FIRE INVESTIGATION REPORT

FRATERNITY HOUSE FIRE
BERKELEY, CALIFORNIA
SEPTEMBER 8, 1990

Prepared by

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ABSTRACT

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:

1) Open stairways,
2) Combustible interior finishes throughout the building,
3) Lack of compartmentation and occupancy separation with fire-rated construction,
4) The lack of firesafety training and fire exit drills.
I. INTRODUCTION

The National Fire Protection Association (NFPA), with the assistance of the International Conference of Building Officials (ICBO), investigated the Phi Kappa Sigma fraternity house fire in order to document and analyze significant factors that resulted in the loss of life and property.

This study was funded by the NFPA as part of its ongoing program to investigate technically significant fires. The NFPA's Fire Investigations Division documents and analyzes incident details so that it may report lessons learned for life safety and property loss prevention purposes.

The NFPA was assisted in data collection and analysis by ICBO under an agreement between NFPA and the three model building code organizations to investigate significant structural fires and other emergencies throughout the United States. In addition to ICBO, the other cooperating model building code groups are the Building Officials and Code Administrators International (BOCA) and the Southern Building Code Congress (SBCCI). The three model building code groups assist NFPA by providing technical staff support for on-site field work and building code analysis.

The NFPA became aware of the fire several days after its occurrence on September 8, 1990. Michael S. Isner of the Fire Investigations Division travelled to Berkeley to document the facts related to the fire incident. The NFPA investigator was joined and assisted by William D. Wall, P.E., ICBO. A five-day, on-site study and subsequent analysis of the event were the basis
for this report. Entry to the fire scene and data collection activities were made possible through the cooperation of the Berkeley Fire Department and the California State Fire Marshal's Office.

This report is another of NFPA's studies of fires having particular educational or technical interest. The information presented is based on the best data available during the on-site data collection phase and during the report development process. It is not NFPA's intention that this report pass judgment on, or fix liability for, the loss of life and property at the Phi Kappa Sigma fire. This report presents the findings of the NFPA data collection and analysis effort.

The firesafety conditions at the fraternity house and the findings regarding factors that contributed to the loss of life or property are based on NFPA analysis of collected data and observations during the investigation. Current codes and standards were used as criteria for this analysis so that conditions at the facility on the day of the fire could be compared with current fire protection practices. It is recognized that these codes and standards may not have been in effect during construction or operation of the fraternity house. NFPA has not analyzed the building as to compliance with the codes and standards that were in existence when it was built or during its operation.

The cooperation and assistance of Assistant Fire Chief/Fire Marshal Rayford Hiatt of the Berkeley Fire Department and Fire Marshal Hugh Council of the California State Fire Marshal's Office are acknowledged and appreciated.
Special thanks are given to William D., Wall, P.E., Senior Regional Engineer, ICBO, for his contributions to this report. In addition to providing assistance in the data collection phase, he was instrumental in preparing the sections of the report that pertain to the Uniform Building Code and Uniform Fire Code, and he actively participated in the formulation and review of this report.

Finally, I wish to thank Maureen DiTullio, Division Secretary, for her assistance during the preparation of this report.
II. BACKGROUND

Occupancy Classification

The Phi Kappa Sigma House was designed specifically for use as a fraternity house with space allocated for sleeping rooms, bathrooms, and storage areas. In addition, there were two Class C assembly rooms, i.e., a living room and a dining room. These two assembly rooms were not separated from the sleeping room area with fire-rated construction.

According to the 1988 Life Safety Code® (LSC), the occupancy classification for the sleeping room portion of the building would have been "Existing Hotel and Dormitory," and Chapter 17 requirements would apply. In addition, the two assembly rooms are Class C, and the requirements of Chapter 9, "Existing Assembly Occupancies," of the LSC would apply to the two assembly rooms. The most restrictive requirements from the two Life Safety Code chapters would be applied to the entire building, since the assembly and sleeping room areas were not separated.

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1 Codes such as NFPA 101-1988, Life Safety Code, and the 1988 Uniform Building Code will be used in this report as the basis for comparison of existing conditions in the facility with selected requirements of these codes. It is recognized, however, that the codes were not in effect during the construction or use of this facility.

2 Registered Trademark, The National Fire Protection Assoc., Inc.

The Life Safety Code lists a "Class C" assembly area as an area with an occupant load of 50-300 people.
Under the Uniform Building Code™ (UBC), these assembly rooms would be classified as Group A, Division 3 occupancies. The sleeping portion would have been considered a Group R, Division 1 occupancy. Thus, the building would have been considered a mixed occupancy.3,4

The City of Berkeley issued a building permit for the Phi Kappa Sigma building on July 6, 1956. At that time the building was classified as a Group H occupancy, three-story, 50-room building to be occupied as a fraternity house. Of the 50 rooms, approximately 30 were used as sleeping rooms. The most recent fire department records revealed that the building was considered an R-1 occupancy (same as Group H prior to 1976 UBC) at the time of this fire.

Applicable Codes and Enforcement

This fraternity house was an off-campus building; therefore, the City of Berkeley was the authority having jurisdiction (AHJ). In 1956, when the building was constructed, the city was enforcing the 1952 edition of the UBC and the City of Berkeley Fire Prevention Code. At the time of the fire, the city was enforcing the 1988 edition of the UBC with the State of California 1989 amendments to the UBC and the 1979 edition of the Uniform Fire Code with local amendments.

3 Uniform Building Code, International Conference of Building Officials (ICBO), Whittier, CA.

4 The 1988 UBC classifies an assembly area with an occupant load of at least 50 but less than 300 as a Group A, Division 3 assembly occupancy.
Periodic inspections were performed by the Berkeley Fire Department. Typically, the fire companies annually inspected fraternity and sorority houses. When a discrepancy was noted, the facility would be reinspected by the fire company, and if the problem had not been corrected, the matter was referred to the Division of Fire Prevention for the issuance of a citation. Inspectors from this office continued to inspect the facility until the problem had been resolved.

The last fire department inspection (exterior inspection only) of the Phi Kappa Sigma property was performed on August 31, 1990 by the fire prevention bureau when they issued a permit for football parking. The inspector also indicated that all combustible vegetation and trash around and in the parking area needed to be removed. The most recent inspection during which fire fighters viewed the interior of the building occurred on February 28, 1990. The inspector noted violations regarding exits, fire alarm systems, fire extinguishers, and automatic extinguishment for the kitchen hood and duct system. According to the inspection records, the facility had a history of exit, maintenance, and housekeeping violations.

The Building Site
The Phi Kappa Sigma house was constructed on property that sloped down toward the west, making the Warring Street (east) side of the site the high point (see Figure 1). Residential buildings were constructed on properties adjacent to the other three sides of the Phi Sigma Kappa property. The distance between the fire building and adjacent exposed structures ranged from 15 ft to 25 ft.
The Building

As a result of the sloping site, only the top two stories in the sleeping room area and the living room were visible from the street side. When viewed from the north side, the building appeared to be a three-story structure (see Figure 2), and from the west side, the building appeared to be a four-story structure.

The largest section of the L-shaped building was 120 ft long and 32 ft wide (see Figure 3). The basement in this section of the building contained a boiler/mechanical room and a large room that was referred to as the "pledge room" and was sometimes used for sleeping. The first story contained a dining room, kitchen, and several other rooms.

A 48-ft by 26-ft living room extended to the south from the lobby (see Figure 4). This room had a 14-foot high ceiling and a set of folding doors that could close off part of the living room. The 4-ft wide panels of the folding doors had metal hinges, a combustible frame, combustible finish materials, and were the full height of the room. One panel was fixed to the room's east wall, another panel was fixed to the west wall, and a ceiling mounted track allowed the rest of the panels to be moved toward the center of the room. A latching mechanism could secure the doors when both sides were fully extended.

More than 50 percent of the perimeter of the basement and first story were sufficiently above grade that each could be considered a story according to NFPA and ICBO criteria. However, the Berkeley Fire Department report classified the building as a three-story structure. In order to maintain consistency between the NFPA investigation report and the Berkeley Fire Department report, the building will be considered a three-story with basement structure in this report.
Investigators believe that at the time of the fire, the folding door panels were fully extended, closing off the south one-third of the room. A grand piano, wood frame couch, rolls of old carpeting, and other combustible materials were being stored in the space behind the folding doors.

The remaining two-thirds of the living room was sparsely furnished. Reportedly, there were several large frame photographs on the walls and three couches in the room. One of these couches had three cushions, foam padding, a thermoplastic fabric covering, and wood frame. This couch was near the windows in the west wall and was the initial item ignited. The construction of the other two couches was not known. The finish floor surface for this part of the room was 1/4-in. thick hardwood floorboards, nailed to a 1/2-in. thick plywood subfloor.

Openings for the living room included large windows in the west and south walls, windows and a door in the east wall, an opening for the stairway to the dining room level (first story), and an opening leading to the lobby. Neither the opening to the stairway nor the opening to the lobby was equipped with doors. The top two stories contained sleeping rooms. The building occupants called the first sleeping room level (2nd story, see Figure 5) the first floor, and they called the top sleeping room level (3rd story, see Figure 6) the 2nd floor.
The building as constructed was of Type V (000) Construction according to NFPA 220, Standard on Types of Building Construction, and according to UBC, the construction was Type V-N. 6,7 All exterior and interior bearing walls, floor/ceiling assemblies, and stairways were of wood construction. Similarly, the ceiling/roof assembly and all nonbearing walls were also constructed with wood. Diagonal wood boards were used as sheathing, and this material was covered with either metal panels or stucco.

The interior walls in the sleeping room corridors, stairways, and sleeping rooms had 1/4-in. thick, 4-ft by 8-ft sheets of luan paneling. All of these walls also had a sublayer of 1/2-in. gypsum wallboard, and some walls in the sleeping room area had an additional sublayer of 1/2-in. thick plywood to resist loads imposed during earthquakes. A few sleeping rooms had a second layer of the 1/4-in. thick sheet wood paneling, and one room had rustic barn board covering its walls.

The ceilings in both the sleeping rooms and adjacent corridors were painted gypsum wallboard nailed directly to joists. The living room ceiling consisted of plaster that was approximately 1-in. thick and applied over a metal lath nailed to the joists. Like the walls in the sleeping room area,

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6 NFPA 220, Standard on Types of Building Construction, 1985 edition. A Type V (000) structure will have a 0-hour fire rating for the exterior bearing walls (first digit); a 0-hour fire rating for structural frame or columns and girders supporting loads for more than one story (second digit); and a 0-hour fire rating for the story assembly (third digit).

7 UBC Table 17-A establishes that there are no ratings required for the floor/ceiling, roof/ceiling, exterior and interior walls; however, 1-hr rated stair and shaft enclosures are required.
walls in the living room had a gypsum wallboard substrate. The gypsum wallboard was covered with 3/8-in. thick tongue and groove philippine mahogany planking.

Most of the sleeping room doors were hollow-core wood. However, one sleeping room on both the second and the third stories had a solid-core wood door because the original doors for each of these rooms had been damaged and were replaced.

**Means of Egress**

The sleeping room portion of the building had one enclosed exit stairway (Stairway 1, Figure 3). This stairway was at the west end of the building and provided exiting from all levels. This exit stairway discharged at grade at the rear of the building. At the time of the fire, the exterior exit door was closed and secured with a dead bolt and padlock. Reportedly, this was a standard practice in this building, and occupants would normally leave through the pledge room or through exits for the first story dining room.

Apparently, Stairway 1 had been equipped with solid-core wood doors at all story levels. The door closing device had been removed from the first story door, but this door appeared to have been closed during the fire. The second story door was open during the fire, and the third story door also appears to have been open. However, damage was so extensive on the third story that investigators were not able to determine whether a door had been in place on this level.
Stairway 2 (see Figure 4) connected the lobby with the second story corridor, and Stairway 3 connected the lobby with the third story corridor. Reportedly, both stairways were equipped with hollow-core wood doors on the top landings of each stairway and were open during the fire.

In addition to the two exit stairways, occupants of the third story had access to a door that opened to a patio area on the roof of the living room. There was no stairway or other means to reach grade from the patio, however.

**Fire Protection Systems**

In January 1986, the fire department approved plans for a new local alarm system that was subsequently installed in the building. The system included one alarm bell on stories with sleeping accommodations, i.e., basement and stories two and three. The building's fire/evacuation alarm system was activated with manual pull stations, and upon activation all bells operated simultaneously. This alarm system was not connected to the fire department or any other monitoring facility.

Battery-operated, single-station smoke detectors had been installed in some sleeping rooms. The smoke detectors were installed as a result of a recent in-house program to upgrade the fire protection provisions in the building. Reportedly, 30-40 more smoke detectors were in storage in a closet and were intended to be installed in all sleeping rooms. Smoke detectors had not been installed in the living room.
A standpipe system supplied water to hose cabinets on stories one, two and three. The second story cabinet was the only one equipped with 1 1/2-in. linen hose and a nozzle. In addition to supplying the hose cabinets, the standpipe system also provided water to a single sprinkler located at the top of the building's laundry chute. A single sprinkler was also installed at the top of the building's trash chute, and this sprinkler was supplied by the domestic water system.

Several fire extinguishers had been provided for the building. After the fire, most of the observed fire extinguishers were empty and were in the first story furnace room. These extinguishers were dusty and appeared to have been in storage for some time before the fire. Another fire extinguisher had been thrown into the building's trash chute, and a 2 1/2-gal air-pressurized-water fire extinguisher was on the third story.

**Heating, Ventilating, and Air Conditioning Systems**

The building did not have a central ventilating or air conditioning system; however, it originally had a central heating system. This system included a gas-fired boiler for a hot water heating system. At the time of the fire, this system had been permanently shutdown, and no central heat was being provided to any room. Residents would use space heaters in their sleeping rooms when necessary.

**Occupant Status**

The Berkeley fraternity was a self-governing chapter of the Phi Kappa Sigma, a nationally recognized fraternal organization. The Phi Kappa Sigma general office prepared and distributed a Home-Owners Guidebook
that was intended to educate students and alumni regarding the responsibilities of house ownership. Firesafety and evacuation drills are among the many topics discussed in the guidebook.

At the local chapter level, the fraternity president, who was a student like the other residents of the building, administered the fraternity's programs and monitored activities. In addition to the in-house, self-administered control, adult alumni advisors monitored the facility activities and assisted the residents on an informal basis. For example, one alumnus became concerned with the level of fire protection in the facility and initiated the in-house program to install smoke detectors in the sleeping rooms.

The fraternity normally housed 35 students. On the evening of this fire many residents were out, and only 8 to 10 residents were in their respective rooms. However, several of the residents had guests so the exact number of people in the building at the time of the fire was not known.
THE FIRE

Discovery and Initial Activities

At approximately 1:00 a.m. on Saturday, September 8, 1990, the Phi Kappa Sigma president and a friend returned to the fraternity house. As the president parked his car along the north side of the building, the friend saw light smoke coming out of the bathroom window on the second story and brought it to the attention of the president. They quickly went to the front of the building, and upon entering the lobby area, they could see a couch that was next to the west wall in the living room was burning.

The flames were clearly visible, were approximately 4 to 6 ft high, and were extending over the full length of the three cushion couch. Ceiling-level smoke was passing over them while they stood in the lobby, and neither witness felt any heat at that time.

The president ran up Stairway 2 to the second story and called the fire department using a pay telephone near the top of these stairs. Upon completing the call, he ran down the second story corridor banging on doors to alert sleeping occupants. At the west end of the corridor, he went up Stairway 1 and found hot smoke as he entered the third story. He ran down this corridor knocking on doors again to alert sleeping occupants. As he reached the east end, the smoke, heat, and fire on the third story increased, and he exited the building through the patio access door (see Figure 6), jumped onto the roof covering the entrance, and then jumped to the ground.
A few moments after the president ran to the telephone, his friend attempted to go up Stairway 3 to alert the third story occupants. As she entered the stairway, she began to feel heat from the smoke above her, and before reaching the third story, the heat in the stairway increased noticeably. She described the conditions as being similar to those in a sauna and as being the hottest thing she had ever experienced. The heat forced her to go back down, and she left the building through the front entrance.

**Emergency Forces Response**

The Berkeley Fire Department received several 911 calls regarding the fire at the Phi Kappa Sigma house. The first call was made by a calm, unidentified male and was received at 1:01:56 a.m. This caller was followed by an extremely excited male, who is believed to be the fraternity president, at 1:02:16 a.m. At least nine other calls were also received reporting this fire. The first alarm assignment was dispatched at 1:03 a.m. and included three engines, one truck, and an assistant chief.

The 911 operator/dispatcher also notified the police department of the incident, and several officers were dispatched. One police officer who was only a few blocks from the scene arrived before the fire fighters. The officer entered the building through the front door and ordered two unidentified people who were near the living room out of the building. At this time, the fire was involving the couch and a section of the wall adjacent to the couch. The heat in the lobby area was moderate.
The police officer crossed the lobby and had started up Stairway 2 to the second story when conditions in the building changed suddenly and dramatically. Fire raced over his head, the heat became unbearable, and he was hit with debris as air near the floor of the second-story corridor began to rush toward the room of origin. He went back out the door that he entered.

The police officer ran around the building attempting to find another way in. He could not open the exit discharge door for Stairway 1, but found that he could enter through an exterior door for the pledge room (see Figure 3). He ran up Stairway 1 and found a tremendous amount of heat and flame in the stairway at the second story level. These conditions forced him to leave the building again.

The first engine company arrived at approximately 1:07 a.m. The company officer saw that flames were already venting from several windows and were shooting 50 to 100 ft into the air. He also noted some flames were affecting an exposed apartment building adjacent to the fraternity's south side. The engine company officer immediately requested a second alarm response and directed his crew to protect the exposed apartment building.

The assistant chief arrived on the scene at the same time as the engine company. He radioed the dispatch center, confirming the need for a second alarm assignment, and two engines and one truck were dispatched at 1:09 a.m.
During his initial size-up, the assistant chief also found fire coming out of the south windows to the living room, and he too became concerned for the exposed apartment building and for its occupants. Flames were venting from most openings in the building's east face. These openings included the door and windows in the entrance to the living room, the front main entrance to the building, and the ground level window in the sleeping room section of the building. In addition, heavy smoke was coming from top story windows.

When viewing the building's north face, the assistant chief found heavy smoke coming out of several top story windows at the northeast corner and flames visible in many other windows on this story. In addition, there was a distinct glow over the building. The assistant chief did not know if this glow was caused by fire venting through the roof or from fire venting from windows on the other side of the building.

Despite reports that people were trapped on the roof, the assistant chief did not find any such persons during his initial size-up. However, he did find that a person was trapped in a top story room. This person was at a window in the northeast corner of the building, and because of the window design, the occupant could not lean out of the window. The heavy smoke venting out that window initially obscured this person, preventing the officer from immediately seeing him.

The assistant chief made the crew of the first due truck company aware of the trapped person and of the need to protect the exposed apartment building. Upon arrival at the scene, the truck crew found that trees and
wires prevented the use of their aerial ladder for the rescue. Some members of this crew raised a ground ladder and rescued the trapped man, who was uninjured. Moments after the rescue was made, the room he was in became fully involved in fire. Other crew members prepared the aerial ladder for use as a ladder pipe to protect the exposed apartment building (Exposure 1, Figure 1).

Even before the second alarm units began to arrive, the assistant chief requested a third alarm response. This request, which was made at 1:11 a.m., resulted in the call back of off-duty staff and suppression personnel.

The first responding assistant chief assumed the role of incident commander. His initial plan included the establishment of water supplies, exposure protection before attempting to attack the fire building, and the evacuation of adjacent buildings. As the first and second alarm companies arrived, they were immediately assigned to various tasks and to the sectors around the building in order to meet his goals. Approximately 5 min after the arrival of apparatus, the engine crew was using an effective water stream to protect the exposed apartment, the south exposure, and the truck company had set up their ladder pipe to protect the same building.

The chief of the fire department arrived on the scene approximately 1/2 hour into the incident. After conferring with the first incident commander, the chief assumed command of the fire, and the assistant chief became the operations chief. The new incident commander initially chose to maintain the tactical strategy that was already in place, i.e., protecting exposures, evacuation, and exterior attack against the fire building. He also initiated a
county "Red Alert" and requested a mutual aid response. Of the responding mutual aid companies, three engines went to the scene and another three engine companies and a truck company went to cover the city.

At approximately 2:00 a.m., the incident commander attempted an interior attack. Fire fighters brought a hose line in the building's front entrance, and as they entered the building, they found that the lobby floor had burned and apparently collapsed. The fire fighters next attempted to advance the hose line through the front entrance to the living room, and they found that floor had burned and apparently collapsed, too. Other fire fighters attempted to attack the fire area by using Stairway 1. Like the fire fighters in the front of the building, they found that Stairway 1 had burned and collapsed, which made access to the fire area impossible by normal means.

At approximately 2:15 a.m., the fraternity members made fire fighters aware that at least one of the building residents was missing and was known to have been sleeping in a "second floor" room. Not realizing that the building residents referred to the top story as the "second floor" and thinking that the building was a three-story structure (as a result of the building's appearance from the north side), fire fighters initiated their search in what they believed to be the building's "second" story, i.e., the first sleeping room level.

Since the fire fighters knew they could not enter the building via the stairways, they raised ground ladders to windows on the north side of the building. Fire fighters with hose lines extinguished the fire room by room
and searched each room as soon as possible. This tactic was complicated by the need to use blocks on the sloping grade in order to provide a level base for the ground ladders. The room by room fire extinguishment and search continued until the victim was found in a third story sleeping room. Coincidentally, this victim was found in a room equipped with one of the smoke detectors, and this room also was the third story room with the solid-core door.

The incident commander found that the room by room attack from ground ladders was proving to be effective against the fire, so this attack was maintained until fire fighters gained control of the fire and could enter the building to complete their extinguishment. Upon entering the building, fire fighters found that the fire had caused a section of the third story corridor to collapse and burned through several areas of this corridor. As a result, both the second and third story corridors were impassible. Fire fighters created their own passageway by cutting holes in the walls between rooms as they advanced their interior fire attack along these two stories.

The fire was declared to be officially "under control" at 4:11 a.m., and the overhaul operations and search for hot spots began. While these operations were in progress, fire fighters were made aware that a second fraternity member and his girlfriend were missing and most likely still in the building. A search for these people was initiated at 4:30 a.m. and their bodies were found approximately 11 hours later at about 3:30 p.m. in the third story corridor under debris from the roof that had collapsed.
In total, six staff officers and 52 personnel from fire companies responded to the scene. Eleven engines, two trucks, and three ambulances were committed to the scene, and three neighboring communities sent seven fire companies in response to the mutual aid request by the Berkeley Fire Department.

**Casualties**

Three people died in this fire. The cause of death for all three victims was smoke inhalation and burns. The male victim who was found in the third story room had a blood/alcohol level of 0.20 percent and a carbon monoxide (carboxyhemoglobin) level of 65 percent.\(^8\) The second male victim had blood/alcohol and carbon monoxide levels of 0.07 percent and 69.4 percent, respectively, and the female victim's levels were 0.11 percent and 56.5 percent, respectively.

In addition to the three fatalities, two residents were injured. The fraternity president sprained his ankle when he jumped off a roof during his escape, and one of the fraternity members was treated for first degree

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8 A blood alcohol level of 0.1 percent is a commonly accepted threshold limit at or above which a person can legally be presumed as being under the influence of alcohol.

9 The Occupational Safety and Health Administration (OSHA) Occupational Health Guideline for Carbon Monoxide makes the following statement regarding CO intoxication: "...The diagnosis of CO intoxication depends primarily on the demonstration of blood. Levels over 60% are usually fatal; 40% is associated with collapse and syncope; above 25% there may be electrocardiographic evidence of a depression of the S-T segment; between 15% and 25% there may be headache and nausea. The reaction to a given blood level of carboxyhemoglobin is extremely variable: some persons may be in coma with a carboxyhemoglobin level of 38% while others may maintain an apparently clear sensorium with levels as high as 55%..."
burns on his back, arm, and head. He sustained these injuries during his escape through the second story corridor.

**Damage**

The building was extensively damaged by this fire. Virtually all of the philippine mahogany planking in the living room was consumed. In addition, most of the combustible furnishings and the folding partition doors were completely destroyed. The majority of the hardwood flooring and plywood subfloor that was north of the partition doors was consumed, and the floor joists were heavily charred but were still in place. The extensive destruction of flooring and subflooring gave the appearance of a collapsed floor when fire fighters attempted to enter the building.

Flooring south of the partition doors in the living room was not consumed; however, it did have varying degrees of fire damage. Investigators believe the difference between damage to the flooring south of the partition doors compared to the damage north of the partition doors was a result of the doors closing off the south one-third of the room. In addition, furnishings and materials, such as rolls of carpeting, were being stored in this section of the room, which protected the floor.

Similar to the flooring in the living room, the hardwood floors and subflooring in the lobby were consumed by the fire, and the floor joists were heavily charred. The burning in the lobby area was so extensive that all the gypsum board covering the walls had fallen away, and the wood studs in the walls were heavily charred. Some studs were completely consumed.
Conditions on the second and third story, for the most part, were similar to those in the living room and lobby. Virtually all the interior finish material was consumed by the fire. The substrates, including gypsum wallboard and plywood sheathing on most walls, had been burned, and many wood studs were heavily charred. Some of the wood roof assembly collapsed or was consumed by the fire. In addition, one section of the third story corridor, approximately 10 ft long, collapsed and fell down to the second story corridor.

Stairway 3 was completely consumed by the fire. All interior finish materials and wall substrates were destroyed. All stair treads and risers were consumed, and even the stringers and wall studs were heavily charred or totally consumed by the fire.

Similar conditions were present in Stairway 1 at the second and third story levels. All wall and stair tread materials were consumed, and the structural components, i.e., stringers and studs, were heavily charred or consumed. However, the damage decreased in the lower levels of Stairway 1. From the second story to the first was damaged, but usable, and this stairway was undamaged in the area between the first story and the basement.

In addition to the lower levels of Stairway 1, several building areas were not heavily damaged by fire. The rooms in the basement and on the first story had little or no fire damage. In addition, the sleeping room on the second story had heavy smoke damage, but the contents and interior finish materials were not burned. The lack of burning in this second story room is believed to be a result of the closed solid-core wood door.
**Time Line**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>1:00 (+) a.m.</td>
<td>Phi Kappa Sigma president and his friend return to the house and find smoke coming from a third story window.</td>
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<tr>
<td></td>
<td>The president and friend enter lobby area and see a couch burning in the living room.</td>
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<td></td>
<td>President goes to a second story pay telephone and calls the Berkeley Fire Department.</td>
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<tr>
<td>1:01:56 a.m.</td>
<td>The first of many calls reporting this fire is received.</td>
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<tr>
<td>1:02:16 a.m.</td>
<td>Fire department receives the call believed to have been made by the fraternity president.</td>
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<tr>
<td>1:03 a.m.</td>
<td>First alarm assignment is dispatched. This response includes one engine, one truck, and an assistant chief.</td>
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<tr>
<td>1:05 (+) a.m.</td>
<td>Police officer arrives on the scene and enters building.</td>
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<td></td>
<td>As he is entering the short open stairway to the second story, fire conditions change dramatically, and he is forced out of the building.</td>
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<td></td>
<td>Police officer enters building through the basement pledge-room door.</td>
</tr>
<tr>
<td></td>
<td>By the time he reaches the third story via the west stairway, the second story corridor and stairway up to the third story are blocked by heavy smoke and fire.</td>
</tr>
<tr>
<td>1:07 a.m.</td>
<td>Both first assignment companies and the assistant chief arrive on scene. Second alarm is requested.</td>
</tr>
</tbody>
</table>
The initial size-up reveals that fire was venting from most windows on the building’s east face, many windows on the building’s north face, and a red glow is visible above the building.

The initial strategy included protecting exposures, evacuation of adjacent buildings, establishing a water supply, and exterior fire attack.

1:11 a.m. Third alarm requested; recall of off-duty staff and suppression personnel.

1:12 a.m. Engine company has established the first water stream used to protect the exposed building, and the trapped person had been rescued.

1:35 a.m. Berkeley Fire Chief arrives on scene and assumes command of the fire.

2:00 a.m. An interior attack is attempted and fire fighter cannot make entry into the building because floors and stairs have burned away.

2:15 a.m. Fraternity members tell fire fighters that one building resident is missing.

4:11 a.m. Fire is declared under control.

Overhaul and search for hot spots begin.

4:30 a.m. Two more building occupants are reported as missing.

A search of the building is begun.

3:30 p.m. The bodies of the two missing people are found buried in the debris.
ANALYSIS

Cause and Origin
Local investigators determined that the fire was caused by a visitor in the fraternity house. A 23-year-old male visitor was waiting in the living room for a friend who was a member of the fraternity. At approximately 12 p.m., the visitor ignited the couch with a butane cigarette lighter. When the couch began to burn, he suppressed the flames and left the building. Apparently, this fire smoldered for a while and then returned to open burning.

Fire Growth and Spread
The statements of several witnesses indicate that the fire involving the couch along the west wall in the living room was openly burning and that the smoke layer was very high in the room when it was discovered. The open design of the building allowed combustion products to readily leave the room of origin and, more importantly, allowed the fire to draw enough air to maintain efficient burning. Though the witnesses saw smoke passing over their heads in the lobby area, the 12-ft high ceilings and steady spread of smoke up stairways into the second and third stories prevented witnesses from initially feeling the heat from this fire.

The fire spread from the couch to the mahogany planking and continued its rapid growth. Approximately 5 min after the fire was first observed by the fraternity president, the burning in the room of origin dramatically increased, signifying that flashover occurred and that most of the
furnishings and other combustible contents in the room of origin were probably burning at this time.

The rapidly propagating flame front spread from the living room, through the lobby, and into the second and third story corridors in a matter of seconds. The speed with which the flames spread down the sleeping room corridor is verified by the police officer who was forced out of the lobby by the fire early in the scenario. After leaving the lobby, the officer ran around the building and re-entered the building through the pledge room. By the time he reached the second story level, hot smoke and flames were already entering the stairway through the door opening.

The combustible interior finish in the corridors and stairways allowed the fire to burn fiercely in these areas. The fire burned through the hollow-core wood doors that were used for most sleeping rooms, and the contents and combustible interior finish in these rooms contributed even more fuel to the fire. With burning occurring on both sides of many interior partitions, the wall coverings and substrates of both plywood and gypsum wallboard either were consumed by the fire or deteriorated and fell away. As a result, the studs and other interior structural members also became part of the fuel load.

One of the second story sleeping rooms had a solid-core wood door that was closed during the majority of this 3-hr long fire. The door maintained its integrity through most of the incident and kept the fire from entering the room. In addition, the walls maintained their integrity, and fire did not enter this room by breaching the wall even though flames attacked the
walls from the corridor side. The contents and combustible interior finish materials did not burn, verifying the effectiveness of compartmentation even under extreme fire conditions.

**Factors Affecting Fire Suppression and Rescue Operations**

The distance between buildings had a direct impact on fire suppression operations. Immediately upon arrival, fire fighters found that they had an exposure problem because flames were venting out of the south windows of the living room, and the adjacent apartment building (Exposure 1, Figure 1) was close enough that fire fighters became concerned that fire could spread to that building. Flames did ignite the exterior of another building (Exposure 2, Figure 1) and spread to the interior of that building. The protection of these two buildings and their occupants required the use of resources that potentially could have been used to attack the fire in the building of origin. Furthermore, the attack against the fire in the building of origin was delayed several minutes because the first fire crews concentrated their resources on protection of exposures.

All ladder pipe operations had to be performed from the east (street) side of the building even though tree and overhead wires limited the operation of aerial equipment from this side. A parking lot was available on the building's north side. However, the steep slope and the narrow design of the parking lot would have caused the apparatus to be too close to the building, eliminating the potential for safe aerial operations from this side of the building. Close buildings, fences, and grade variations prevented crews from positioning aerial equipment on the south and west sides.
The fire fighters using ground ladders on the building's north side also experienced difficulties. The grade was so steep on this side of the building that blocks had to be used in order to give the ladder a relatively flat base before being raised. The need to use blocks increased the complexity of the ground ladder operations and the risk to fire fighters on the ladders.

Engine companies assigned to west and south sides of the building could not position their engines close to the fire building. As a result, the companies assigned to the west side had to hand lay hose lines through adjacent properties. This required fire fighters to carry their equipment over a six-foot high wall. Similarly, fire fighters who were assigned to protect a small, exposed wood frame building (Exposure 2, Figure 1) adjacent to the fire building's south side had to hand lay their hose lines to the building. In addition to increasing the setup time, positioning hose lines through adjacent properties and over fences reduced the operational flexibility once fire crews were in position.

Finally, the building had been equipped with operable windows for the sleeping rooms. However, these windows did not provide a clear opening. One trapped person could not easily lean out the window and make his presence known to fire fighters. In addition, fire fighters were hampered by the window design during rescue and other exterior operations.

**Code Analysis**
In the interest of comparing conditions and other details regarding this incident with the current national consensus codes, the 1988 edition of the NFPA Life Safety Code (LSC) and the 1988 edition of the Uniform Building Code...
Code (UBC) will be used as the bases for comparison.\textsuperscript{10,11} It is recognized, however, that these codes were not part of the legal requirements governing lifesafety at the Phi Kappa Sigma House. The following discussion concerns requirements that have particular relevance to this fire. It is not intended to be a complete description of all parts of the code that pertain to this fraternity house.

Although the LSC does not require sprinklers for existing dormitories, it does provide significant incentives for buildings equipped with them by modifying the requirements for travel distance, exit discharge, vertical openings, interior finish, corridor walls, and smoke barriers. Had the Phi Kappa Sigma house been equipped with complete automatic sprinkler protection, the fire could have been controlled and possibly extinguished early in the sequence of events mitigating the hazard to occupants.

Section 3308(h) of the UBC requires an automatic sprinkler system to be installed in buildings containing 20 or more guest rooms.\textsuperscript{12} The UBC also requires sprinkler systems in hotels (the Phi Kappa Sigma house would be

\begin{itemize}
  \item \textsuperscript{10} The LSC contains requirements for both new and existing buildings. However, the LSC requirements for existing dormitories will be used during this code analysis because the Phi Kappa Sigma house was not new at the time of the fire.
  \item \textsuperscript{11} The UBC requirements used in this analysis are for new buildings. Appendix Chapter 1 of the UBC contains requirements for existing buildings. However, unless specifically adopted, the requirements in that appendix chapter are not considered part of the code.
  \item \textsuperscript{12} The LSC requires an approved supervised automatic sprinkler system in all new high-rise buildings used as a hotel or dormitory (paragraph 16-3.5.2).
\end{itemize}
considered a "hotel") three or more stories in height.\textsuperscript{13} Residential or quick response standard sprinklers are required.

Paragraph 5.1.3.1 of the \textbf{LSC} Chapter 5, \textit{Means of Egress}, requires that the separation for exits that connect three stories or less have a 1-hr fire resistance rating including 1-hr fire protection rated doors. The door at the top of Stairway 3 was normally left in the open position and door closing devices were removed from the doors to Stairway 1. Therefore, both stairways could be considered as being open. Stairway enclosures that met the code requirements would have provided occupants with more time for escape or potential rescue by fire fighters. In this specific case, the \textbf{UBC} requires the same rated enclosures for stairways and doors as the \textbf{LSC}. In addition, the 1988 \textit{Uniform Fire Code}, in Sections 10.401 and .402, requires fire-resistive construction and protection of openings to be maintained as specified in the \textbf{UBC}.\textsuperscript{14}

Paragraph 17.3.3.1 of the \textbf{LSC} requires that the interior wall finishes for exit enclosures, and corridors and lobbies that are part of an exit access, be Class A or Class B.\textsuperscript{15} Though the class of interior finishes for this facility

\textsuperscript{13} The Phi Kappa Sigma house has been classified as a three-story structure in order to maintain consistency between this report and the Berkeley Fire Department report. See Footnote 5.

\textsuperscript{14} The Uniform Fire Code is sponsored jointly by the Western Fire Chiefs Association and the International Conference of Building Officials.

\textsuperscript{15} Paragraph 6-5.3.2 defines interior wall and ceiling finishes as follows:

- Class A Interior Wall and Ceiling Finish. Flame spread 0-25, smoke development 0-450.
- Class C Interior Wall and Ceiling Finish. Flame spread of 76-200, smoke development of 0-450.
was not known, it appears that neither the philippine mahogany planking in the living room nor the luan paneling throughout the rest of the building would have met the criteria for Class A or B finish. Underwriters Laboratories Inc. Building Materials Directory indicates that untreated plywood of various thicknesses has flame spread rates ranging from 100 to 200. According to this information, even the best untreated plywood could not qualify as a Class B building material. Regardless of the actual classification, it's clear that the 38-year-old interior finish materials in the building allowed the fire to spread readily, and the materials greatly increased the fuel load for the building.

Under the UBC, interior finish in the living room (A-3) would need to comply with Class III (same as Class C under NFPA). The corridor flame spread requirement in Table No. 42-B establishes Class II (same as Class B under NFPA); however, if an approved sprinkler system is provided, Class III material is acceptable. Enclosed vertical exit ways, such as the stairway enclosures, are required to meet Class I (same as Class A under NFPA) with relaxation to Class II if sprinkler protection is provided.

The LSC recognizes that compartmentation resulting from fire-rated construction can help to protect occupants. Accordingly, the LSC contains the following minimum fire resistance requirements. Paragraph 17-3.6 of LSC, Chapter 17, Existing Hotels and Dormitories, requires a 30-min fire resistance rating for interior corridor walls and a 20-min fire protection rating for room doors. Section 17-3.7, Subdivision of Building Spaces.
requires that every guest story be divided into at least two smoke compartments. Both of these sections require building compartmentation that would have affected the fire spread in the building and would have increased the potential for occupant survival.

In addition, the LSC recognizes that a fire in one part of a building can affect occupants in another part of the same building if separation safeguards are not provided. This is an especially acute situation when the building contains more than one class of occupancy as was the case in the Phi Kappa Sigma house. The following LSC paragraph addresses this situation:

1-4.7 Mixed Occupancies. Where two or more classes of occupancy occur in the same building or structure, and are so intermingled that separate safeguards are impracticable, means of egress facilities, construction, protection, and other safeguards shall comply with the most restrictive life safety requirements of the occupancies involved.

Section 503, and thus Table 5-B, of the UBC require a 1-hr fire resistive separation between assembly room (A-3) and the sleeping room (R-1) portions of the building. Not only are the walls and floors that form the separation required to be rated but the openings, such as doors, are also required to be rated for 1-hr. This type of separation would have contained the fire to the assembly portion of the building providing occupants of the sleeping room portion of the building with more time to escape.

Section 507 of the UBC limits the story height at which a particular occupancy may be located in a building. Type V-N construction (as built) limits hotel/dormitory/apartment (R-1 occupancy) to the second story.
Those residential uses are allowed on the fourth story in buildings constructed to meet several types of construction, but the most common one are Type II 1-hr or Type III 1-hr.\textsuperscript{16} The former essentially requires noncombustible building elements throughout while the latter requires noncombustible exterior walls but allows combustible interior building elements. In either case, the building elements must be at least 1-hr fire-resistant construction.

Corridors under the UBC that serve residential occupancies with an occupant load of 10 or more are required by Section 3305(g) to be 1-hr fire-resistant and have 20-min smoke and draft control assemblies with gasketing and closer to protect door openings.

Paragraph 31-6.3.1 of the Life Safety Code requires that fire exit drills be regularly conducted. In addition, the Phi Kappa Sigma Home-Owners Guidebook suggests that board members ensure that fire exit drills occur at least once a semester. There was no record or information that indicated fire exit drills were performed in this facility. This lack of training may have contributed to the failure of the building occupants to use a manual pull station to activate the building's fire/evacuation alarm system. Had this system been used immediately upon discovery of the fire, the sleeping occupants would have received the alarm several moments before they did during this fire scenario.

\textsuperscript{16} Type II one-hour requires noncombustible materials throughout and walls, floors and roofs to be one-hour. Type III 1-hr requires 4-hr noncombustible exterior walls (some exceptions are allowed) and 1-hr combustible interior walls, floors, and roofs.
Section 1211 of the UBC requires a manual and automatic approved fire alarm to be installed in structures such as this one; however, an exception allows a local alarm capable of notifying all occupants to be substituted when the building is protected throughout by an approved supervised fire sprinkler system.

Paragraph 17-3.4.4 of the LSC and Section 1210 of the UBC requires that an approved single station smoke detector powered from the building electrical service to be provided in each sleeping room. It appears, however, that smoke detectors installed only in the sleeping rooms would have done little to change the outcome of this incident since the fire started in the assembly room and spread over the combustible interior finish in that room, lobby, open stairways, and corridors.

**Discussion**

In 1965, John Morris, a former Safety Coordinator for the University of Illinois published an article entitled, "Off-Campus Housing - A College Fire Problem." Mr. Morris described conditions, such as combustible decorations, open stairs, and inoperative alarm systems, that have contributed to fatal fires in fraternities. In addition, he discussed programs that have been initiated by local fire departments, universities, and fraternal organizations to control fire hazards.

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In the 1970's the NFPA investigated three fatal fraternity house fires. On February 2, 1975 three persons were injured and a fraternity house was heavily damaged when a fire struck the Chi Phi Fraternity House in Amherst, Massachusetts. The fire started in a waste paper basket, spread to a polyurethane-padded couch, and ultimately involved several first story rooms. Heavy smoke and fire blocked an open decorative stairway, the primary means of egress, forcing second story occupants to jump out windows. On January 8, 1976, two Ohio State University students died in a fire at the Alpha Rho Chi Fraternity House. NFPA investigators identified rapid fire growth on combustible decorations, an open stairway, and lack of any detection, alarm, and suppression equipment as being major contributing factors in this loss. And on August 29, 1976, five Baker University students died when fire struck the Kappa Sigma Fraternity House in Baldwin City, Kansas. The factors contributing to this loss were an open stairway, lack of a second means of egress from the upper stories, and the lack of a smoke detection and alarm system.

Many of the significant factors in these three fires were discussed in Mr. Morris' article written one decade before these incidents. More importantly, one factor, i.e., open stairways, discussed by Mr. Morris contributed to the Phi Kappa Sigma loss and to the three fraternity fires investigated by the NFPA in the 1970's.


Moreover, the LSC, UBC, and other model codes contain requirements that address the factors that significantly contributed to the loss. Specifically, those factors are:

1) Open stairways,
2) Combustible interior finishes throughout the building,
3) Lack of compartmentation and occupancy separation with fire-rated construction,
4) The lack of firesafety training and fire exit drills.

To ensure a firesafe environment for the occupants of fraternity and sorority houses, the responsible social organizations must ensure that their chapter houses contain the fire protection provisions required by applicable codes and that the residents also maintain and operate the facility in a safe manner. The local authority having jurisdiction (AHJ), be it the fire department, educational institution or another agency, must inspect the facilities and ensure the code requirements are being enforced.

Mr. Morris's concluding statement in his 1965 Fire Journal article, "Off-Campus Housing - A College Fire Problem" appears to be applicable even today:

"Firesafety in student housing is literally a matter of life and death, and a responsibility that ought to be shared by the college, the local or state enforcement authority, and the organization owning or operating a residence. Each should make certain that its segment of responsibility has been properly carried out."
EXPOSURE 3

EXPOSURE 4

EXPOSURE 2

EXPOSURE 1

PHI KAPPA SIGMA

PARKING

WARRING STREET

- - - - - 3 FOOT BLOCK WALL
- - - - 6 FOOT WOOD FENCE
- - - - - - - - - - - - 6 FOOT WALL
- - - - - - - - - - - - - - - - - CHAIN LINK FENCE

PLOT PLAN
Figure 1
THIRD STORY
Figure 6