the fire in terms of dollars, lives and the "historic fabric" affected.

It is exceedingly difficult to give a general cost estimate for the retrofit of fire sprinkler systems in an existing building. Truly, every building is different; however, some of the variables in determining cost include:

- Height
- Type of Construction
- Configuration
- Available water supply
- Type of pipe
- Is a fire pump needed?
- Are soffits needed?

But the impact of fires in historical structures cannot be reduced to dollars and cents; the non-monetary losses are the real cost. We must consider the buildings themselves *and* the treasures that lie within, these cannot be replaced no matter what the cost; we owe that to our children; it is our legacy.

TAX INCENTIVE FOR RETROFITTING FIRE SPRINKLERS

Section 179 of the United States Tax Code allows businesses to deduct the full purchase price of qualifying equipment and/or software purchased or financed during the tax year. That means that if you buy (or lease) a piece of qualifying equipment, you can deduct the full price from your gross income as an expense. This had the effect of lowering your income for tax purposes.

Section 179 does come with limits. The total amount that may be written off is capped at $1 million and limits the total amount of equipment purchased in a given year to $2.5 million. In addition, the deduction begins to phase out on a dollar-for-dollar after more than $2.5 million is spent by a given business. Under this phase out the entire deduction goes away once $3.5 million in purchases is reached. This phase out is used to make sure that only small and medium sized businesses may use the deduction.

Congress in 2017 made a major enhancement to section 179 and included fire sprinklers and suppression as an eligible deduction.
The Tax Cut and Jobs Act of 2017 (P.L. 115-97) increased fire safety in two important ways:

- For small businesses – fire sprinklers became an eligible expenditure for section 179 expensing in non-residential structures. This will allow critical occupancies such as night club venues to install fire sprinklers. This is exactly what this benefit was intended for, to prevent another Station Nightclub Fire where 100 people lost their life, which occurred in Rhode Island in 2003. However, residential structures were not included.
- For larger businesses – Qualified Improvement Properties (QIP) were intended to be included as being eligible for bonus depreciation. QIP includes fire sprinklers and any other non-structural improvement to the inside of a commercial building. Under the Tax Cut and Jobs Act, QIP would be eligible for immediate expensing for the first 5 years, tapering down to zero over the next 5 years. This provision, however, needs a technical correction from Congress due to a drafting error in the Conference Report. This technical correction has not yet been enacted.

[28] Retrieved from https://en.wikipedia.org/wiki/National_Museum_of_Brazil

[29] Retrieved from https://www.sciencealert.com/museum-fire-brazil-museu-nacional-rio-de-janeiro-200-years-history-scientific-collection

TAX INCENTIVE FOR RETROFITTING FIRE SPRINKLERS

(continued)

Other Incentives:

- The City of Enid, OK provides grants up to $25,000 for the installation of sprinklers in their downtown historic district.
- Grapevine, TX provided low-interest, 20-year loans.
- Skagway, AK also provided grant-related funds – up to $100,000.
- Lockport, IL provided grants for up to 50% of the total cost, not to exceed $15,000.
- When Annapolis, MD need to "rebrick" the streets in their historic downtown, the Public Works Department, in conjunction with their water purveyor, installed taps for fire sprinklers in front of each building to lessen the cost of retrofits when the time came to install.

INSURANCE PREMIUM DISCOUNTS

The owners of the Saligman House, a senior living facility in Philadelphia, began a retrofit project for their 5 high-rise residential buildings. After completion of the first building, their insurance company offered them a 15% discount across their whole portfolio.

Insurance premium reductions in many commercial properties can help to recoup the investment within a decade.

CONCLUSIONS

Given that historic structures have stood the test of time, it's part of their historic fabric, the chances of historic structures experiencing a fire in any given year is exceedingly small.

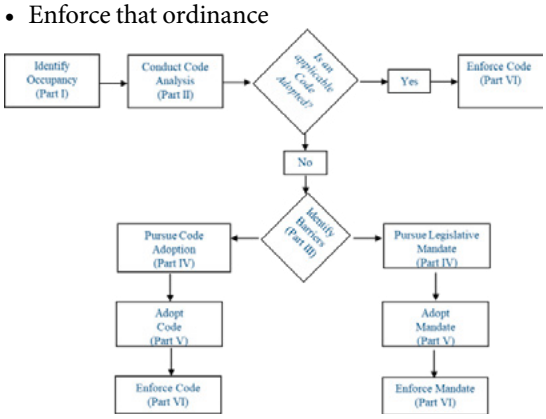
But a small chance is not "no" chance. It could take centuries before a fire strikes, but the consequences are more than catastrophic; the consequences are cataclysmic. The loss a historical structure and the artifacts within cannot be replaced; the rebuild is simply a facsimile; the artifacts are gone forever. Such structures and their contents are lost to the dream of preserving the historical fabric, after all, in many cases sprinklers weren't even invented when the building was built. Therein lies the irony, in order to protect the historical authenticity of the structure, one condemns the structure to destruction when a fire strikes. Can, or should, one take that chance?

Those in charge of fire protection at the Cathedral Notre Dame de Paris took that chance and now, look at the results.

When all voluntary efforts have been utilized to get owners of historical buildings to install sprinklers, either the code adoption or specific retrofit legislation may be needed.

The process is depicted below, but it can be distilled down to:

- Do you have a code that requires retrofit?
  - If so, enforce it
  - If not, adopt one
- If the code does not address your particular situation, a separate stand-alone ordinance may be needed.
  - If you have one, enforce it
  - If not,
    - ◊ Identify the problem
    - ◊ Gather the stakeholders
    - ◊ Prepare an ordinance
- Adopt that ordinance
- Enforce that ordinance



RESOURCES

www.nfsa.org
www.nfsa.org/guides/

www.nfpa.org
www.nfpa.org/Codes-and-Standards

www.gsa.gov
www.gsa.gov/cdnstatic/Fire_Safety_Retrofitting_in_Historic_Buildings.pdf

www.usfa.fema.gov
www.usfa.fema.gov/current_events/061218.html

www.nfpa.org/-/media/Files/Membership/member-sections/Metro-Chiefs/Wingspread-VI-final-ereportfull.ashx?la=en

www.iccsafe.org

www.savingplaces.org

About NFSA
Established in 1905, the National Fire Sprinkler Association (NFSA) is the voice of the fire sprinkler industry. NFSA leads the drive to get life-saving and property protecting fire sprinklers into all buildings; provides support and resources for its members – fire sprinkler contractors, manufacturers and suppliers; and educates authorities having jurisdiction on fire protection issues. Headquartered in Linthicum Heights, MD, NFSA has regional operations offices throughout the country.

NFSA Mission Statement
To protect lives and property from fire through the wide-spread acceptance of the fire sprinkler concept.

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

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