Hazard and Life Safety Analysis

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Steven David Hitchcock

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Professor Robert Fitzgerald, Major Advisor

1. **Fire Protection**
2. **Student Housing**
3. **Regulations**

Abstract:

This project studies the current regulations for fire protection in student housing. Applicable regulations are reviewed via statistical and case study analysis. A series of recommendations are then made for the improvement of fire protection in student housing based upon the statistical and case study analysis. Ramifications of cost and installation feasibility are also considered.

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1.0 Introduction

A majority of student housing structures, including dormitories, fraternities and sororities, are older buildings built before the current mandates for fire safety systems were put in place. When the mandates were enacted, these older student-housing structures were exempted. This exemption from the current lodging house mandates increases the risk of damage and/or death occurring due to a fire in a student housing.

In many cases involving severe damage to housings and in almost every case of fire related student deaths, it has been shown that the lack of greater fire suppression and warning systems was a cause of the tragic results. Often, it is only after a severe fire incident that a campus community reviews the level of fire safety in its student housings. After such reviews, many universities will increase the level of fire safety protection on campus. This was the case after the tragic fraternity house fire at UNC Chapel Hill[1].

As a result of the recent epidemic of fires in student housing, lawmakers have begun to address the issue of increasing fire safety mandates on the campuses of private and public institutions[2].

This report analyzes the current mandates on fire safety requirements in student housing. It begins by outlining types of fire protection systems. The two major fire protection systems, alarm/notification systems and fire suppression systems are defined and discussed. The purpose of both types of fire protection system are also presented.

Following the description of these fire protection systems, the actual mandates and regulations are introduced. The actual mandates are defined and discussed, as is the exemption of student housing. The exemption of student housing is thoroughly reasoned.

The history of current student housing mandates and the exemptions are presented and discussed, followed by the affirmation of the ramifications of these mandates and the student housing exemptions. The ramifications of mandates and exemptions portray what the exemptions have in actuality mandated of the student housing structures, pertaining to fire protection systems.

Section four analyzes student-housing fires versus the presence of fire protection systems. It first does this through a series of statistical analyses. The statistical analysis is followed by a series of individual case studies, which examine student housing fires and the consequences that fire protection system mandates and regulations had on these actual cases of fire incidence.

Section five presents a cost analysis for the installation of automatic sprinkler systems in student housings. To do this, student housings are organized into five types. Then, the prices for new construction installation, installation of sprinklers in newly built structures, are given. This is accompanied by the price for retrofit installation, which is the installation of sprinklers in previously built structures.

A series of recommendations are then made based upon the statistical data and case studies, as well as the feasibility for retrofitting all student housings based upon the cost analysis data. Finally, new legislation and mandates are presented.

This report identifies a clear series of recommendations for administrators and legislators to consider in revising the regulations providing for improvements in fire safety in student housing.

2.0 Fire Protection Systems

Fire protection systems help to provide a level of safety to the occupants of a building in the case of a fire emergency. The main goal of all fire protection systems is to prevent the loss of life due to an incidence of fire. Additionally, fire protection systems help to limit the amount of structural damage and personal loss that can be caused by fire damage.

Fire protection systems fall into two major categories: detection systems, and suppression systems (mainly sprinkler systems). These categories are further expounded in the next two sections of this report.

These fire protection systems help to provide the occupants with more time to evade a fire disaster. Detection and alarm systems alert the occupants of a fire situation and provide them with additional time to exit the building without sustaining injury or death. Detection and alarm systems also aid in notifying authorities, such as the local fire department, to enable them to get to the fire before it grows out of hand.

Suppression systems provide more time to occupants trying to escape a dangerous fire. By suppressing the fire, sprinklers limit the spread and growth of the fire. This allows the occupants more time and capabilities to leave as well as providing the fire fighters with a much less severe fire upon arrival.

2.1 Detection and Alarm Systems:

In a fire, prompt alert of all occupants becomes very important. Without notification, occupants are at a much greater risk of suffering injury and/or death from fire and smoke. To accomplish the task of notifying all occupants within a housing structure several types of detection and alarm systems exist.

The most common type of detection instrument is single station, battery powered, smoke detectors. These are the types of detectors generally present in family homes. They consist of a battery-powered detection unit that goes off when they detect abnormal quantities of smoke that may occur within a building. Heat detectors may also be used in alarm and notification systems, but are less common. Alarms associated with these detection instruments are required to have a minimum rating of 85 d.b.a. at ten feet[1].

Regulations require that proper detection and alarm systems be installed in all housing structures. These regulations include student housing. Such regulations will be discussed later in this report. Lodging house regulations require all detection instruments located within common areas of a building (not within bedrooms), to be interconnected. However, individual room detection instruments should remain as single station units[4].

These detection systems will generally trigger alarms directly. This is required for all lodging houses. The notification of occupants through alarms is one of the first steps in providing occupants with additional time to safely leave the building.

Pull stations may also be available to activate alarm and notification systems, however they cannot be the only alarm types throughout a building. Because human error can be a factor in the improper implementation of pull station alarms, these alarms have a much lower success rate and should be used in conjunction with other style alarms[1].

Alarm systems may also be monitored by outside agencies. These agencies monitor the status of detection and suppression systems within a building and set off an alarm when there is a change in the status of such systems, which would signify a fire. This type of system generally notifies the fire department, thus allowing for faster arrival times by fire departments[5]. A combination system may exist wherein manual pull stations are connected to the monitored system.

Detection and notification systems independently are an important element in alerting occupants of imminent danger, but without sprinkler systems, they do not provide the highest degree of fire safety and loss prevention possible.

Information and statistics relating to occurrences of fires and the results based upon the fire detection and notification systems present can be found in the case studies section of this report.

2.2 Sprinkler Systems

An American, Henry S. Parmalee, invented sprinklers in 1874. Until the 1940s and 1950s, sprinklers were installed almost exclusively for the protection of industrial buildings and warehouses. Following several catastrophic fires, fire and building officials decided that automatic sprinkler systems provided advanced life safety for building occupants, this lead to the installation of sprinklers in hotels, schools, and businesses.

Building codes over the past two decades have increasingly called for the installation of automatic sprinkler systems. This is especially true in building structures that require rapid evacuation of occupants, and building structures designed to hold large numbers of occupants at one time.

Automatic fire sprinklers are individually heat activated. They are tied into a network of piping that is holding water under pressure. When the heat of a fire raises the sprinkler temperature to its operating point, a soldier link will melt or a liquid filled glass bulb will shatter to open that single sprinkler, releasing water directly over the source of the heat.

Sprinklers operate automatically in the area of fire origin. This prevents a fire from growing undetected. At the same time as the sprinklers suppress the fire; they will generally sound an alarm simultaneously. Automatic sprinklers work to keep a fire small and controllable. One or two sprinklers handle the majority of fires in sprinklered buildings. Each sprinkler head will open when it reaches a specific temperature and spray water on to a fire. The hot gases from a fire are usually enough to make it operate. Only the sprinklers over the fire open. The others remain closed. This limits any damage to areas where there is no fire and reduces the amount of water needed.

The sprinklers are spaced generally on the ceiling so that if one or more operate there is always sufficient flow of water. The flow is calculated so that there is always enough to control a fire taking into account the size and construction of the building and the goods stored in it or its use. Sprinkler heads can be placed in enclosed roof spaces and into floor ducts to protect areas where a fire can start without being noticed. In a large warehouse sprinklers may be placed in the storage racks as well as the roof. At the point where the water enters the sprinkler system there is a valve. This can be used to shut off the system for maintenance.

3.0 Current Requirements

A lodging house can be defined as a structure rented to six or more people who are not related to each other. Lodging houses include student housing such as fraternity and sorority houses, as well as personal homes that have been set up as student leased apartments, in addition to other non-student housing. Dormitories are further defined as buildings or spaces in buildings where group sleeping accommodations are provided for persons not members of the same family group in one room or in a series of closely associated rooms under joint occupancy, with or without meals, but without individual cooking facilities.

The lodging house requirements in Massachusetts regarding fire safety are defined in two areas. The first is the 527 CMR, defined as the Massachusetts Comprehensive Fire Code. The purpose of the 527 CMR as defined in 527 1.01, is to prescribe minimum requirements and controls to safeguard life, property and public welfare from the hazards of fire and explosion created by the storage, handling or use of substances, materials or devices or from conditions hazardous to life, property and the public welfare. It is the responsibility of the Marshal or the head of the fire department or his designee, to enforce the provisions of the code set forth in the Massachusetts Comprehensive Fire Code.

The second area defining lodging house requirements is chapter 148 of the Massachusetts General Laws. This series of regulations defines a series of general laws applicable to the installation and maintenance of appropriate fire protection systems.

3.1 Major applicable regulations:

The following mandates have been defined in the 527 CMR and Chapter 148 of the General Laws of Massachusetts. These mandates are the major regulations that intend to establish a level of fire safety necessary in student housing.

3.1.1 Fire Warning Systems:

The following items are mandated by 527 CMR 24.00-24.09

Installation of Smoke detectors:

1. Automatic smoke and heat detectors must be located in lobbies, common corridors, hallways and stairways of buildings.
2. All automatic smoke and heat detectors located in lobbies, common corridors, hallways and stairways of buildings shall be interconnected.
3. In open stairwells, a detector shall be located at the ceiling of the uppermost and lowermost levels.
4. Smoke detectors in stairwells must be unobstructed.
5. One smoke detector shall be installed in each sleeping area (bedroom).

To install a new fire warning system in a building or structure that already exists, a system plan must first be submitted by the owner of the building or by the installation contactor. This plan is inspected for correspondence with all mandated laws. Once the plan is approved the contractor is issued a permit to install the fire warning system. After the installation is completed, the contractor notifies the fire department and an inspector will make an inspection and test as outlined under fire department guidelines to check that the system is in complete working order. The building owner/contractor will make records of this inspection and provide the fire department with a copy of this record.

3.1.2 Automatic Sprinkler Systems

Chapter 148 of the Annotated Laws of Massachusetts defines the requirements for installing Automatic Sprinkler systems in lodging houses. This section provides an excerpt of the exact mandates as decreed in C. 148-26H. Exemptions are depicted in bold. The ramifications and reasoning behind these exemptions are examined in later sections of this report.

The following is excerpted from Chapter 148 of the Annotated Laws of Massachusetts:

In any city or town, which accepts the provisions of this section, every lodging house or boarding house shall be protected throughout with the provisions of the state building code. **No such sprinkler system shall be required unless sufficient water and water pressure exists**.

For the purpose of this section "lodging house" or "boarding house" shall mean a house where lodgings are let to six or more persons not within the second degree of kindred to the person conducting it, **but shall not include fraternity houses or dormitories, rest homes or group residences licensed or regulated by agencies of the commonwealth**.

Any lodging or boarding house subject to the provisions of this section shall be equipped with automatic sprinklers within five years after acceptance of this act by the city or town.

The following mandate is excerpted from the General Laws of Massachusetts Chapter 148: section 26I.

In a city, town or district which accepts the provisions of this section, any building hereafter constructed or hereafter substantially rehabilitated so as to constitute the equivalent of new construction and occupied in whole or in part for residential purposes and containing not less than four dwelling units including, but not limited to, lodging houses, **boarding houses, fraternity houses, dormitories**, apartments, townhouses, condominiums, hotels, motels and group residences, shall be equipped with an approved system of automatic sprinklers in accordance with the provisions of the state building code. In the event that adequate water supply is not available, the head of the fire department shall permit the installation of such other fire suppressant systems as are prescribed by the state building code in lieu of automatic sprinklers. Owners of buildings with approved and properly maintained installations may be eligible for a rate reduction on fire insurance.

3.2 History of current student housing mandates

Chapter 148- 26H was approved July 16th, 1986 and said to be effective 90 days thereafter. This mandate has since been amended twice; the first amendment was approved Aug. 3rd, 1989, effective 90 days thereafter. The second amendment was approved Nov. 28th, 1989, effective 90 days thereafter.

The first 1989 amendment added the third paragraph, which gave building owners five years from a city's acceptance of the statute to meet the automatic sprinkler system requirements.

The second amendment added a fourth paragraph which stated that whoever is aggrieved by the fire department's interpretation, order, requirement or direction, is allowed 45 days within which to appeal such interpretation.

3.2.1 Reasons for Exempting Student housing from sprinkler requirements

Of all lodging houses, student housing stands at the greatest risk to suffer fire damage. Thus it seems strange that a mandate requiring automatic sprinkler systems in lodging and boarding houses would exempt those houses most at risk. There were several official and unofficial reasons for exempting.

The official reasons for exempting student housing were listed in part with the minutes and official transcripts of the approval of 148- 26H the two main reasons were as follows:

1. Costs to Universities and colleges in retrofitting dormitories and other student housing structures would be too great on the non-profit organizations.
2. Retrofitting student housing with modern sprinkler systems would negatively affect historic buildings with traditional design and interiors.
3. False alarms or release of water could cause undo water damage to historic buildings.

The unofficial reasons are not documented, however through discussions with the NFPA as well as housing officials from WPI, Assumption and Clark, the following factors seemed to be of main importance, first the universities hold a great deal of power in determining legislation. Secondly, the cost to universities and colleges would have required multi-million dollar renovation projects be undertaken by each university. Universities therefore lobbied, successfully, to be exempt from the proposed legislation requiring automatic sprinkler systems. Lobbying appears to have played a major role in the exemption of student housings from these regulations.

3.3 Implications of regulations and exemptions

These mandates require appropriate alarms be installed within all student housings. Automatic sprinkler systems are required in new or completely renovated student housings. However because Lodging houses defined as dormitories, fraternities, and sororities have been exempted from retrofit sprinkler requirements, there are no requirements above and beyond the required smoke/heat alarms for student housing structures built prior to 1986.

This report will first define the prevention systems to be used in protecting student housing. Secondly this report will establish the need for further requirements regarding fire prevention systems in student housings. The necessity for further requirements will be shown through the use of Statistical and individual case analysis.

3.4 Enforcement of Mandates

In most cases the enforcement of these mandates is the responsibility of the fire chief, the Marshall or their designees. In the city of Worcester the main enforcement has been designated to the City Manager's Enforcement Team (CMET).

3.4.1 CMET Membership

CMET is made up of one representative each from the Law department, the Department of Public Health and Code Enforcement, The Police Department, and the Fire Department.

3.4.2 CMET Function

CMET is a special unit established under the jurisdiction of the city manager. It is the function of CMET to coordinate the activities of various city agencies involved in the enforcement of laws, ordinances and regulations adopted to protect and promote the public safety of the people

CMET's responsibilities are to enforce local and state codes, laws, ordinances and regulations relating to conditions affecting the health and safety of residents and their property which shall include lodging houses and violations of fire laws (this is not a complete list of CMET responsibilities).

The team currently consists of an assistant city solicitor, as the senior official and chair, a police officer, a fire inspector, a code enforcement/health inspector, a building inspector and a secretary assigned from the treasurer's office.

4.0 Student housing fires

Two methods are used in this section to analyze the effects of fire protection systems in preventing the loss of human life and averting property damage. First statistical data is presented, compared and analyzed. This data has been obtained from the NFPA and condiers all fires reported to this organization. Non-reported fires and small fires that need not be reported are not included in the statistical analysis.

Secondly, individual cases are examined and analyzed to see where fire protection systems may have helped avoid the occurrence. This section uses expert opinions of those fire fighters who were present at student housing fires as well as the opinions presented in the follow-up case study data to determine whether the lack of fire protection systems played a role in the damage caused by the fire.

4.1 Statistical analysis

The following statistics are taken from the NFPA's School, College, and University Dormitories, and Fraternity and Sorority House Fires in the United States 1993-1997 Annual Averages:

Table 1: Yearly fire statistics in student housing

Year	Fires	Deaths	Injuries	Property Damage ($ in millions)
1980	2,500	9	115	4.8
1981	2,400	0	102	7.5
1982	1,700	0	74	7.3
1983	1,900	0	80	18.7
1984	1,900	0	44	4.8
1985	1,900	0	42	6.1
1986	1,800	2	36	4.6
1987	1,900	0	66	7.5
1988	1,900	0	65	5.8
1989	2,000	0	71	8.7
1990	1,500	0	48	7.4
1991	1,600	6	51	15.1
1992	1,600	0	120	2.8
1993	1,600	0	42	4.9
1994	1,700	0	61	10.0
1995	1,700	0	113	16.7

1996	1,500	0	68	5.9
1997	1,500	0	47	7.0
Annual Average 1993-1997	1,600	0	66	8.9

Table 1 displays the millions of dollars in damage and the multiple injuries that occur every year in student housing. These are statistical estimates from records on sample fires and though deaths are rare it is possible for estimates to show no deaths in a year when a fatal fire has actually occurred.

Table 2: Analyzed-dollar loss associated with sprinklered/non-sprinklered residences for all fires:

	Average value of fire damage	Mean absolute deviation
With sprinklers	$3473	$6073
Without sprinklers	$6081	$10507

These values are kept relatively low because they count all fires, thus small fires that were able to be controlled with fire extinguishers and/or ran out of fuel bring down the average value of fire damage.

Table 3 has removed these small fires

Table 3: Adjusted dollar loss associated with sprinkler/non-sprinklered residences:

	Average value of fire damage	Mean absolute deviation
With sprinklers	$5261	$3145
Without sprinklers	$106081	$12874

Properly installed and maintained sprinkler systems save lives. The NFPA has no record of a fire killing more than two people in a completely sprinklered building where the system was working properly.

The following table consists of fatal college/university Student housing fires known to the NFPA from 1990 to 2000.

Table 4: Statistics regarding fires in student housings (1990-2000)

Date	Location	Deaths	Injuries	Property Damage
09/09/90	Fraternity House, Berkeley, CA	3	2	$2,100,000
12/08/90	Fraternity House, Erie, PA	1	4	Not Reported
02/13/92	Fraternity House, California, PA	1	0	$70,000

10/24/93	Sorority House, Lacrosse, WI	1	2	Not reported
10/21/94	Frate1rnity House, Bloomsburg, PA	5	0	$70,000
05/12/96	Fraterni1ty House, Chapel Hill, NC	5	3	Not Reported
10/19/96	Fraternity1 House, Delaware, OH	1	0	$175,000
01/03/97	Dormitory, Warrensburg, MO	1	0	$45,000
01/10/97	Dormitory, Martin, TN	1	5	$68,000
02/20/97	Dormitory, Brooklyn, NY	1	0	Not Reported
12/09/97	Dormitory, Greenville, IL	1	0	Not Reported
09/18/98	Dormitory, Murray, KY	1	15	Not Reported
02/13/99	Fraternity House, Rolla, MO	1	0	$1,000,000
02/16/99	Fraternity House, Geneseo, NY	1	0	Not Reported
05/08/99	Fraternity House, Columbus, MO	1	0	Not Reported
01/19/00	Dormitory, South Orange, NJ	3	62	Not Reported

4.1.1 Presence of suppression/alarm systems in Student housing:

According to the NFPA, in 1997, smoke or heat alarms were present in 93% of all dormitory fires. Sprinklers were present in a mere 28% of all student-housing fires. On an average the NFPA reports a 36% lower loss in property damage in those structures where sprinklers were present compared to those where sprinklers were not present.

4.1.1.2 Campus Fire Publications

Campus fire watch is a monthly electronic newsletter that focuses exclusively on the issue of campus fire safety. They provide Interviews with fire chiefs, housing and college administrators, legislators, fire safety experts and others.

Campus fire watch helps to profile successful programs at colleges and universities across the United States. Information on important fire safety topics such as sprinklers, fire alarms, building construction, fire department operations, media relations, fire prevention, special hazards, laboratory safety, working with consultants and more are found within their resources.

Most importantly for this report, they provide breaking news on recent fires across the country and case studies of past incidents, with the lessons learned from each of them. In addition, they supply statistical reports regarding campus fire incidents and the nature and results of these fires.

The publisher of Campus Firewatch is Ed Comeau, owner of writer-tech.com, llc, a technical writing firm specializing in fire safety. Mr. Comeau has 20 years of experience as a fire fighter, fire protection engineer and fire investigator. His involvement in campus fire safety began as a fire fighter with the Amherst Fire Department while he was pursuing his undergraduate degree in civil engineering from the University of Massachusetts/Amherst.

As the chief fire investigator for NFPA, he managed the investigations of incidents at colleges and universities, and has been an advocate for improved safety at these institutions. Mr. Comeau has a number of publications to his credit, has conducted investigations around the world and has served as an international speaker on fire safety.

4.1.2 2001 Campus fire statistics:

(The following statistics are taken from Campus Fire watch)

- 2001 Campus fire Incidents: 33
- Deaths: 4
- Residence Hall Incidents: 17
- Greek Incidents: 2

- Off-Campus Incidents: 9
- Academic Buildings: 1

A complete list of Incidents and supporting case information can be found in appendix &.

4.2 Case Studies:

The following section analyzes individual fire incidents in student housing structures. These cases are analyzed to try to discover the reasons for ignition and why, in each case, the fire was capable of causing severe damage to the structure as well as injuring/killing the student occupants. In doing this, each case is examined for the presence of fire protection systems.

The information and statistics regarding the following campus fire incidents was obtained from the NFPA.

4.2.1. Chapel Hill, N.C.

Sunday, May 12, 1996

A tragic fire at the University of North Carolina killed five students. A number of significant factors contributed to the deaths, including a lack of sprinklers, open central stairwells and a lack of an alarm system.

On Sunday, May 12, 1996, an accidental fire occurred at the Phi Gamma Delta fraternity house at the University of North Carolina. Five occupants were killed and three others were injured. The fire and smoke caused heavy damage throughout the building. The fire damage to the building and its contents was estimated at $475,000.

The 70-year-old, three-story-plus-basement fraternity house was designed to be a fraternity house. It had masonry exterior walls and wood frame interior structural components. Nineteen of the building's bedrooms were located on the second and third floors. The first floor had several rooms and the president's suite, and the basement had an open area that contained a bar area, sitting area, and dinning room. In addition, a chapter room, a kitchen, mechanical rooms, rest rooms and several storage rooms were in the basement. The basement's open area and chapter room as well as a small reading room on the first floor had combustible interior finishes. All other rooms in the building had noncombustible interior finishes. An open stairway in the center of the building connected the basement with the floors above.

Single-station, battery powered smoke detectors were installed near the central stairway in the basement and in the corridors on the second and third floors. Portable fire extinguishers were provided throughout the building. Doors to the sleeping rooms were solid, consisting of wood-based composite material. These doors did not have self-closing devices.

On the night of Saturday May 11,1996, approximately 250-300 people were attending a large graduation party in the backyard of the Phi Gamma Delta fraternity house. The party was moved into the basement of the house when rain started to fall. .

Most of the parents in attendance left the party between 10:00 p.m. – 10:30 p.m. The band left at about 1:00 a.m., and a disk jockey continued to play music until about 5:00 a.m. Reportedly he broke down his equipment and left sometime between 5:45 a.m. and 6:00 a.m. He did not note anything unusual before he left.

One of the Phi Gamma members and a companion, who were sleeping in Room 206, were awakened by the sound of an operating smoke detector. The member left the room to investigate. He went down the central stairwell, but before getting to the first floor, he saw smoke and fire on the first floor. He went back to Room 206 and told his companion about the fire. The fraternity member left the room again, went to the window leading to the west end fire escape ladder, and opened the window. When his companion did not join him at the window, he attempted to return to Room 206, but was unable to do so because the floor in the corridor had become hot by that time, and the heat coming up the central stairway prevented him from reaching his companion. He was forced to leave the building by using the west end fire escape ladder. The companion did not escape.

Another Phi Gamma member was sleeping with a companion in a third floor bedroom at the front of the building. The member was awakened by an unspecified means, and he left his room. Once in the third-floor corridor, he saw fire coming up the central stairway. He and his companion exited out the bedroom window and attempted to move along the roof's edge. Both fell or jumped off, landing in the front yard.

Shortly after 6:00 a.m. on Sunday, May12, 1996, a member of the Delta Kappa Epsilon fraternity located on the east side of the Phi Gamma Delta house awoke to noise, screams and yelling coming from the Phi Gamma Delta house. He looked out his window and saw flames coming from the first floor windows of the house. He called 911, reached the PSAP for Chapel Hill at 6:06 a.m., and reported a large fire at the Phi Gamma Delta house. This individual was the first person to report the fire. Seconds later, the PSAP operator received a call from employees at the Carolina Inn, which was across the street from the fire building, and they too reported a serious fire at the Phi Gamma Delta house. They also reported that people might have been trapped inside. These were the first of many back-to-back calls made reporting the fire.

Local and state fire investigators determined that smoking materials most likely ignited combustible materials underneath an alcohol bar in the basement. The fire then spread to the combustible interior finishes and the furnishings in the basements open area and chapter room. Fire and unburned products of combustion spread up the interior stairway and ignited fires on all levels above the basement.

The total number of occupants in the building before the fire was not determined. Five occupants died during this fire. Four of these victims were found in bedrooms, and one victim was found in the doorway to the bedroom in which she was sleeping. Three occupants were also injured while they evacuated the building.

Based on its investigation of this fire, the NFPA has determined that the following factors significantly contributed to the loss of life:

- The presence of combustible interior finish materials.
- The presence of an open stairway.

- The lack of fire-rated construction separating the assembly areas from the residential areas of the building.
- The lack of automatic fire detection and fire alarm systems throughout the building.
- The lack of automatic sprinkler protection.
- The improper use or disposal of smoking materials.

In the wake of the tragedy in Chapel Hill, the Town Council voted unanimously to work toward a plan that would require sprinklers in fraternity and sorority houses. **On June 19, 1996, the state legislature granted the town authorization to enact a retroactive sprinkler law, requiring fraternity and sorority houses in Chapel Hill to comply within five years.** The Chapel Hill Fire Department is working with the fraternity and sorority community on retrofit plans. As of April 2000, 17 of Chapel Hill's 36 fraternity and sorority houses have been retrofitted with sprinkler protection. The vast majority of the remaining chapters have plans underway to complete the installation of sprinkler protection.

There is no question in the mind of the Chapel Hill fire chief that **sprinklers would have made a difference in the Phi Gamma Delta fire**. The fire would have been confined to the basement, and the sprinkler's alarm system would have notified the occupants and the fire department had the sprinkler system been connected to a building fire alarm system and had a provision for automatic fire department notification been installed.

4.2.2 Dormitory Fire, Franklin, Massachusetts, October 25, 1995

On Wednesday, October 25, 1995, at approximately 2:00 am, a fire occurred in an occupied college dormitory. The building was successfully evacuated without loss of life or injury. The building, however, was a total loss.

The building was a three-story, wood frame, **unsprinklered** structure that housed 30 people. At the time of the fire, there were 28 people in the building. It was equipped with an automatic fire alarm system that had spot-type heat detectors in the residents rooms, some common areas, and the basement; smoke detectors in the common areas; and manual pull stations in the hallways.

There were two interior stairwells between the first and second levels and one interior stairwell between the second and third level. An exterior stairwell was located on the south side of the structure, and two fire escape ladders, one on the east side and one on the west side, provided secondary means of egress to the second and third levels.

Based on an investigation conducted by the Franklin Fire Department and the Massachusetts State Fire Marshal's Office, the area of origin was in one of the dormitory rooms on the second floor. The cause of the fire was accidental/undetermined.

Based on the NFPA investigation and analysis of this fire, the following significant factors were considered to have contributed to the loss of property in this incident:

- Lack of early detection of the fire, which allowed for large fire growth to occur

- Lack of an automatic sprinkler system, which would have controlled the fire in the early stages
- Lack of adequate separation between levels, which contributed to the fire spread to the third floor and allowed for the spread of smoke and fire from the area of origin
- Failure to close the door to the room of origin after detection
- Lack of automatic door closures on the individual rooms

4.2.3 Fraternity House Fire, Berkeley, California, Sept. 1990

At approximately 1:00 a.m. on Saturday, September 8, 1990, a fire occurred at the Phi Kappa Sigma fraternity house at the University of California Berkeley. The fire killed three students and resulted in the injury of two others. In addition, the building was heavily damaged by the fire.

The 33-year-old, wood-frame, multistory fraternity house was "L"-shaped with a large living room forming the smallest part, and the sleeping room area forming the largest part. All interior wall surfaces, including the exit stairways, were covered with wood paneling. Except for two, the sleeping rooms had hollow core wood doors. The two exceptions had solid-core wood doors. The doors separating the sleeping room area from the assembly area were normally kept open. In addition, closing devices on some exit stairway doors had been removed.

Fire protection equipment included fire extinguishers, fire hose cabinets, local fire alarm system with bells and the manual pull stations, and single station, battery-operated smoke detectors in a few sleeping rooms.

Local fire investigators have determined that the fire started when a couch in the assembly room was ignited with a butane lighter. The burning couch, in turn, ignited the room's combustible interior finish, and the fire quickly spread to other areas of the building. First arriving fire fighters found the assembly room, an adjacent lobby area, and the two top stories in the sleeping room area fully involved with fire.

The following factors have significantly contributed to the loss of life and property:

- Open stairways,
- Combustible interior finishes throughout the building,
- Lack of compartmentalization and occupancy separation with fire-rated construction,
- The lack of fire safety training and fire exit drills.
- The lack of an automatic sprinkler system

4.2.4 Providence College Dormitory Fire, Dec. 13, 2000

In the early morning on Dec. 13th, in the heart of the Christmas season, a small fire started in Aquinas Hall, A dormitory on the Providence College campus. This fire resulted in the deaths of ten female students who were residents on the fourth floor.

Physical evidence shows the origin of the fire to be within a closet in room 406. The exact source of ignition was not determined. The fire is believed to have started at approximately 2:45 a.m.

The fire grew rapidly. Beginning in the closet in room 406, the fire spread out into the hallway of the fourth floor and grew rapidly spreading down the length of the hallway. The fire spread in both directions down the corridor.

Aquinas Hall had a fire alarm system that consisted of manual pull stations; three heat detectors (135 degrees), and interior alarm horns. One heat detector was located at the top of each stairway. The system was connected to the Providence Fire Alarm and Communications Center through a master fire alarm box. **There were no smoke detectors or automatic sprinklers in the building**. Portable fire extinguishers were provided on each floor.

The Providence Communications Center was notified of the fire at 2:57 a.m. by the activation of a fire alarm pull station located on the fourth floor of Aquinas Hall, near the center stairway. On the initial alarm, three engines, two ladders and a battalion chief from the Providence Fire Department responded. When they arrived, a second alarm was sounded due to the obvious rescue problems involved. The response time was very adequate based on when the first manual pull station was activated.

The fourth floor of Aquinas Hall was heavily damaged. Most rooms were in need of complete reconstruction. The hallway was completely destroyed and also in need of complete reconstruction. The floor did not burn through, nor did the ceiling, but the fire was highly intense and compromised the structure of the floor and ceiling. Damage was estimated at 175,000 dollars, plus a loss of 40,000 dollars in personal belongings.

Ten female students were fatally killed in this fire. Two of the ten student fatalities died from injuries received when they jumped out of their fourth story window. Four died of carbon monoxide poisoning and smoke inhalation, and the remaining four died as a result of direct burns. Twelve students and one fire fighter were injured.

Conclusions:

- This fire was allowed to spread and gain great intensity due to the lack of automatic suppression systems.
- The lack of individual room smoke alarms delayed the notification of both the occupants in the building and the fire department.
- The outside monitoring of the Providence Communications Center aided the fast response by the Providence Fire Department.
- 175,000 dollars in structural damage and 40,000 dollars in contents damage.
- 10 female students lost their lives.

4.2.5 Skidmore College Dormitory Fire, Aril 5, 1996

What started as a simple trash fire spread rapidly throughout the first floor of this modern facility with tragic results. One female student was killed in the early morning fire. More than 83 students were hospitalized, many in serious and critical conditions.

The fire started at approximately 4:00 a.m., on Monday, April 5th, 1986. The fire originated in the first floor trash-holding closet. It was likely ignited by the disposal of a cigarette or other burning item.

The fire spread out of the closet and into the hallway by way of the louver in the door. Once it had reached the hallway the only fuel for the fire was the carpet and the vinyl wall covering that had been painted. It was able to consume 75% of the hallway before it was contained.

Each student room contained a combination fixed-temperature rate-of-rise heat detector. There were no detectors in the hallways, service areas, or lobbies. The detectors were connected to the internal fire alarm only. **There were no automatic sprinkler systems.**

The Saratoga Springs Fire Department received a call from a female student at 4:11 a.m. Arriving fire fighters saw students jumping out of the windows on all floors. They were able to suppress the fire and stop it after it had spread down ¾ of the corridor. They rescued several students.

¾ of the first floor hallway was ruined and any room that had the door open was pretty well destroyed. Other than that, there was actually very little structural damage. Overall damage was estimated at 70,000 dollars.

One female student was found dead in her room. She had died of smoke inhalation while trying to get dressed. 83 other students had to be hospitalized for smoke and burn related injuries.

Conclusions:

- This fire was allowed to spread and gain great intensity due to the lack of automatic suppression systems.
- Experts stated that had the trash-holding closet been equipped with adequate sprinklers, the fire would have been easily suppressed within the closet.
- The lack of smoke alarms delayed the notification of both the occupants in the building and the fire department.
- The fire caused 70,000 dollars in damage.
- The fire lead to one death and 83 injuries.

4.2.6 Case Study conclusions

The case studies have shown that many factors contribute to student deaths in incidences of campus fires. One of the main factors in all of these cases is the lack of automatic sprinkler systems. Additional factors include alarm systems, building construction, construction materials, stairways, and escape exits.

The main factor to be dealt with here is time. From the ignition of the fire to its advanced growth and multi-room spread, there must be significant time to one, allow for the exit of all occupants without injury, and two allow for the arrival of the fire department. In none of these cases was there adequate time allowed and the results were disastrous.

These studies have displayed a variety of results in a variety of differently designed buildings. Each of these individual cases demonstrates the regulations and mandates in place were not enough to adequately prevent damage and at times the loss of lives due to fire spread and growth.

Due to a lack of mandates and regulations, the fire protection systems necessary for allowing time for the escape of occupants, and delayed multi-room spread were not present. This allowed for the injury of occupants and severe damage of all structures. In most cases the lack of sprinkler systems allowed growth and spread to occur at a rate, which lead to the complete loss of the housing structure.

This series of case studies points to the need for further regulations requiring fire prevention and suppression systems in student housings.

5.0 Cost analysis for the installation of sprinkler Systems

This section provides estimates on the expected costs involved in installing automatic sprinkler systems in various student housings. The cost data obtained has been derived from a series of obtained estimates and previous averages. The data is based on the cost per square foot and varies based upon the type of structure involved.

5.1 Classification of Student Housing

To initiate creating an average for the costs of installing automatic sprinkler systems, I began by grouping student housings into five general categories. These five categories represent the five major types of student housing. These categories of student housing are then used to formulate the average costs for each type of student housing.

The first type of student housing is a single-family dwelling. This represents housing structures where students in general will be rented an apartment style accommodation on an individual floor basis.

The second grouping of student housing structures is an apartment style dormitory. These dormitories are generally one to two stories high and each unit is a separate entity with multiple residents. The units are generally grouped together into a large complex with each unit adjoining another unit.

The third type of student housing is a large house or duplex structure. This is the basis for most fraternity/sorority houses as well as many smaller, community oriented dormitories.

The fourth type of student housing is the classic dormitory hall. These structures may have up to four floors of occupants. Generally, single rooms and suites branch off of main hallways.

The final type of classification used in this cost analysis is the high-rise dormitory. Any dormitory building with five or more floors of living space is considered a high-rise dormitory for this cost analysis.

5.2 Process for determining an average price

Several steps were taken to determine average prices for automatic sprinkler systems for each of the previously established housing classifications. The first step involved contacting sprinkler companies directly. Five companies from varying parts of the United States were contacted and asked to give pricing estimates. The five types of housing structures were identified and each company was asked to give an estimate based upon what they considered to be an average quote for the installation of automatic sprinkler systems in each structure type.

Secondly, The NFPA and NFSA were contacted to find additional estimates and/or guidelines. The NFSA has an index based upon commercial or residential properties and the NFPA gave statistically based estimates.

Finally, actual cases of automatic sprinkler system installation over the past three years were used to determine if the obtained estimates were accurate. All cases displayed final prices (in $/sq. foot) to be in within the high and low estimates.

5.3 Cost Analysis Data

Each classification of student housing has been assigned an average price for new construction and retrofit installation. The high and low-end estimates have also been included so that the range of quotes is apparent. All averages have been rounded to the nearest cent.

Table 5: Single Family House:

	Average Price	Low-end estimate	High-end estimate
New Construction	0.97 ($/sq. foot)	0.80 ($/sq. foot)	1.20 ($/sq. foot)
Retrofit installation	2.72 ($/sq. foot)	2.25 ($/sq. foot)	3.75 ($/sq. foot)

Note: Price quotes for single-family homes are dropping rapidly sue to increased demand. This decline in price is most severe in the area of retrofit installation.

Table 6: Apartment style dormitories:

	Average Price	Low-end estimate	High-end estimate
New Construction	1.01 ($/sq. foot)	.85 ($/sq. foot)	1.25 ($/sq. foot)
Retrofit installation	2.23 ($/sq. foot)	1.75 ($/sq. foot)	3.50 ($/sq. foot)

Table 7: Large House/Duplex:

	Average Price	Low-end estimate	High-end estimate
New Construction	0.94 ($/sq. foot)	0.80 ($/sq. foot)	1.25 ($/sq. foot)
Retrofit installation	2.45 ($/sq. foot)	2.00 ($/sq. foot)	3.00 ($/sq. foot)

Table 8: Classic dormitory hall:

	Average Price	Low-end estimate	High-end estimate
New Construction	1.14 ($/sq. foot)	.95 ($/sq. foot)	1.40 ($/sq. foot)
Retrofit installation	1.86 ($/sq. foot)	1.45 ($/sq. foot)	2.80 ($/sq. foot)

Table 9: High rise dormitory:

	Average Price	Low-end estimate	High-end estimate
New Construction	1.29 ($/sq. foot)	1.00 ($/sq. foot)	1.75 ($/sq. foot)
Retrofit installation	2.43 ($/sq. foot)	2.00 ($/sq. foot)	3.25 ($/sq. foot)

These tables display the different costs for the installation of automatic sprinkler systems based upon the structure of the student housing. Costs run higher for the retrofitting of automatic sprinkler systems because the labor required for these systems is much more involved. The highest retrofitting price is the estimate for a standard one family house. The need for retrofitting is increasing, and costs are dropping as the demand increases. This is especially true in the single-family homes.

5.4 Savings involved in sprinkler system installation

In estimating the cost for automatic sprinkler system installation, it is important to realize that sprinkler installation is also an investment that will later reduce costs on insurance. Sprinkler systems are a valuable investment for building owners; sprinkler systems not only aid in saving student lives and property damage, they also provide savings on future items.

The installation of sprinkler systems can return money to the building owner. The primary savings involves lower insurance rates. Sprinkler systems lower insurance rates by up to 15%. Although this drop in the rate of insurance fees is not the norm, in most cases the lowered insurance rates will allow the sprinkler systems to eventually pay for themselves. In as short as 6 years the money spent on installing sprinklers can be saved, from that point additional savings can be seen as a profit turned through the investment in sprinkler systems. It must be noted that the average estimate for complete payback is 18 years.

In some cases, a second savings possibility involves the reduction of taxes. To encourage the installation of automatic sprinkler systems, governments have begun to offer tax-based benefits to owners who have taken the steps to install proper sprinkler systems. These tax savings may be available on a federal or state level.

6.0 Proposed Legislation

Over the course of this report, additional legislation has begun implementation dealing with items within this report. The following section outlines proposed legislation and the goals thereof.

6.1 College Fire Prevention Act

The College Fire Prevention Act was enacted by the Senate and the House of Representatives of the United States of America on February 27, 2001.

The goal of this act is to provide funding for sprinkler systems, or other fire suppression or prevention systems, in public and private college and university housings. This is to include fraternity and sorority housings as well as dormitories.

The act sets forth to authorize appropriations in the amount of $100,000,000 for each of the fiscal years 2002 through 2006. The Secretary of Education, with the United States Fire Administration, is authorized to award grants to states, as well as colleges and universities, for installing fire sprinkler systems in student housings.

The stipulation of the act requires that the Secretary of Education not award a grant under this act unless the entity receiving the grant provides matching funds in an amount equal to not less than one-half of the cost of the activities for which the grant is applied.

6.2 New state Legislation

Many states have begun to address the needs for further legislation mandating the installation of fire protection systems in student housings. This has often been prompted by tragic fires; These tragedies help initiate a state wide review of the current safety levels in all public and private institutuions. This generally leads to the proposal of new and stricter fire safety mandates.

States such as Maine, Pennsylvania and Oregon have all passed legislation requiring institutions to install sprinkler systems in ALL student housings. Massachusetts has two proposals currently being reviewed, they are *House 1073* and *House 1074*.

6.2.1 House 1073

House 1073 is an act RELATIVE TO AUTOMATIC SPRINKLERS. If enacted, it would unexempt student housings from the mandates and regulations of other lodging houses set forth in the Massachusetts general laws and the 527 CMR.

Section one of House 1073 would change section 26H of chapter 148 of the General Laws, as appearing in the 1998 Official Edition, by amending and by striking out, in line 15, the words “fraternity houses or dormitories,”.

SECTION 2 of House 1073 amends said section 26H of said chapter 148 by further amending and by inserting after the word "commonwealth", in line 16, the following words : but shall include dormitories, fraternity houses and sorority houses.

7.0 Recommendations

7.1Process for devising Recommendations

After reviewing the statistical data on fire incidents, presence of fire prevention systems and costs of installing automatic sprinklers in student housing a series of recommendations regarding changes to current mandates on student housing were set to be created. In doing this The City Manager's Enforcement Team (CMET) was consulted.

The following recommendations were established based upon the statiscal and case study data presented earlier in the report. The data displayed a clear need for greater mandates regulating the installation of fire protection systems in ALL student housings.

7.1.1 Recommendations

This report recommends that changes be made in both the Massachusetts General Law and the Commonwealth of Massachusetts Requirements. These changes should mandate the following:

1. All institutions of higher learning shall be required to install automatic sprinkler systems in all student housings.
2. The owning parties of any lodging house defined as student housing, including fraternity and sorority housings shall be required to install automatic sprinkler systems.
3. Each institution or owning party shall, within 2 years of acceptance, be responsible for developing and implementing a plan for the installation of automatic suppression systems those residential structures.
4. Lodging houses shall be required to continue to meet the requirements regarding mandated detection and alarm systems.
5. In any student housing in which the occupancy exceeds 8 students, there shall be required an outside agency for monitoring the status of the detection and alarm systems within the student housing
6. A five-year period will be established in which these conditions shall be met.

7.2 Reasoning for recommendations

These recommendations take into consideration the overall costs associated with implementing these systems. These costs are well within reasonable considerations when contrasted with the expected losses from the effects of fire damage.

These recommendations raise the standards for older student housing structures to meet those of new construction. Logic would dictate that these mandates should establish equal degrees of protection; this has not been true in the past. New construction will be required to add the presence of an outside monitoring agency if they have not had such monitoring in the past.

It is further recommended that the funding for the implementation of these requirements not fall completely on the institutions. Funding for these projects should come from both sate and federal level governments. This funding should be of the highest priority.

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Appendix A

School, College, and University Dormitories, and Fraternity and Sorority House Fires in the United States 1993-1997 Annual Averages

Kimberly D. Rohr
Fire Analysis and Research Division
National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269

June 2000

School, College, and University Dormitories and Fraternity and Sorority House Fires, by Ignition Factor Reported to U.S. Fire Departments 1993-1997 Annual Averages, Unknowns Allocated

Ignition Factor	Fires		Civilian Deaths		Civilian Injuries		Property Loss (in Millions)	
Incendiary or suspicious	520	(32.7%)	0	(0.0%)	13	(19.6%)	$1.3	(15.1%)
Unattended	300	(18.3%)	0	(0.0%)	6	(9.3%)	$1.6	(18.2%)
Abandoned or discarded material	240	(14.9%)	0	(0.0%)	9	(12.9%)	$0.6	(6.3%)
Combustible too close	100	(6.1%)	0	(0.0%)	16	(23.7%)	$0.7	(7.8%)
Short circuit or ground fault	70	(4.3%)	0	(0.0%)	5	(6.9%)	$1.4	(15.4%)
Unclassified or unknown-type misuse of heat	60	(3.6%)	0	(0.0%)	4	(5.8%)	$0.9	(10.2%)
Other electrical failure	40	(2.2%)	0	(0.0%)	0	(0.7%)	$0.5	(5.9%)
Unclassified or unknown-type misuse of material	30	(1.8%)	0	(0.0%)	5	(7.2%)	$0.1	(0.6%)
Part failure, leak or break	30	(1.8%)	0	(0.0%)	1	(1.4%)	$0.3	(3.3%)
Lack of maintenance/worn out	30	(1.8%)	0	(0.0%)	0	(0.0%)	$0.1	(0.8%)
Overloaded	20	(1.1%)	0	(0.0%)	0	(0.0%)	$0.0	(0.2%)
Inadequate control of an open fire	20	(1.1%)	0	(0.0%)	1	(1.4%)	$0.0	(0.5%)
Accidentally turned on or not turned off	20	(1.1%)	0	(0.0%)	0	(0.0%)	$0.5	(5.9%)
Unclassified or unknown-type operational deficiency	20	(1.1%)	0	(0.0%)	0	(0.0%)	$0.1	(0.8%)
Unclassified or unknown-type mechanical failure or malfunction	20	(1.1%)	0	(0.0%)	0	(0.0%)	$0.0	(0.5%)
Unclassified ignition factor	20	(1.0%)	0	(0.0%)	0	(0.7%)	$0.2	(2.4%)
Other known ignition factor	70	(6.0%)	0	(0.0%)	7	(10.4%)	$0.5	(6.1%)
Total	1,610	(100.0%)	0*	(0.0%)	66	(100.0%)	$8.9	(100.0%)

*Note that these are statistical estimates from records on a sample of fires. Because deaths are very rare, it is possible for the estimate to show no deaths in a year when a fatal fire did occur and is on NFPA's list of fatal campus fires. In particular, the sample omitted eight fatal fires known to NFPA, representing a total of 16 deaths over the five years of 1993-1997.

Structure fires (incident type 11) in school, college and university dormitories and fraternity and sorority houses (fixed property use 461-462) are included in this table. Fires in which the cause was unknown or not reported have been allocated proportionally as part of the calculation. Fires and casualties are rounded to the nearest one; direct property damage is rounded to the nearest thousand. Percentages are calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. Sums may not equal due to rounding errors.

The statistics in this analysis are national estimates of fires reported to U.S. fire departments. Fires are given as annual averages based on five years of data (1993-1997). Estimates are based on data from the NFPA's annual stratified random sample survey and the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS), and are combined using statistical methods developed by analysts at NFPA, USFA and the U.S. Consumer Product Safety Commission. National estimates do not reflect unreported fires.
Source: National Estimates based on NFIRS and NFPA survey.

School, College, and University Dormitories and Fraternity and Sorority House Fires, by Area of Origin Reported to U.S. Fire Departments 1993-1997 Annual Averages, Unknowns Allocated

Area of Origin	Fires		Civilian Deaths		Civilian Injuries		Property Loss (in Millions)	
Bedroom	380	(23.8%)	0	(0.0%)	37	(56.3%)	$5.0	(56.3%)
Kitchen	340	(21.0%)	0	(0.0%)	3	(4.0%)	$0.5	(5.7%)
Hallway, corridor or mall	270	(16.9%)	0	(0.0%)	2	(2.5%)	$0.3	(3.4%)
Trash	110	(6.9%)	0	(0.0%)	3	(4.0%)	$0.1	(1.2%)
Lounge area	100	(6.0%)	0	(0.0%)	10	(14.9%)	$1.5	(16.8%)
Bathroom	80	(5.0%)	0	(0.0%)	1	(1.9%)	$0.2	(1.9%)
Laundry room or area	50	(3.3%)	0	(0.0%)	1	(1.8%)	$0.0	(0.4%)
Interior stairway	30	(1.6%)	0	(0.0%)	4	(5.5%)	$0.0	(0.2%)
Heating equipment or water heater area	20	(1.3%)	0	(0.0%)	0	(0.0%)	$0.3	(3.0%)
Closet	20	(1.1%)	0	(0.0%)	0	(0.0%)	$0.1	(0.7%)
Lobby or entrance way	20	(1.0%)	0	(0.0%)	2	(3.8%)	$0.0	(0.2%)
Other known area of origin	190	(12.1%)	0	(0.0%)	4	(5.3%)	$0.9	(10.1%)
Total	1,610	(100.0%)	0*	(0.0%)	66	(100.0%)	$8.9	(100.0%)

*Note that these are statistical estimates from records on a sample of fires. Because deaths are very rare, it is possible for the estimate to show no deaths in a year when a fatal fire did occur and is on NFPA's list of fatal campus fires. In particular, the sample omitted eight fatal fires known to NFPA, representing a total of 16 deaths over the five years of 1993-1997.

Structure fires (incident type 11) in school, college and university dormitories and fraternity and sorority houses (fixed property use 461-462) are included in this table. Fires in which the cause was unknown or not reported have been allocated proportionally as part of the calculation. Fires and casualties are rounded to the nearest one; direct property damage is rounded to the nearest thousand. Percentages are calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. Sums may not equal due to rounding errors.

The statistics in this analysis are national estimates of fires reported to U.S. fire departments. Fires are given as annual averages based on five years of data (1993-1997). Estimates are based on data from the NFPA's annual stratified random sample survey and the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS), and are combined using statistical methods developed by analysts at NFPA, USFA and the U.S. Consumer Product Safety Commission. National estimates do not reflect unreported fires.

Source: National Estimates based on NFIRS and NFPA survey.

School, College, and University Dormitories and Fraternity and Sorority House Fires, by Equipment Involved Reported to U.S. Fire Departments 1993-1997 Annual Averages, Unknowns Allocated

Equipment Involved	Fires		Civilian Deaths		Civilian Injuries		Property Loss (in Millions)	
No equipment involved	950	(59.1%)	0	(0.0%)	47	(71.5%)	$4.2	(47.6%)
Stove	210	(13.0%)	0	(0.0%)	2	(3.0%)	$0.6	(7.2%)
Portable cooking or warming unit	40	(2.3%)	0	(0.0%)	1	(2.2%)	$0.0	(0.1%)
Oven	40	(2.3%)	0	(0.0%)	0	(0.0%)	$0.0	(0.1%)
Lamp or light bulb	40	(2.2%)	0	(0.0%)	3	(4.5%)	$0.1	(1.4%)
Light fixture, lampholder or sign	40	(2.2%)	0	(0.0%)	2	(3.6%)	$0.5	(5.7%)
Unclassified or unknown-type cooking equipment	30	(1.8%)	0	(0.0%)	0	(0.0%)	$0.3	(3.7%)
Dryer	30	(1.6%)	0	(0.0%)	0	(0.0%)	$0.0	(0.3%)
Cord or plug	20	(1.2%)	0	(0.0%)	3	(4.1%)	$1.4	(15.7%)
Washing machine	20	(1.2%)	0	(0.0%)	0	(0.0%)	$0.0	(0.0%)
Unclassified other object or exposure to fire	20	(1.1%)	0	(0.0%)	2	(2.6%)	$0.1	(0.7%)
Other known equipment involved	170	(12.0%)	0	(0.0%)	6	(8.4%)	$1.6	(17.6%)
Total	1,610	(100.0%)	0*	(0.0%)	66	(100.0%)	$8.9	(100.0%)

*Note that these are statistical estimates from records on a sample of fires. Because deaths are very rare, it is possible for the estimate to show no deaths in a year when a fatal fire did occur and is on NFPA's list of fatal campus fires. In particular, the sample omitted eight fatal fires known to NFPA, representing a total of 16 deaths over the five years of 1993-1997.

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The statistics in this analysis are national estimates of fires reported to U.S. fire departments. Fires are given as annual averages based on five years of data (1993-1997). Estimates are based on data from the NFPA's annual stratified random sample survey and the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS), and are combined using statistical methods developed by analysts at NFPA, USFA and the U.S. Consumer Product Safety Commission. National estimates do not reflect unreported fires.

Source: National Estimates based on NFIRS and NFPA survey.

School, College and University Dormitories and Fraternity and Sorority House Fires, by Form of Material First Ignited Reported to U.S. Fire Departments 1993-1997 Annual Averages, Unknowns Allocated

Form of Material	Fires		Civilian Deaths		Civilian Injuries		Property Loss (in Millions)	
Trash	320	(19.9%)	0	(0.0%)	10	(14.6%)	$0.4	(4.6%)
Cooking materials	290	(17.8%)	0	(0.0%)	3	(4.5%)	$0.6	(7.0%)
Magazine or newspaper	190	(11.6%)	0	(0.0%)	2	(2.6%)	$0.1	(1.2%)
Unclassified form of material	80	(5.0%)	0	(0.0%)	3	(5.0%)	$0.2	(2.1%)
Electrical wire or cable insulation	70	(4.5%)	0	(0.0%)	3	(4.9%)	$1.5	(16.4%)
Clothing not on a person	50	(3.1%)	0	(0.0%)	3	(5.0%)	$0.2	(2.7%)
Upholstered furniture	50	(2.9%)	0	(0.0%)	7	(10.0%)	$0.5	(5.9%)
Bedding	40	(2.7%)	0	(0.0%)	9	(13.7%)	$2.5	(28.4%)
Box, carton or bag	40	(2.6%)	0	(0.0%)	1	(1.3%)	$0.1	(0.8%)
Multiple forms-	40	(2.4%)	0	(0.0%)	1	(1.9%)	$0.3	(3.1%)
Mattress or pillow	40	(2.2%)	0	(0.0%)	5	(7.0%)	$0.2	(2.6%)
Decorations	30	(1.7%)	0	(0.0%)	2	(3.7%)	$0.0	(0.3%)
Floor covering or surface	20	(1.4%)	0	(0.0%)	0	(0.0%)	$0.1	(1.4%)
Appliance housing/casing	20	(1.3%)	0	(0.0%)	3	(4.3%)	$0.0	(0.6%)
Linen other than bedding	20	(1.3%)	0	(0.0%)	0	(0.0%)	$0.0	(0.2%)
Cabinetry	20	(1.3%)	0	(0.0%)	0	(0.0%)	$0.1	(0.8%)
Interior wall covering or fixed items	20	(1.2%)	0	(0.0%)	0	(0.6%)	$0.1	(1.4%)
Structural member or framing	20	(1.2%)	0	(0.0%)	0	(0.0%)	$0.8	(8.7%)
Unclassified or unknown-type adornment or recreation material	20	(1.1%)	0	(0.0%)	0	(0.0%)	$0.0	(0.1%)
Curtain, blind or drapery	20	(1.0%)	0	(0.0%)	2	(3.2%)	$0.0	(0.2%)
Other known form of material	210	(13.8%)	0	(0.0%)	12	(17.8%)	$1.0	(11.4%)
Total	1,610	(100.0%)	0*	(0.0%)	66	(100.0%)	$8.9	(100.0%)

*Note that these are statistical estimates from records on a sample of fires. Because deaths are very rare, it is possible for the estimate to show no deaths in a year when a fatal fire did occur and is on NFPA's list of fatal campus fires. In particular, the sample omitted eight fatal fires known to NFPA, representing a total of 16 deaths over the five years of 1993-1997.

Structure fires (incident type 11) in school, college and university dormitories and fraternity and sorority houses (fixed property use 461-462) are included in this table. Fires in which the form of material was unknown or not reported have been allocated proportionally as part of the calculation.Fires and casualties are rounded to the nearest one; direct property damage is rounded to the nearest thousand. Percentages are calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. Sums may not equal due to rounding errors.

The statistics in this analysis are national estimates of fires reported to U.S. fire departments. Fires are given as annual averages based on five years of data (1993-1997). Estimates are based on data from the NFPA's annual stratified random sample survey and the U.S. Fire Incident Reporting System (NFIRS), and are combined using statistical methods developed by analysts at NFPA, USFA and the U.S. Consumer Product Safety Commission. National estimates do not reflect unreported fires.

Source: National Estimates based on NFIRS and NFPA survey.

School, College, and University Dormitories and Fraternity and Sorority House Fires, by Type of Material First Ignited Reported to U.S. Fire Departments 1993-1997 Annual Averages, Unknowns Allocated

Type of Material	Fires		Civilian Deaths		Civilian Injuries		Property Loss (in Millions)	
Untreated or uncoated paper	500	(30.8%)	0	(0.0%)	16	(24.2%)	$0.6	(7.0%)
Food or starch	150	(9.1%)	0	(0.0%)	0	(0.0%)	$0.0	(0.4%)
Fat or grease (food)	130	(8.1%)	0	(0.0%)	1	(1.9%)	$0.6	(6.4%)
Cotton, rayon or finished goods	120	(7.3%)	0	(0.0%)	8	(12.9%)	$1.0	(11.0%)
Unclassified or unknown-type plastic	110	(7.0%)	0	(0.0%)	4	(6.4%)	$1.3	(15.1%)
Unclassified or unknown-type wood or paper	100	(6.1%)	0	(0.0%)	4	(6.2%)	$0.2	(1.7%)
Manufactured fabric, fiber or finished good	90	(5.9%)	0	(0.0%)	15	(22.5%)	$1.5	(16.6%)
Multiple types	50	(3.4%)	0	(0.0%)	2	(2.5%)	$0.7	(7.4%)
Sawn wood	50	(3.2%)	0	(0.0%)	0	(0.6%)	$1.1	(12.6%)
Unclassified type of material	40	(2.3%)	0	(0.0%)	0	(0.7%)	$0.0	(0.2%)
Unclassified or unknown-type fabric, textile or fur	40	(2.2%)	0	(0.0%)	3	(5.2%)	$1.4	(15.3%)
Cardboard	30	(2.2%)	0	(0.0%)	1	(1.4%)	$0.1	(0.6%)
Polyvinyl	30	(1.7%)	0	(0.0%)	2	(3.8%)	$0.1	(0.6%)
Rubber	30	(1.6%)	0	(0.0%)	0	(0.0%)	$0.0	(0.4%)
Other known type of material	140	(9.3%)	0	(0.0%)	8	(11.8%)	$0.4	(4.8%)
Total	1,610	(100.0%)	0*	(0.0%)	66	(100.0%)	$8.9	(100.0%)

*Note that these are statistical estimates from records on a sample of fires. Because deaths are very rare, it is possible for the estimate to show no deaths in a year when a fatal fire did occur and is on NFPA's list of fatal campus fires. In particular, the sample omitted eight fatal fires known to NFPA, representing a total of 16 deaths over the five years of 1993-1997.

Structure fires (incident type 11) in school, college and university dormitories and fraternity and sorority houses (fixed property use 461-462) are included in this table. Fires in which the type of material was unknown or not reported have been allocated proportionally as part of the calculation. Fires and casualties are rounded to the nearest one; direct property damage is rounded to the nearest thousand. Percentages are calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. Sums may not equal due to rounding errors.

The statistics in this analysis are national estimates of fires reported to U.S. fire departments. Fires are given as annual averages based on five years of data (1993-1997). Estimates are based on data from the NFPA's annual stratified random sample survey and the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS), and are combined using statistical methods developed by analysts at NFPA, USFA and the U.S. Consumer Product Safety Commission. National estimates do not reflect unreported fires.

Source: National Estimates based on NFIRS and NFPA survey.

School, College and University Dormitory Fires, by Cause Reported to U.S. Fire Departments 1993-1997 Annual Averages

Cause	Fires		Civilian Deaths		Civilian Injuries		Direct Property Loss	
Incendiary or suspicious	480	(32.9%)	0	(0.0%)	11	(23.5%)	$958,700	(15.9%)
Cooking	269	(18.4%)	0	(0.0%)	3	(7.0%)	$434,300	(7.2%)
Smoking	170	(11.6%)	0	(0.0%)	7	(13.8%)	$368,900	(6.1%)
Other equipment	119	(8.2%)	0	(0.0%)	2	(3.7%)	$338,000	(5.6%)
Electrical distribution	100	(6.9%)	0	(0.0%)	6	(11.9%)	$917,700	(15.2%)
Other heat, flame or spark	98	(6.7%)	0	(0.0%)	14	(28.7%)	$2,156,400	(35.7%)
Appliances, air conditioning	84	(5.8%)	0	(0.0%)	3	(6.6%)	$434,100	(7.2%)
Open flame, ember or torch	81	(5.5%)	0	(0.0%)	1	(2.1%)	$232,100	(3.8%)
Heating	31	(2.2%)	0	(0.0%)	0	(0.0%)	$47,800	(0.8%)
Exposure	10	(0.7%)	0	(0.0%)	0	(0.0%)	$13,200	(0.2%)
Children playing	8	(0.5%)	0	(0.0%)	1	(1.8%)	$19,900	(0.3%)
Natural causes	8	(0.5%)	0	(0.0%)	0	(0.9%)	$111,900	(1.9%)
Total	1,460	(100.0%)	0*	(0.0%)	48	(100.0%)	$6,033,000	(100.0%)

*Note that these are statistical estimates from records on a sample of fires. Because deaths are very rare, it is possible for the estimate to show no deaths in a year when a fatal fire did occur and is on NFPA's list of fatal campus fires. In particular, the sample omitted eight fatal fires known to NFPA, representing a total of 16 deaths over the five years of 1993-1997.

Structure fires (incident type 11) in school, college and university dormitories (fixed property use 461) are included in this table. Fires in which the cause was unknown or not reported have been allocated proportionally as part of the calculation. A detailed explanation of what is included in each cause can be found in the appendix.Fires and casualties are rounded to the nearest one; direct property damage is rounded to the nearest hundred dollars. Percentages are calculated on the actual estimates, so two figures with the same rounded-off estimates may have different percentages. Sums may not equal due to rounding errors.

The statistics in this analysis are national estimates of fires reported to U.S. fire departments. Fires are given as annual averages based on five years of data (1993-1997). Estimates are based on data from the NFPA's annual stratified random sample survey and the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS), and are combined using statistical methods developed by analysts at NFPA, USFA and the U.S. Consumer Product Safety Commission. National estimates do not reflect unreported fires.

Source: National Estimates based on NFIRS and NFPA survey.

Projecting NFIRS to National Estimates

To project NFIRS results to national estimates, one needs at least an estimate of the NFIRS fires as a fraction of the total so that the fraction can be inverted and used as a multiplier or scaling ratio to generate national estimates from NFIRS data. But NFIRS is a sample from a universe whose size cannot be inferred from NFIRS alone. Also, participation rates in NFIRS are not necessarily uniform across regions and sizes of community, both of which are factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that a second data base - the NFPA survey - is needed to project NFIRS to national estimates and to project different parts of NFIRS separately. This multiple calibration approach makes use of the annual NFPA survey where its statistical design advantages are strongest.

There are separate projection formulas for four major property classes (residential structures, non-residential structures, vehicles, and other) and for each measure of fire severity (fire incidents, civilian deaths, and civilian injuries, and direct property damage).

For example, the scaling ratio for 1996 civilian deaths in residential structures is equal to the total number of 1996 civilian deaths in residential structure fires reported to fire departments, according to the NFPA survey (4,080), divided by the total number of 1996 civilian deaths in residential structure fires reported to NFIRS (1,504). Therefore, the scaling ratio is 4,080/1,504 = 2.71.

The scaling ratios for civilian deaths and injuries and direct property damage are often significantly different from those for fire incidents. Except for fire service injuries, average severity per fire is generally higher for NFIRS than for the NFPA survey. Use of different scaling ratios for each measure of severity is equivalent to assuming that these differences are due either to NFIRS under-reporting of small fires, resulting in a higher-than-actual loss-per-fire ratio, or possible biases in the NFIRS sample representation by region or size of community, resulting in severity-per-fire ratios characteristic only of the oversampled regions or community sizes.

Note that this approach also means that the NFPA survey results for detailed property-use classes (e.g., fires in storage structures) may not match the national estimates of the same value.

Calculating National Estimates of Particular Types of Fires

Most analyses of interest involve the calculation of the estimated number of fires not only within a particular occupancy but also of a particular type. The types that are mostly frequently of interest are those defined by some ignition-cause characteristic. The six cause-related characteristics most commonly used to describe fires are: form of the heat that caused the ignition, equipment involved in ignition, form or type of material first ignited, the ignition factor that brought heat source and ignited material together, and area of origin. Other characteristics of interest are victim characteristics, such as ages of persons killed or injured in fire.

For any characteristic of interest in NFIRS, some reported fires have that characteristic unknown or not reported. If the unknowns are not taken into account, then the propensity to report or not report a characteristic may influence the results far more than the actual patterns on that characteristic. For example, suppose the number of fires remained the same for several consecutive years, but the percentage of fires with cause unreported steadily declined over those years. If the unknown-cause fires were ignored, it would appear as if fires due to every specific cause increased over time while total fires remained unchanged. This, of course, does not make sense.

Consequently, most national estimates analyses allocate unknowns. This is done by using scaling ratios defined by NFPA survey estimates of totals divided by only those NFIRS fires for which the dimension in question was known and reported. This approach is equivalent to assuming that the fires with unreported characteristics, if known, would show the same proportions as the fires with known characteristics. For example, it assumes that the fires with unknown ignition factor contain the same relative shares of child-playing fires, incendiary-cause fires, short circuit fires, and so forth, as are found in the fires where ignition factor was reported.

Rounding Errors

The possibility of rounding errors exists in all our calculations. One of the notes on each table indicates the extent of rounding for that table, e.g., deaths rounded to the nearest one, fires rounded to the nearest hundred, property damage rounded to the nearest hundred thousand dollars. In rounding to the nearest one, functional values of 0.5 or more are rounded up and functional values less than 0.5 are rounded down. For example, 2.5 would round to 3, and 3.4 would round to 3. In rounding to the nearest one, a stated estimate of 1 could be any number from 0.5 to 1.49, a roughly threefold range.

The impact of rounding is greatest when the stated number is small relative to the degree of rounding. As noted, rounding to the nearest one means that stated values of 1 may vary by a factor of three. Similarly, the cumulative impact of rounding error - the potential gap between the estimated total and the sum of the estimated values as rounded - is greatest when there are a large number of values and the total is small relative to the extent of rounding.

Suppose a table presented 5-year averages of estimated deaths by item first ignited, all rounded to the nearest one. Suppose there were a total of 30 deaths in the 5 years, so the total average would be 30/5 = 6.

In case 1, suppose 10 of the possible items first ignited each accounted for 3 deaths in 5 years. Then there would be 10 entries of 3/5 = 0.6, rounded to 1, and the sum would be 10, compared to the true total of 6.

In case 2, suppose 15 of the possible items first ignited each accounted for 2 deaths in 5 years. Then there would be 15 entries of 215 = 0.4, rounded to 0, and the sum would be 0, compared to the true total of 6.

Here is another example: Suppose there were an estimate of 7 deaths total in 1992 through 1996. The 5-year average would be 1.4, which would round to 1, the number we would show as the total. Each death would represent a 5-year average of 0.2.

If those 7 deaths split as 4 deaths in one category (e.g., smoking) and 3 deaths in a second category (e.g., heating), then we would show 4 x 0.2 = 0.8 deaths per year for smoking and 3 x 0.2 = 0.6 deaths per year for heating. Both would round to 1, there would be two entries of 1, and the sum would be 2, higher than the actual rounded total.

If those 7 deaths split as 1 death in each of 7 categories (quite possible since there are 12 major cause categories), then we would show 0.2 in each category, always rounding to 0, and the sum would be 0, lower than the actual rounded total. The more categories there are, the farther apart the sum and total can -- and often do -- get.

Note that percentages are calculated from unrounded values, and so it is quite possible to have a percentage entry of up to 100%, even if the rounded number entry is zero.

Firefighter Deaths and Injuries

There are special procedures for fire service deaths and injuries. NFPA maintains a comprehensive listing of fire service on-duty deaths which can be used to produce answers not dependent on projection from samples. This is desirable because the number of fire service deaths at the fireground for fires of a particular cause is typically very small - less than 10 a year - so sample-based estimates would have very large uncertainty ranges, relative to the statistics being estimated.

For fire service injuries, the NFPA survey does not produce projections of fire service injuries at the fireground by major property type. Therefore, one must use a single scaling ratio instead of the four ratios (one each for residential structures, non-residential structures, vehicles, and other properties) that are used to scale up the other measures of fire severity.

Appendix B

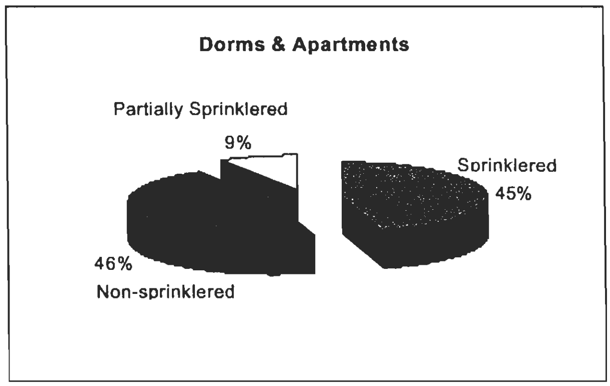
Honorable Valerie Lewis
Commissioner of Higher Education

Honorable Arthur L. Spada
Commissioner of Public Safety
State Fire Marshal

College Dormitory Fire Safety Code Study

In addition to the requirements of the Connecticut State Fire Safety Code, Connecticut General Statutes, Chapter 541, § 29-315 requires that as of October 1, 1973, all new buildings having more than four stories and used for human occupancy shall have an automatic fire extinguishing system. As a result of several fires, revisions to the statute established more stringent requirements for hotels, motels and residential facilities for the elderly.

There are twenty-three institutions of higher education in Connecticut that provide residential facilities to their students. These dwellings which number just over three hundred, range in size and number of occupants. The majority, sixty-nine percent, are dormitory occupancies as defined by the Connecticut State Fire Safety Code, and apartment buildings comprise another twenty-five percent of all collegiate residential facilities. Approximately forty percent are state owned.



Out of this total, one hundred twenty-eight are fully protected by an automatic fire sprinkler system, twenty-four are partially sprinklered and one hundred twenty nine do not have sprinklers. (See chart) In breaking it down even further, fifty-three percent of the dormitories (one hundred ten) are fully equipped with sprinklers and twenty-four percent of the apartment buildings (eighteen) are sprinklered.

A table illustrating the residential breakdown of each college and university is attached to this report.

Recommendation

Connecticut's institutions for higher education are diligent in protecting the lives of students entrusted in their care. Recent fires in collegiate residential facilities have raised the awareness of the public. This in turn has elevated the expectation that the institutions for higher education are providing a minimal level of risk. According to some parents, this level of safety afforded to the students has become one of the factors they evaluate when selecting a college or university.

The most recent example illustrating the effectiveness of a sprinkler system occurred at the same dormitory that heightened the nation's awareness for fire safety. On January 19, 2000 a fire occurred in Boland Hall which is on the Seton Hall University campus in Orange, New Jersey. Three students died in that fire. In addition to other fire code violations, the building did not have an automatic fire extinguishing system. A fire sprinkler system has since been installed. On December 8, 2000 , a small fire occurred in a trash can in Boland Hall. Six hundred people occupied the building at the time. One sprinkler head activated and extinguished the fire without any reported injuries.

The second fire in Boland Hall further justifies the need for an engineering safeguard, such as sprinklers, and not simply an educational program. One would expect that students in any dormitory where others were killed by a fire the previous semester should be more conscientious of fire prevention, yet, a fire occurs in a trash can. This cavalier attitude of the occupants is summed up by a statement made by Francis Brannigan in a May 2000 Firehouse Magazine article about dormitory fires. He wrote, "Automatic sprinklers give academic freedom to do stupid things."

College and University Dormitory Survey

KEY: **S**=Sprinklered **N**=Non-Sprinklered **P**=Partially Sprinklered

Name of Institution	Dormitory			Apartment			Lodging/Rooming			Other Type of Structure			
	S	N	P	S	N	P	S	N	P		S	N	P
University of Connecticut	18	23	5	3	29		7						
Eastern Connecticut State University	3	1		4	1	5							
Central Connecticut State University	6	1		1									
Southern Connecticut State University			5	1		6							
Western Connecticut State University	4			1									
Albertus Magnus College	1	2*											
Briarwood College					1								
Connecticut College	14	9											
Fairfield University	7	2*											
Holy Apostles College and Seminary		1					1	1					
International College of Hospitality Management		4											
Mitchell College	4	3											
Quinnipiac University	4			6	13								
Sacred Heart University	6			2									
St. Basil College		1											
St. Joseph College		5											
Teikyo Post University		5			1								
Trinity College	14	11											
University of Bridgeport	2	2											
University of Hartford	9	7*											
University of New Haven	2	3*											
Wesleyan University	2	18	3					4		Town Houses		7	
Yale University	14	2											

Notes:

1.) Three attached dormitories at Wesleyan University are presently provided with approximately 80 % sprinkler protection.
2.) Partial sprinkler protection in buildings at the University of Connecticut and at Southern Connecticut State University is provided primarily in mechanical spaces and storage rooms.
   * Albertus Magnus College - Sprinkler installation in progress in 2 dormitories.
   * Fairfield University - Sprinkler installation in progress in 2 dormitories.
   * University of Hartford - Sprinkler installation in progress in 2 dormitories.
   * University of New Haven - Sprinkler installation in progress in 1 dormitory.
3,) All existing dormitories required to be provided with sprinkler protection are in compliance.

Appendix C

Legislative Budget and Finance Committee

A JOINT COMMITTEE OF THE PENNSYLVANIA GENERAL ASSEMBLY

Offices: Room 400 • Finance Building • Harrisburg • Tel: (717) 783-1600
Mailing Address: P.O. Box 8737 • Harrisburg, PA 17105-8737
Facsimile (717) 787-5487

The Feasibility of Retrofitting High Rises, College Dorms, and Certain Other Buildings With Fire Sprinklers

Volume I

(A Report in Response to Senate Resolution 132)

January 2001

Effectiveness of Sprinkler Systems

As the tables below show, automatic sprinklers systems have proven to be effective, although not perfect, in reducing deaths and property damage due to fire.

	U.S. Average Annual Civilian Deaths per Thousand Fires			Average Number of Fires per Year
Property Use	**Without Sprinklers**	**With Sprinklers**	**Percent Reduction**	
Health care facilities				
Care of aged facilities	10.8	1.9	82%	3,100
Care of sick facilities	4.9	0.7	86%	2,600
Residential properties				
All Apartments	8.7	1.6[1]	81%	75,000
Hotels and motels	17.3	<1[2]	100%	1,400
Dormitories and barracks[3]	1.5	0.0	100%	1,600

1 The majority of sprinklers are installed in high-rise apartment buildings
2 Based on fewer than two deaths per year; the results may not be significant
3 Includes fraternities and sororities

	Average Direct Property Damage per Fire		
Property Use	**Without Sprinklers**	**With Sprinklers**	**Percent Reduction**
Health care facilities			
Care of aged facilities	$2,800	$1,700	39%
Care of sick facilities	$5,400	$2,150	60%
Residential properties			
Apartments	$ 8,500	$4,400	49%
Apartments (at least 7 stories tall)	$ 3,200	$1,800	43%
Lodging	$12,700	$4,300	66%
Lodging (at least 7 stories tall)	$13,400	$4,500	67%
Dormitories and barracks	$ 7,400	$4,700	36%

Although their record in preventing multiple deaths is clear for the occupancy classes included in this report, automatic sprinklers cannot be expected to save the lives of those (typically one or two persons) who are closest to the heat source and the material ignited. Examples include ignition of bedding or a person's clothing. To be effective, sprinklers must also be properly designed, inspected, and maintained.

Cost and Feasibility of a Sprinkler Retrofit Requirement

The report attempts to estimate the cost, both on a per-building and statewide basis, to retrofit buildings with sprinkler systems in the occupancy classes outlined in the resolution. Local government officials, including several fire chiefs, were interviewed to assess the feasibility of their municipalities implementing and enforcing such a requirement.

Existing Sprinkler Requirements

The cost to retrofit the Commonwealth's high-rises, college dormitories, and other buildings of public access housing individuals depends foremost on the number of such buildings that are already sprinklered. Several municipalities (Philadelphia, Harrisburg, Bethlehem, and Allentown) have already enacted sprinkler retrofit ordinances covering many high-rises and other buildings in the occupancy classes included in this report.

In addition to these local retrofit ordinances, Title 34 Section 50.91 of the Commonwealth Fire and Panic Act (Act 299 of 1927) requires all high-rise buildings (buildings that exceed 75 feet in height) to have automatic sprinkler systems. However, this mandate only applies to buildings built after 1984 or that undergo a major renovation after 1984.

The Pennsylvania Construction Code Act (Act 45 of 1999) established a statewide building code which adopts the 2000 International Building Code (IBC). When the IBC code becomes effective (after the Department of Labor and Industry issues regulations, anticipated in early 2001) automatic sprinkler systems will be required in all Group "R-2" IBC classification buildings (which includes dormitories) that are more than two stories high or have more than 16 dwelling units. This requirement, however, only applies to new construction and, in specific instances, buildings undergoing alterations. It does not require existing buildings be retrofitted with sprinkler systems.

Although Pennsylvania only recently adopted a statewide building code, it should be noted that building codes and standards have traditionally been adopted at the local level, either through the adoption of a model code or a distinct local code. Currently, an estimated 1,100 of the Commonwealth's 2,600 communities have adopted building code requirements. The majority of these utilize BOCA's National Building Code as their model, which, since 1989, has required sprinkler systems in new construction and in major renovations of buildings for virtually all of the occupancies examined in this study, and some for several years before then.

Factors Affecting Sprinkler Retrofitting Costs

The cost to retrofit a building with an automatic sprinkler system depends on many factors. Buildings with steel frames, masonry exterior curtain wall construction, and open floor arrangements are the least expensive to retrofit, given the open and accessible ceiling areas, similar floor-to-floor construction, can be the least expensive on a per square foot basis.

Wood-framed buildings—the least expensive, and, therefore, the most common type of construction for buildings of three stories or less—are typically the most expensive to retrofit on a per square foot basis. Sprinkler retrofits for wood-framed buildings can be the most expensive because roof peaks, crawl spaces, and other concealed combustible spaces need to be protected by sprinklers. Costs increase further if the sprinklers are to be unobtrusive and blended into the architecture of the building.

Other factors affecting cost include the availability of an adequate water supply, the possible need for asbestos and PCB abatement in conjunction with sprinkler installation, whether the work must be done during off-hours, additional requirements imposed by local government authorities, and whether the work is to be done by union or non-union workers. Often sprinkler systems are installed in conjunction with other improvements, such as plumbing, electrical, and HVAC system upgrades, which increases overall project costs.

For these reasons, the report includes a low and high estimated cost range, from $3.50 per square foot plus 10 percent for engineering to $8.50 per square foot plus 12 percent for engineering. We use differing low and high cost per square foot values from occupancy class to occupancy class. The selection of these values was based on actual project quotations and field experience. Given the interest in college dormitories, we developed a more targeted overall estimate for this occupancy.

Although fire insurance premiums are generally less for buildings with sprinklers, these savings are typically modest, particularly for buildings constructed of non-combustible materials and for occupancy classes that historically have had low losses (and therefore, already have low premiums).

Cost to Retrofit Buildings with Sprinkler Systems

We estimate there are approximately 7,000 buildings in Pennsylvania in the occupational classes covered in this report. Of these, we estimate approximately 40 percent are currently sprinklered. The following table shows our estimates of the cost to fully sprinkler the unsprinklered and partially sprinklered buildings in the occupancy classes listed. The range is due to a variety of factors including type of construction, aesthetic considerations, adequacy of the existing water supply, asbestos and PCB abatement issues, and other factors that could not be estimated with precision.

Pennsylvania Summary of Cost to Sprinkler Statistics

	Approximate Quantity of Buildings	*Percent Unsprinklered*	*Low Cost to Sprinkler (Millions)*	*High Cost to Sprinkler (Millions)*	*Report Chapter*
Institutional Occupancies					
Care of the aged facilities	1,600	46%	$132	$248	Chapter 4
Residential Occupancies					
Lodging	1,900	56%	$148	$281	Chapter 5
Dormitory	1,250	88%	$141	$328	Chapter 2
Fraternity, Sorority	900	68%	$21	$40	Chapter 3
High Rise					
Commercial	775	50%	$560	$1,100	Chapter 6
Apartments	400*	50%	$35	$83	Chapter 6

*Based on an average of 40,000 sq. ft. per building

Feasibility of Municipalities Implementing a Sprinkler Retrofit Requirement

Based on our interviews with local officials, including officials in Bethlehem, Harrisburg, and Philadelphia, which have enacted sprinkler retrofit ordinances, we believe the cost to implement and enforce a sprinkler retrofit ordinance would not be significant.

Today, the installation of sprinklers is a standard component of most new building construction, especially in communities that have adopted a building code. Those communities have an infrastructure in place to administer sprinkler-related code requirements, and this infrastructure will be expanded as a result of the recently adopted statewide building code.

Typically, the building owners are required to have their sprinkler systems inspected and certified annually. These inspections are almost always carried out by private firms and paid for by the building owner, resulting in little cost to the municipality. Because sprinkler systems are highly favored by the fire protection community, it is unlikely that the nominal costs incurred by municipalities to enact and enforce a sprinkler retrofit ordinance would be a problem.

Recommendations

Overall, the number of fatalities in Pennsylvania due to fire in the occupancy classes covered in this report have fallen significantly over the past twenty years, from an average of 9.9 fatalities per year in the 1980's to an average of 4.9 fatalities per year in the 1990's. As the percentage of buildings with sprinklers and other active and passive fire management systems increases, it can be anticipated that the number of fatalities will continue to decline.

Nevertheless, Pennsylvania remains vulnerable to tragic fires, such as the 1994 and 2000 fraternity house fires at Bloomsburg University, which resulted in eight fatalities, and the 1997 fire at a board and care home at Harveys Lake, which resulted in ten fatalities. Excluding off-campus housing used by students, no fatal fires have occurred at a college dormitory in Pennsylvania for at least 20 years. However, a three-fatality fire did occur at a Seton Hall University dormitory in neighboring New Jersey in 2000. If the General Assembly decides further steps should be taken to minimize the potential for such fire occurrences in Pennsylvania, we recommend two options be considered:

- **Option 1: Require that sprinklers be installed in existing buildings in the occupancy classes of concern.** We are not aware of any state that has enacted a sprinkler retrofit requirement covering all of the occupancy classes included in this report. However, several states have enacted such a requirement for specific occupancy classes, such as nursing homes, high-rise buildings or college dormitories.

  Advances in sprinkler technology have made it technically feasible to install sprinklers in virtually any building. The State Capitol building in Harrisburg, for example, has been recently retrofitted with a sprinkler system. The report outlines the likely overall cost to enact such a requirement for the various occupancy classes covered in the report. The economic feasibility for individual buildings must be estimated on an individual building basis. Whereas the large majority of the buildings in the occupancy classes reviewed are privately owned, the economic feasibility of requiring these buildings to be retrofitted with sprinkler systems would vary greatly depending upon the particulars of each situation.

  The State System of Higher Education, as an example, has recently determined to install sprinklers in 136 of its 146 residence halls at a cost of approximately $50 million; the 10 remaining residence halls will not be used for student housing beyond 2005. Similarly, it can be assumed that it would not be economically feasible to sprinkler many of the other buildings in the occupancy classes reviewed in this report, such as smaller establishments, buildings that have partial occupany, and buildings that are near the end of their useful life.

- **Option 2: Require that buildings in the occupancy classes of concern be brought up to safety levels equivalent to the current IBC code requirements.** This option would require the buildings in those occupancy classes that are of concern to have levels of safety equivalent to the levels of safety prescribed by the International Building Code's requirements for fire and life safety. As explained in the report, Chapter 34 of the IBC allows an "equivalency scoring approach" which assigns values to a building based on 18 factors, including egress, fire alarm systems, vertical openings, sprinkler systems, and other safety features of the building. This approach allows for flexibility in how the standards are met while ensuring that, overall, the building has a reasonable level of fire safety.

We also recommend that:

- **The Commonwealth report fire incident data to the National Fire Reporting Incident System.** Pennsylvania is one of few states that does not report fire incident data to the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS). Although some local fire departments were very cooperative in providing us with the information they had, this information was not uniform, nor did it cover the entire state. Currently, the State Fire Commissioner is initiating a program in cooperation with local fire departments to collect fire incident data and report this data to NFIRS. This will greatly aid state agencies in tracking Pennsylvania fire experience and evaluating future mitigation programs.

Appendix D

Firewatch

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Breaking News

Incidents Identified (2001)	33
People Killed	4
Residence Hall Incidents	17
Greek Incidents	2
Off-Campus Incidents	9
Academic	1

Updated 3/18/01

Unless otherwise indicated, the following information has been taken from press accounts and not independently verified. More information on each of these incidents is contained in the Campus Firelog in each issue of Campus Firewatch.

March 18, 2001

Dormitory Fire
Princeton University
Princeton, NJ

A fire in a dormitory room was started by an overloaded electrical outlet. The fire, which started under a bed, was contained to the room and destroyed all of the contents.

March 13, 2001

Dormitory Fire (Under construction)
Lamar University
Beaumont, TX

Two dormitories that were under construction and were approximately 70% complete were destroyed in a suspicious fire.

March 12, 2001

Dormitory Fire
Green Mountain College
Poultney, VT

A fire in a second-story room of a three story building was started by a cigarette that ignited a mattress. The occupant attempted to stomp out the fire, but was unsuccessful and left the room to alert the other occupants in the building. The fire caused significant damage to the room as well as another room and the hallway in the area. There was water damage and smoke damage throughout the building. There were reported to be either 6 or 12 students in the dorm, which normally houses 62 people, because the school was on spring break.

March 11, 2001

Off-campus apartment fire
Pennsylvania State
State College, PA

The following information was provided by official sources.

On Sunday March 11 at approx 5:30 PM, a fire occurred in an off-campus student housing duplex in State College, PA. One occupant was at home sleeping at the time of the fire. Fire was contained to one half of the duplex, causing extensive damage on all floors. No injuries were reported. All six occupants were displaced. Following an inspection today, three of the six were permitted to move back in to the unburned side.

The building was a two story, two family dwelling. There were smoke detectors on all levels, but some had been removed or disconnected.

The fire was believed to have been caused by improper disposal of smoking materials on the back porch.

March 6, 2001

Boiler Fire
Erie Community College
Amherst, NY

A fire caused by a malfunctioning boiler in a student center caused $250,000 in damage. Smoke was spread throughout the building, forcing it to be closed down.

March 6, 2001

Dormitory Fire-Sprinkler Save
Clemson University
Clemson, South Carolina

The following information was provided by official sources.

Late yesterday evening, Clemson University had a trash chute fire in Byrnes Hall, a high-rise residential facility. The fire was contained until the arrival of the fire department by a single activated sprinkler head in the trash chute at the seventh level. The water flow trigger the building's fire alarm system. Evacuation of the dorm was without incident. Damage was minimal, limited to smoke and water which was removed by PPV and water vacs. CUFD units were on the scene for 2 hours.

March 5, 2001

Dormitory Fire
University of New Hampshire
Durham, NH

A student was melting paraffin wax on top of a stove when the wax was ignited. The occupants attempted to extinguish the wax by pouring water on it, which caused the wax to splatter, spreading the fire. The fire was eventually extinguished with a broom prior to fire department arrival. One student received second degree burns. Fire extinguishers located in the hallway were not used.

March 5, 2001

Dormitory Fire
Rutgers University
New Brunswick, NJ

Three students were charged with arson and risking widespread injury as a result of a game they were playing. The three students were bored and had spent the night flicking lit matches in a corridor. They ignited a cardboard box, which they attempted unsuccessfully to stomp out. They were then able to smother it with a cushion. Campus police identified the students by following a trail of burnt matches to their room. The students no longer live on campus.

February 27, 2001

Dormitory Fire
Colby-Sawyer College
New London, NH

The following information was provided by official sources.

A fire in a closet was controlled by the activation of a single sprinkler head, resulting in minor damage.

This fire contrasted dramatically to a fire several weeks ago at Blair Hall, Plymouth State College. A candle fell on a bed, no sprinkler. The room was totally gutted out the room and caused serious smoke and water damage throughout the building. PSC is the only University of New Hampshire campus that is not sprinklered.

February 23, 2001

Dormitory Fire
Oklahoma State University
Stillwater, Oklahoma

A fire in a dormitory was caused by a hairdryer. It was determined to be accidental, and the damage was limited to the area around the hairdryer.

February 19, 2001

Dormitory Fires-Arson
Western Kentucky University
Bowling Green, KY

Several fires were determined to be arson. In two separate fires, combustible materials were placed on top of kitchen stoves and the burners were turned on. No one was injured in either fire.

February 26, 2001

Fatal off-campus fire
Binghamton University
Binghamton, NY

A fire started by a lamp killed a 23-year-old junior. About 12 other people were able to escape the fire. It was reported that there were a number of disconnected smoke detectors .

February 24, 2001

Campus Apartment Fire-Sprinkler Save
University of Maryland
College Park, Maryland

The following information was provided by official sources.

Cooking oil in a pan on the kitchen stove caught fire and spread to the kitchen cabinets and vent above. The fire activated the fire sprinkler in the kitchen. The sprinkler extinguished the fire and activated the fire alarm system. One resident was in the kitchen at the time of the fire and two other residents were sleeping in their rooms.

The residents that were sleeping were awakened by the fire alarm. All the residents evacuated and called 911. There were no injuries.

Damage was relatively minor and limited to the cabinets, vent, and light fixture cover above the stove, and some wet carpeting. The sprinkler was replaced by Facilities Management and the system was placed back in service.

February 8, 2001

Dormitory Fire
University of Vermont
Burlington, VT

An unattended candle in a dormitory room started a fire that caused $4,000.00 in damage. The fire was contained to the room of origin by a police officer who closed the door to the room.

It was reported that the fire alarm system failed during the incident and did not activate. One resident reported attempting to pull four or five fire alarm pull stations,

and then people wound up going door to door to alert the occupants. According to the university, the 28-year old fire alarm system was disabled by a short-circuit in a heat detector.

February 8, 2001

Dormitory Fire-Sprinkler Save
Rowan University
Glassboro, NJ

The following information was provided by media accounts and university officials.

A fire was started in a dormitory room by a faulty electric fan motor. The fire was contained to the room of origin by the activation of the room's sprinkler system. (See related article about the fire protection program at Rowan University in "Fire Protection Improving" in the September, 2000 issue of Campus Firewatch.)

Thursday, February 8, 2001

Dormitory Room Fire
Plymouth State College
Plymouth, NH

An early morning fire in a dormitory forced 200 students to be evacuated from the building. The fire occurred in a first floor room and took an hour and 30 minutes to bring under control. Damage was estimated at $30,000 and 84 students have been displaced by the fire.

Monday, February 5, 2001

Off-campus apartment fire
University of New Hampshire
Durham, NH

The following information was provided by official sources.

Approximately 18 UNH students were awoken early this morning to the sound of smoke detectors in their off campus apartments. The apartments are located in a "taxpayer" over the Town and Campus store. Fortunately everyone escaped without injury.

The wiring associated with a light fixture in the Town and Campus stock room malfunctioned causing a fire between the ceiling and the roof assembly. Two sprinkler heads activated and even though the fire was above the sprinklers they kept the fire in check until fire crews from Durham and several neighboring communities could reach the blaze. Firefighters had to

Monday, February 5, 2001

Off-Campus Apartment Fire
University of Massachusetts
Amherst, MA

A fire in an off-campus townhouse rented by UMass students destroyed the apartment and its contents. The fire was discovered when one of the students returned home and found the apartment ablaze. No one was injured in the fire.

February 3, 2001

Campus Apartment High-Rise Fire
Boston University
Boston, MA

A fire on the 16th floor of a BU residence hall at 8:40 a.m. forced the evacuation of the building's occupants. Damage was confined to the apartment of origin. One of the occupants attempted to extinguish the fire but was unable to operate the fire extinguisher. The fire alarm system activated, and another occupant began pounding on adjacent apartment doors, warning the residents of the fire. One person reported that this was instrumental in their evacuating because of the number of false alarms that had been occurring.

Saturday, February 3, 2001

Conference Center Fire
University of Louisiana-Lafayette
Lafayette, LA

A fire in a car parked in a garage beneath a conference center forced students and faculty members to evacuate when smoke entered the building. No one was injured.

Saturday, February 3, 2001

Campus Apartment High-Rise Fire
Boston University
Boston, MA

A fire on the 16th floor of a BU residence hall at 8:40 a.m. forced the evacuation of the building's occupants. Damage was confined to the apartment of origin. One of the occupants attempted to extinguish the fire but was unable to operate the fire extinguisher. The fire alarm system activated, and another occupant began pounding on adjacent apartment doors, warning the residents of the fire. One person reported that this was instrumental in their evacuating because of the number of false alarms that had been occurring.

Previous updates have been archived

Appendix E

U.S. DORMITORY FIRE STATISTICS

In light of the fatal fires that have recently occurred at colleges and universities around the country, NFPA has compiled relevant data from the following NFPA reports: "School, College, and University Dormitories, and Fraternity and Sorority House Fires," "U.S. Experience with Smoke Alarms," and "U.S. Experience with Sprinklers." When using these statistics (which are being provided primarily for members of the media) please make sure to credit NFPA appropriately. For further information, please contact NFPA's Public Affairs Division at (617) 984-7275.

How often do fires occur in school, college, and university dormitories and fraternity and sorority houses?

In 1997, the latest year for which national fire statistics are available, an estimated 1,500 structure fires occurred in school, college, and university dormitories and fraternity and sorority housing. These fires resulted in no deaths, 47 injuries, and $7 million in direct property damage. Between 1993 and 1997, there were an estimated average of 1,600 structure fires per year, resulting in no deaths, 66 injuries, and $8.9 million in direct property damage per year.

Note that these are statistical estimates from records on a sample of fires. Because deaths are very rare, it is possible for the estimate to show no deaths in a year when a fatal fire did occur and is on NFPA's list of fatal campus fires. In particular, the sample omitted eight fatal fires known to NPFA, representing a total of 16 deaths over the five years of 1993-1997. Half of the fires and three-fourths of the deaths were in fraternity or sorority houses.

Between 1980 and 1997, the estimated annual average was 1,800 structure fires, 1 death, 69 injuries, and $8.1 million in direct property damage. (The separate list of fatal fires known to NFPA averaged 2 deaths per year during this period.)

These figures show a generally declining fire problem.

How many fires occur specifically in fraternity and sorority housing?

Between 1993 and 1997, an annual average of 154 structure fires occurred in fraternity and sorority houses, resulting in no deaths, 18 occurred in fraternity and sorority houses, resulting in no deaths, 1[illegible] injuries, and $2.9 million in direct property damage per year.

What are the most common causes of fires at school, college, and university dormitories and fraternity and sorority housing?

The leading cause of fire in these types of occupancies is incendiary or suspicious causes. The second and third leading causes of these on- and off-campus housing fires are cooking and smoking, respectively.

How often are smoke or fire alarms and fire sprinklers present in dormitory fires?

In 1997, smoke or fire alarms were present in 93% of all dormitory fires, but sprinklers were present in only 28% of these fires. These figures apply only to properties where fires occurred; the overall fraction of properties with these active systems is probably higher. On average, direct property damage per fire is 36% lower in dormitory fires where sprinklers are present compared to those where sprinklers are not present.

Just how effective are sprinklers?

Properly installed and maintained sprinklers prevent deaths outside the area of origin in all but a few unusual situations. In fact, NFPA has no record of a fire killing more than two people in a completely sprinklered public assembly, educational, institutional or residential building where the system was working properly. More generally, sprinklers typically reduce your chances of dying by one-half to two-thirds is any kind of property where they are used.

The following table consists of fatal college/university fraternity and sorority house fires known to NFPA from 1990 to 2000. The list was last updated on May 2000. Note that the civilian casualty figures differ from the statistical estimates, which come from records on a sample of fires.

Date	Location	Civilian Deaths	Civilian Injuries	Property Loss
09/09/90	Fraternity House, Berkeley, CA	3	2	$2,100,000
12/08/90	Fraternity House, Erie,PA	1	4	Not Reported
02/13/92	Fraternity House, California, PA	1	0	$70,000
10/24/93	Sorority House, LaCrosse, WI	1	2	Not Reported
10/21/94	Fraternity House, Bloomsburg, PA	5	0	$70,000
05/12/96	Fraternity House, Chapel Hill, NC	5	3	Not Reported

10/19/96	Fraternity House, Deleware, OH	1	0	$175,000
01/03/97	Dormitory, Warrensburg, MO	1	0	$45,000
01/10/97	Dormitory, Martin, TN	1	5	$68,000
02/20/97	Dormitory, Brooklyn, NY	1	0	Not Reported
12/09/97	Dormitory, Greenville, IL	1	0	Not Reported
09/18/98	Dormitory, Murray, KY	1	15	Not Reported
02/13/99	Fraternity House, Rolla, MO	1	0	$1,000,000
02/16/99	Fraternity House, Geneseo, NY	1	0	Not Reported
05/08/99	Fraternity House, Columbia, MO	1	0	Not Reported
01/19/00	Dormitory, South Orange, NJ	3	62	Not Reported

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Appendix F

FYI - Accidental Discharge of Fire Sprinklers

Automatic fire sprinkler systems are widely considered the single most effective tool for protecting life and property from unfriendly fire. There has never been a multiple loss of life from fire among building occupants protected by a properly designed, installed and maintained fire sprinkler system. Having an automatic sprinkler system protecting your home or workplace has been compared to having firefighters at the ready 24 hours a day. Automatic sprinklers respond individually to heat from a fire, distributing water under pressure at the source of a small fire before it can become large and deadly.

The idea of having water at the ready can be a concern to some due to the prospect of water damage. It is increasingly recognized that less water is needed to suppress small fires than large fires, and that a sprinkler system typically uses less than one-tenth the water to control a fire than the fire department would use in a nonsprinklered building. But what happens if there is accidental leakage from the automatic fire sprinkler system?

The fire sprinkler industry takes many precautions to ensure than accidental leakage does not occur. The automatic sprinklers and other system components are tested and listed by Underwriters Laboratories and Factory Mutual Research Corporation to make sure that these devices are not prone to leakage. Component designs are typically tested for integrity at four to five times the maximum water pressures they will see in service, and every single sprinkler is tested at twice its maximum service pressure before it leaves the factory. As a final step in the installation process, the entire sprinkler piping system is also tested under an elevated pressure for a two-hour period, and any leaks must be located and corrected.

There have been some instances where the performance of an automatic fire sprinkler has been so efficient that it is not immediately apparent that a fire took place. But if an automatic sprinkler has discharged water in the clear absence of a fire, an investigation should be undertaken to determine why the sprinkler operated. In almost all cases, a reason can be found. Typically, the reasons include inadvertent overheating, freezing, mechanical damage, corrosion, or deliberate sabotage.

Overheating - Automatic sprinklers respond to heat, and cannot differentiate between "good heat" and "bad heat". Where sprinklers are located very close to unit heaters, under skylights and in other areas exposed to high heat, the applicable rules of NFPA standard 13 - *Installation of Sprinkler Systems* require that higher temperature rated sprinklers be used. This means that the solder elements or glass bulbs used as the operating mechanisms will be designed to activate at temperatures of 200-300°F (93-149°C) instead of the normal 155-165°F (68-74°C). If new sources of heat are added, a qualified contractor should be hired to make the necessary modifications. Temporary heat-producing sources such as construction lighting and television cameras have also been known to activate sprinklers.

Freezing – Although special types of sprinkler systems are available for use in areas subject to freezing, most sprinkler systems are wet pipe systems, meaning that the piping is normally filled with water. If a system or even a small portion of a system is exposed to freezing temperatures, water in the piping can turn to ice, expanding in volume and producing thousands of pounds of pressure. Such pressures can break fittings, but can also force open the valve caps of sprinklers, resulting in apparent accidental discharge or leakage when the system subsequently thaws.

Mechanical Damage – The frame, the seat and the operating mechanism (solder link or glass bulb) of an automatic sprinkler together form a sealed unit that is expected to maintain its integrity, but also to operate efficiently if a fire ever threatens its protected area. The sprinkler parts are joined somewhat like a coiled spring, holding the energy needed to activate when released by heat from a fire. Mechanical impacts to sprinklers can result in damage and separation of parts. Although it is obvious that a large force can immediately open a sprinkler, it is less obvious that a smaller impact can do the same thing over time. For this reason, it is important that sprinklers be carefully handled during the installation process, and that the proper wrenches be used during their installation. Special wrenches are often required by the manufacturers' literature to reduce the possibility of slippage that can damage the sprinkler operating mechanism, potentially resulting in a release of parts weeks or months later. Building renovations can also result in impacts of sprinklers, leading to an inadvertent discharge or leakage at a later date.

Corrosion – Corrosion can result in a weakening of parts, and a subsequent release of water. This can occur among very old sprinklers, or sooner with sprinklers installed in a harsh environment. Many fire codes require enforcement of NFPA 25 - *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. This standard requires that the building owner replace sprinklers that exhibit corrosion, loading or other damage.

Deliberate Sabotage - Deliberate acts of sabotage must also be considered when investigating the reasons for sprinkler discharge. Vandalism and insurance fraud have been found in the past to be motivations for tampering with sprinklers.

Manufacturing Defect - The likelihood of an automatic sprinkler opening in the absence of the above reasons was historically found to be extremely low - on the order of one per year per sixteen million sprinklers in use. These statistics were based on the use of traditional sprinklers, however, not the more sensitive sprinklers of today that feature lighter operating mechanisms for enhanced fire performance. Although very rare, the possibility of a manufacturing defect can be considered when all other potential reasons for inadvertent operation have been ruled out. This could take the form of a problem in loading or tolerances on the parts. The sprinkler manufacturer should be contacted, and arrangements can be made for professional analysis.

Keys to proper analysis of the reasons for unexpected sprinkler discharge:

1. **Salvage of all sprinkler parts**. Pieces of the sprinkler operating mechanisms can often be located during clean-up activities and, like the sprinkler frame remaining in the piping, are extremely valuable in helping to determine the reason for sprinkler operation.

2. **Complete observation of the surrounding physical environment**. The history of the sprinkler is important. For newer sprinklers, this includes the conditions under which it was shipped to the jobsite, stored and installed. For sprinklers that have been in service for some time, the conditions of use include the possibility of damage from materials handling equipment, the potential exposure to freezing conditions, and the possibility of temporary heat sources.

Following an unexpected operation of a fire sprinkler, prompt and thorough collection of parts and data can mean the difference between an unexplained mystery and a documented problem. Better understanding of the reasons sprinklers operate accidentally will help ensure that fire sprinkler systems are there when needed…to protect lives and property.

Appendix G

College Fire Prevention Act (Introduced in the Senate)

107th CONGRESS

1st Session

S. 399

To provide for fire sprinkler systems, or other fire suppression or prevention technologies, in public and private college and university housing and dormitories, including fraternity and sorority housing and dormitories.

IN THE SENATE OF THE UNITED STATES

February 27, 2001

Mr. EDWARDS (for himself and Mr. DODD) introduced the following bill; which was read twice and referred to the Committee on Health, Education, Labor, and Pensions

A BILL

To provide for fire sprinkler systems, or other fire suppression or prevention technologies, in public and private college and university housing and dormitories, including fraternity and sorority housing and dormitories.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the `College Fire Prevention Act'.

SEC 2. FINDINGS.

Congress makes the following findings:

(1) On Wednesday, January 19, 2000, a fire occurred at a Seton Hall University dormitory. Three male freshmen, all 18 years of age, died. Fifty-four students, 2 South Orange firefighters, and 2 South Orange police officers were injured. The dormitory was a 6-story, 350-room structure built in 1952, that housed approximately 600 students. It was equipped with smoke alarms but no fire sprinkler system.

(2) On Mother's Day 1996 in Chapel Hill, North Carolina, a fire in the Phi Gamma Delta Fraternity House killed 5 college juniors and injured 3. The 3-story plus basement fraternity house was 70 years old. The National Fire Protection Association identified several factors that contributed to the tragic fire, including the lack of fire sprinkler protection.

(3) It is estimated that between 1980 and 1998, an average of 1,800 fires at dormitories, fraternities, and sororities, involving 1 death, 70 injuries, and $8,000,000 in property damage were reported to public fire departments.

(4) Within dormitories, fraternities, and sororities the number 1 cause of fires is arson or suspected arson. The second leading cause of college building fires is cooking, while the third leading cause is smoking.

(5) The National Fire Protection Association has no record of a fire killing more than 2 people in a completely fire sprinklered public assembly, educational, institutional, or residential building where the sprinkler system was operating properly.

(6) New dormitories are generally required to have advanced safety

systems such as fire sprinklers. But such requirements are rarely imposed retroactively on existing buildings.

(7) In 1998, 93 percent of the campus building fires reported to fire departments occurred in buildings where there were smoke alarms present. However, only 34 percent had fire sprinklers present.

SEC. 3. AUTHORIZATION OF APPROPRIATIONS.

There are authorized to be appropriated to carry out this Act $100,000,000 for each of the fiscal years 2002 through 2006.

SEC. 4. GRANTS AUTHORIZED.

(a) PROGRAM AUTHORITY- The Secretary of Education, in consultation with the United States Fire Administration, is authorized to award grants to States, private or public colleges or universities, fraternities, and sororities to assist them in providing fire sprinkler systems, or other fire suppression or prevention technologies, for their student housing and dormitories.

(b) MATCHING FUNDS REQUIREMENT- The Secretary of Education may not award a grant under this section unless the entity receiving the grant provides, from State, local, or private sources, matching funds in an amount equal to not less than one-half of the cost of the activities for which assistance is sought.

SEC. 5. PROGRAM REQUIREMENTS.

(a) APPLICATION- Each entity desiring a grant under this Act shall submit to the Secretary of Education an application at such time and in such manner as the Secretary may require.

(b) PRIORITY- In awarding grants under this Act, the Secretary shall give priority to applicants that demonstrate in the application submitted under subsection (a) the inability to fund the sprinkler system, or other fire suppression or prevention technology, from sources other than funds provided under this Act.

(c) LIMITATION ON ADMINISTRATIVE EXPENSES- An entity that receives a grant under this Act shall not use more than 4 percent of the grant funds for administrative expenses.

SEC. 6. DATA AND REPORT.

The Comptroller General shall--

(1) gather data on the number of college and university housing facilities and dormitories that have and do not have fire sprinkler systems and other fire suppression or prevention technologies; and

(2) report such data to Congress.

SEC. 7. ADMISSIBILITY.

Notwithstanding any other provision of law, any application for assistance under this Act, any negative determination on the part of the Secretary of Education with respect to such application, or any statement of reasons for the determination, shall not be admissible as evidence in any proceeding of any court, agency, board, or other entity.

Status: On 2/27/01 this legislation was referred to the Senate Committee on Health, Education, Labor, and Pensions. Updated 03/02/01

Appendix H

ARTICLE 8. CITY MANAGER'S ENFORCEMENT TEAM

§ 1. Establishment

Under Authority of Article Six of the Home Rule Charter there is hereby established under the jurisdiction of the city manager an agency of the city to be known as the "City Manager's Enforcement Team" (hereinafter "CMET").

§ 2. Function

It shall be the function of CMET to coordinate the activities of various city agencies involved in the enforcement of laws, ordinances and regulations adopted to protect and promote the public health and safety of the people.

§ 3. Membership

(a) CMET shall be made up of at least one representative each from the Law Department, the Department of Public Health and Code Enforcement, the Police Department and the Fire Department, and such other personnel as the city manager may designate from time to time.

(b) The representative of the Law Department assigned to the group shall be the senior official and chair of the CMET, unless otherwise designated by the city manager.

§ 4. Duties & Responsibilities

(a) CMET shall be responsible for enforcement of those local and state codes, laws, ordinances and regulations relating to conditions affecting the heath and safety of residents and their property which shall include, but not be limited to the following:

(1) lodging houses;

(2) violations of health, fire building, zoning, sanitary and other laws;

(3) abandoned cars;

(4) hazardous waste and illegal dumping;

(5) nuisance complaints;

(6) public utility programs (i.e. streetlight outages; missing stop and street signs, etc.).

(b) CMET shall have the power to take the following actions in pursuit of the stated goals:

(1) conduct investigations initiated by CMET members;

(2) receive complaints from the public and conduct investigations related thereto;

(3) issue orders requiring compliance;

(4) seek enforcement action employing legal and administrative actions seeking civil and/or criminal remedies.

(c) CMET shall have the authority to hold public meetings and neighborhood meetings in order to receive and disseminate information related to the stated goals.

(d) CMET shall make reports directly to the city manager or any other official he or she may identify and shall perform such other duties as the city manager may assign or request.

§ 5. Administration

(a) CMET shall be located within the Meade Street building of the Department of Public Health & Code Enforcement, or at any other location designated by the city manager.

(b) CMET will have the power to call upon all resources, files, information and assistance as may be required from any department of the city. This includes the power to use appropriate personnel and resources of the Assessing Department, Treasury Department, especially REAP information, and OPCD.

12/97

The City Manager's Enforcement Team (CMET) is a special unit established under the jurisdiction of the City Manager. It is the function of CMET to coordinate the activities of various city agencies involved in the enforcement of laws, ordinances and regulations adopted to protect and promote the public safety of the people.

CMET's responsibilities are to enforce local and state codes, laws, ordinances and regulations relating to conditions affecting the health and safety of residents and their property which shall include but not be limited to the following:

(1) lodging houses;
(2) violations of health, fire, building, zoning, sanitary and other laws;
(3) abandoned cars;
(4) hazardous waste and illegal dumping;
(5) nuisance complaints;
(6) Public utility programs;

Additionally, CMET performs such other duties as the City Manager may assign or request, inspects suspected drug houses during Zero Tolerance efforts, inspects group homes for state licensing, handles properties of particularly difficult landlords, operates the "drug letter" program and the confidential tip line.

The team conducts annual pre-licensing inspections of all of the 162 licensed lodging houses in the city. The team inspects to ensure compliance with the State Building Code, the State Sanitary Code, Fire laws, and police issues, including follow up on notification of property owners/managers about drug arrests on their rental property.

The team currently consists of an Assistant City Solicitor, as the senior official and chair, a Police Officer, a Fire Inspector, a Code Enforcement/Health Inspector, a Building Inspector and a secretary assigned from the Treasurer's Office.

In an average month CMET conducts 62 inspections, 96 reinspections, issues 8 orders and responds to an average of 15 new complaints. CMET inspectors appear in court when needed to present testimony and evidence in support of City of Worcester enforcement actions.

Appendix I

F.Y.I

Fire Sprinkler Facts

Sprinklers were invented by an American, Henry S. Parmalee, in 1874 to protect his piano factory.

Until the 1940s and 1950s, sprinklers were installed almost exclusively for the protection of buildings, especially warehouses and factories. Insurance savings, which could pay back the cost of the system in a few years time, were the major incentives.

Following fires with large losses of life (Coconut Grove Nightclub, Boston 1942-492 dead; LaSalle Hotel, Chicago, 1946-61 dead; Winecoff Hotel, Atlanta 1946-119 dead) fire and building officials searched for a means to provide life safety for building occupants. They found that factories and other buildings equipped with automatic sprinklers had an amazingly good life safety record compared with similar unsprinklered buildings.

Ø *What determines where and when sprinklers are required?*

Building codes over the past two decades have increasingly called for sprinklers throughout buildings for life safety, especially buildings in which rapid evacuation of occupants is difficult or the hazard posed by contents is high.

Ø *Why are there additional local ordinances?*

Where the building codes don't go far enough, many states and cities enact special tough sprinkler ordinances. The State of West Virginia, for example, requires sprinklers throughout all new buildings exceeding 40 feet in height. The city of Oak Brook, Illinois, requires sprinklers throughout all new buildings exceeding 1,000 square feet in area except single-family dwellings. Some communities, such as San Clemente, California, and Greenburgh, New York, require fire sprinkler protection even in new single-family homes.

Ø *What is retrofit legislation?*

In addition to requiring sprinklers throughout new buildings, some cities have encouraged sprinkler installation in existing buildings. These include NewYork City's landmark Local Law 5 for high-rise office buildings, and a Chicago ordinance requiring sprinklers throughout all nursing homes.

High-rise hotels have been required to retrofit with fire sprinklers in the states of Nevada and Florida, and in the city of Honolulu, Hawaii.

Recent high-rise retrofit laws include those enacted in Atlanta in 1989 and in Philadelphia in 1991.

Ø *What's happening outside the U.S.?*

In some countries, such as Japan, automatic fire sprinkler systems are used almost exclusively for life safety protection, and are being required throughout new and existing buildings.

Ø *How do sprinklers operate?*

Automatic fire sprinklers are individually heat-activated, and tied into a network of piping with water under pressure. When the heat of a fire raises the sprinkler temperature to its operating point (usually 165°F), a solder link will melt or a liquid-filled glass bulb will shatter to open that single sprinkler, releasing water directly over the source of the heat.

Ø *Why are sprinklers so effective?*

Sprinklers operate automatically in the area of fire origin, preventing a fire from growing undetected to a dangerous size, while simultaneously sounding an alarm.

Automatic fire sprinklers keep fires small. The majority of fires in sprinklered buildings are handled by one or two sprinklers.

Ø Why are sprinklers important for life safety?

Sprinklers do not rely upon human factors such as familiarity with escape routes or emergency assistance. They go to work immediately to reduce the danger.

Sprinklers prevent the fast developing fires of intense heat which are capable of trapping and killing dozens of building occupants.

Ø *What about smoke?*

Smoke, a by-product of fire, is generally the cause of death to building occupants. Although smoke is produced as sprinklers extinguish a fire, such quantities of smoke are less than those which would be produced by an unsprinklered fire permitted to grow.

Ø *Who decides design and installation procedures for sprinkler system?*

Proper design and installation of sprinkler systems is standardized nationally in a consensus standard promulgated by the National Fire Protection Association - NFPA 13.

A basic premise of proper sprinkler protection is that sprinklers be installed throughout all building areas. Partial sprinkler protection is a game of chance, since a fire originating in an unsprinklered area can overpower sprinklers given a head start.

Ø *What is the life safety record for fully sprinklered buildings?*

Aside from fire fighting and explosion fatalities, there has never been a multiple loss of life in a fully sprinklered building due to fire or smoke. Individual lives have been lost when the victim or his clothing or immediate surroundings became the source of the fire.

A National Fire Protection Association study for the years 1971-1975 found that approximately 20 lives are lost each year in this country in sprinklered buildings, as compared to approximately 4,000 per year in unsprinklered buildings. Some 68% of the lives lost in sprinklered buildings were due to explosions, and an additional 18% were due to the fact that the fire originated in an unsprinklered area of the building.

Ø How reliable are fire sprinklers?

All fire protection features have a reliability factor. Walls and shafts can be breached by means of poke-throughs and building alterations. Exit doors can be blocked or locked.

Sprinklers may be the most reliable fire protection system known. Detailed fire records for Australia and New Zealand (where fire must be reported) for the years 1886 through 1968 showed that 99.76% of all fires were extinguished or controlled by the sprinklers. Fire records in this country are less dependable due to lack of full reporting, especially for small fires where the sprinklers are successful. Nevertheless, the range includes a 96.2% success record reported by the National Fire Protection Association for the years 1925 through 1969, 98.4% success record for New York city high-rise buildings between 1969 and 1978, and a 98.2% success record for U.S. Department of Energy facilities between 1952 and 1980.

Ø How can you be sure a system will operate when needed?

Electrical supervision of sprinkler systems to monitor valves and water flow is a major plus in assuring system reliability and effectiveness, and is required by many building codes for large and important system installations.

Ø Can sprinklers discharge accidentally?

Loss records of Factory Mutual Research indicate that the probability of a standard response spray sprinkler discharging accidentally due to a manufacturing defect is only 1 in 16,000,000 sprinklers per year in service.

Ø How much does a new sprinkler system cost?

The cost of a complete sprinkler system depends on many factors, such as the building type and construction, availability of public water supply, and degree of hazard of the occupancy. For new construction, systems usually cost from $1.00 to $1.50 per square foot, less than the cost of carpeting.

The major model code organizations, in releasing average costs of sprinkler systems for building permit purposes, listed the following add-on costs for new construction in 1990:

Ø Building Officials and Code Administrators: 93› to $2.00/sq. ft.

Ø International Conference of Building Officials: $1.50/sq. ft.

Ø Southern Building Code Congress: $1.50/sq. ft.

Ø How much does retrofit cost?

Retrofit installations in existing buildings can be expected to cost somewhat more than for new construction, depending on the difficulty of installation and other factors. A general rule of thumb is to add 50%.

Ø *What are "trade-offs"?*

The system cost can often be offset by insurance savings, and by specific design alternatives or "trade-offs" permitted by most building codes in view of the superior protection afforded by sprinklers. These trade-offs often include reduced fire-resistant requirements for structural components, longer exit travel distances, and larger building areas and heights.

Ø *Aren't sprinklers ugly?*

Due to advances in sprinkler technology, sprinklers look better than ever, if you can see them at all. Sprinklers can be concealed behind ceilings, out of sight until needed to extinguish a fire. Sprinklers are also available in a range of colors and sizes to blend into the background of any room.

Ø *What about water damage?*

Reports of water damage due to fires in sprinklered buildings are often exaggerated due to comparisons with the small fire loss which occurs thanks to the sprinklers.

The amount of water which is put on a fire by fire department hoses in an unsprinklered building fire is nearly always tens to hundreds of times more than that which sprinklers would have discharged. During a fire, only those sprinklers closest to the fire activate, limiting the total amount of water needed. The fire damage, as reflected by insurance claims, is also many times greater.

There have been hundreds of multiple-death (three or more people killed) building fires in the United States since fire sprinklers were invented. These fires, all in unsprinklered buildings, have killed thousands of people, not to mention the property damage. A few of the more notable fires are listed here, though, unfortunately, the complete list is much longer. (Number of deaths in bold type.)

Appendix J

For Release: Friday, June 9, 2000
Contact: John Birtwell
Jason Kauppi
(617) 727-2759

CELLUCCI, SWIFT MAKE FIRE SAFETY A PRIORITY ON CAMPUS

Governor Paul Cellucci and Lieutenant Governor Jane Swift today announced a plan to protect students at public colleges and universities by committing to install fire sprinklers in dormitories constructed before building codes required the fire suppression systems. Cellucci and Swift have committed to investing $50 million over four years to ensure students and property are protected.

"The recent string of dormitory fires and loss of life in Massachusetts and across the nation reminds us that we must be vigilant in ensuring the safety of students at our colleges and universities," Cellucci said. "While our children seek a quality education and prepare for promising careers, we must make sure their living quarters are safe and that tragedy is avoided."

"While our current building codes require the installation of fire sprinklers in new dormitories, we must address those dormitories built prior to the new rules," Swift said. "The Commonwealth will install the sprinklers and shoulder the cost so we can continue to keep our colleges and universities affordable to all students."

At Massachusetts 29 state colleges and universities, nearly three-quarters of the dormitories lack fire sprinklers and are still considered to meet the building code. Many dormitories were not required to have sprinklers installed at the time they were originally constructed.

"In 1999, there were 150 fires in dormitories in Massachusetts," said State Fire Marshal Stephen D. Coan. "Any one them could have been like the recent Seton Hall fire in New Jersey that killed three students. This initiative is a major step toward preventing such tragedies from occurring here in the Commonwealth."

"The fire service of Massachusetts is extremely pleased with the Governor and Lieutenant Governor's initiative. Dormitory fires pose a great potential for loss of life. We must protect our investment in our own future, by protecting students life safety while they are in our care at our colleges and universities," said Devens Fire Chief Thomas E. Garrity, president of the Fire Chiefs' Association of Massachusetts.

Cellucci and Swift filed legislation to provide the Division of Capital Asset Management and Maintenance the authority to fund fire sprinkler installation in state dormitories. The buildings fall under the authority of the State College and University of Massachusetts Building Authorities, which would have to raise student fees to finance the safety measures. While smoke alarms give people early warning of fire, sprinkler systems can help control the fire and save the life of a person unable to escape.

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Appendix K